Online : www.e-krishiuasb.karnataka.gov.in

THE MYSORE JOURNAL OF AGRICULTURAL SCIENCES

Vol. 51 (2) April - June, 2017 ISSN-0047-8539

UNIVERSITY OF AGRICULTURAL SCIENCES
BENGALURU, INDIA

Frequency of Publication : **Quarterly** **MJAS 51 (2) 2017 : 201-500**

SUBSCRIPTION RATES

Membership	Inland (₹)	Foreign			
		US $		UK £	
		SM*	AM**	SM*	AM**
Annual Membership					
Individual	400.00	60.00	80.00	30.00	40.00
Institution	500.00				
Life Membership					
Individual	3000.00				
Institution	5000.00				
Single copy	100.00				

* SM – Surface Mail ** AM – Air Mail

Note : 1. All correspondence should be addressed to the Editor, Communication Centre, UAS, GKVK, Bengaluru - 560 065, India. E-mail : editor@uasbangalore.edu.in / editoruasb@gmail.com

2. All the authors of the review article / research paper / research note should be the subscribers (Annual membership fee ₹ 400-00 / Life membership fee ₹ 3000-00) of the Journal and should pay processing fee of ₹ 100-00 per article.

3. Subscription amount should pay through bank challen to the S/B Account No. 0425101030928, Canara Bank, GKVK, Bengaluru-560 065 and upload the same or Demand Draft drawn in favour of the Editor, Communication Centre, UAS, GKVK, Bengaluru-560 065

4. Authors should submit the article through proper channel along with the duly signed declaration stating that the article has neither been published nor sent for publication in any other Journal

This Journal is being abstracted by CAB International
Online : www.e-krishiuasb.karnataka.gov.in
Also available in Website : www.uasbangalore.edu.in

Edited and Published by Dr. B. N. Manjunatha
Communication Centre, University of Agricultural Sciences, Bengaluru - 560 065, India

Mysore J. Agric. Sci., 51 (2) : 201-500, 2017

CONTENTS

PART II - RESEARCH NOTES

PART III - ABSTRACTS OF THESIS

Mysore J. Agric. Sci., 51 (2) : 201-207, 2017

Artificial Recharging Borewells in Groundwater Over Exploited Zone of Karnataka - An Institutional Approach

S. Anitha and M. G. Chandrakanth
Department of Agricultural Economics, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail : anu.s.naik@gmail.com

Abstract

In this study modest attempt to analyze the efforts of Village Panchayath in recharging drinking water borewells is undertaken. For the study, 30 village panchayaths were randomly selected from Bengaluru rural, Kolar and Chickballapur districts of EDZ of Karnataka. Results revealed that on an average 23 borewells were dugged in Village panchayaths for drinking water supply among them 43 per cent of wells failed in the past five years. About 75 per cent of failed borewells were recharged by the Village Panchayath under Mahatma Gandhi National Rural Employment Guarantee Scheme (MGNAREGS) from the past five years. About 66 per cent of borewells which are recharged were successfully yielding water. In each Village Panchayaths on an average 7 drinking water borewells were recharged and cost incurred for construction of the recharge structure is of Rs.53000, unskilled and material payment in 50:50. In the recent past five years, about 1700 drinking water borewells were recharged under MGNAREGS of EDZ. The farmers and other groundwater users in dry agro-climatic zones need to take initiative in individual groundwater borewell recharge activities to a large extent for getting the benefit of recharge of borewells.

Keywords: Artificial borewell recharge, over exploited zone, MGNAREGS, village panchayath

In India 90 per cent of domestic water and 80 per cent of irrigation water is drawn from the groundwater source. Groundwater is the preferred source of drinking water as well as irrigation in India. India is the highest pumper of ground water (220-230 BCM), twice that of the USA and six times higher than the Western Europe. This shows the enormous dependency on groundwater for drinking and irrigation needs. About 65 per cent irrigated area of India constitutes hard rock area where recharge is 5 to 10 per cent of the rainfall. In addition, human efforts to recharge are grossly inadequate. In addition, users of groundwater either farmers or others do not appreciate that groundwater gets recharged by rejuvenating their borewells.

India is the largest pumper of groundwater due to which there has been large scale massive failure of irrigation wells. Lack of efforts to recharge them has exacerbated the well failure probability. Climate change is imposing severe thrust to groundwater on both demand and supply sides. The hydro-geological and socio-economic factors are both influenced by agro climatic factors in shaping groundwater for different uses and users.

Farmers are pumping twice that of groundwater recharged

The groundwater development in the parlance of hydrogeology usually refers to groundwater extraction. But in reality, groundwater development should include the component of recharge of groundwater also. The Eastern Dry agro-climatic Zone (EDZ) tops in the degree of groundwater development as the extraction as a per cent of recharge surpasses 195 per cent and entire region classified as "over exploited" (Anon., 2009). This implies that farmers and users of groundwater are pumping almost twice the natural recharge in the eastern dry agro climatic zone.

The Karnataka Ground Water (Regulation and Control of Development and Management) Act, 2011 envisages farmers in EDZ to implement the act in the notified area. The notified area is defined as the area critical for groundwater development. The details of the notified area in EDZ as on 2012 are listed (Table I). Accordingly, the major portion of the critical zones of groundwater extraction has been in the EDZ. Here no further extraction of groundwater is

TABLE I

List of notified areas for control and regulation of groundwater in EDZ of Karnataka

Districts	Taluks
Bangalore Urban	Anekal, Bangalore North, Bangalore South
Bangalore Rural	Devanahalli, Doddaballapura, Hoskote, Nelamangala
Chikkaballapur	Chikkaballapur, Chinthamani, Gouribidanur, Gudibanda
Kolar	Bagarpet, Malur, Mulbagilu
Tumkur	Koratagere, Madhugiri

permissible and accordingly the institutional finance is not provided for groundwater extraction in EDZ.

The EDZ also has to support drinking water needs in addition to food, fodder, fruits, vegetables, flowers and other needs of Bangalore metropolitan including industrial water. The drinking water needs of Kolar and Chikkaballapur, Bangalore Urban and Tumkur districts are growing due to rapid urbanization. EDZ also does not have perennial rivers. In addition, there has been large scale sand mining which is responsible for well failure of dug wells and borewells over time. EDZ has the entrepreneurial farmers who demonstrated successfully the use of micro-irrigation technology for narrow spaced crops such as green leafy vegetables, potato, tomato, cabbage, knol kohl and flower crops. Given this massive need for groundwater resource in over exploited EDZ, the options before the policy makers are as under:

1) Restriction of groundwater extraction with stringent enforcement of The Karnataka Ground Water (Regulation and Control of Development and Management) Act, 2011.

2) Support and facilitate groundwater recharge programme at micro level involving village panchayaths for drinking water borewells, Department of Agriculture for irrigation borewells

3) Undertake capacity building regarding groundwater development at village panchayath level.

Considering the three alternatives for policy makers, it is desirable to focus on second and third options. In this study a modest attempt is made to analyze the efforts of the Village panchayaths in EDZ in recharging drinking water borewells in villages.

METHODOLOGY

The study is conducted in EDZ of Karnataka. In this study, 30 gram panchayaths have been randomly selected in order to analyze the performance of drinking water borewells which have been recharged during the past five years. While CDZ pioneered in demonstrating success of recharging the irrigation wells, the success of recharging drinking water borewells has been ably demonstrated in EDZ by recharging approximately 1700 borewells by the village panchayaths. The descriptive statistics and regression analysis were used to express the result.

It is heartening to learn that 75 per cent of failed wells from the past five years have been recharged by panchayaths. In order to find the elasticity of successful recharge, the number of borewells recharged which are successfully yielding water have been regressed on the total number of borewells recharged since the past five years in each sampled panchayath. The fitted model is:

Natural Log of the number of recharged borewells which are successfully yielding groundwater =

- 0.457+ 1.04 (Natural log of Total number of borewells which are recharged)

n = Total number of observations 29, Adjusted R^2 is 0.83, F value is 137.68 and is significant.

RESULTS AND DISCUSSION

The total number of borewells drilled in Village panchayath for drinking water purpose ranged from 15 in Kallinayakanahalli, to 32 in Mastenahalli in Chikkaballapur district (Table II). The proportion of borewell failure ranges from 27 per cent in Kurudi to 51 per cent in Doddaganjur. The number of borewells recharged from past five years' ranges from 2 borewells in Pathapalya to 18 borewells in Kaivara in Chikkaballapur. The percentage of borewells functioning after recharge ranges from 16 per cent in

TABLE II

Drinking water borewell recharged and extent of recharge in village panchayaths of Chikkaballapur district.

Sl. No.	Name of the Village Panchayath	Taluk	Total No. of Borewells drilled in village panchayath	No. of Borewells failed in past Five Years	Percentage of Borewell failed	No. of Borewell recharged in past five years	No. of Re-charged Borewell yielding water	Percentage of Borewell yielding water
1	2	3	4	5	6 = (5/4)*100	7	8	9 = (8/7)*100
1	Pathapalya	Bagepalli	28	8	28.57	2	1	50.00
2	Thalagavara	Chintamani	21	7	33.33	5	5	100.00
3	Santhekallahalli	Chintamani	30	10	33.33	12	4	33.33
4	Mastenahalli	Chintamani	32	15	46.88	6	1	16.66
5	Kaivara	Chintamani	22	8	36.36	18	14	77.78
6	Permachanahalli	Chintamani	18	5	27.78	5	3	60.00
7	Chinnasandra	Chintamani	26	8	30.77	3	2	66.67
8	Doddaganjur	Chintamani	23	12	51.43	6	4	66.67
9	Irgampalli	Chintamani	25	14	44.44	12	10	83.33
10	Kadadanamari	Chintamani	20	8	40.00	3	3	100.00
11	Kadalaveni	Gouribidanuru	16	7	43.75	16	10	62.50
12	Kallinayakanahalli	Gouribidanuru	15	6	40.00	7	6	85.71
13	Kurudi	Gouribidanuru	18	5	27.78	3	2	66.67
14	Allipura	Gouribidanuru	23	10	43.48	4	2	50.00
		Average	22.64	8.79	37.71	7.29	4.71	64.48
		Total	317.00	123.00		102.00	66.00	

TABLE III

Drinking water borewell recharged and extent of recharge in village panchyaths of Kolar district.

Sl. No.	Name of the Village Panchayath	Taluk	Total No. of Borewells drilled in village panchayath	No. of Borewells failed in past five years	Percentage of Borewell failed	No. of Borewell recharged in past five years	No. of recharged Borewell yielding water	Percentage of Borewell yielding water
1	2	3	4	5	6 = (5/4)*100	7	8	9 = (8/7)*100
1	D N Doddi	Maluru	20	9	45.00	12	10	83.33
2	Lakkuru	Maluru	28	7	38.89	6	4	66.67
3	Rajenahalli	Maluru	26	11	27.78	9	9	100.00
4	Arabhikotthanuru	Kolar	27	10	37.04	13	9	69.23
5	Channasandra	Kolar	22	14	63.64	7	4	57.14
6	Manighatta	Kolar	25	12	47.06	6	3	50.00
7	Vemagal	Kolar	18	10	55.56	6	3	50.00
		Average	23.71	10.43	45.00	8.43	6.00	68.05
		Total	166.00	73.00		59.00	42.00	

TABLE IV

Drinking water borewell recharged and extent of recharge in village panchayaths of Bangalore Rural district

Sl. No.	Name of the Village Panchayath	Taluk	Total No. of Borewells drilled in village panchayath	No. of Wells failed in past five years	Percentage of Borewell failed	No. of Borewell recharged in past five years	No. of recharged Borewell yielding water	Percentage of Borewell yielding water
1	2	3	4	5	6 = (5/4)*100	7	8	9 = (8/7)*100
1	Melekote	Doddaballapura	24	8	33.33	10	7	70.00
2	Bashettihalli	Doddaballapura	27	12	46.88	10	6	60.00
3	Kundana	Devanahalli	22	8	36.36	4	3	75.00
4	Koira	Devanahalli	27	7	25.93	14	10	71.43
5	Avathi	Devanahalli	16	15	93.73	7	7	100.00
6	Bettakote	Devanahalli	24	14	58.33	3	2	66.67
7	Bidaluru	Devanahalli	18	8	44.44	4	2	50.00
8	Bijjavara	Devanahalli	19	10	52.63	4	3	75.00
9	Venkatagirikote	Devanahalli	26	12	46.15	9	5	55.56
		Average	**22.56**	**10.44**	**48.64**	**7.22**	**5.00**	**69.30**
		Total	203.00	94.00		65.00	45.00	

TABLE V

The elasticity of successful borewell recharge

Features	Co efficients	t Stat
Intercept	-0.46	-2.64
Natural log of total number of borewells recharged	1.04	11.73

TABLE VI

Cost for drinking bore well recharge structure (12 feet×12 feet×10 feet) construction in MGNAREG scheme by the Gram panchayaths

Items	Unit cost (in Rs)	Quantity	Total (in Rs)
20 MM Jelly (cum)	970.35	2.96	2874.17
40 MM Jelly(cum)	800.45	3.25	2604.92
Boulders (cum)	588.80	9.46	5572.21
Sand (cum)	1429.99	3.93	5619.01
Nylon mesh(mtr)	556.67	3.00	1670.01
cement (bags)	349.49	5.28	1843.88
size stone (cum)	192.03	9.90	1901.71
Name board	1136.67	1.00	1136.67
Skilled labour charge (Rs)	500.00	2.00	1000.00
Unskilled labour payment through NMR	142 labour days		28988.60
Total Payment			53211.17

Mastenahalli to 100 per cent in Thalagavara and Kadadanamari of Chikkaballapur district, on an average 64 per cent of recharged borewells are successfully yielding the water (Table II).

The average number of borewells drilled for drinking water in Village panchayath of Kolar district is 24 and among them 45 per cent (10 borewells) were failed during past five years. The number of borewells recharged from past five years' ranges from 6 to 13 borewells in Kolar and Malur Taluks, on an average 8 borewells per village panchayath were recharged in Kolar district. The percentage of borewells successfully yielding water ranges from 50 per cent in Manighatta and Vemagal to 100 per cent in Vemagal of Kolar district (Table III).

In Bangalore rural district, the total number of borewells drilled in Village panchayath for drinking water purpose ranged from 16 in Avathi, to 27 in Koira Village panchayath. The proportion of borewell failure ranges from 26 per cent in Koira to 93 per cent in Avathi. The number of borewells recharged from past five years' ranges from 3 borewells in Bettakote to 14 borewells in Koira. The percentage of borewells successfully yielding water ranges from 50 per cent in Bidaluru and 100 per cent in Avathi (Table IV).

The elasticity of 1.04 indicates that for every one per cent increase in the number of borewells recharged, there is one per cent increase in success in yielding water due to recharge, which implies 100 per cent success in recharge efforts of drinking water wells. This demonstrate that in the over exploited recharge, where the extraction exceeds recharge, groundwater recharge efforts have been successful (Table V).

About 60 per cent of village panchayaths face acute shortage of drinking water during the summer season (January to June) and as an immediate measure the panchayaths supply drinking water from private water tankers. The corresponding expenditure on drinking water supply ranges from Rs. 2.5 lakh to Rs. 16 lakhs and on an average Rs. 5.83 lakhs per village has been spent for supplying drinking water to people. In comparison the expenditure on groundwater recharge is comparatively low (being Rs. 3.71 lakh) and is also sustainable as the average number of borewells recharged per village panchayath is around seven, and the cost incurred to recharge per well is Rs. 53000/-.

The borewell recharge process includes digging a 12 feet x12 feet x10 feet pit around the bore well. At the bottom, in the casing, five feet of the bore well should be drilled around 100 to 200 holes and covered with nylon mesh, to make sure that silt should not enter the bore well. Then four feet should be filled with locally available stones or boulders around the casing, next 1.5 feet be filled with 40 mm jelly, next 1.5 feet with

20 mm jelly. A layer of charcoal powder has to be spread to absorb microorganisms. Then a nylon mesh has to be placed above the charcoal powder. Then two feet of sand layer needs to be spread on the top to enable silt free water to recharge the borewell. Next a one feet wall around the recharge structure with one inlet and outlet for rainwater from the catchment area needs to be constructed for the percolation pit to function.

In the MGNAREG scheme gram panchayaths of Kolar and Chikkaballapur districts have recharged on an average four to five drinking water borewells from past five years. The cost incurred to construct 12 feet × 12 feet × 10 feet recharge structure was of Rs. 53211. The structure construction generates on an average 142 man days for unskilled labour which accounts of Rs. 28988 (54 %) of the total cost and material component is of Rs. 24289 (46 %) which is paid to material supplier from the panchayath (Table VI).

The study indicates that 66 per cent of the drinking water borewells recharged successfully are yielding water in Eastern dry agro-climatic zone of Karnataka. This demonstrates that in the over exploited zone, the benefits due to recharge are certain and accordingly farmers and other groundwater users in EDZ needs to take initiative in individual groundwater borewell recharge activities to a large extent. The government should create awareness through capacity building programmes about the groundwater recharge for the farmers at village panchayath level with the help of the State Agricultural Universities and other concerned agencies.

References

ANONYMOUS, 2009, Groundwater information booklet -Kolar District, Central Ground Water Board, Karnataka : p. 1 - 22

CHANDRAKANTH, M. G., 2015, *Water resource economics*, Springer, London.

KIRAN KUMAR R. PATIL, 2014, Economics of coping mechanism in ground water irrigation role of markets, technologies and institution. *Ph.D. Thesis* (Unpub.), Univ. of Agril. Sci., Bengaluru.

KIRAN KUMAR R. PATIL, CHANDRAKANTH, M. G. AND ANITHA, S., 2016, Bore well economics and sustainable groundwater management. *Jal Kranthi Abhiyan Groundwater Conference*, p. 77 - 87.

http://nrega.nic.in/netnrega/home.aspx

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 208-215, 2017

Farm Land Values and Portfolio Management in Rural-urban Continuum of Bengaluru North

H. V. Harishkumar and B. V. Chinnappa Reddy
Department of Agricultural Economics, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: harishpal0083@gmail.com

Abstract

The study analyses the impact of urbanization on farm land prices and portfolio management of sale proceeds in North Bengaluru. To capitalize on current high farmland prices augmented sales of farmland is observed in high urban influence areas. It is resulting in marginalization of farm holdings putting their livelihoods under risk in the long run. Forced sales are more pronounced in second gradient because of pressure from real estate business for villas and recreational infrastructure which requires more land. It is observed that about 32 per cent of land sale proceeds were used for construction of house which is a basic amenity and a symbol of social status as felt by the respondents in the area. About 16 per cent of proceeds were used for wasteful consumption purposes like performing marriages, gambling and others. In third gradient, the number of farmers selling land and extent of sales are increasing over the period (2002-16) indicating the influence of urbanization in the form of slow rise in the value of the farmland which may have potential threat on farmlands and livelihood of farmers.

Keywords: Farm land value, urbanization, transformation, portfolio management, livelihood

Bengaluru is one of the fastest growing cities in the world and is globally known for its development in terms of information technology, biotechnology, real estate and its diversity. Bengaluru topped the list of 134 world's most dynamic cities, which considered 42 variables including recent and projected changes in city GDP, population, commercial real estate constructions, rents and other factors *viz.,* education, innovation and environment (Anon., 2017). These developments have led to transition in land use, land values, labour markets, water resources, lifestyles and livelihood options. Similar rapid surge in urban expansion can be observed across the country. For instance, as a result of urban expansion, land use/land cover has changed drastically at the periphery of the Jalandhar city and it has led to the transformation of the rural landscape into the urban landscape where inbuilt up area has increased to 37 per cent (2010) from 8 per cent (1975) at the cost of reduction in farm land from 52 per cent to 31 per cent (Seema, 2014). The developments like establishment of International airport, National highways, Hardware Park, Financial city project and other industries in the Bengaluru north has triggered the process of transformation of farm lands by surging prices and this has increased marginalization of farm holdings in high urban influence areas. Larry and Burton (2012) reported that 37 per cent of respondents sold farmland to capitalize on current high land prices and resulting capital gains and reported that the farm land values had doubled in just five years and increased five folds during a period of 11 years in South Dakota, USA.

These developments attracted the investment by real estate sector and the agricultural lands turned as common floor for Flats, Villas, Cargos and Godowns, Schools and Colleges, Hospitals, Malls and Supermarkets, Resorts, Hotels and Restaurants', Courier operators, Parking yards, Advertisement boards etc. Xiaowei and Jay (2013) expressed that urban influencing factors were playing a critical role in affecting the overall farmland value and high real estate earnings had led to rising farmland prices.

In the above context the study aims at analysing the marginalization of farm holdings, escalation in the farm land values over the period, kind and nature of farmland sales in different periods and their extent, reasons behind the sale of farmlands and portfolio management of sale proceeds in the rural-urban continuum of Bengaluru North. The irreversible transformation of farm lands has created a concern about sustainability of agriculture surrounding the Bengaluru city. Kavitha *et al*. (2015) expressed their concern to protect and conserve the farmlands by proper policy and guidelines, as over the years, expansion of Bengaluru to the fringes has declined the magnitude of agricultural land by 16.31 per cent. Similar concerns were also expressed by Li jiang *et al.* (2013), who alerted that the urban expansion is likely to continue and would result in reduction in the production in China due to reduced agricultural land use intensity. Santhakumar (2014) suggested for any development, the land value and its influencing factors have to be verified for preparation of plans, projects and policies to achieve a comprehensive solution.

METHODOLOGY

Agriculture has seen transitions in terms of land use system, land values, water, labour, marketing system in rural-urban interface of Bengaluru North, because of developments in the area. Hence the study was conducted in the rural-urban continuum of Bengaluru North to analyze the influence by urbanization process on farm land values.

A multistage random sampling procedure was employed for the selection of study area and sample respondents. At first level Bengaluru Urban (Urban), Bengaluru Rural (Peri-Urban) and Chikkaballapur (Rural) districts were selected and in next level Bengaluru North, Devanahalli and Gudibande taluks were selected and in each taluk four villages were selected at random. In the next and last level, 15 sample farmers were randomly selected from each village thus forming a total sample size of 180 with equal spread of 60 from each gradient. The sample farmers were interviewed using a pre-tested schedule and data on socio-economic characters, land holdings, farm land values at five years' interval since 2001, land sale details and portfolio management of its proceeds was collected. Analytical measures like descriptive measures and percentage changes were used in analyzing the rise in farmland values, number and extent of land sales and its portfolio management.

Garret ranking technique

To analyze the reasons for the sale of farmland in the study area, a list of reasons for sale of farm lands was developed during the preliminary survey conducted in the study area and the sample farmers were asked to rank the reasons at the time of interview using a pretested schedule. The garret ranking technique was employed to prioritize the ranks given by the sample farmers. The order of the rank given in ascending order was converted to per cent position using the formula.

$$\text{Per cent position} = \frac{100*(Rij-0.50)}{Nj}$$

Where R_{ij} = Rank given for i^{th} reason by j^{th} respondent

N_j = Number of items ranked by j^{th} respondent

The per cent position of each rank was converted into scores by referring to the table given by Garret and Woodworth (1969). Then for each reason, the scores of individual respondents were summed up and divided by the total number of respondents from whom scores were gathered. The mean scores for all the factors were ranked, following the decision criterion that higher valued reason will secure the first rank and so on.

RESULTS AND DISCUSSION

As the influence of urbanization increases the marginalization of farm lands is more pronounced and this phenomenon can be observed in Table I. In the first gradient, where urban influence is highly conspicuous, 6.66 per cent of the sample respondents were landless. But they were still cultivating the land by leasing in the land from other farmers. These respondents had completely sold their land before the year 2000 and no assets were generated out of sale proceeds because of conspicuous consumption. Majority of the respondents were marginal farmers with an average land holding of 0.36 hectares. In the second gradient, where urban influence is comparatively lower, majority of respondents belonged to small (46.66 %) and marginal farmer group (41.66 %) with an average holding size of 1.66 and 0.42 hectares. In the third gradient where urban influence is very low, majority of respondents were classified under medium farmers with an average land holding size of 2.46

TABLE I

Classification of sample farmers based on size of land holdings across gradients

Farmer category	Gradient - I (Urban) (n=60) Average land size (ha)		Gradient - II (Peri-Urban) (n=60) Average land size (ha)		Gradient - III (Rural) (n=60) Average land size (ha)	
Sample size	No.	%	No.	%	No.	%
Landless farmers	4	0	0	0		0
		(6.66)			(0.00)	(0.00)
Marginal farmers (< 1 ha)	34	0.36	25	0.42	4	0.49
	(56.66)		(41.66)		(6.66)	
Small farmer (1-2 ha)	13	1.37	28	1.66	19	1.34
	(21.66)		(46.66)		(31.66)	
Medium farmer (2-5 ha)	7	2.31	7	2.37	37	2.46
	(11.66)		(11.66)		(61.66)	
Large farmer (> 5 ha)	2	6.07	0	0.00	0	0.00
	(3.333)		(0.00)		(0.00)	
Average farm size (ha)		0.97 *		1.22 *		1.97 *
t-stat		6.20		12.29		19.79

Note : * Significant at 1 per cent level of significance; Figures in parentheses represent percentages to total

hectares. Ramalinge Gowda *et al*. (2012) reported similar results in Magadi taluk of Bengaluru district, where in long-term, the rise in land prices was associated with reduced farm holding size. As the influence of urbanization decreases, the average holding size of farm increases and these changes were statistically significant at one per cent level.

In any land sales there exists two prices, one is registered price indicating the fundamental value fixed by the state government and other is sale price or market price i.e. the actual price at which the land is transacted. The actual sale price is the true reflector of land values. These values were obtained from farmers through their memory recall by asking them the actual sale price of nearby similar lands which were transacted in that year and is elicited in the Table II.

In first gradient, the farm land values have tripled every five years since 2001 and between 2006 to 2011 the highest percentage increase was observed and it is attributed to the establishment of international airport in 2008 and road development like signal-free corridor on a stretch of elevated expressway and up gradation of NH7 to six lanes from Hebbal to Devanahalli airport. The average land value of farm size of 0.97 ha was Rs.5.652 crores at the end of 2016.

In the second gradient, the farm land values during 2002-06 and 2007-12 increased four times mainly due to establishment of international airport in the area and in the latest period (2012-16) land values have not increased to the earlier extent. The land values have seen highest increase in 2001-2006, because of anticipation of future developments in the area. The average land value of farm size of 1.22 ha was Rs. 2.522 crores at the end of 2016. In third gradient, the land values were relatively lower than the first two gradients because of low urban influence. Here also the percentage increase in land values was highest during the period 2006-11. The average land value of farm size of 1.97 ha was 0.662 crores at the end of 2016. Larry and Burton (2012) reported similar results that the farm land values had doubled in just five years and increased five folds in 11 years in South Dakota, USA.

As the urban influences increases, the number of farmers selling farm land increases as presented in Table III. In the first gradient, majority (65 Per cent) of respondents sold their lands in different periods and the average size of farm land sale was 0.496 hectares. Of the total farmers sold the land, 10.26 per cent had completely sold their farm land and are now cultivating the land by leasing in and for the rest partial sales

TABLE II

Land values in different periods and across different gradients

Year	Gradient - I (Urban)		Gradient - II (Peri Urban)		Gradient - III (Rural)	
	Value (Rs. Lakhs/ ha)	Percentage increase	Value (Rs. Lakhs/ ha)	Percentage increase	Value (Rs. Lakhs/ ha)	Percentage increase
2001	14.33	-	1.98	-	0.64	-
2006	46.19	222.41	26.68	1250.00	3.24	403.85
2011	195.38	322.99	112.88	323.15	22.97	609.92
2016	582.67	198.23	206.74	83.15	33.59	46.24
Average land holding size (ha)		0.97		1.22		1.97
Average land value per farm (Rs in lakhs)		565.20		252.20		66.2.

were reported. Around eight per cent of total farmers who sold land due to force of the real estate business firms and the rest voluntarily sold their lands. In the gradient two, 45 per cent of sample respondents sold their farm land and the average size of sale was 0.552 hectares and all were partial sales. Of the total farmers sold the land 18.52 per cent of farmers reported the forced sales and it is mainly due to pressure from real estate business where in the lands were purchased for construction of villas and recreational infrastructure which requires more land than apartment constructions.

In the gradient three, 23.33 Per cent of sample respondents sold the lands and the average size of sale reported was 0.477 hectare. In gradient three no complete and forced sale were reported as the pressure on land is comparatively lower when compared to the other two gradients. No much difference was observed across the gradients with regard to size of land sold.

TABLE III

Number of farmers sold the farmland and kind and nature of sale across the gradients

Particulars	Gradient - I (Urban)	Gradient - II (Peri Urban)	Gradient - III (Rural)
Sample Size	n = 60	n = 60	n = 60
Number of farmers who sold land (No.)	39 {65.00}	27 {45.00}	14 {23.33}
Average land sale (ha)	0.50	0.55	0.48
Type of sale Complete sale (No.)	4 (10.26)	0 (0.00)	0 (0.00)
Partial sale (No.)	35 (89.74)	27 (100.00)	14 (100.00)
Nature of sale Voluntary sale (No.)	36 (92.30)	2 2 (81.48)	14 (100.00)
Forced sale (No.)	3 (07.70)	5 (18.52)	0 (0.00)

Note : {}- Figures in the parenthesis are the percentage of sample size,
() - Figures in the parenthesis are the percentage to the total number of farmers sold the farm land

But Ramalinge Gowda *et al*. (2012) reported contrasting results that the average size of land sold in farms with high urban influence areas (0.56 acres) was less than that of farms with low urban influence (6.5 acres).

The sale of farm land at five-year interval is presented in Table IV in order to attribute factors responsible for sale and value of the sale. In gradient one during 2012-16, majority (30.76 Per cent) of farmers sold the land but the extent of sale was more (34.49 Per cent) during 2002-06 and it is attributed to perking up of urbanization process and anticipated developments like international airport. Because of high per hectare land price and quite high transaction of land, the total value of sale was highest in the latest period. In total 19.363 hectares of land worth Rs.2702.13 lakhs was sold by 39 respondents for non-agricultural uses.

In the second gradient, the number of farmers sold the land as well extent of land transacted and value of transaction was high during 2007-11 and this is mainly attributed to the operation of international airport during May, 2008 in the region. In total 14.921 hectare of land worth Rs.1375.64 lakhs was sold by 27 sample respondents for non-agricultural uses in this gradient.

In third gradient no sales were reported before 2001 among sample respondents and it is interesting to note that number of farmers selling the land and extent of sale were increasing over the period indicating the influence of urbanization in the form of slow rise in the value of the farmland. In total 6.68 hectares' worth of Rs.158.467 lakhs was transacted by 14 sample respondents for agricultural uses. Santhakumar (2014) also reported that urban pressures, future development potential of the area, location, land scarcity, availability of infrastructure and land use change have a great influence for the variation in land value.

The sale proceeds of farm land were used by the sample respondents for different purposes which include conspicuous and wasteful consumption as well meaningful investment in the form of asset generation and are considered as different portfolios which are presented in Table V. It could be observed that majority of the proceeds flowed to construction of house across the gradient, since house is a basic amenity. Besides it is status symbol to have a good house. Hence higher

TABLE IV

Sale of farm land at different periods across gradients

Period	Gradient - I (Urban)			Gradient - II (Peri Urban)			Gradient - III (Rural)		
	Number	Extent	Value	Number	Extent	Value	Number	Extent	Value
Before 2001	9 (23.07)	5.86 (30.26)	69.52 (2.57)	3 (11.11)	0.91 (6.10)	1.18 (0.08)	0 (0.00)	0.00 (0.00)	0 (0.00)
2002-2006	11 (28.20)	6.68 (7.70)	208.21 (34.49)	7 (25.92)	3.30 (22.12)	71.05 (5.16)	2 (14.28)	0.86 (12.87)	2.49 (1.57)
2007-2011	7 (17.94)	1.74 (8.96)	205.31 (7.597)	12 (44.44)	7.47 (50.06)	723.66 (52.60)	5 (35.71)	1.52 (22.72)	29.08 (18.34)
2012-2016	12 (30.76)	5.09 (26.27)	2219.09 (82.12)	5 (18.51)	3.24 (21.70)	579.76 (42.14)	7 (50.00)	4.30 (64.39)	126.90 (80.07)
Totalt stat	39	19.36* 10.12	2702.13* 6.62	27	14.92* 7.01	1375.64* 5.28	14	6.68* 4.65	158.47* 5.57

Note : () - Figures in the parenthesis are the percentage to the total
* Significant at 1 per cent level of significance

investment on housing is observed. The next important purpose was sharing of land sale proceeds among girl children. This was commonly seen in the first two gradients in order to avoid legal problems in future. Conspicuous and wasteful consumption was also one of the major expenses in the portfolio of the first two gradients. This includes gambling, going for family trips, enjoying luxurious lifestyles for short period *etc.* and it was most pronounced in first gradient. Use of land proceeds for marriages and other ceremonies was also one of the components of portfolios in the first two gradients where it has formed a major component in

TABLE V

Portfolio management of land sale proceeds across the gradients (Rs. in Lakhs)

Portfolios	Gradient - I (Urban)	Gradient - II (Peri Urban)	Gradient - III (Rural)
Asset based portfolios			
Construction of house	22.64 (32.67)	14.92 (29.28)	3.96 (35.04)
Bank savings	4.41 (6.36)	2.03 (3.98)	0 (0.00)
Purchase of liquid assets like gold	3.16 (4.56)	3.38 (6.63)	0.33 (2.91)
Purchase of Household materials like sofas, dining table, computer etc…	2.96 (4.28)	1.32 (2.59)	0.10 (0.88)
Investment in Agriculture in the form of agriculture machinery	2.65 (3.82)	1.26 (2.47)	1.06 (9.40)
Investment in Agriculture in the form irrigation structure i.e. bore well	2.37 (3.42)	1.40 (2.75)	1.35 (11.99)
Invested in non-farm business	2.10 (3.03)	0 (0.00)	0 (0.00)
Purchase of vehicles	2.03 (2.93)	1.7 (3.33)	0.35 (3.09)
Investment in Agriculture in the form of orchard establishment	1.17 (1.68)	0.79 (1.55)	0.86 (7.60)
Purchase of plot or site or flat	0.95 (1.37)	2.25 (4.41)	0 (0.00)
Purchase of agricultural land	0.55 (0.79)	0 (0.00)	0 (0.00)
Non-asset based portfolios			
Shared among girl children's	6.63 (9.56)	2.51 (4.92)	0 (0.00)
Conspicuous and wasteful consumption	5.14 (7.41)	3.41 (6.69)	0.10 (0.88)
Performed marriage and other ceremonies	4.45 (6.42)	6.78 (13.30)	1.35 (11.99)
Children's education	3.93 (5.67)	2.67 (5.25)	0.59 (5.21)
Towards servicing old debts	3.78 (5.46)	6.06 (11.90)	1.24 (10.96)
Hospital expenses	0.32 (0.47)	0.45 (0.88)	0 (0.00)
Total	69.24	50.93	11.29

Note : () - Figures in the parenthesis are the percentage to the total the portfolio next to construction of house in second gradient. A considerable proportion of sale proceeds have been maintained in the form of bank savings in the first two gradients.

Clearing old debts from the sale proceeds of farm land was common across all gradients and is received top priority in the second gradient. In third gradient, 28.99 Per cent of proceeds were invested in agriculture, this form less than nine per cent of total proceeds in the first two gradients, indicating the use of proceeds for non-agricultural activities. However, the habit of bank savings out of sale proceeds was not observed in the third gradient. In general asset based portfolio share is high in third gradient (70.91 Per cent) compared to first (64.91 Per cent) and second (56.99) gradients.

Using the garret ranking technique, the reasons behind the sale of farmlands were elicited in the study area and results are presented in the Table VI. Construction of house and performance of marriages were identified as major reasons for sale of land across all the gradients. Forced sale and remoteness of land parcel were the factors that least influenced the sale. But Larry and Burton (2012) reported contradictory reasons like high land prices and debt servicing as reasons for selling farmland in South Dakota, USA.

Urbanization process has created the marginalization of farm lands and it will have long run impact on food production in the study area. Rural gradient, where urban influences is low now showing tendency of increase in number as well extent of sales because of slow rise in prices and in future it may create problems of marginalization and conversion of farm land for non-agricultural uses. Next to housing majority of land sale proceeds were used for wasteful and conspicuous consumption, hence awareness on

TABLE VI

Reasons for sale of farmland across the different gradients

Reasons	Gradient - I (Urban)			Gradient - II (Peri Urban)			Gradient - III (Rural)		
	Total score	Avg. score	Rank	Total score	Avg. score	Rank	Total score	Avg. score	Rank
House construction	3833	79.85	I	3650	77.66	I	1561	70.95	I
To carry out ceremonies	3009	62.69	II	3470	73.83	II	1483	67.41	II
To purchase site	2160	45.00	VII	2216	47.15	VII	1177	53.50	VI
To purchase Agricultural land at remote areas	1939	40.40	VIII	1815	38.62	VIII	1320	60.00	III
To purchase assets like vehicles, gold etc…	2641	55.02	V	2728	58.04	III	1178	53.55	V
For children's education	2720	56.67	IV	2472	52.60	V	1141	51.86	VII
To clear old debts	2769	57.69	III	2504	53.28	IV	1226	55.73	IV
Remoteness of parcel	1434	29.88	IX	1107	23.55	X	729	33.14	VIII
Forced sale	1242	25.88	X	1238	26.34	IX	564	25.64	X
Luring prices	2205	45.94	VI	2253	47.94	VI	599	27.23	IX

portfolio management need to be created so that the farmers income can be sustained in the long run by way of investing in capital assets. Presently the transacted land in first two gradients is used for non-agricultural purposes and in future there are chances of resurgence of same problem in rural gradient too. Hence, proper policies should be evolved for protection of agricultural lands in the study area, so that the livelihood of large number of farmers can be safeguarded in the long run.

REFERENCES

ANONYMOUS, 2017, City momentum index. Jones Lang LaSalle, Chicago, p. 9 - 12.

GARRETT, H. E. AND WOODWORTH, R. S., 1969, *Statistics in Psychology and Education*. Vakils, Feffer and Simons Pvt. Ltd., Bombay, p. 329.

KAVITHA, A., SOMASHEKAR, R. K. AND NAGARAJA, B. C., 2015, Urban expansion and loss of Agriculture land - A case of Bengaluru city. *Int. J. Geomatics Geosci.,* **5** (3) : 492 - 498.

LARRY JANSSEN AND BURTON PFLUEGER, 2012, South Dakota agricultural land market trends 1991 - 2012. *South Dakota State University,* South Dakota, p.1-28.

LI JIANG, XIANGZHENG DENG AND KAREN C. SETO, 2013, The impact of urban expansion on agricultural land use intensity in china. *Land use pol.,* **35** : 33 - 39.

RAMALINGE GOWDA, U. C., CHANDRAKANTH, M. G., SRIKANTHAMURTHY, P. S., YADAV, C. G., NAGARAJ, N. AND CHANNAVEER, 2012, Economics of peri-urban agriculture-case of Magadi off Bangalore. *Econ. Pol. Weekly*, **47** (24) : 75 - 80.

SANTHAKUMAR SWAMIDURAI, 2014, Factors affecting urban land value in Indian cities - Chennai city as a case study. *Int. J. Res. Scientific Innovation,* **1** (3) : 31 - 34.

SEEMA RANI, 2014, Monitoring land use/land cover response to urban growth of the city of Jalandhar using remote sensing data. *Int. J. Adv. Res.*, **2** (6) : 1122 - 1129.

XIAOWEI CAIAND AND JAY E NOEL, 2013, California Farmland Valuation : A Hedonic Approach. Poster presented In : *Agric. Appl. Econ. Assoc. Joint Annual Meeting*, Washington, DC. August 4 - 6.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 216-222, 2017

Dynamics of Agri-Horti Crops in Hilly Zone of Karnataka : An Economic Analysis

R. Rangegowda and K. B. Umesh
Department of Agricultural Economics, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail : rangegowda33@yahoo.com

Abstract

The present study aimed at analyzing the trends in area, production and yield of banana for two different periods *viz.,* Period-I (1995-96 to 2004-05) and Period-II (2005-06 to 2014-15) of Karnataka and India using growth and instability indices. The analysis for two periods was purposefully made to capture the impact of National Horticulture Mission (2005-06) on area, production and productivity of banana. The results revealed that, growth rates of area, production and productivity of banana in India and Karnataka during Period-II was found higher, positive and significant compared to Period-I. The study also focused on shift in cropping pattern between major agriculture and horticultural crops in Hilly Zone of Karnataka for the period from 2001-02 to 2015-16. The results revealed that majority of horticulture crops shown positive trend compared to agriculture crops. Thus, it could be inferred that farmers in Hilly Zone of Karnataka are shifting from traditionally grown less remunerative crops to more remunerative horticultural crops.

Keywords: Growth rates, crop diversification, instability index

Horticulture is the fastest growing sector within agriculture, presently contributes 30 per cent of agricultural GDP (Agarwal *et al.,* 2016). The horticultural sector has also received considerable attention in recent years as it is recognized as a potentially important source of growth, employment generation and foreign exchange earnings (Singh, 2015). The horticulture sector encompasses a wide range of crops viz., fruits, vegetables, plantations, ornamental crops, etc. India, with its wide variability of climate and soil, is highly favorable for growing a large number of horticultural crops. Horticulture has emerged as the key instrument of the Indian agricultural development strategy for reduction of poverty, unemployment and malnourishment. The, horticultural-based agricultural diversification in India has been most prominent in the southern states of India (Saraswati *et al*., 2012).Karnataka is one of the progressive states of India with a great potential for development of horticultural crops. The state is blessed with ten agro-climatic regions suitable for growing variety of horticultural crops all-round the year. Of the ten agro-climatic zones, Hilly Zone contribute maximum chunk to fruit production in Karnataka.The agriculture in Karnataka is gradually diversifying towards high-value food commodities especially towards fruits, vegetables, spices, etc. Keeping all these issues in mind, the present study tries to examine the shift in cropping pattern between major agriculture and horticultural crops in Hilly Zone of Karnataka. One of the major landmark reasons to emphasie this sector is being reflected in establishing National Horticulture Mission (NHM) in 2005-06. There by, the study also aimed to explore the impact of establishment of NHM (2005-06) on area, production and productivity of banana in India and Karnataka.

Methodology

For achieving the objectives of the study, secondary data were collected from various published sources of Government of Karnataka and Government of India on area, production and productivity of banana for the country and Karnataka for two time periods *viz.,* Period-I (1995-96 to 2004-05) and Period -II (2005-06 to 2014-15). Data were drawn from indiastat.com and various issues of The Horticultural Statistics at a Glance. Taluk-wise area under major cereals, pulses, oilseeds, vegetables, spices, fruit crops, and other major commercial crops of Shivamogga district which comes under Hilly Zone for 2001-02 to 2014-15 were collected from the Directorate of Economics and Statistics, Bengaluru. For the purpose of evaluating the objectives of the study, based on the nature and extent of data, the following analytical tools were employed for processing the data to arrive at meaningful results and draw useful conclusions.

1. Compound annual growth rate analysis
2. Instability analysis
3. Crop diversification Indices

1. Compound Annual Growth Rate Analysis

For evaluating the compound annual growth rates of the selected variables cited below. Exponential function of the following form was used.

$$Y_t = A\, B^t\, V_t \quad \ldots (1)$$

Where,

Y_t = area/production/productivity/other variable under consideration in the year t

A = Intercept indicating Y in the base period (t = 0)

B = 1 + g

t = time period

V_t = Random disturbance term

Equation (1) was converted into linear form by taking logarithmic as follows:

$$\ln Yt = \ln A + t * \ln B + \ln V_t$$

This is of the following form

$$Qt = a + b_t + U_t \quad \ldots (2)$$

Where,

Qt = ln Y

a = ln A

b = ln B

Ut = ln V_t

The parameters 'a' and 'b' were estimated using the Ordinary Least Squares estimation technique. Later, the original 'A' and 'B' parameters in equation (1) were obtained by taking antilogarithms of 'a' and 'b'.

Average annual compound growth rate (%) was calculated as follows:

$$g = (B - 1) * 100$$

2. Instability Analysis

The coefficient of variation was used as a measure to study the variability in the area, production and productivity of banana. The coefficient of variation (CV) was computed using the following formula.

$$CV = (\text{Standard Deviation} / \text{Mean}) \times 100$$

Linear trend was fitted to the original time series data on area, production and productivity for the two study periods. The formula suggested by Cuddy and Della (1978) was used to compute the degree of variation around the trend, means coefficient of variation was multiplied by the square root of the difference between the unity and coefficient of determination (R^2). A high degree of instability index signifies violent variations.

Instability Index = (Standard Deviation / Mean) * 100 * $(1- R^2)^{0.5}$

R^2 = Coefficient of determination

3. Crop diversification Indices

Herfindahl Index (HI)

Herfindahl Index (Pant *et al*., 2005) given below is computed by taking sum of squares of acreage proportion of each crop in the total cropped area. Mathematically, the index is given as below

$$\mathbf{HI} = \sum_{i=1}^{N} \mathbf{P_i^2}$$

Where,

N = total number of crops

P_i = represents area proportion of the i^{th} crop in total cropped area.

This index takes a value one when there is complete concentration and approaches zero when diversification is perfect. Thus the HI is bounded by Zero and one. One minus HI will gives the Simpsons index of diversification (SI) and similar to HI the range of SI range between zero to one but interpretation is quite opposite to HI *i.e.*, Value of SID closer to zero indicates near to the specialization and value closer to one indicates diversification .

Composite Entropy Index (CEI)

This index possesses all desirable properties of above mentioned indices and is used to compare diversification across situations having different and large number of crops since it gives due weightage to the number of crops. The formula of C.E.I. is given by:

$$\mathbf{C.E.I} = \left(\sum_{i=1}^{N} \mathbf{P_i^* \log P_i}\right) \mathbf{x} \left(\mathbf{1} - \left(\frac{\mathbf{1}}{N}\right)\right)$$

The value of Composite Entropy Index increases with the decrease in concentration and rises with the number of crops. The value of C.E.I. ranges between zero to one.

Results and Discussion

Growth performance of Banana in Karnataka and India

Growth in area, production and productivity of banana in India and Karnataka was estimated by using the exponential function. The study period (1995-96 to 2014-15) was divided into two sub periods viz, Period – I (1995-96 to 2004-05) and Period-II (2005-06 to 2014-15) due to significant shift in area, production and productivity of Horticultural crops in general and banana in particular. This break in two study periods was synchronized with introduction of National Horticulture Mission (NHM) during 2005-06 by Government of India, and has contributed for the increase in area, production and productivity of banana in India and Karnataka.

The results presented in Table-I on compound annual growth rates (CAGR) for Karnataka and India revealed that, the growth rates of area during all the three study periods Period I (1995-96 to 2004-05), Period II (2005-06 to 2014-15) and Overall Period (1995-96 to 2014-15) for Karnataka were found positive and significant (1.86%, 5.98% and 4.28 %, respectively). The respective figures for area of banana in India's 1.59, 4.64 and 3.40 per cent and were also found significant. The banana production in Karnataka and India also showed significant growth during the Period-II and Overall Period, however the growth rate of banana production during the period-I was not significant. Inspite of significant area increase under banana during pre-NHM period, the growth rate of banana production was not significant due to non-significant growth rate of banana productivity for both Karnataka and India. The findings of Kumar and Chandrashekar (2015) also confirmed highly and significant positive growth rates for major horticultural crops in Karnataka.

Instability analysis of Banana in Karnataka and India

The results on instability analysis of banana showed a moderate degree of instability during Period-I (8.22%) and relatively high degree of

Table I

Growth rates in area, production and productivity of Banana in Karnataka and India

Karnataka			Karnataka		
Period	CAGR (%)		Period	CAGR (%)	
Area (000 ha)					
Period-I (1995-96 to 2004-05)	1.86	*	Period-I (1995-96 to 2004-05)	1.59	*
Period-II (2005-06 to 2014-15)	5.98	**	Period-II (2005-06 to 2014-15)	4.64	**
Overall period (1995-96 to 2014-15)	4.28	**	Overall period (1995-96 to 2014-15)	3.40	**
Production (000 tonne)					
Period-I (1995-96 to 2004-05)	2.71		Period-I (1995-96 to 2004-05)	2.28	
Period-II (2005-06 to 2014-15)	9.86	**	Period-II (2005-06 to 2014-15)	7.84	**
Overall period (1995-96 to 2014-15)	6.17	**	Overall period (1995-96 to 2014-15)	5.86	**
Productivity (kg/ha)					
Period-I (1995-96 to 2004-05)	0.85		Period-I (1995-96 to 2004-05)	0.69	
Period-II (2005-06 to 2014-15)	3.82	**	Period-II (2005-06 to 2014-15)	2.56	**
Overall period (1995-96 to 2014-15)	1.89	*	Overall period (1995-96 to 2014-15)	2.06	*

instability during Period-II in Karnataka (11.74%). With respect to banana area in the country, Period – II (2000-01 to 2013-14) showed high degree of instability (15.07%) compared to Period-I (1995-96 to 2004-05) where it was only 5.18 per cent. The results on production of banana in Karnataka represent relatively high degree of instability during Period II (2005-06 to 2014-15) and Overall Period (1995-96 to 2014-15) with instability indices of 26.09 and 32.78 per cent, respectively compared to India (Table II).

The instability analysis on productivity of banana in Karnataka also indicated comparatively high degree of instability for Period - II (2005-06 to 2014-15)and overall period (1995-96 to 2014-15) with respective indices values of 35.75 and 31.29 per cent compared to India. Similar findings were reported by Singh *et al*. (2014), on high degree of instability for horticultural crops in Karnataka.

Growth rates of major crops in Hilly Zone of Karnataka (2001-02 to 2015-16)

The results on growth rates for area under major cereals, pulses, oilseeds, vegetables, spices, fruit crops and other major commercial crops of Shivamogga district of Hilly Zone for the period from 2001-02 to 2015-16 are presented in the Table III. The analysis was carried out using exponential function. The estimated growth results revealed that Hosanagara taluk showed the highest positive and significant growth in area under rubber (9.52%) followed by Areacanut (7.23 %), total spices (6.02%) and banana (3.90%). On the other hand the highest negative and significant growth rate of area was observed for total pulses (-27.85%) followed by total vegetables (-2.87%) and paddy (-0.77%). The results on Soraba taluk showed that, the highest positive and significant growth in area was noticed for ginger (12.87%) followed by Rubber (8.41 %), areacanut (6.91%), banana (7.72%) and total spices (5.91%). While, the highest negative and significant growth rate was observed for total oilseeds (-15.24%) followed by total vegetables (-14.29%) and total pulses (-6.8/0%).

In Thirthahalli taluk area under banana (8.43%) showed a positive and significant growth followed by rubber (7.21%), arecanut (4.02 %) and total spices (3.69%).While declining trend was observed for area under total pulses (-14.24%), total vegetables (-10.29%) and coconut (-4.31%). Area under banana (10.56%) showed a significant growth rate followed by rubber (7.84%), total fruits (4.32%) and ginger (4.19%) in Sagar taluk. The growth performance of area under different crops for the Shivamogga district

TABLE II

Instability indices for area, production and productivity of banana in Karnataka and India

Karnataka	Instability Index	India	Instability Index
		Area	
Period-I (1995-96 to 2004-05)	8.22	Period-I (1995-96 to 2004-05)	5.18
Period-II (2005-06 to 2014-15)	11.74	Period-II (2005-06 to 2014-15)	15.07
Overall period (1995-96 to 2014-15)	9.31	Overall period (1995-96 to 2014-15)	14.50
		Production	
Period-I (1995-96 to 2004-05)	6.94	Period-I (1995-96 to 2004-05)	14.58
Period-II (2005-06 to 2014-15)	26.09	Period-II(2005-06 to 2014-15)	18.06
Overall period (1995-96 to 2014-15)	32.78	Overall period (1995-96 to 2014-15)	21.59
		Productivity	
Period-I (1995-96 to 2004-05)	18.82	Period-I (1995-96 to 2004-05)	5.84
Period-II (2005-06 to 2014-15)	35.57	Period-II (2005-06 to 2014-15)	11.60
Overall period (1995-96 to 2014-15)	31.29	Overall period (1995-96 to 2014-15)	9.89

TABLE III

Growth rates of major crops in hilly zone of Karnataka (2001-02 to 2015-16)

	Shivamogga District								Shivamogga District	
	Hosanagara		Soraba		Thirthalli		Sagar			
	Mean Area (in ha)	CAGR (%)	Mean Area (in ha)	CAGR (%)	Mean Area (in ha)	CAGR (%)	Mean Area (in ha)	CAGR (%)	Mean Area (in ha)	CAGR (%)
Banana	784.53	3.90 **	705.40	7.72 **	811.60	8.43 **	944.13	10.56 **	4967.33	9.64 **
Total Fruits	1179.00	2.02 *	3251.67	2.91 **	1207.73	3.08 **	1950.87	4.32 **	10559.40	6.77 **
Ginger	820.93	3.17 *	959.13	12.87 **	154.40	3.91 **	736.13	4.19 **	3784.60	9.52 **
Cardamom	53.87	3.34 **	16.60	5.12	143.80	-0.02 *	96.00	2.48 **	301.80	1.62 *
Pepper	149.33	2.84 *	105.00	-3.14	356.53	0.30	205.00	3.35 **	826.53	1.40
Total Spices	3674.80	6.02 **	3951.47	5.91 **	7567.60	3.69 **	4981.60	3.48 **	42099.87	5.31 **
Arecanut	2632.33	7.23 **	2590.80	6.91 **	6838.00	4.02 **	3844.07	3.72 **	36141.60	5.55 **
Coconut	447.00	-0.30	424.73	-2.18 **	587.07	-4.31 **	608.60	-1.96 **	6395.27	-1.62 **
Coffee	21.13	4.84 **	32.87	-3.84 *	312.47	0.86	116.13	2.19	506.80	0.97
Rubber	372.93	9.52 **	361.00	8.41 **	212.87	7.21 **	414.53	7.84 **	1408.53	6.27 **
Total Vegetables	9.13	-2.87	29.07	-14.29 *	15.21	-10.29 **	16.53	-8.94 **	390.53	-5.31 **
Paddy	11521.93	-0.77 **	28662.67	-0.72 **	14985.00	-1.62 **	15529.87	-0.90 **	128650.40	-0.94 **
Total cereals	11876.53	-0.56 **	36039.80	1.26 **	14988.00	-1.62 **	17007.00	-0.13	172571.87	0.35
Total Pulses	32.47	-27.85 **	802.33	-6.80 **	183.45	-14.24 **	217.40	-18.97 **	2941.53	-7.48 **
Total Food Grains	11909.47	-0.62 **	36811.00	1.04 **	14843.67	-2.05 **	17156.93	-0.27 *	175197.40	0.17
Total Oilseeds	59.40	1.27	969.80	-15.24 **	8.60	-5.83 **	295.20	-8.43 *	3296.20	-7.32 **

Note : **&* indicates Significant at one per cent and five per cent, respectively
CAGR : Compound Annual Growth Rate

as a whole, revealed that banana (9.64%) registered the highest positive and significant growth rate followed by ginger (9.52%), total fruits (6.77%) and rubber (6.24%). The findings are in conformity with the results of Kamble and Wali (2016),

Instability indices of major crops in Hilly Zone of Karnataka (2001-02 to 2015-16)

The details on instability indices for area under major cereals, pulses, oilseeds, vegetables, spices, fruit crops and other major commercial crops of Shivamogga district for the period from 2001-02 to 2015-16 is presented in the Table IV. The estimated instability index for Hosanagara taluk revealed high degree of instability for total vegetables (48.27%) followed by total pulses (39.39%), total oilseeds (29.17%), cardamom (19.98%), ginger (18.57%) and coffee (23.50%). While competitively high degree of instability was registered for area under total vegetables (100.98%) and followed by cardamom (61.45%), total pulses (36.18%), ginger (30.02%), and coffee (28.73%) for Soraba taluk. Similarly, the instability results for Thirthahalli taluk depicted that, area under total oilseeds (87.54%) showed high degree of instability followed by total vegetables (65.21%), total pulses (56.02%), ginger (22.80%) and coffee (18.68%). With respect to Sagar taluk, the area under total oilseeds (111.32%) showed high degree of instability followed by total vegetables (79.29%), total pulses (61.06%), rubber (38.11%), ginger (23.39%) and coffee (20.65%).

For the district as whole, higher degree of instability was observed for area under total oilseed crops (27.58%) followed by ginger (26.02%), total pulses (22.24%), total fruits (19.98%), rubber (18.57%), pepper (17.69%) and total vegetables (15.54%).

TABLE IV

Instability indices of major crops in hilly zone of Karnataka (2001-02 to 2015-16)

Crops	Shivamogga District				Shivamogga District
	Hosanagara	Soraba	Thirthalli	Sagar	
Banana	18.15	14.44	16.27	9.70	8.04
Total Fruits	15.35	11.48	10.17	4.44	19.98
Ginger	28.54	30.02	22.80	23.39	26.02
Cardamom	29.04	61.45	18.13	14.60	12.87
Pepper	21.59	30.39	20.08	10.71	17.69
Total Spices	10.10	9.34	4.56	5.04	3.49
Arecanut	8.64	5.12	5.70	4.35	2.85
Coconut	7.04	6.91	9.44	3.74	4.76
Coffee	23.50	28.73	18.68	20.65	12.82
Rubber	13.58	26.44	10.11	38.11	18.57
Total Vegetables	48.27	100.98	65.21	79.29	15.45
Paddy	2.05	2.16	1.43	1.70	5.38
Total cereals	1.83	3.80	1.42	2.19	2.96
Total Pulses	39.39	36.18	56.02	61.06	22.24
Total Food Grains	1.88	3.33	4.13	2.13	2.88
Total Oilseeds	29.17	26.39	87.54	111.32	27.58

Crop Diversification in Hilly Zone of Karnataka (2001-02 to 2015-16)

The pattern of crop diversification in Hilly Zone of Shivamogga district was captured by using Herfindal, Simpson and Composite entropy Index for the period from 2001-02 to 2015-16 and results are presented in the Table V. The results form composite entropy index revealed that, among four selected taluks of Shivamogga district, Soraba registered the high percentage of crops diversification (66%) followed by Sagar (63%), Thirthahalli (57%) and Hosanagar (54%). Similarly, the results from Simpson index showed that, Soraba showed the higher degree of crops diversification (61%) followed by Sagar (64%), Thirthahalli (56%) and Hosanagar (52%) taluks of Shivamogga district. These findings are in confirmatory with the results of Ramappa *et al*., (2015).

TABLE V

Crop diversification in hilly zone of Karnataka (2001-02 to 2015-16)

Diversification Index	Herfindal Index	Simpson Index	Composite Entropy Index
Hosanagara	0.48	0.52	0.54
Soraba	0.36	0.64	0.66
Thirthahalli	0.44	0.56	0.57
Sagar	0.39	0.61	0.63
Shivamogga Dist.	0.33	0.67	0.69

The trends in area, production and yield of banana for two study periods *viz., Period-I* (1995-96 to 2004-05) and Period-II (2005-06 to 2014-15) for Karnataka and India were analysed using growth and instability indices. The bifurcation of study period was purposefully made to capture the impact of National Horticulture Mission (2005-06) on growth performance of area, production and productivity of banana. The study revealed that the area, production and productivity of banana both in India and Karnataka during the period from 2005-06 to 2014-15 showed significant growth rates compared to Period-I (1995-96 to 2004-05). The significant growth rates in area, production and productivity in banana during Period-II was synchronized with introduction of NHM during 2005-06 by Government of India. The NHM contributed for the significant increase in area, production and productivity of banana in India and Karnataka. The results on shift in cropping pattern in Hilly Zone of Karnataka for the period from 2001-02 to 2015-16 revealed that, majority of horticulture crops exhibited positive trend compared to agricultural crops. Thus, farmers in the Zone shifted crop area from traditionally grown, less remunerative crop to more remunerative horticultural crops.

REFERENCES

AGARWAL, YADAV, P., KUMAR, S. AND PANDEY, D., 2016, Horticultural crops in India-growth, instability and decomposition approach. *Agric. Situation in India*, **3** (2) : 26 - 30.

CUDDYJ, D. A. AND DELLA VALLE, P. A., 1978, Measuring the instability of time series data. *Oxford bulletin of Econ. Statist.*, **40** (1) : 79 - 85.

KAMBLE, A. S. AND WALI, V. B., 2016, Dynamics of horticultural crops in Karnataka an hozels decomposition analysis. *Indian J. of Appl. Res.*, **6** (8) : 199 - 122.

KUMAR, S. A. AND CHANDRASHEKAR, H. M., 2015, Production performance of selected horticultural commodities in Karnataka. *Int. J. of Management Res & Rev.,* **9** (5) : 669 - 675.

PANT, MANOJ AND PATTANAYAK, M., 2005, Does openness promote competition: a case study of Indian manufacturing. *Econ. and Polit. Weekly,* **24** (9) : 4226 - 4231.

RAMAPPA, K. B., UPADHYAY, J. AND NAGARAJU, Y., 2015, Growth of horticulture sector in Karnataka-post reform period. *Indian J. Econ. Dev.,* **11** (3) : 661 - 672.

SARASWATHI, P. A., BASAVARJAA H., KUNNAL. L. B., MAHAJANA SHETTI, S. B. AND BHAT, A. R. S., 2012, Growth in area, production and productivity of major crops in Karnataka. *Karnataka J. Agric. Sci.,* **25** (4) : 431 - 436.

SINGH, R., 2015, An analysis of spatio-temporal changes in the pattern of crop diversification in Indian agriculture. *Int. Res. J. of Soc. Sci.,* **4** (12): 15 - 20.

SINGHA. K., CHOUDHARY R. AND VISHNU. K., 2014, Growth and diversification of horticulture crops in Karnataka: an inter-district analysis. *SAGE Publications*, **12** (3) : 1 - 12.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 223-232, 2017

Economic Feasibility of Custom Hiring Service Models in Agriculture in Eastern Dry Zone of Karnataka

P. S. Ranjith Kumar and G. S. Mahadevaiah
Department of Agricultural Economics, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail : ranjithagmaco225@gmail.com

Abstract

The huge capital investment in purchase of farm machinery and equipment (FME) made small and marginal farmers not accessible to FME. Therefore, the Government of Karnataka has promoted Custom Hiring and Service Centres (CHSC) to meet the machinery needs of farmers in a big way**.** The study has been conducted in Eastern Dry Zone of Karnataka. The results of the study indicated that the formal institutions providing Custom hiring service (CHS) of FME are owning more number of tractors and other FME compared to informal institutions.The cost of establishment of CHS models of formal institutions was higher compared to informal institutions. The annual machinery hours supplied by formal institutions such as Model I and II were 5,328.11 and 3,215 respectively and informal institutions such as Model III and IV were 2,895 and 1,973, respectively. However, the machinery hours supplied by formal institutions are more, the net returns realized by Model III of informal institution was high due to its higher hiring charges than formal institutions. Further, the discounted measures such as BC ratio, NPV and IRR of different CHS models have indicated that the Model I, II and III were economically feasible. Since, the formal institutions are economically feasible the government can promote these models to supply farm machinery needs of farmer.

Keywords: Custom hiring, institutions, economic feasibility, farm machinery, discounted measures

Agriculture sector is a labour intensive activity. It requires labour throughout its production process. The cost of cultivation data shows that labour accounts for more than 50 per cent of the total variable cost of production for most of the crops (Raghavan, 2008). Due to rapid economic growth, increase in non-farm incomes, increase in minimum wages and adoption of employment generation programmes like, MGNREGA have witnessed a significant increase in agricultural wages in the recent years (Anon., 2015a). Further, it has been observed that the percentage of agricultural workers to total workers in India has been gradually declining from 59.1 per cent in 1991 to 54.6 per cent in 2011. It is expected to further decline to 25.7 per cent by 2050 leading to severe farm labour shortage (Anon., 2015b). The basic requirement to meet this labour scarcity is to reduce labour usage and maximize labour productivity which depends greatly on the availability and judicious use of mechanised power by the farmers (Singh and Sangeet*,* 2013).

Karnataka is one of the major agrarian state in the country with 190.5 lakh ha of geographical area with 99.23 lakh ha of net sown area (2013-14) and has about 78.32 lakh ha operational holdings (Agri. Census 2010-11) of which 76 per cent are small and marginal holdings. The state is blessed with different agro-climatic regions favorable to grow diversified agriculture and horticulture crops. However, at present the state is facing several challenges in agriculture sector. The major challenge is to get higher yields with the minimum cost of production, in spite of vagaries of nature, decrease in the availability of agriculture labours, migration of farmers from rural area to cities, increased wages in the non-farm sector etc. Therefore, farm mechanization is the need of the hour is to increase production and productivity besides reducing cost of production and drudgery in the agricultural operations.

Though government has promoted farm mechanization through various schemes by providing subsidies for farm machinery and equipment (FME), majority of the beneficiaries were large farmers. The huge capital investment required for purchase of FME made small and marginal farmers not accessible to FME (Anon., 2016).Therefore, to provide FME services to small/marginal and medium holders at affordable charges the Government of Karnataka has promoted CHSCs (Custom Hiring and Service Centre) in a big way. Keeping this in view the present study has been undertaken in Eastern Dry Zone of Karnataka with an objective to study the economic feasibility of CHS (Custom Hiring Service) models in agriculture.

Methodology

Purposive multi-stage random sampling procedure was used in the present study. The sample respondents were collected from Kolar district of Eastern Dry Zone of Karnataka. Mulbagal taluk of Kolar district was selected and a sample of 10 CHS providers from this taluka were interviewed using the pre-tested scheduled. The sampling design of the study has been given in Table I.

The sample of the study comprises of both formal and informal institutions providing CHSs of FME to farmers in the study region. The formal institutions are government sponsored/subsidized CHSCs and informal institutions are CHS provided by farmers owning FME. The formal institution comprises of Model I and Model II, whereas informal institutions comprises of Model III and Model IV. The Model I represents the custom hiring service centre (CHSC) operated by NGO (*i.e,.* SKDRDP: Shri Kesthra Dharmastala Rural Development Project). The Model II represents the CHSC operated by private firm (Mercury in collaboration with John Deere), Model III represents the CHS provided by the farmers owning FME only for the hiring purpose (own usage is negligible) and Model IV represents CHS provided by the farmers owning FME after meeting their own farm machinery requirement.

Analytical tools used: The analysis was carried out using the following analytical tools

1. Descriptive statistical tools such as summation, mean and percentages
2. Financial models used in the study are discounting methods such as Net Present Value (NPV), Benefit-Cost Ratio (BCR) and Internal Rate of Returns (IRR)

Net Present Value (NPV)

Net present value is the difference between the discounted annual inflow and discounted annual outflow during the life of the project. Net present value is estimated as follows:

$$NPV = \sum_{t=1}^{n} \frac{Bt-Ct}{(1+r)^t}.$$

Where Bt denotes Benefit (Cash inflow) in year t, Ct denotes cost (Cash outflow) in year t, n denotes

Table I
The sampling design of the study

Distict	Taluk	Suppliers of CH services n = 10				Total
		Fromal Institutions		Informal Institutions		
		Model I : CHSCs owned by NGO	Model II : CHSCs owned by Private	Model III : FME owned by Farmers for hire purpose only	Model IV : FME owned by Farmers for own hire purpose	
Kolar	Mulbagal	1	1	4	4	**10**

Note : CHSCs: Custom hiring and service centers; CHS: Custom hiring service ;FME: Farm machinery & equipment investment lifespan, r denotes cost of capital and t denotes time measured in years. If the calculated NPV is positive, it implies the investment is viable, and where the NPV is equal to zero implies that the investment breaks even. The rule with NPV is to accept investments with a zero or greater NPV.

Benefit cost ratio (BCR)

The discounted gross benefit divided by the discounted gross cost. A decision of B/C ratio is to accept projects with a ratio above one that is B/C>1. Its formula for estimation is as follows:

$$B-C\ Ratio = \frac{\sum_{t=1}^{n}\frac{B_t}{(1+r)^t}}{\sum_{t=1}^{n}\frac{C_t}{(1+r)^t}}$$

Where,

Bt = Benefits in year t
Ct = Cost in year t
n = Investment lifespan
t = time measured in years
r = Cost of capital

It refers to the ratio of discounted cash flows to investments. The minimum ratio required is 1:1. This indicates the coverage of costs without any surplus benefits. But usually the ratio should be more than unity in order to provide some additional returns over the cost for clear decision.

Internal Rate of Return (IRR)

It is the rate of return, which equates the present worth of benefits to the present worth of costs, which means the net present worth is zero, or it is the rate of return, which makes the net present value of a project is zero. This represents the average earning power of an investment made on purchase of farm machinery.Mathematically, it is represented as:

$$IRR = \frac{\sum_{t=1}^{n} B_t - C_t}{(1+r)^t} = 0$$

Where,

Bt = Benefits in year t
Ct = Cost in year t
n = Investment lifespan
t = time measured in years
r = Cost of capital

IRR is the discount rate which just makes the net present worth of cash flow equal to zero. The investment is considered viable if the calculated IRR is greater than that of the bank interest rate on fixed deposits (opportunity cost of capital) which is 9 per cent.

- Depreciation on each capital equipment and machinery was calculated using the straight line method.

$$\text{Annual depreciation} = \frac{\text{Purchase value} - \text{Junk value}}{\text{Economic life of the asset}}$$

- Annual interest on the investment was calculated as follows:

$$I = \frac{P - S}{2} \times \frac{i}{100}$$

Where,

P = Purchase Value of the machinery
S = Salvage value
I = Annual Interest rate
i = 11.5 per cent because term loan is being given at this rate of interest

Results and Discussion

The Custom hiring service centres offer farm machineries and equipment on rental basis to farmers who cannot afford to purchase high-end agricultural machineries and equipments.The CHCs play a pivotal role in introducing high technology agricultural machinery to even small farmers with the objective to increase crop production, improve quality, timeliness and efficiency of agriculture operations Chahal *et al.* (2014) and Kulkarni (2009).

The Table II shows that the formal institutions possess more number of tractors compared to informal institutions in the study region. The Model I and II are owning four tractors each with capacity ranges from 45 to 50hp (horse power) and the total cost incurred was Rs. 23,23,944/- and Rs. 23,04,424/-, respectively. Whereas Model III and IV were owning two and one tractor each with capacity ranges 22 to 60 hp and 35 to 40hp, respectively and the cost incurred was Rs. 9,55,000/- and 4,17,600/-, respectively. Though Model III owns only two tractors but the engine capacity ranges from 22 to 60hp. It shows that the Model III is having greater advantage with respect to demand from the farmers since higher the hp of the tractor will perform better in farm operations.Whereas Model I and II are having advantage in serving to more number of farmers since they are own more number of tractors.

TABLE II

Comparison of profile of tractors available with formal and informal institutions of CHSCs in Kolar district

(n=10)

Formal Instutions							Formal Instutions					
Model I				Model II			Model III			Model IV		
Farm machinery & Equipment	hp	No.	Cost / Unit (Rs.)	hp	No.	Cost / Unit (Rs.)	hp	No.	Cost / Unit (Rs.)	hp	No.	Cost / Unit (Rs.)
	35	1	5,75,000	45	2	5,60,340	50-60	1	5,30,000	35-40	1	4,17,600
Tractor	45	1	5,65,200	50	2	5,91,872	22-35	1	4,25,000	-	-	-
	50	2	5,91,872	-	-	-	-	-	-	-	-	-
Total		4	23,23,944		4	23,04,424		2	9,55,000		1	4,17,600

Note : In informal institutions the tractors purchased at different years and different brands; hp= horse power

The farm machinery inventory available with the different CHS models in Kolar district are given in Table III. The FME were divided into eight categories according to the operations for which these machineries are used like land development, tillage, sowing and planting and other operations. The Model I owned highest number of equipments followed by Model III, Model II and Model IV which is 29, 12, 11 and 6, respectively. In all CHS models the number of tillage equipment was maximum.

Among all CHS models the tillage equipment accounts more in number compared to all other equipments. The Model I owns maximum number (19) of tillage equipments which was followed by Model III (10), Model I (8) and Model IV (4). The total cost incurred by Model I on tillage equipments was highest followed by Model II, Model III and Model IV i.e. Rs.13,56,350/-, Rs. 4,31,000/-, Rs. 3,68,500/- and Rs. 1,45,450/-, respectively and percentage to total cost was 62, 59, 73 and 52 per cent, respectively. This implies that the utilization of these implements was maximum.This shows that the demand for tillage implements was quite high in the study region. The results are in line with the study conducted by the Kamboji *et al.* (2012), where the agricultural cooperative societies were having maximum number of tillage equipment due to more demand from the farmers.

In Model I, Rs. 21,98,050/- was invested on FME except tractor cost followed by Model II (Rs. 7,36,000), Model III (Rs. 5,04,000/-) and Mode IV (Rs. 2,82,200/-) which shows that Model I is having more number of FME and able to serve more number of farmers in the region. The Model I and Model II are the only sources for the farmers to avail machinery and equipment related to sowing, weeding, harvesting and threshing, the FME are not available for such operation in Model III and Model IV.

Due to huge capital requirement and non-availability of skilled labour to operate FME has led to non-availability of these implements in different custom hiring service models.

Table IV revealed the cost of establishment of CHS models in Kolar district. The total cost incurred to establish CHSC by Model I was Rs. 71,97,962/- followed by Model II (Rs. 45,47,773/-), Model III (Rs. 25,76,352/-) and Model IV (Rs. 10,40,368/-). The fixed cost was highest in Model I which was Rs. 52,83,863/- followed by Model II (Rs. 35,43,717/-), Model III (Rs. 16,78,353/-) and Model IV (Rs. 8,35,497/-) and accounts for 73.4, 77.9, 65.1 and 80.3 per cent of total cost, respectively. The variable cost was more in Model I which was Rs. 19,14,099/- followed by Model II (Rs. 10,04,056/-), Model III (Rs. 8,97,999/-) and Model IV (Rs. 204,871/-) with

TABLE III

Farm machinery inventory available with the different CHS models in Kolar district

(n = 10)

Particulars	Model I			Model II			Model III			Model IV		
	No.	Total Cost (Rs.)	% share to total cost	No.	Total Cost (Rs.)	% share to total cost	No.	Total Cost (Rs.)	% share to total cost	No.	Total Cost (Rs.)	% share to total cost
Land development equipment	1	11,000	1	-	-	-	1	10,500	2	1	11,750	4
Tillage equipment	19	13,56,350	62	8	4,31,000	59	10	3,68,500	73	4	1,45,450	52
Sowing & planting equipment	3	2,14,000	10	2	1,52,000	21	-	-	-	-	-	-
Intercultivation & weeding equipment	1	58,200	3	-	-	-	-	-	-	-	-	-
Plant protection equipment	1	12,500	1	-	-	-	-	-	-	-	-	-
Harvesting equipment	2	2,51,000	11	1	1,53,000	21	-	-	-	-	-	-
Threshing	1	1,20,000	5	-	-	-	-	-	-	-	-	-
Transportation machinery or equipment	1	1,75,000	8	-	-	-	1	1,25,000	25	1	1,25,000	44
Grand total	29	21,98,050	100	11	7,36,000	100	12	5,04,000	100	6	2,82,200	100

TABLE IV

Cost of establishment of CHS models in Kolar district

(n = 10)

Particulars	Model I		Model II		Model III		Model IV	
Fixed cost	Costs (Rs.)	Per cent Share	Costs (Rs.)	Per cent Share	Costs (Rs.)	Per cent Share	Costs (Rs.)	Per cent Share
				Fixed Cost				
Machinary and equipments	45,21,994	85.6	30,40,424	85.8	14,59,000	86.9	6,99,800	83.8
Depreciation	3,95,183	7.5	3,22,709	9.1	1,29,150	7.7	96,732	11.6
Site Rent	36,000	0.7	78,000	2.2	10,450	0.6	-	0.0
Computer & related expenses	48,458	0.9	62,500	1.8	-	0.0	-	0.0
Furniture & Fixtures	15,598	0.3	10,500	0.3	-	0.0	-	0.0
Interest on Investment	2,34,013	4.4	15,734	0.4	75,503	4.5	36,215	4.3
Insurance Premium	32,617	0.6	13,850	0.4	4,250	0.3	2,750	0.3
Sub total	52,83,863	73.4	35,43,717	77.9	16,78,353	65.1	8,35,497	80.3
				Variable Cost				
Salary	5,53,016	28.9	3,10,500	30.9	1,87,005	20.8	40,053	19.6
Fuel Charges	11,04,686	57.7	5,35,500	53.3	4,89,640	54.5	1,12,750	55.0
Repair & Maintenance	2,43,303	12.7	1,50,506	15.0	2,08,809	23.3	49,568	24.2
Water/Electricity charges	2,798	0.1	2,300	0.2	-	0.0	-	0.0
Miscellaneous	10,295	0.5	5,250	0.5	12,545	1.4	2,500	1.2
Sub total	19,14,099	27.5	10,04,056	22.1	8,97,999	34.9	2,04,871	19.7
Total	71,97,962		45,47,773		25,76,352		10,40,368	

TABLE V

Cost and returns of CHS models in Kolar district

(n = 10)

Particulars	Model I	Model II	Model III	Model IV
Total annual cost (Rs.)	19,14,099	10,04,056	8,97,999	2,04,871
Hiring hours (per year)	5,328.11	3,215	2,895	1,973
Gross returns (Rs./year)	20,72,555	16,63,800	24,30,905	3,05,700
Net returns (Rs./year)	1,58,456	6,59,744	15,32,906	1,00,882
Returns per rupee invested	1.08	1.66	2.70	1.49

the share of 27.5, 22.1, 34.9 and 19.7 per cent in the total cost respectively. Across all the CHS models the cost of FME (including tractor cost) was the major component contributing tothe fixed cost followed by others. The fuel charges, salary, repair and maintenance are the major components which are contributing to variable cost followed by others.

The cost of FME in Model I was Rs. 45,21,994/-, Model II (Rs. 30,40,424/-), Model III (Rs. 14,59,000/-) and Model IV was Rs. 6,99,800/- with percentage share to total variable cost was more than 80 per cent in all CHS models. The variable costs such as fuel charges, salary, repair and maintenance were highest in Model I, which is Rs. 11,04,686/-, Rs. 5,53,016/- and Rs. 2,43,303/-, respectively followed by other models.

The cost is returns of CHS models in Kolar district was given Table V. The total annual cost incurred was highest in Model I which was Rs. 19,14,099/- followed by Model II (Rs. 10,04,056/-), Model III (Rs. 8,97,999/-) and Model IV (Rs. 2,04,871/-). It clear that all the CHS models were able to cover their expenditures, though there is huge difference in the yearly profits (Sidhu and Vatta, 2012).The annual machinery hours supplied by Model I was 5,328.11, 3,215, 2,895 and 1,973, respectively. The net returns are high, Rs. 15,32,906/- in Model III followed by Model II (Rs. 6,59,744/-), Model I (Rs. 1,58,456/-) and Model IV (Rs. 1,00,882/-). Though the machinery hours supplied by formal institutions was highest, the net returns were more in Model III of informal institution. Since the formal institutions have charged the hiring rates fixed by the district steering committee which is much lower compared to hiring rates of informal institutions. The results are supported by the study conducted by Hiremath, *et al*. (2015). He found that the private owners charge higher rates (average Rs. 50 per hour) for machineries compared to CHSCs.The return per rupee invested was higher in Model III followed by others.

The results of the economic feasibility of CHS models in agriculture are presented in the Table VI. The discounted measures such as Net Present Value (NPV), Benefit-Cost Ratio (BCR) and Internal Rate

TABLE VI

Economic feasibility of CHS models in Kolar

Discounted measures	Model I	Model II	Model III	Model IV
B-C ratio	1.09	1.24	1.85	0.98
NPV (Rs.)	18,95,932	27,96,218	68,49,577	-27,835
IRR (per cent)	17.24	24.92	80.44	7.99

Note : Discount rate: 9 per cent

TABLE VII

Hiring charges of tractor mounted and other FME in formal and informal institutions of CHS models in Kolar district

(n=10)

Farm machinery & equipment	Units	Formal institutions	Informal institutions	Absolute difference	Percentage difference
Land development equipment					
Leveller blade	Rs./hr	350	600	-250	-42
Tillage equipment					
Trailer	Rs./load	400	600	-200	-33
MB Plough(single bottom fixed)	Rs./hr	450	850	-400	-47
MB Plough (single bottom reversible)	Rs./hr	450	850	-400	-47
MB Plough (double bottom fixed)	Rs./hr	450	850	-400	-47
MB Plough (3 bottom fixed)	Rs./hr	450	850	-400	-47
Disc plough	Rs./hr	600	1,175	-575	-49
Rotovator (42 blades)	Rs./hr	600	850	-250	-29
Rotovator (36 blades)	Rs./hr	600	800	-200	-25
Cultivator (9 tyne)	Rs./hr	400	600	-200	-33
Cultivator (5 tyne)	Rs./hr	400	600	-200	-33
Forrow opener ridger (5tyne)	Rs./hr	500	800	-300	-38
Forrow opener ridger (3tyne)	Rs./hr	500	800	-300	-38
Bed preparation machine	Rs./ac	1,300	2,000	-700	-35
Harrow	Rs./hr	350	600	-250	-42
Disc harrow (14 disc)	Rs./hr	475	750	-275	-37
Mulching paper machine	Rs./ac	500	800	-300	-38
Cage wheel	Rs./hr	-	1,200	-	-
Rotary tiller	Rs./hr	300	700	-400	-57
Sowing & planting equipment					
Seed cum fertilizer drill	Rs./hr	550	700	-150	-21
Post hole digger	Rs./ pit	15	-	-	-
Inter-cultivation and weeding equipment					
Brush cutter	Rs./day	150	350	-	-
Plant protection equipment					
Knapsack sprayer (without fuel)	Rs./day	100	100	-	-
HTP sprayer	Rs./day	150	150	-	-
Harvesting equipment					
Ragi Reaper	Rs./hr 500	-	-	-	-
Groundnut pod stripper	Rs./hr 300	-	-	-	-
Threshing					
Multi crop thresher (top feed)	Rs./q 50	75	-25	-33	

Note : FME : Farm machinery and equipment of Return (IRR) were computed by assuming (i) Increasing annual recurring cost of FME as increase in fuel, labour and repair charges and operator wages year after year for 10 years, and (ii) Increasing annual gross returns as CHS models operates at its full potential.

The annual net cash inflows were discounted at a discount rate of 9 per cent to obtain the present value of net benefits from CHS model. The initial investment made on to establish CHS model was then deducted from the present value of their net benefits. It can be seen from Tables VI that, the NPV of the investment was highest in Model III which is Rs. 68,49,577/-, followed by Model II (Rs. 27,96,218/-), Model I (Rs. 18,95,932/-) and Model IV showed negative NPV i.e.(- Rs. 27,835/-). The investment made on Model I, Model II and Model III are economically feasible since NPV values are positive.

The benefit-cost ratio indicates the returns per rupee invested in CHS models. The magnitude of the ratio also indicates the priority to be assigned for each of the alternative investment opportunities. The table VI shows that Model III is having highest B-C ratio of 1.85, followed by Model II, Model I and Model IV which is 1.24, 1.09 and 0.98, respectively. This clearly indicates all CHS models except Model IV are financially feasible since benefit cost ratio of these CHS models are having more than one.The internal rate of return measures the rate of return that can be earned by CHS model. The results in Table VI also revealed that, Model I, II and III are considered as economically feasible since IRR for Model I, Model II and Model III was higher than the opportunity cost of capital, which was 9 per cent as considered in the evaluation. In Model IV, the IRR was 7.99 which was less than the opportunity cost of capitaland also NPV is negative. Therefore, Model IV is not economical feasible.

The Table VII reveals the hiring charges of tractor mounted and other FME in formal and informal institutions of CHS models in Kolar district. It was observed that there was a wide variation in respect of hiring charges being charged by formal and informal institutions of CHS models. However, hiring charges of agricultural machinery from the formal institutions such as Model I and II was at much lower rate (Kamboji *et al.* (2012) and Sidhu & Vatta (2012) compared to informal institutions.

It is clear from the table VII that the percentage variation of hiring charges ranges from 21 per cent to 49 per cent. This means that formal institutions provide custom hiring services at 21 to 49 per cent less than the local rates. The same pattern was observed in Punjab, where the cost of hiring farm machinery from private owners was higher between 9 and 40 per cent as compared to machinery hiring from Co-operative Agro-Machinery Service Centres (AMSC) (Sidhu and Vatta, 2012). It shows that these formal institutions have further scope to expand their hiring services to farmers.

The maximum variation in hiring charges was observed in tillage equipment. The custom hiring charge was high for Bed preparation machine which is Rs. 1300 per acre and Rs. 2000 per acre in formal and informal institutions, respectively and the variation observed was Rs. 700 per acre that means the formal institutions offers bed preparation machine service to farmers at Rs. 700/- lesser than the informal institutions. The same interpretation holds goods for other implement also.

The formal institutions are owning more number of tractors and other FME compared to informal institutions showed that the formal institutions are having greater advantage in meeting machinery needs of large number of farmers. It is observed that in all CHS models the tillage equipment are more in number. It means that there is more demand for tillage equipment as compared to others. The formal institutions are the only sources of equipment related to sowing and planting, intercultivation and weeding, plant protection, harvesting and threshing in the study region.Therefore, there is a need to strengthen the formal institution CHS models by increasing the number of farm machinery. It will solve the problem of timely non-availability of machinery services to farmers particularly during peak season, especially to the small / marginal and medium farmers.

The repair and maintenance of FME is the major component which adds to the variable cost of CHS models. This needs to be addressed by the government by establishing FM service stations at local level on PPP mode. The discounted measures such as BC ratio, NPV and IRR of different CHS models have indicated that the formal institutions such as Model I, II and informal institution model III were economically feasible. Since the formal institutions are economically feasible the government should promote these models,especially where the FME services are not available. The expansion of these models will bring more competition in the custom hiring services of FME and will bring down the price differentials between CHS models offormal and informal institutions.It will further reduce the burden on farmers from paying higher hiring charges to informal institutions which in turn reduce the costs of operations.

References

Anonymous, 2016, Farm mechanization in India: the custom hiring perspective, Ministry of Agriculture and Farmers Welfare, Government of India, p. 48 - 70.

Anonymous, 2015b, State of Indian Agriculture 2015 - 16, Government of India, Ministry of Agriculture & Farmers Welfare Department of Agriculture, Cooperation & Farmers Welfare, Directorate of Economics and Statistics, New Delhi.

Anonymous, 2015a, Transforming agriculture through mechanization, FICCI, New Delhi, p.16 - 34.

Chahal, S. S., Kataria, S. A. and Gill, B. S., 2014, Role of co-operatives in institutionalization of custom hiring services in Punjab. *Agric. Eco. Res. Rev.,* **27** : 10 - 110.

Hiremath, G. M., Lokesh, G. B.., Maraddi and Suresh. S. P., 2015, Accessibility of farm machinery services - CHSCs for small and marginal farmers. *Int. J. Manmgt. Sco. Sci.,* **3** (2) : 897 - 907.

Kamboj, P., Rohinish, K.and Anoop, D., 2012, Farm machinery services provided by selected cooperative societies. *Agric. Eng. Int. : CIGR J.*, **14** (4) : 123 - 133.

Kulkarni, S. D., 2009, Mechanization of agriculture -Indian scenario. Proceedings 5th APCAEM TC Meeting & Expert Group Meeting on Application of Agricultural Machinery for Sustainable Agriculture. Philippines.

Raghavan, M., 2008, Changing pattern of input use and cost of cultivations, Review of Agriculture. *Eco. Pol. Weekly*, **43** : 123 - 128.

Singh, S., Kingra, H. S. and Sangeet, 2013, Custom hiring services of farm machinery in Punjab: Impact and policies. *Indian Res. J. Ext. Edu.*, **13** (2) : 45 - 50.

Sidhu, R. S. and Vattta, K., 2012, Improving economic viability of farming: a study of co-operative agro machinery service centres in Punjab. *Agric. Econ. Res. Rev.*, **25** : 427 - 434.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 233-239, 2017

Dynamics of Cropping Pattern and Crop Diversification in Southern Dry Zone of Karnataka – An Econometric Analysis

M. SATISHKUMAR AND K. B. UMESH
Department of Agricultural Economics, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail : sati.4855@gmail.com

ABSTRACT

The paper has examined the dynamics of cropping pattern and crop diversification in Southern Dry Zone of Karnataka for the period 2001-02 to 2015-16 using compound growth rate, crop diversification indices and Markov chain analysis. The results revealed that the area under vegetables and spices and fruits and nuts has shown significant positive growth rate at both district and taluk level. The area under sugarcane and coconut had shown significant positive growth rate of 2.38 per cent and 3.11 per cent, respectively at district level. Whereas, the area under sugarcane (9.51 %) had shown significant positive growth rate and area under horsegram (-5.36 %) had shown significant negative growth rate at taluk level. The crop diversification indices indicated shift in cropping pattern towards diversification in both areas. The transition probability matrix indicated that the horticultural crops in general and coconut crop in particular have retained a higher share in terms of area under crops.

Keywords: Crop diversification, growth rate, markov chain analysis, transition probability matrix

THE changes in cropping pattern are basically the result of the adoption of new crops and the intensification of cultivation through multiple cropping. The changes in cropping pattern over time are also a function of changes in the extent and quality of irrigation and the relative costs of and returns to competing crops and crop combinations (Gairhie, 2011). The change in cropping pattern in particular span of time clearly indicates the changes that have taken place in the agricultural development (Sikandar, 2014). The availability of inputs for intensive agriculture, the cropping system in some state has undergone a paradigm shift, from a much diversified cropping pattern to a mono-cropped one. Crop diversification provides the farmers with a wider choice in the production of a variety of crops in a given area so as to expand production related activities on various crops and also to bring down the possible risk. Diversification of crops has immense potential as an economic driver within the agricultural sector (Kumar and Gupta, 2015). In view of this, the present study was undertaken in southern dry zone of Karnataka to assess the changes in cropping pattern and crop diversification using time series data.

METHODOLOGY

The Cauvery command area coming under Southern dry zone of Karnataka was purposively selected for the study. Based on net irrigated area which is a proxy for greater degree of mechanization, the Mandya taluk of Mandya district was selected. The analysis was carried out at both district and taluk levels in the present study.

Nature and sources of data

The study is mainly based on the time series data obtained from Directorate of Economic and Statistics (DES), Bengaluru. The data pertaining to area under different crop groups and principal crops for a period from 2001-02 to 2015-16 (15 years) was considered. The annual compound growth rates and instability index (Cuddy and Valle, 1978) for area were computed for the study period.

To assess the extent of crop diversification, the following indices were used

a) Herfindahl Index (HI) - It is the sum of square of the proportion of acreage under each crop to the total cropped area and is given by the equation:

$$\mathbf{HI} = \sum_{i=1}^{N} P_i^2 \quad \text{———} \quad (1)$$

Where, P_i represents acreage proportion of the i^{th} crop in total cropped area. The Herfindahl index takes the value of one when there is specialization and approaches zero when there is diversification.

b) Simpson Index (SI) - It is the most suitable index for measuring diversification of crops in a particular geographical region and is calculated by equation:

$$\mathbf{SI} = 1 - \sum_{i=1}^{N} P_i^{2} \quad (2)$$

Where, $P_i = A_i / \Sigma A_i$ is the proportion of the i^{th} activity in acreage. Simpson index of near zero, indicates that the zone or region is near to specialization in growing of a particular crop and if it is close to one, then the zone is fully diversified in terms of crops.

Markov Chain Analysis

To assess the shift in cropping pattern of area under crops during 2001-02 to 2015-16, transitional probabilities were calculated based on linear programming (LP) approach using LP SOLVER IDE software. To know the shift in cropping pattern, different crops like paddy, ragi, other cereals (maize and millets), horsegram, cowpea, other pulses (redgram, blackgram, avare and greengram), sesamum, other oilseeds (groundnut, niger seed and castor), sugarcane, coconut, horticulture crops (vegetables, spices and fruits) and other crops (chilly, mulberry etc.,) were considered. Markov chain analysis develops a transitional probability matrix 'P', whose elements P_{ij} indicate the probability (share) of crop switching from the i^{th} crop to the j^{th} crop over time. Its diagonal elements represent retention share of respective crop in terms of area under crops. This can be algebraically expressed as Equation:

$$E_{jt} = \Sigma\, [E_{it\,-1}]\, P_{ij} + e_{jt} \quad (3)$$

i=1,...,n

where,

E_{jt} = Area under j^{th} crop in the year 't'

E_{it}-1 = Area under i^{th} crop during the year 't-1'

P_{ij} = The probability of shift in area under i^{th} crop to j^{th} crop

e_{jt} = The error-term statistically independent of E_{it}-1, and

n = The number of crops.

The transitional probabilities P_{ij} arranged in (m × n) matrix have the following properties:

$\Sigma P_{ij} = 1$ and 0 dH P_{ij} dH 1

i=1,...,n

The transitional probability matrix (T) based on LP framework is estimated using Minimization of Mean Absolute Deviation (MAD).

Min, OP* + Ie

Subjected to

X P* + V = Y

GP* = 1

P* > 0

Where, P* is the transitional probability matrix, '0' is the zero vector, 'I' is an appropriately dimensional vector of areas, and 'e' is the vector of absolute errors.

Results and Discussion

Growth and instability in area of major crop groups in Southern Dry Zone of Karnataka

The results from Table I indicate that though there was a negative growth rate in area under cereals and minor millets, pulses and oilseeds at district level, the growth rates were statistically non-significant. The area under commercial crops, vegetables and spices and, fruits and nuts had shown significant positive growth rate of 2.35, 8.31 and 2.36 per cent at district level, respectively. The results of instability index indicate that the variation in area under major crop groups was minimum.

At taluk level, the area under vegetables and spices and fruits and nuts had shown significant growth rate of 7.39 and 9.88 per cent, respectively. Whereas, the area under pulses had shown significant negative growth rate of 4.47 per cent. The instability index indicates that the area under oilseeds and fruits and nuts was more unstable when compared to other crop groups (Table I).

Growth and instability in area of major crops in Southern Dry Zone of Karnataka

At district level, the results from Table II revealed that the area under sugarcane and coconut had shown significant positive growth rate of 2.38 and 3.11 per cent, respectively. While, the area under remaining crops had shown non-significant growth rates. The area under sugarcane had shown significant positive growth rate (9.51 %) and area under horsegram had shown significant negative growth rate (5.36 %) at taluk level. The findings of Ashwini (2014) has aptly supported the findings of this study.

TABLE I

Growth and instability in area of major crop groups in southern dry zone of Karnataka (2001-02 to 2015-16)

Crop Group	Mandya district			Mandya taluk		
	Mean area (000, ha)	CGR (%)	Instability Index (%)	Mean area (000, ha)	CGR (%)	Instability Index (%)
Cereals and minor millets	136.11	-0.63	18.95	21.18	1.31	23.51
Pulses	41.15	-1.61	24.89	05.55	-4.47 *	32.62
Oilseeds	09.66	-3.41	38.93	00.57	3.15	78.69
Commercial crops	37.41	2.35 *	15.53	10.81	1.55	23.03
Vegetables and Spices	06.70	8.31 **	14.75	00.67	7.39 **	28.32
Fruits and Nuts	27.17	2.36 **	08.71	02.56	9.88 **	62.81

Note : * Significance at 5 %, ** Significance at 1 %

TABLE II

Growth and instability in area of major crops in southern dry zone of Karnataka (2001-02 to 2015-16)

Crop Group	Mandya district			Mandya taluk		
	Mean area (000, ha)	CGR (%)	Instability Index (%)	Mean area (000, ha)	CGR (%)	Instability Index (%)
Cereals and minor millets	136.11	-0.63	18.95	21.18	1.31	23.51
Paddy	71.15	0.16	20.75	14.27	1.86	23.23
Ragi	60.15	-1.13	24.84	6.76	0.31	40.12
Horse gram	29.95	-2.68	38.34	4.71	-5.36 *	35.96
Cowpea	5.99	-2.68	37.58	0.38	5.85	55.44
Sesamum	4.84	1.86	58.14	0.32	11.52	119.99
Sugarcane	36.78	2.38 *	9.35	10.74	1.54	23.13
Coconut	21.44	3.11 **	10.49	2.09	9.51 *	66.42

Note : * Significance at 5 %, ** Significance at 1 %

The instability index had shown that the area under sesamum was more unstable at both district and taluk levels. The area under coconut at district level had shown more instability when compared to that at taluk level. Similarly, the fluctuation in area under other major crops also had shown more fluctuation at district level compared to that at taluk level except in horsegram (Table II).

TABLE III

Crop diversification in southern dry zone of Karnataka (2001-02 to 2015-16)

Index	Mandya district	Mandya taluk
Herfindahl Index (HI)	0.32	0.35
Simpson Index (SI)	0.68	0.65

TABLE IV

Transition probability matrix of changes in cropping pattern for Mandya district of Karnataka (2001-02 to 2015-16)

	Paddy	Ragi	Other cereals	Horsegram	Cowpea	Other pulses	Sesamum	Other oilseeds	Sugarcane	Coconut	Horticulture	Other Crops
Paddy	0.5547	0.1314	0.0000	0.0000	0.0000	0.0218	0.0000	0.0000	0.2916	0.0005	0.0000	0.0000
Ragi	0.0501	0.3690	0.0479	0.1426	0.0312	0.0000	0.0044	0.0170	0.0963	0.1108	0.0406	0.0901
Other cereals	0.0000	0.0000	0.0000	0.0000	0.0000	0.1131	0.0000	0.0000	0.6539	0.2330	0.0000	0.0000
Horsegram	0.3117	0.3585	0.0000	0.1322	0.0002	0.0046	0.0337	0.0343	0.0000	0.0000	0.0000	0.1248
Cowpea	0.3429	0.0000	0.0775	0.0000	0.1627	0.0000	0.2190	0.0000	0.0000	0.0000	0.1979	0.0000
Other pulses	0.8814	0.0000	0.0000	0.0000	0.0000	0.0000	0.1186	0.0000	0.0000	0.0000	0.0000	0.0000
Sesamum	0.0000	0.6073	0.0000	0.0000	0.0000	0.0000	0.2761	0.1166	0.0000	0.0000	0.0000	0.0000
Other oilseeds	0.0000	0.5462	0.0000	0.2899	0.0000	0.0458	0.0189	0.0992	0.0000	0.0000	0.0000	0.0000
Sugarcane	0.1851	0.3538	0.0000	0.0000	0.0204	0.0575	0.0000	0.0000	0.2801	0.1031	0.0000	0.0000
Coconut	0.0000	0.0000	0.0344	0.4296	0.0808	0.0000	0.0000	0.0000	0.0000	0.4511	0.0041	0.0000
Horticulture	0.0000	0.0000	0.0284	0.1762	0.0000	0.0000	0.0000	0.0000	0.0000	0.0664	0.7290	0.0000
Others	0.7548	0.0000	0.0000	0.0000	0.0000	0.0646	0.0000	0.0934	0.0000	0.0000	0.0000	0.0872

TABLE V

Transition *probability matrix of changes in cropping pattern for Mandya taluk of Mandya district (2001-02 to 2015-16)*

	Paddy	Ragi	Other cereals	Horsegram	Cowpea	Other pulses	Sesamum	Other oilseeds	Sugarcane	Coconut	Horticulture	Other Crops
Paddy	0.5456	0.0622	0.0000	0.0517	0.0000	0.0084	0.0000	0.0178	0.2174	0.0081	0.0000	0.0888
Ragi	0.0000	0.2350	0.0000	0.0042	0.0000	0.0157	0.0000	0.0000	0.6379	0.0859	0.0213	0.0000
Other cereals	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Horsegram	0.0000	0.5819	0.0000	0.3930	0.0000	0.0251	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cowpea	0.0000	0.9253	0.0000	0.0000	0.0000	0.0000	0.0747	0.0000	0.0000	0.0000	0.0000	0.0000
Other pulses	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sesamum	0.0000	0.0000	0.0000	0.3208	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6792	0.0000
Other oilseeds	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
Sugarcane	0.5784	0.0000	0.0000	0.1771	0.0120	0.0000	0.0000	0.0000	0.2325	0.0000	0.0000	0.0000
Coconut	0.0000	0.1559	0.0000	0.0000	0.0586	0.0000	0.1341	0.0000	0.0701	0.5813	0.0000	0.0000
Horticulture	0.0193	0.0000	0.0566	0.0000	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.8134	0.1101
Others crops	0.0284	0.3685	0.0070	0.0000	0.0795	0.0000	0.0034	0.0000	0.4209	0.0000	0.0853	0.0070

Crop diversification in Southern Dry Zone of Karnataka

The average value of Herfindahl index for different crop groups was 0.32 for Mandya district and 0.35 for Mandya taluk, indicating crop diversification at both the district and taluk levels. Similarly, the average value of Simpson index also indicated diversification at district and taluk levels (Table III). Birthal *et al.* (2008) reported that the marginal and small farmers optimize their cropping pattern in a way that enables them to obtain higher income without adversely affecting their food security.

Transition probability matrix of changes in cropping pattern for Mandya district of Karnataka (2001-02 to 2015-16)

It is evident from Table IV that the horticulture crops and paddy were the major crops of the district as reflected by the probability of retention of 0.7290 and 0.5547, respectively, followed by coconut (0.4511), ragi (0.3690) and sugarcane (0.2801). While other cereals and other pulses have shown instability in the retention of area with the probability value of zero. Horsegram, cowpea, sesamum, other oilseeds and other crops were least stable crops with probability retention of area of 0.1322, 0.1627, 0.2761, 0.0992 and 0.0872 of the total cultivatable area of the district, respectively. Similar results were reported by Harish (2006) in his study.

When the leading crops of the district is consider, sugarcane gained major proportion of area from paddy, ragi and other cereals, while it has lost its major share to ragi (0.3538) and paddy (0.1851). The probability of transition of paddy had shown a shift towards ragi, other pulses, sugarcane and cotton. The gained area over the year can be attributed from ragi, sugarcane, other crops and pulse crops. Ragi had gained a larger proportion of area from sesamum, other oilseeds, horsegram and sugarcane (Table IV).

Transition probability matrix of changes in cropping pattern for Mandya taluk of Mandya district (2001-02 to 2015-16)

The results from Table V revealed that the probability of retaining of paddy and ragi, the principal food crops of the taluk was 0.5456 and 0.2350, respectively. The probability of retention was higher for horticulture crops (0.8134), followed by coconut (0.5813). The other cereals, cowpea, other pulses, sesamum and other oilseeds had shown instability in the retention of area with probability value of zero. Among pulses, the horsegram was the major crop which had probability of retention of 0.3930. The probability of retention of sugarcane was 0.2325 over the previous years' share and the other crops had retained meager area of its previous years' share.

The paddy, sugarcane and ragi were the major crops of the taluk. The paddy gained a larger proportion of its share from sugarcane (0.5784). However, the probability of transition from paddy had shown loss of area to ragi, horsegram, other pulses, other oilseeds, sugarcane, coconut and other crops (Table V). Sugarcane had lost its major proportion to paddy (0.5784) and horsegram (0.1771). While it has gained larger area from other cereals (1.00) and ragi (0.6379). Ragi is the major staple food crop of the area, which has gained larger proportion from other pulses, cowpea and horsegram, but lost its major proportion of area to sugarcane (0.5784).

The study revealed that the area under commercial crops, vegetables and spices and fruits and nuts had shown significant positive growth rates at both district and taluk level. The area under sugarcane and coconut had shown significant positive growth rate at district. Whereas, the area under sugarcane had shown significant positive growth rate and area under horsegram had shown significant negative growth rate at taluk level. The average value of Herfindahl and Simpson indices indicated the diversification at district and taluk level. The transition probability matrix had indicated that the horticultural crops and coconut have retained a higher share in terms of area under crops. Whereas, other cereals and other pulses have shown instability at district level and other cereals, cowpea, other pulses, sesamum and other oilseeds had shown instability at taluk level in the retention of area with probability value of zero. The water scarcity has made the farmers to diversify their cropping pattern. Crop diversification ensures livelihood security to the farmers. Therefore, in addition to crop diversification, the farmers should be educated regarding the research based recommendations and technologies on the farm which would strengthen the crop diversification process in the study area.

References

Ashwini, B. C., 2014, Development of irrigation infrastructure, cropping pattern and profitability of crops cultivated in Cauvery river basin of Karnataka. *M. Sc. (Agri.) Thesis (Unpub.)*, Univ. Agric. Sci., Dharwad.

Birthal, P. S., Joshi, P. K., Sonia Chauhan and Harvinder Singh, 2008, "Can horticulture revitalise agricultural growth?". *Indian J. Agric. Econ.,* **63** (3) : 310 - 321.

Cuddy, J. D. A. and Della Valle, P. A. 1978. Measuring the instability of time series data. *Oxford Bulletin Econ. Stat.*, **40** (1) : 79 - 85.

Gairhie, S., 2011, Land use dynamics in Karnataka - An economic analysis. *M. Sc. (Agri.) Thesis (Unpub.),* Univ. Agric. Sci., Dharwad.

Harish .M. H., 2006, An economic appraisal of land use dynamics in Mandya district. *M. Sc. (Agri.) Thesis (Unpub.)*, Univ. Agric. Sci., Dharwad.

Kumar Sanjeev and Gupta Sakshi, 2015, Crop diversification towards high-value crops in India: A state level empirical analysis. *Agric. Econ. Res. Rev.*, **28** (2) : 339 - 350

Sikandar Mulani, S., 2014, *Socio economic development in Solapur district*. Laxmi book publication, Solapur.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 240-243, 2017

Intermittent Mating and Egg Laying by Coffee White Stem Borer, *Xylotrechus quadripes* Chevrolat (Coleoptera : Cerambycidae)

F. R. Pattan and H. Khader Khan
Department of Agricultural Entomology, College of Agriculture, UAS, GKVK, Bengaluru-560 065

Abstract

The present investigation on reproductive biology of Coffee White Stem Borer *Xylotrechus quadripes* Chevrolat (Coleoptera : Cerambycidae) was carried out at the Chandrapore coffee estate, Mudigere, India during 2015 – 2017. Immediately after emergence the beetles started mating. The average duration of was 25 seconds but the oviposition started only after 24 hours. A female mated 5.07± 1.49 times with the same mounted male, before commencing egg laying. Maximum eggs were laid in the first week of emergence with an average of 35.28 ± 19.01 eggs on the 4th day. Oviposition period varied from 6 to 22 days. A female beetle mated multiple times 12.2 ± 2.04 in its life span of 27.74 ± 5.65 days, exhibiting peculiar intermittent mating and throughout egg laying behavior. Fecundity ranged from 89 to 265 eggs (140.72 ± 42.50).

Keywords: *Xylotrechus quadripes*, *coffea arabica*, oviposition, multiple mating

Xylotrechus quadripes (Chevrolat), the coffee white stem borer (CWSB), is a major pest of arabica coffee (*Coffea arabica* L.) in some Asian countries. CWSB grubs make tunnels in the main stem and thick primary branches of coffee plants. The pest causes substantial economic loss every year since infested plants have to be uprooted (they act as source infestation and further spread of the pest). CWSB has two flight periods in India (Subramanian, 1934): the pre-monsoon flight period begin in April and extends to the end of May and the post-monsoon period starts from September to until the end of December. In India, coffee has been at the receiving end of the onslaught by CWSB since several decades. Its preferential attack on arabica (as against robusta) and the persistently high population density has had a telling blow on coffee in India; farmers have either abandoned cultivation of coffee or have shifted to robusta coffee. CWSB was noticed as early as in 1838 (Stokes, 1838) and owing to its serious nature it was brought under the destructive insects and pests act VI, 1917 by the erstwhile Mysore Govt., making it compulsory to undertake strict control measures to prevent its spread. However, it has to be acknowledged that despite considerable efforts, the pest has not been brought under check till date. It is noteworthy that most of the efforts made so far have gone towards managing the pest rather than in understanding its biology and ecology, which may be the reason behind the series of failures throughout the coffee growing areas of the country. The present work is a part of detailed study on reproductive biology of CWSB conducted during 2015-17.

Material and Methods

Study area : The studies were conducted from 2015-17 at Chandrapore Coffee Estate in Mudigere, Karnataka (India) (13^0 0' 44^0 N; 75^0 41'36^0 E, 962.25 m above MSL). The estate is spread over the 432 acre of land and it was completely uprooted and replanted in 2008 because of the severe incidence of *X. quadripes*.

Mudigere is with in the range of Western Ghats of Karnataka and is located in the Agro Climatic Region-V, Zone-9. It receives an annual rainfall ranging from 900 to 3700 mm (mean: 2400 mm) and most of it is received from June to August months (104 rainy days). The average maximum temperature is 30°C (April) and minimum temperature is 14°C (January). The relative humidity ranges between 50 and 80 per cent.

The source and stock culture of adults for studies : In the month of September - October a total of 1229 infested plants were identified, uprooted and brought to the laboratory and were placed in nylon mesh house (10 feet x 10 feet x 06 feet). The uprooted coffee plants were five to eight years old. Daily observations on emergence of the adult beetles in the mesh house were recorded and then sex ratio was calculated. When the adult beetles began to emerge in mesh house, they were collected and released in to plastic boxes (2 kg capacity) for mating. Each mated pair was carefully transferred to a larger cage (4 feet x 2 feet x 2 feet) provided with coffee sticks for egg laying.

To facilitate CWSB to lay eggs in the plastic container, the mouth of the container was closed tightly with muslin cloth. Then the container was inverted on a sheet of white paper in such a way that muslin cloth covered mouth was resting on the sheet of paper (Fig. 1).

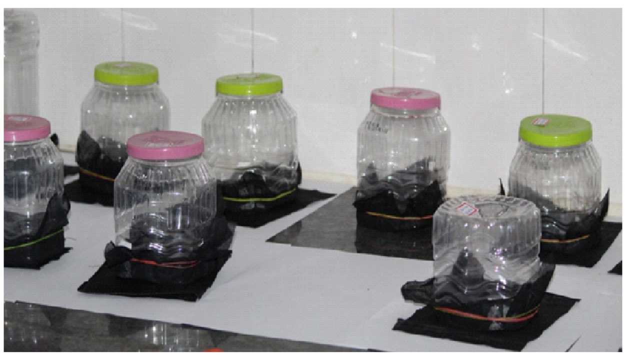


Fig. 1 : Plastic boxes with closed tightly with muslin cloth to facilitate eggs laying

Observations on the reproductive biology : Twenty five pairs (13 pairs in November, 2015 and 12 pairs in November, 2016) of virgin male and female beetles were transferred to the container immediately after emergence with sex ratio of 1:1. The observations were recorded on the copulation duration, pre-oviposition period, oviposition period, number of successful copulations to lay one clutch of eggs, process of alternative mating and egg laying against to the adult longevity and total number of eggs laid by a female.

Results and Discussion

Intermittent mating and egg laying: The mating started soon after emergence of both sexes from the stems of infested coffee tree. Each of them mated several times in a day but the oviposition started only after 24 hours (Table I). When the beetles were allowed to mate at 1:1 sex ratio, it was always the male that attracted the female, as was also observed by Venkatesha *et al.* (1995). However, Veeresh (1995) had reported that the males are attracted to females in CWSB. One successful copulation took 3-50 seconds duration. After 3-7 such copulations the female started laying eggs. The adult female intermittently mated with the male and laid batches of eggs. This intermitted mating and oviposition continued throughout its life. On an average a female mated 12.2 times (n=10). CWSB females seen occasionally mounted on conspecific females (Fig. 2). The maximum number of eggs per batch was 19.3. Most of the eggs were laid within such six batches and later the number of eggs per batch decreased as was the frequency of mating (Fig. 3).

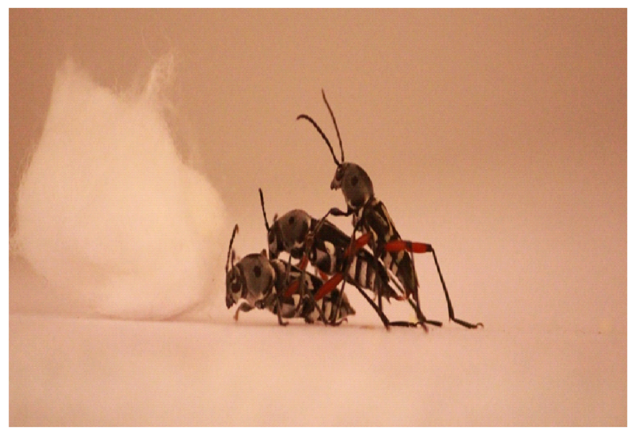


Fig. 2: Male successfully copulating with female and the female mounted on the other female under 5:3 (male: female) sex ratio

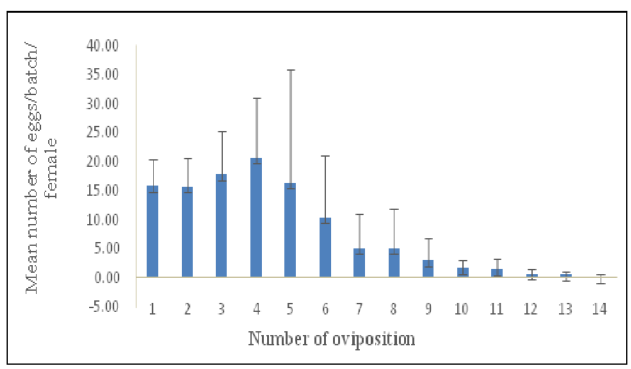


Fig. 3. The mean number of eggs per batch per female laid by *Xylotrechusquadripes*

Adult longevity: The average lifespan of 25 mated pairs were 27.74 days for females and 20.88 days for males (Table II). The longevity of females were longer than that of males. Linsey (1959) also

TABLE I

Courtship behaviour of Xylotrechus quadripes *under controlled condition*

Time of the day	Courtship behaviour exhibited by *X. quadripes*
10:30	Male sat on the floor of the mating box (designed for oviposition) and female was bit active often flying and sat at the roof of the box.
10:35	First male started fluttering wings and cleaning antennae then sidewise movement of antennae. Repeated movement of wings and antennae by male, but female just sat at the corner of the roof.
10:45	Female started fluttering wings and moving antennae.
10:55	Finally female started hovering around the male (not very close). Then again sat at the corner of the roof and did suchrepeated warm up exercises.
11:10	Later female started hovering around the male and finally landed at very close to male (approx. 5-6 cm).
11:13	Then female started antennal movement and wing fluttering movements.
11:25	Male makes the first move by moving towards female and touches the female and tried to mount on the females.
11:40	But female tried to escape.
11:43	Then male follows the female again attempted to mount on it, but female did not cooperate and again she ran away.
11:50	Finally this time male successfully mount on the top of the female and tries to copulate with female.
12:00	Male started mating with female (exchange of sexual organs).
13:10	One successful copulation took 3-50 seconds duration. After 3-7 such copulations the female started search of egg laying site. It started moving all along the border of the box and repeated insertion of the oviposition. Finally after 5-6 revolving rounds she starts laying eggs into the muslin cloths.
16:20	Again she sat at the roof of the mating box….

TABLE II

The longevity of mated adults of Xylotrechus quadripes

Sexes	No. individuals examined	Longevity (Days) Mean ± SD	Range (Days)
Males	25	20.88 ± 4.88	7 – 35
Females	25	27.74 ± 5.65	11 - 41

recorded longer lifespan of females compared to males. Majority of the eggs were laid within the first week and the eggs per day per female reached maximum (38.28 ± 19.01 eggs / day) on the fourth day of emergence (Fig. 4). On an average a single female was able to lay 140.72 ± 42.50 eggs. When the male of the mating couple died and a new male was introduced, the number of eggs per female temporarily increased in some mated females. Oviposition period varied from 6 to 22 days. Visitpanich (1994) reported that oviposition period varied from 2- 39 days with lower number of eggs per day (maximum of 15 eggs per female on fourth day) for longer duration. But in the present study the number of eggs laid per day per female was twice as many with a shorter oviposition period.

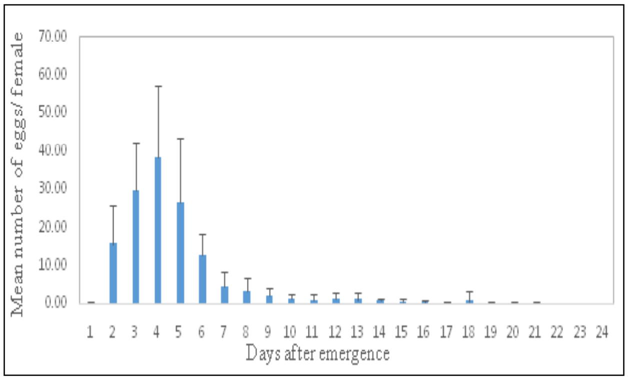


Fig. 4: The mean number of eggs laid by *Xylotrechus quadripes* (n = 25)

Sex ratio varied along the winter flight period

In two winter flight periods of 2015 and 2016 (both in laboratory and field conditions) males emerged first compared to females by four to five days (protandry) than that of females. At the flag end of flight period there were only females emerging but no males to mate. Sex ratio (Male : female) reduced as the flight period progressed. But in summer flight period (2016) protandry was not observed (Fig. 5).

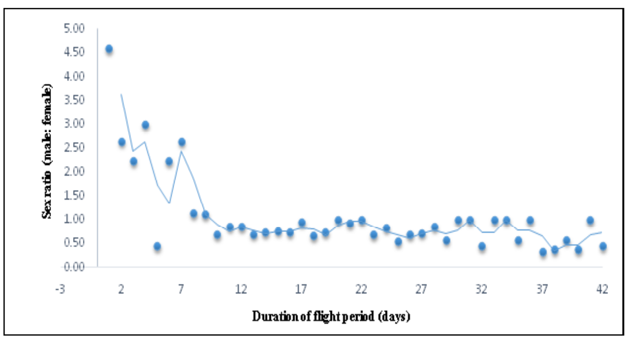


Fig. 5: Sex ratio of *Xylotrechus quadripes* varied along the flight period

The present study implies that the CWSB exhibits female biased sex ratio coupled with multiple mating to lay eggs. If the male is available at the time of emergence then they would mate within a week and lay maximum eggs, but it will not happen in nature because coffee estate is multistoried cropping system. It is difficult to locate mate hence the adult longevity of beetles is may be high.

References

Linsley, E. G., 1959, Ecology of Cerambycidae. *Annual Review of Ent.*, **4** : 99-133.

Stokes, H., 1838, Report of the Commissioner, Mysore, p. 1838.

Subramaniam, T. V., 1934, The Coffee Stem Borer. *Entomological Series-Bulletin*, Dept. of Agriculture (Mysore, India), **11**: 1–18.

Veeresh, G. K., 1995, Bioecology and Management of Coffee White Stem borer: *Xylotrechus quadripes* (Chev.). University of Agricultural Sciences, GKVK, Bengaluru, p. 56.

Venkatesha, M. G., Bhat, P. K. and Seetharama, H. G., 1995, Courtship behaviour of the coffee white stem borer, *Xylotrechus quadripes* (Chevr.) (Coleoptera : Cerambycidae). *J. Coffee Res.*, **25** : 88–93.

Visitpanich, J., 1994a, The biology and survival rate of the coffee stem borer, *Xylotrechus quadripes* Chevrolat (Coleoptera, Cerambycidae) in Northern Thailand. *Japanese J. Ent.*, **4**: 731–745.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 244-249, 2017

Artificial Diet for Rearing of *Conogethes punctiferalis* Guenee (Lepidoptera : Crambidae)

K. P. Kumar and H. Khader Khan
Department of Agricultural Entomology, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail : kumarkp4830@gmail.com

Abstract

This experiment was conducted to develop an artificial diet for rearing of castor shoot and capsule borer, *Conogethes punctiferalis* Guenee under laboratory conditions. The results revealed that artificial diet-1 yielded a larval survival rate of 95.46 per cent, mean pupal weights of 61.15 mg for females and 50.24 mg for males, fecundity rate of 39.02 eggs per females and took shortest period to complete the life cycle (31.48d). These outcomes indicated that *C. punctiferalis* adapted well to the artificial diet and successive rearing conditions. The diet could serve as a viable alternative to the natural host plants for consecutive rearing of the insects.

Keywords : artificial diet, *Conogethes punctiferalis*

The castor shoot and capsule borer, commonly called as yellow peach moth *Conogethes punctiferalis* Guenee (Lepidoptera : Crambidae) is major insect pest of castor, *Ricinus communis* L. and is widely distributed in south and East Asia, Australia, New Zealand and Papua New Guinea (CAB International, 2011). The larva of *C. punctiferalis* is highly destructive and typically polyphagous attacking more than 120 wild and cultivated plants *viz.*, peach, apple, pine trees, chestnut, durian, citrus, papaya, cardamom, ginger, egg plant, sunflower, maize and forestry crops (Lu, *et al*., 2010; Li *et al.,* 2015) and cause a huge yield loss of more than 55 per cent in castor (Ganesha, 2012). Effective management of *C. punctiferalis,* often relies on sound integrated pest management (IPM) strategy. To develop and improve IPM strategies, studies were carried out to understand its bio-ecology, physiology and toxicology. One of the pre-requisites for conducting these studies is availability of a large number of healthy eggs, uniformly developed larvae, pupae and adults for testing. Hence, a successful artificial diet for rearing *C. punctiferalis* in laboratory is highly desirable to facilitate studies for developing sound IPM programmes.

The development of artificial diets, pioneered by Vanderzant *et al.* (1962), facilitated the continuous production of insects. Since then, many species of lepidopterans, coleopterans and dipterans have been successfully reared under controlled laboratory conditions (Gupta *et al.,* 2005). The rearing of *C. punctiferalis* on meridic diets proposed by Honda *et al.* (1979) suggested that colonies fed on these diets had a larger variation in the development duration than the colonies fed on natural host plant materials. However, they still could not produced large number of uniform larvae due to low larval survival and adult emergence, insufficient nutrition of diets *etc.* Considering the sparse information on artificial diet for mass-rearing *C. punctiferalis,* the present study on artificial diet was planned.

Material and Methods

Insects: The initial *C. punctiferalis* population was established with a collection of larvae from castor fields at the Dryland Research Station, University of Agricultural Sciences, GKVK, Bengaluru (13^0 05" N, 77^0 34" E with 924m MSL), Karnataka, India during 2015-16 and the borer population was maintained on fresh castor for one generation. The stock borer culture was held in laboratory under the 26 ± 1^0C, 70-80 per cent relative humidity and a photo period of 16 : 8 h light : dark.

Artificial diets: The semi-synthetic diet formulated for *Conogethes* sp. (Ambanna, 2014) was used as a starting medium for preparation of meridic diet for castor shoot and capsule borer and the diet was modified by the addition of young capsule powder as a token stimuli and variation of casein amount as mentioned below :

1. Artificial diet 1 (Castor young capsule based meridic diet) - Castor leaf powder as a token stimuli.

2. Artificial diet 2 (Plain meridic diet) - without the addition of any capsule powder and reduced amount of casein.

3. Natural diet- castor capsule as a control.

The ingredients for the diets were divided into three parts (A, B&C) as shown in Table I. Part A: The ingredients were weighed and kept separately before mixing. Castor young capsule powder was homogenized with 400 ml of water in a blender. The homogeneous mixture was mixed with soybean powder, casein, yeast extract powder and sucrose in a stainless steel pot. The mixture was autoclaved for 30 min at 125^0C. Part B: Agar with 300 ml of distilled water was heated to boiling to dissolve the agar completely. At this point, this part was poured into part A, blended for 3min, and allowed to cool for future use. Part C: The weighed ascorbic acid, Wesson's salt, sorbic acid, multivitamin multimineral capsules, vitamin E, methyl parahydroxy benzoate and streptomycin sulphate were dissolved in 75 ml of distilled water. The solution was added to the mixture of part A and B and blended for 3min. Before the mixture became cold, the diet was poured plastic vials (5 x 4 cm) filling 3/4th the volulme and sealed with plastic cling cap, and the diet was allowed to solidify to room temperature.

Rearing procedure: To compare two formulated artificial diets with the natural diet, 30 neonate larvae obtained from stock culture were transferred into each screw capped plastic vial (5 x 4 cm) using a fine hair brush. The vials were covered with a transparent plastic lid with small holes for ventilation. From the 2nd to 5th generations, the population was solely reared on the artificial diets. Larval survival and development were checked daily. When the larvae reached penultimate stage, the cloth (100 x 75mm) was placed in the diet blocks to provide pupation sites. After pupation, the newly formed pupae were collected from rearing vials, sexed, numbered, weighed and placed in plastic boxes (15 x 6 cm) for adult emergence. Pupal survival, duration and adult emergence were observed daily. Each treatment was replicated five times with a total of 150 larvae per diet treatment per generation.

For each diet treatment, newly emerged adults (1:1; female: male) were paired and released into the ventilated glass cages (60 x 60 x 60 cm) containing castor inflorescence (raceme). The panicle and young capsules were placed in 500 ml conical flask with water to mimic natural ambience and fed with 10 per cent honey solution soaked in cotton swabs/wads, black cloth for mating and oviposition. Eggs deposited on plant parts, cotton swabs and black cloth were collected and counted. Collection of eggs was continued until female in the cage. Adult longevity also was recorded. Eggs were counted under a microscope (Nikon SMZ25, 1x, WD: 60) and placed into the petri dishes (8cm). The number of hatched F_1 larvae was counted daily.

Castor panicle with flowers and young capsules collected from castor field in Dryland Research Station, University of Agricultural Sciences, GKVK, Bengaluru was used as a control diet treatment. Rearing conditions and experimental procedures were the same as that of the artificial diet treatments. The total life cycle mean of four generations were cumulated for statistical analysis.

Statistical analysis: The biological parameters including incubation period, larval development, larval survival (ratio of larvae to pupae), pupal duration, weight and survival rate (ratio of pupae to adult), pre-oviposition duration and egg hatchability over mean four generations were recorded, and compared among the diet treatments using analysis of variance (ANOVA). Significant differences of mean of four generations in different treatments (diets) were tested. All analysis was performed with SPSS 16.0 statistical software. The life table parameters were calculated for each diet using Jack knife analysis; each parameter was compared at 95 per cent confidence interval.

RESULTS AND DISCUSSION

The data on the number of days required to complete each insect stage is presented in Fig. 1. Duration of the larval (16.37 d) and pupal stages (7.12 d) on the artificial diet-1 was shorter than the artificial diet-2 and the natural diet. There was no

TABLE I

Composition of ingredients in the artificial diet used to rear C. punctiferalis

Parts	Ingredient	Artificial diet 1 (Quantity)	Artificial diet 2 Quantity	Functions
A	Soybean powder (Commercially available)	130gm	100 gm	As a main ingredient/carrier
	Castor leaf powder (Locally prepared)	80 gm	-	As a token stimuli to initiate and maintain continuous feeding
	Yeast powder (RM027-500G, HiMedia Lab. Pvt Ltd.)	25gm	25gm	Source of protein and vitamin
	Casein (GRM497-500G, HiMedia Lab. Pvt Ltd.)	20gm	10gm	A protein source which provides amino acids and Carbohydrates for tissues
	Sucrose (GRM134-500G, HiMedia Lab. Pvt Ltd.)	15 gm	15 gm	As a source of sugar
	Distilled water	400ml	400ml	As a solvent for diet ingredients
B	Agar-agar (GRM666-500G, HiMedia Lab. Pvt Ltd.)	15gm	15gm	Solidifying agent
	Distilled water	300ml	300ml	As solvent
C	Ascorbic acid (PCT0207-100G, HiMedia Lab. Pvt Ltd.)	3gm	3gm	Normal growth and development, egg hatching and pupal survives
	Wesson's salt mixture (TS1100, HiMedia Lab. Pvt Ltd.)	1.5gm	1.5gm	As source of salt required to maintain membrane structure and function
	Sorbic acid (FD236-0.200g, HiMedia Lab. Pvt Ltd.)	1gm	1gm	As preservative so that the diet does not deteriorate
	Multivitamin multimineral capsules (BECADEXAMIN, GlaxoSmithKiline. Pvt Ltd.)	2 nos.	2 nos.	SuppliesVitamins
	Methyle parahydroxy benzoate (GRM1291-500G,	2 gm	2 gm	As food and flovor ingredient, stimulant
	Strepomycine sulphate (CMS220-5G, HiMedia Lab. Pvt Ltd.)	0.5gm	0.5gm	As an antibiotic for reducing microbial contamination
	Vit. E capsule USP 400mg (Evion 400, MERCK Ltd.)	2 nos.	2 nos.	As a source of vitamins for reproduction

Values in the table show the quantities in 1000g of artificial diets

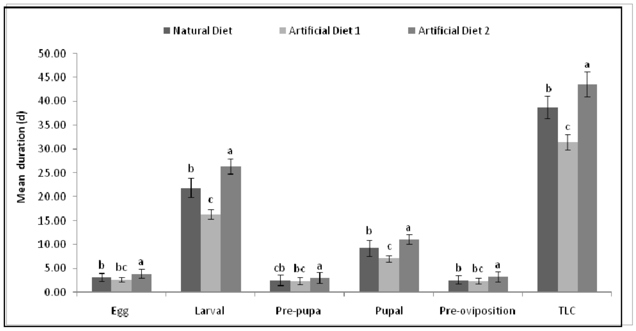


Fig.1: Duration of developmental stages (egg to adult, N=30) of *Conogethes punctiferalis* reared onarticificial diets (1 and 2) and natural host. TLC-total life cycle. Bars represent Means±SE; significant differences among three host plants are indicated by letters over each bar (*P>0.05*, LSD test).

significant difference in pre-oviposition period among the diets. On artificial diet-2, the insect took longest period to complete life cycle (43.56±2.60 d) and it was statistically significant from the duration required to complete the total life cycle on artificial diet-1 and natural diet. Artificial diet-1, wherein castor capsule powder was incorporated as on ingredient, the insect took minimum number of days to complete the life cycle (31.48±1.50 d). In natural diet, the duration required was in between the two artificial diets (38.78±2.34 d). The total life cycle of *C. punctiferalis* reared on artificial diet-1 was shorter than the artificial diet-2 and the natural diet over four generations (Fig. 2). Therefore, for a balanced diet and optimum yield of quality insects. The artificial diet should be inclusive of both essential and non-essential ingredients. Further, the texture and structure of the artificial diet should be attractive, so that the insect feeding on artificial diet has stimulating effect. Li *et al.* (2015) reported that a generation developmental time for *C. punctiferalis* on artificial diet ranged from 42.4 d to 63.3 d.

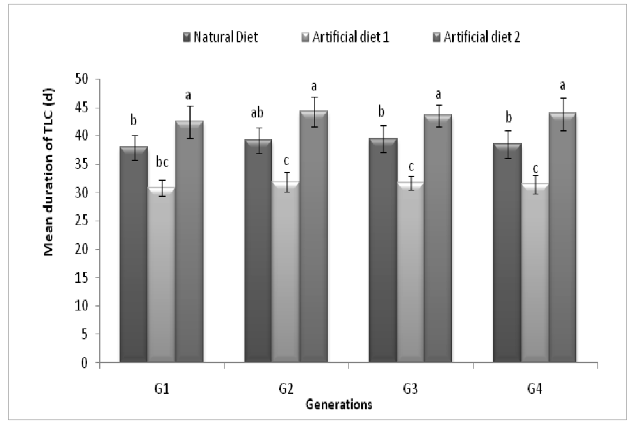


Fig.2: Total life cycle of *C. punctiferalis* reared on three diets *viz.*, artificial diet-1, artificial diet-2 and natural diet over four successive generations. Generations (G1, G2, G3 and 4); Bars represent Means ± SE; significant differences among three diets over four generations were indicated by letters over each bar (P>0.05, LSD test).

Data on quantitative and qualitative parameters of *C. punctiferalis* reared on artificial diets is presented in Table II. Insect fed with artificial diet-1 laid maximum number of eggs (39.02±1.67). This was statistically significant and higher than the number of egg laid by females reared on natural and artificial diet-2. A similar trend in values with respect to pupal weight and adult longevity was observed (Table II).

TABLE II
Pupal weight, adult longevity and fecundity of Conogethes punctiferalis *reared on artificial and natural diets*

Diets	Pupal Weight (mg)		Adult Longevity (d)		Mean** no. eggs per
	Female	Male	Female	Male	Female
Natural Diet	53.27±0.47b	40.72±0.83b	8.23±0.30b	7.03±0.30ab	24.41±0.31b
Artificial Diet 1	61.15±1.05a	49.24±1.03a	8.05±0.42c	6.15±0.29c	39.02±1.67a
Artificial Diet 2	49.42±0.57ab	39.67±0.93b	9.45±0.35a	7.67±0.14a	19.64±0.84ab

Means ± SE (N=15) within a column and followed by the same letter are not significantly different at (*P>0.05*; LSD test); ** mean of 50 females (N-=50).

TABLE III
Viability (%) of eggs, larval and pupal stages of C. punctiferalis *on artificial and natural diets*

Diets	Mean (%) survival		
	Eggs	Larvae	Pupae
Natural diet	79.20±3.85ab (N=35)	84.70±0.50b (N=45)	82.35±1.80a (N=30)
Artificial diet 1	92.45±1.30a (N=35)	95.46±1.85a (N=45)	91.50±2.55a (N=30)
Artificial diet 2	63.75±2.85b (N=35)	72.9±1.87ab (N=45)	69.84±1.30b (N=30)

Means ± SE within a column and followed by the same letter are not significantly different at (*P>0.05*; LSD test).

The pupal weight was higher on the artificial diet-1 compared to all the diets (61.02 mg per female, 49.24 mg per male). Therefore, artificial diet-1 proved superior over natural and artificial diet-2. Accordingly, the artificial diet formulated by Ambanna (2014) for *C. punctiferalis* rearing resulted that minimum pupal weight (0.37 mg) on plain semi-synthetic diet was significantly lower than natural and castor diet. Li *et al.* (2015) reported that mean pupal weights of 73.6 mg for males and 77.3 mg for females and a fecundity rate of 97.9 eggs / female.

Survival rates of eggs, larvae and pupae also were significantly affected by diets. Li *et al.* (2014) observed that the survival and reproduction of *C. punctiferalis*were impacted by the choice of the host plant material incorporated in meridic diets. The viability of the egg stage from females reared on artificial diet-1 (92.45%) was higher than artificial diet-2 (63.75%) and natural diet (79.20%) (Table III). Percentage survival of larvae from egg to pupation and pupae from larvae to adult emergence on Artificial diet-1 proved superior over natural and artificial diet-2 and the data showed statistical significant difference among the three diets offered aid lebitum to *C. punctiferalis* (Table III). Possibly, the high viability values obtained on artificial diet-1 are related to the fact that artificial diet have more quantity and equilibrium of nutrients required for the insect development. Cohen (2004) suggested that relative amounts of components of artificial insect diet impact performance and fitness of insects. Li *et al.* (2015) found that highest concentration of chestnut meal contained diets resulted in enhanced survival rate, shortened developmental duration, increased pupal weight, and increased number of eggs produced by females.

TABLE IV
Fertility life table of C. punctiferalis *from the parameters of moths reared on artificial diets (1&2) and natural diet. Mean generation time (T), net reproductive rate (R_0) and intrinsic rate of increase (r_m)*

Diets	Parameters		
	T^1(d)	R_o^1	r_m^1
Natural diet	38.75 8b	145.2b	0. 067
Artificial diet 1	30.90 c	210.8c	0.071
Artificial diet 2	44.65 a	95.45a	0.034

[1] parameters (N=4)followed by the same letter do not differ by the Jaccknife test

Generation time (T) for artificial diet-1 was shorter than that with natural diet and artificial diet-2 (Table IV). These biological parameters produced a net reproductive rate (*Ro*) (The rate of population increased in each generations) of 145.2, 210.8 and 95.45 on the natural, artificial diet-1and artificial diet-2, respectively. The r_m value is an indicator of fitness, with a higher value indicating a higher level of fitness. The r_m value for *C. punctiferlis* larvae fed on the artificial diet-1 (0. 071) was higher than natural diet (0.067) and artificial diet-2 (0.034). Li *et al.* (2015) reported that the r_m value of 0.074 for the cohort fed on artificial diet indicating a higher level of fitness than the cohort fed on fresh corn and other diets.

In summary, the development of a successive rearing method using an artificial diet for *C. punctiferalis* under laboratory or other artificial conditions was successful. We believe that castor capsule powder and less aomunt of casein were key components for the succes of this diet in enhancing *C. punctiferalis* performance. This artificial diet also has the following favorable characters. The diet is economical for rearing of *C. punctiferalis*; most materials used are common foodstuff and chemicals that are easily accessible; It making procedure is simple and easy to follow. The cost of Rs. 70-80/- for 1,000g of diet is enough to rear 150 larvae to pupae. This diet possesses favourable properties for the successive rearing. Larvae feeding on it exhibited superior performance in multiple life-history traits during four continuous generations of rearing. The diet is efficient to use. The whole process is convenient, time-efficient, and requires less labour than the conventional rearing.

REFERENCES

AMBANNA, P., 2014, Development of a rearing protocols for *Conogethes punctiferalis* Guenee (Lepidoptera : Crambidae). *M.Sc. (Agri.) Thesis* (Unpub.), Univ. Agril. Sci., Bengaluru.

CAB INTERNATIONAL, 2011, *Conogethes punctiferalis* datasheet. *In Crop Protection Compendium.* CAB International, Wallingford, UK.

COHEN, A. C., 2004, Insect Diets: Science and Technology. *CRC Press, Boca Raton, FL*, p. 312.

GANESHA, 2012, Studies on biology of castor shoot and capsule borer, *Conogethes punctiferalis* (Lepidoptera : Pyralidae) and their management. *M.Sc. (Agri.)Thesis* (Unpub.), Univ. Agril. Sci., Bengaluru.

GUPTA, G. P., RANI, S. AND BIRAH, A., 2005, Mass rearing of the spotted bollworm, *Eariasvitella* (Lepidoptera : Noctuidae) on an artificial diet. *Int. J. Trop. Insect Sci.,* **25:** 134–137.

HAN, L., LI, S., LIU, P., PENG, Y. AND HOU, M., 2012, New artificial diet for continuous rearing of *Chilo suppressalis* (Crambidae : Lepidoptera). *Ann. Entomol. Soc. Am.,* **105**(2): 253-258.

HONDA, H., KANEKO, J., KONNO, Y. AND MATSUMOTO, Y., 1979, A simple mass rearing method of the yellow peach moth, *Dichocrocis punctiferalis* Guenee, (Crambidae : Lepidoptera) on an artificial diet. *Appl. Entomol. Zool.,* **14**(4): 464-468.

LI, D. Y., AI, P. P., LANG, L. X., ZHANG, M. M. AND SUN, S. L., 2015, Development of an Artificial Diet for Rearing *Conogethes punctiferalis* (Lepidoptera : Crambidae). *J. Entomologi. Sci.,* **50**(2) : 89-98.

LU, J. Q., WANG, Z. Y., HE, K. L. AND LIU, Y., 2010, Research history, progresses and prospect on the yellow peach moth, *Conogethes punctiferalis* (Guenée) (Crambidae : Lepidoptera). *Plant Protection*, **36** : 31-38 (in Chinese).

VANDERZANT, E. S., FORT, S. W. AND RICHARDSON, C. D., 1962, Rearing of bollworm on artificial diet. *J. Econ. Entomol.* **,55 :** 140–148.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 250-258, 2017

Population Dynamics of Thrips *Scirtothrips dorsalis* Hood as Influenced by Staggered Planting of Chilli under Bengaluru Conditions

K. L. Manjunatha and N. Srinivasa
Department of Agricultural Entomology, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail : nagappasrinivas@yahoo.com

Abstract

Population dynamics of thrips, *Scirtothrips dorsalis* Hood as influenced by staggered planting of chilli crop under Bengaluru conditions (IIHR, Hessaraghatta) was studied during kharif and rabi seasons of 2015-16 and 2016-17. During kharif season of 2015-16, peak population of thrips over different plantings was 11.93-28.87 thrips / plant when the crop age was between 74 and 103 days, coincided with IInd FN of October. Also a second peak (6.6 - 12 thrips / plant) on kharif crop was during mid - December, when the crop age was 132-160 days. During 2016-17 thrips incidence was relatively low (1.4 - 4.33) during mid-October and modest (3.93-8.33) during early December (crop aged 168 - 200 days). On rabi crop of 2015-16, a more evident peak (26.33-76.20 thrips) was during Ist FN of March when the crop age was 104-136 days, but the peak activity of thrips was observed from entire February to beginning of March during 2016-17 rabi season (36-46.13 thrips / plant, the crop aged 85-108 days). Multiple linear regression analysis indicated positive impact of maximum temperature, bright sunshine hours and evaporation, negative effect of rainfall and wind speed on the abundance of thrips, which accounted for 50-79 per cent variation in the activity of thrips attributed to weather factors. With reference to age of the crop / crop phenology, thrips activity started at the early stage, reached peak by middle age with one to two distinct peaks and declined further as the crop attained maturity. This crop age-related population buildup pattern of *S. dorsalis* was more or less similar irrespective of the planting time and the cropping season.

Keywords : Chilli, population dynamics, thrips and staggered planting

Chilli (*Capsicum annuum* L.) is one of the important spice cum vegetable crops grown for domestic market as well as export purpose. In India, Karnataka occupies a prime place in chilli cultivation and enjoys (I and II) position in crop area coverage (25.75%) and production (29%), respectively (Anon, 2014-15). About 25 insects have been recorded infesting chilli leaves and fruits, of which, thrips, *S. dorsalis* is considered as the most serious and important pest (Butani, 1976). Amin (1979) described the symptoms of chilli leaf curl malady caused by feeding injury of thrips, while, Dadasaheb (2013) estimated loss in the yield of green chilli due to thrips to range from 74 to 75 per cent. The variability in thrips populations on crops is determined by the natural growth of the population and the influence of weather on thrips activity and their multiplication rate (Kirk, 1997). An understanding of the factors that influences such population changes is essential in predicting the population of thrips. Weather variables including rainfall, temperature, relative humidity and wind speed have been reported as important factors that significantly affect thrips numbers (Ananthakrishnan, 1993: Kirk, 1997). A basic understanding of the relationship of weather factors with thrips population is important in developing an integrated management strategy for thrips on chilli crop and in planning suitable control measures under a given set of climatic conditions. The prime objective of the present study was to determine the population fluctuation pattern of thrips on staggered planted chilli crop and to investigate on the association of population density of thrips with weather parameters, natural enemies abundance and phenology of the crop. The data generated as well would be useful for predicting chilli thrips outbreaks under varied climatic conditions and to evolve suitable control / management strategies.

Material and Methods

To study the population dynamics of the thrips, *S. dorsalis* under field conditions, the chilli cultivar, Arka Meghana was grown in 0.2 ha area with a spacing of 60×30cm with staggered planting at fortnightly interval during May-June months in kharif and during October-November months in rabi season. The study was carried out in the Vegetable block of Indian Institute of Horticultural Research, Hessaraghatta, Bengaluru during kharif and rabi seasons of 2015-16 and 2016-17. Recommended agronomic practices except plant protection measures were followed for raising the crop. The whole experimental plot was divided into 3 equal quadrats considering them as replications. Population of thrips was recorded at weekly interval from five randomly selected plants in each quadrate by tapping the growing tip of the plant on a white acrylic sheet. Observations were recorded as soon as the thrips appeared / noticed to be fairly active and continued up to final picking / harvest of chilli fruits. The data recorded were expressed as average number of thrips / 3 tappings / plant. To determine the effect of various weather parameters on fluctuation of *S.dorsalis* on chilli crop, weather data of meteorological laboratory in the IIHR farm were made used. Weather data including natural enemies abundance and crop age (as independent variables) and thrips population data (dependent variable) were subjected to Correlation and Multiple Regression Analysis to determine the influence of these factors on the activity of thrips during the cropping period in different seasons.

Results and Discussion

Scirtothrips dorsalis population data as influenced by planting date (&crop age) during rainy season/ kharif of 2015-16 and 2016-17 are presented in Table 1-4.

Kharif season 2015-16 (planting July-August 2015)

Occurrence of *S.dorsalis* on chilli crop was observed from 3rd week of September (*i.e.,* 38th std. week) and continued for the entire crop period. Thrips population was low (1.07, 0.33 and 0.13 thrips/plant) on I, II and III plantings, which corresponded to 75, 65 and 55 days age of the crop, respectively. Thrips number gradually increased and reached peak 21.53, 23.27, 28.87 and 11.93 thrips/plant) corresponding with planting and crop age (I,II, III and IV plantings, 103, 93, 83 and 74 days old crop) by 3rd week of October (42ndstd.week). Further, the population showed a declining trend till 1st week of November. Subsequent peak of 17.6 thrips /plant was evident on 131 days old crop of the I planting by second week of November, but on other plantings, thrips population was found till 1st week of December. Another simultaneous population peak was observed on all plantings (11.47, 12.00, 11.53 and 6.6 thrips / plant corresponding with 159, 149, 139 and 133 days age of chilli crop) during second week of December (50th std. week). As the crop matured with final harvest of chilli fruits, thrips population recorded a declining trend (Table I).

With respect to the age of the crop the thrips population was initially low (1.07, 0.33, 0.13 and 0.13 thrips / plant) on I, II, III and IV plantings (55 to 75 days old early stage crop,) and showed peak21.53, 23.27, 28.87 and 11.93 thrips / plant, on 103 to 74 days old mid stage crop,and decreased to (4.53, 6.80, 4.53 and 2.93 thrips / plant on 187 to 161 days late stage crop nearing maturity stage (Fig.1). The occurrence of thrips on first planting is late (75 days after planting) compared to other plantings (60 to 65 days after planting)and the lowest incidence (0.13-11.93 thrips/ plant) was observed on the fourth crop planted during first week of August (31st std. week) compared to other plantings (up to 29 thrips/plant).

Kharif season 2016-17 (planting May-June)

During kharif 2016-17 (May-June planting) the population of thrips on first planting showed build-up from early stage and reached peak (5.73 thrips / plant) during 4th week of July, the population decreased by the 3rd week of October, then observed increasing by 4th week of October. The population increased to (6 thrips / plant) during last week of November and recorded modest population till the maturity of the crop with I, II, III, IV and V plantings, the incidence remained low till the late stage of the crop, that reached peak inch before the crop maturity (8.33, 3.93, 8.47 and 12.73 thrips / plant) by 48, 47, 50 and 50 standard weeks, which corresponds to 189, 168 days crop age, during second and first fortnights of November and December. The population was usually low during early

TABLE I

Population of thrips, S. dorsalis *on staggered planting of chilli during kharif season 2015-16*

Recording of observation (std. week)	Number of thrips*			
	Planting-1 (crop age)	Planting-2 (crop age)	Planting-3 (crop age	Planting-4 (crop age)
23/09/15 (38)	1.07 (75)	0.33(65)	0.13 (55)	-
1/10/15 (39)	5.00(82)	1.27(72)	0.20(62)	-
9/10/15 (40)	4.33(89)	2.67(79)	0.53(69)	0.13(60)
14/10/15 (41)	11.47(96)	12.33(86)	10.60(76)	4.20(67)
20/10/15 (42)	21.53(103)	23.27(93)	28.87(83)	11.93(74)
27/10/15 (43)	18.13(110)	18.07(100)	17.27(90)	9.27(81)
04/11/15 (44)	12.93(117)	15.33(107)	10.27(97)	7.20(88)
14/11/15 (46)	17.60(131)	14.00(121)	12.27(111)	5.93(95)
21/11/15 (47)	2.93(138)	2.73(128)	3.33(118)	1.73(102)
26/11/15 (48)	3.27(145)	3.53(135)	3.80(125)	1.93(119)
06/12/15 (49)	6.73(152)	6.87(142)	5.20(132)	3.00(126)
15/12/15 (50)	11.47(159)	12.00(149)	11.53(139)	6.60(133)
21/12/15 (51)	4.33(166)	5.87(156)	7.20(146)	3.20(140)
29/12/15 (52)	8.33(173)	7.73(163)	7.87(153)	3.87(147)
08/01/16 (2)	7.13(180)	6.27(170)	5.67(1160)	4.60(154)
21/01/16 (3)	4.53(187)	6.80(177)	4.53(167)	2.93(161)

** mean of 3 tappings of young shoots/plant*

and mid-stage of the crop, increased as the crop advanced and remained active till the crop end. The occurrence of the thrips across different plantings also followed the same pattern. The activity observed early on first planting compared to subsequent plantings (Table II and Fig.1).

Rabi 2015-16 (planting October-November 2015)

The thrips population data as influenced by planting date (&crop age) during rabi season of 2015-16 are presented in Table III. Thrips incidence was relatively late compared to kharif crop, but modest, 5.73, 4.67 and 4.47 thrips/plant on I, II and III plantings corresponding with 108, 98 and 92 days old crop. The population gradually increased and reached peak (39.27 76.20, 51.87 and 26.33 in I, II, III and IV plantings when the crop age was 136, 126, 120 and 104 days, respectively by second week of March (10[th] std. week). The thrips activity gradually decreased towards maturity. The thrips population observed more

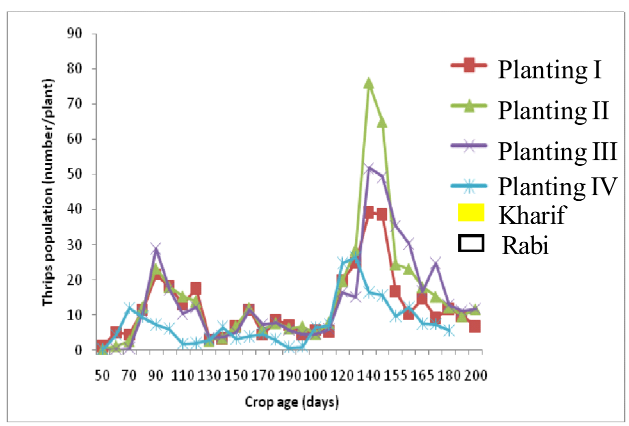


Fig. 1: Influence of crop age on chilli thrips population during 2015-16

TABLE II

Population of thrips, S. dorsalis *on staggered planting of chilli during kharif season 2016-17*

Recording of observation (std. week)	Number of thrips*				
	Planting-I (crop age)	Planting-II (crop age)	Planting-III (crop age	Planting-IV (crop age)	Planting-V (crop age)
13/07/16 (28)	0.47(61)	0.80(49)	0.60(35)	-	-
20/07/16 (29)	3.47(68)	1.73(56)	0.47(42)	-	-
27/07/16 (30)	5.73(75)	3.00(63)	0.47(49)	-	-
03/08/16 (31)	0.73(82)	0.27(70)	0.07(56)	-	-
10/08/16 (32)	3.60(89)	1.60(77)	0.87(63)	0.07(54)	-
17/08/16 (33)	1.53(96)	2.20(84)	0.73(70)	0.53(61)	0.20(52)
23/08/16 (34)	1.20(103)	0.93(91)	0.73(77)	0.87(68)	0.13(59)
31/08/16 (35)	1.60(110)	1.27(98)	0.33(84)	1.60(75)	1.73(66)
06/09/16 (36)	0.33(117)	0.33(105)	1.33(91)	1.07(82)	0.13(73)
14/09/16 (37)	0.93(124)	0.67(112)	0.47(98)	1.53(89)	1.07(80)
21/09/16 (38)	0.33(131)	0.47(119)	0.40(105)	0.40(96)	0.53(87)
28/09/16 (39)	0.67(138)	0.27(126)	0.27(112)	2.07(103)	1.47(94)
05/10/16 (40)	0.53(145)	0.60(133)	0.73(119)	0.67(110)	1.13(101)
13/10/16 (41)	0.27(152)	0.33(140)	0.67(126)	1.73(117)	0.60(108)
19/10/16 (42)	2.13(159)	2.07(147)	2.27(133)	0.87(124)	2.13(115)
26/10/16 (43)	4.33(166)	3.20(154)	3.07(140)	4.27(131)	1.40(122)
02/11/16 (44)	2.80(173)	1.40(161)	0.93(147)	0.60(138)	0.47(129)
09/11/16 (45)	2.67(180)	2.60(168)	2.47(154)	1.93(145)	2.13(136)
19/11/16 (46)	2.27(187)	6.33(175)	2.00(161)	5.53(152)	2.60(143)
24/11/16 (47)	2.53(194)	7.27(182)	3.93(168)	3.87(160)	2.60(150)
30/11/16 (48)	6.00(201)	8.33(189)	3.40(175)	2.07(167)	4.13(157)
06/12/16 (49)	5.73(208)	2.40(196)	-	5.60(174)	6.00(164)
14/12/16 (50)	3.87(215)	3.60(203)	-	8.47(181)	12.73(171)
21/12/16 (51)	-	-	-	7.87(188)	8.73(178)

* *mean of 3 tappings of young shoots/plant*

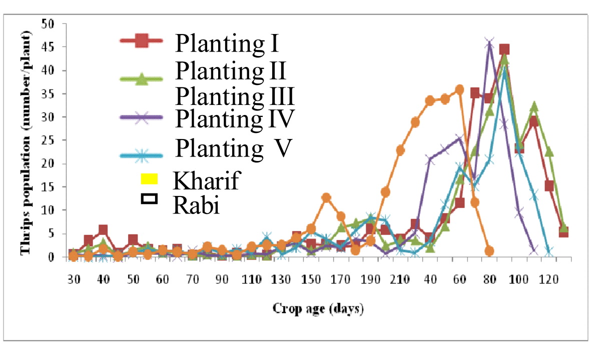


Fig. 2: Influence of crop age on chilli thrips population during 2016-17

on I, II and III plantings (5.73-39.27, 4.67-76.20 and 4.47 to 51.87 thrips / plant, respectively) compared to IV planting planted during last week of November (0.80-26.33 thrips / plant).

Rabi 2016-17(planting October –November 2016)

Thrips population during rabi 2016-17 increased gradually from the early stage of the crop and the peak population of 44.53, 42.53, 46.13, 39.80 and 36 thrips / plant was observed from 6-9 standard weeks (February 2017) on 85-108 days crop, was gradually

TABLE III

Population of thrips, S. dorsalis *on staggered planting of chilli during rabi season 2015-16*

Recording of observation (std. week)	Number of thrips*			
	Planting-I (crop age)	Planting-II (crop age)	Planting-III (crop age	Planting-IV (crop age)
10/02/16 (6)	5.73 (108)	4.67 (98)	4.47 (92)	0.80 (76)
17/02/16 (7)	5.27 (115)	7.87 (105)	5.93 (99)	1.07 (83)
23/02/16 (8)	19.87 (122)	19.73 (112)	16.53 (106)	6.40 (90)
03/03/16 (9)	24.87 (129)	28.60 (119)	15.13 (113)	7.13 (97)
11/03/16 (10)	39.27 (136)	76.20 (126)	51.87 (120)	24.67 (104)
18/03/16 (11)	38.73 (143)	65.07 (133)	49.27 (127)	26.33 (111)
25/03/16 (12)	16.73 (150)	24.53 (140)	35.40 (134)	16.33 (118)
30/03/16 (13)	10.27 (157)	23.20 (147)	30.27 (141)	15.47 (125)
05/04/16 (14)	14.73 (164)	18.00 (154)	16.73 (148)	9.60 (132)
15/04/16 (15)	9.20 (171)	15.27 (161)	24.73 (155)	12.13 (139)
23/04/16 (16)	11.73 (178)	12.20 (168)	12.80 (162)	7.47 (146)
28/04/16 (17)	9.80 (185)	9.73 (175)	11.13 (169)	7.27 (153)
06/05/16 (8)	6.60 (192)	11.73 (182)	11.73 (176)	5.53 (160)

** mean of 3 tappings of young shoots / plant*

TABLE IV

Population of thrips, S. dorsalis *on staggered planting of chilli during rabi season 2016-17*

Recording of observation (std. week)	Number of thrips*				
	Planting-I (crop age)	Planting-II (crop age)	Planting-III (crop age	Planting-IV (crop age)	Planting-V (crop age)
28/12/16 (52)	7.00(66)	3.53(55)	-	-	-
06/01/17 (1)	4.07(73)	2.00(62)	0.80(54)	1.40(40)	-
11/01/17 (2)	8.27(80)	6.60(69)	2.40(61)	1.00(47)	1.47(36)
19/01/17 (3)	11.60(87)	16.73(76)	5.20(68)	3.40(54)	3.47(43)
25/01/17 (4)	35.13(94)	22.80(83)	21.00(75)	11.27(61)	13.93(50)
01/02/17 (5)	33.93(101)	31.40(90)	23.13(82)	19.20(68)	22.93(57)
08/02/17 (6)	44.53(108)	42.53(97)	25.47(89)	15.20(75)	29.00(64)
15/02/17 (7)	23.33(115)	24.33(104)	16.80(96)	21.00(82)	33.60(71)
22/02/17 (8)	29.13(122)	32.33(111)	46.13(103)	39.80(89)	33.93(78)
01/03/17 (9)	15.20(129)	22.67(118)	28.60(110)	22.60(96)	36.00(85)
08/03/17 (10)	5.20(136)	6.33(125)	9.60(117)	13.40(103)	11.73(92)
15/03/17 (11)	0.53(143)	0.87(132)	1.53(124)	1.07(110)	1.27(99)

* mean of 3 tappings of young shoots / plant

decreased. Thrips incidence ranged from 0.53-44.53, 0.87-42.53, 0.80-46.13, 1.07-39.80 and 1.27-36 thrips / plant on I, II, III, IV and V plantings, respectively. As observed and recorded in other seasons, the thrips population build up from early stage of the crop, reached peak on middle aged crop and declined at crop maturity. This population buildup trend was more or less similar or uniform with all the plantings (Table IV and Fig. 2).

Influence of abiotic and biotic factors on the abundance of chilli thrips

Incidence of *S. dorsalis versus* abiotic (weather parameters) and biotic (natural enemies and crop age) over different plantings during 2015-16 revealed significant positive association of minimum temperature (0.19**), afternoon relative humidity (0.11**), evaporation (0.33**), wind speed (0.14*), sunshine hours (0.24**) and natural enemies (coccinellids, spiders *etc.)* (0.10**), while rainfall (-0.21**) exhibited negative significant association with thrips population with I planting. In the II planting, the thrips population was positively correlated with maximum temperature (0.41*), evaporation (0.41*) and natural enemies (0.70**). Significant positive correlation for thrips population in III and IV plantings were, maximum temperature (0.53*; 0.57*), minimum temperature (0.38**; 0.47*), evaporation (0.50**; 0.50*) and natural enemies (0.7**; 0.76*).

Multiple linear regression analysis indicated that thrips population increased by 5.21 units, 4.81units and decreased by 0.18 units with maximum temperature, minimum temperature and crop age, respectively with I planting. With II planting, the population decreased by 7.04 and 29.03 units with wind speed and crop age, respectively. The population decreased by 7.34 and 3.88 units with wind speed with III and IV plantings, respectively (Table V).

TABLE V

Correlation and regression analysis of thrips population with abiotic (weather factors) and biotic factors (natural enemies and age of the crop - phenology) during 2015-16

Variables	Correlation (Linear)				Multiple Linear Regression			
	P I	P II	P III	P IV	P I	P II	P III	P IV
X_1	0.34	0.41*	0.53*	0.57**	5.21*	4.44	5.47	0.93
X_2	0.19**	0.22	0.38**	0.47*	4.81**	-3.15	-2.86	0.54
X_3	0.02	-0.11	-0.15	-0.09	0.61	1.22	0.71	0.41
X_4	0.11**	-0.02	0.04	0.04	0.39	0.35	0.05	-0.17
X_5	0.33**	0.41*	0.50**	0.50**	-0.80	1.14	-1.60	-0.51
X_6	0.14**	0.08	0.05	0.22	-2.90	-7.04*	-7.34*	-3.88*
X_7	-0.21**	-0.22	-0.27	0.33	-0.14	-0.13	-0.12	-0.04
X_8	0.24**	0.22	0.23	0.09	1.57	0.50	0.10	0.10
X_9	0.10**	0.70**	0.70**	0.76**	7.38	29.03**	20.81	13.09**
X_{10}	-0.04	0.05	0.16	0.04	-0.18*	-0.12	-0.12	0.01

**Significant at 1 per cent; *Significant at 5 per cent; P-Planting

X_1- Max. Temp.; X_2-Min. Temp.;X_3- RH (Morning); X_4- RH (Afternoon); X_5- Evaporation; X_6- Wind speed; X_7-Rainfall; X_8- Sunshine hours; X_9- Natural enemies; X_{10}- Crop age.

Multiple regression analysis of thrips population during 2015-16 as follows:

1. Y (Thrips I planting) =-96.32+5.21*X_1-4.81**X_2+0.61X_3+0.39X_4-0.80X_5-2.90X_6-0.14X_7+1.57X_8 +7.38X_9-0.18*X_{10}; R^2=0.63
2. Y (Thrips II planting) =-153+4.44X_1-3.15X_2+1.22X_3+0.35X_4+1.14X_5-7.04*X_6-.13$X_7$0.50X_8 +29.03X**$_9$-0.12X_{10}; R2=0.77
3. Y (Thrips III planting) =-121+5.47X_1-2.86X_2+0.71X_3+0.05X_4-1.60X_5-7.34*X_6-0.12X_7+0.10X_8 -20.81X_9-0.12X_{10}; R2=0.71
4. Y (Thrips IV planting)=-48.49+0.93X_1+0.54X_2+0.41X_3-0.17X_4-0.51X_5-3.88*X_6-0.04X_7+0.10X_8+13.09**X_9-0.10X_{10}; R2=0.79

During 2016-17, the correlation between thrips population and biotic and abiotic factors revealed that morning RH (-0.48** and -0.52**), afternoon RH (-0.43* each), wind speed (-0.41* each) and natural enemies (-0.45** and -0.36*) showed significant negative correlation, whereas, evaporation (0.42* and 0.47**) and sunshine hours (0.42* and 0.44**) had significant positive influence on thrips activity in I and II plantings, respectively. In III and IV plantings, the minimum temperature (-0.42** and -0.41*) was negatively correlated, while evaporation (0.46** and 0.46**) and sunshine hours (0.42* and 0.38*) were significantly positively correlated, respectively. The minimum temperature (-0.54**) and morning RH (-0.38*) showed significant negative correlation, whereas evaporation (0.47**) showed significant positive correlation in V planting. With regression analysis it was evident that afternoon RH helped the buildup of thrips population, while minimum temperature adversely affected build-up of thrips at all plantings (Table VI).

The overall influence of different weather factors as well as natural enemies abundance and crop age on the population of thrips is indicated by multiple linear regression equations (Table V and VI). The factors studied accounted for higher impact of 63 -79 per cent on the activity of thrips over different plantings during 2015-16, but the effect of these factors was although statistically significant, the extent of variation explained by these factors on the activity of thrips during 2016-17 was relatively low, 50-64 per cent. This evidently showed the greater influence of weather factors on thrips abundance being more apparent in 2015-16 and the plantings during the year were spread over July- August period compared to May- June period in 2016-17.

Table VI

Correlation and Regression analysis of thrips population with abiotic (weather factors) and biotic factors (natural enemies and age of the crop / phenology) during 2016-17

Variables	Correlation (Linear)					Multiple Linear Regression				
	P I	P II	P III	P IV	P V	PI	P II	P III	P IV	P V
X_1	0.06	0.13	0.33	0.37*	0.35	-0.66	0.93	1.42	1.03	1.83
X2	0.68**	0.63**	-0.45**	-0.41*	-0.54**	-4.06	-3.91*	-5.16**	-2.49*	-4.30**
X_3	-0.48**	-0.52**	-0.30	-0.30	-0.38*	-0.21	-0.77	-0.23	-0.27	-0.81
X_4	-0.43*	-0.43*	-0.22	-0.22	-0.30	0.76*	0.84*	0.95*	0.59*	0.89*
X_5	0.42*	0.47**	0.46**	0.46**	0.47**	4.66	0.88	2.20	2.10	1.32
X_6	-0.41*	-0.41*	-0.27	-0.25	-0.29	-0.84	-0.34	0.91	-0.20	1.06
X_7	-0.19	-0.21	-0.19	-0.18	-0.18	-0.01	-0.02	0.00	-0.02	-0.09
X_8	0.42*	0.44**	0.42*	0.38*	0.31	0.28	0.45	0.56	0.44	-0.68
X_9	-0.45**	-0.36*	-0.21	-0.18	-0.12	-2.91	1.82	2.53	-2.46	2.43
X_{10}	-0.20	-0.11	0.07	-0.01	-0.20	-0.04	-0.03	0.09	0.04	0.00

**Significant at 1 per cent, *Significant at 5 per cent, P-Planting

X_1- Max. Temp.; X_2-Min. Temp.; X_3- RH (Morning); X_4- RH (Afternoon); X_5- Evaporation; X_6- Wind speed; X_7- Rainfall; X_8- Sunshine hours; X_9- Natural enemies; X_{10}- Crop age.

Multiple regression analysis of thrips population during 2016-17 as follows:

1. Y (Thrips I planting)=74.24-0.66X_1-4.06**X_2 0.21X_3+0.76*X_4+4.66X_5-0.84X_6-0.01X_7+0.28X_8 -2.91X_9-0.04X_{10}; R^2=0.64
2. Y (Thrips II planting)=71.59+0.93X_1-3.91**$X_2$0.77X_3+0.84X*$_4$+0.88X_5-0.34X_6-0.02X_{7+}0.45X_8 +1.82X_9-0.03X_{10}; R^2=0.60
3. Y (Thrips III planting)=-14.43+1.42$X_1$5.16**X_2+0.23X_3+0.95*X_4+2.20X_5+0.91X_6-0.00X_7+0.56X_8 +2.53X_9+0.09X_{10}; R^2=0.56
4. Y (Thrips IV planting)= +4.57+1.03X_1-2.49*X_2-0.27X_3+0.59*X_4+2.10X_5-0.20X_6-0.02X_7+0.44X_8 -2.46X_{9+}0.04X_{10}; R^2=0.50
5. Y (Thrips V planting)=+53.42+1.83X_1-4.30**X_2-0.81X_3+0.89*X_4+1.32X_5+1.06X_6-0.09X_7-0.68X_8+2.43X_{9+}0.00X_{10}; R^2=0.60)

Seasonal activity of chilli thrips under Bengaluru conditions as studied over staggered planting during July- August (kharif season of 2015-16) indicated the gradual buildup of the pest from 60 days age of the crop registering a peak by II FN of October (11.93-28.87 thrips / plant), when the crop was between 74 and 103 days age. A second peak (6.6-12 thrips) across different plantings was during mid-December. In 2016-17, plantings in May-June period also recorded an early distinct peak by last week of July (3-5.73 thrips), when the crop was 60-75 days old. However, further buildup could record a more distinct peak between last week of November and first week of December (3.93-8.33 thrips). Similar peak incidence of chilli thrips on kharif / rainy season crops were observed during October in Parbhani area of Maharashtra (Bhede *et al.,* 2008), during November-December period in Anand region of Gujarat (Barot *et al.,* 2012) and in Guntur of Andhra Pradesh (Pathipati *et al.,* 2014). The peak incidence of thrips during September on kharif crop has been reported by Meena *et al.* (2013) from Udaipur of Rajastan and this variation in the present Bengaluru study is attributed to locational difference.

Rabi crops planted during October-November under Bengaluru conditions in the present study experienced peak population of thrips from the beginning of February to middle of March and this was the only distinct peak observed on rabi season crops. The peak thrips incidences have been reported by Patel *et al.* (2009) and Barot *et al.* (2012) in Anand of Gujarat during February-March period, which corresponds to the present report of distinct peak during February- March in the rabi season.

The overall influence of different weather parameters on the activity of thrips in the present study during 2015-17 period indicated positive influence of maximum temperature, bright sunshine hours and evaporation and negative influence of RH, rainfall and wind speed being more evident (Table V and VI). Reports of maximum atmospheric temperature favoring the buildup of thrips on chilli crops in Anand region of Gujarat (Patel *et al.,* 2009; Barot *et al.,* 2012), Pune area of Maharashtra (Misal *et al.,* 2016), Udaipur region of Rajastan (Meena *et al.,* 2013) and Guntur of Andhra Pradesh (Pathipati *et al.,*2014) supported the finding of the present study. So also the negative influence of total rainfall as well as morning and afternoon relative humidities.

Bright sunshine period during chilli cropping period significantly influenced the build-up of thrips in the entire period of present study, as observed by Barot *et al.* (2012) and Patel *et al.* (2009) in Gujarat and by Bhede *et al.* (2008) and Misal *et al.* (2016) in Maharashtra. Positive influence of minimum temperature in the present study did not agree with the adverse effect on thrips buildup in Guntur area of Andhra Pradesh (Pathipati *et al.,* 2014) and Anand region of Gujarat (Barot *et al.,* 2012).

A critical analysis of data relevant to dynamics of thrips buildup and associated infestation level over two years period (2015-17) revealed the severity of thrips damage on chilli crop during the rabi season, particularly during Feb.-March period under Bengaluru conditions. This is so as the number of thrips exceeded the apparent economic threshold level of 1 thrips / leaf reported by Patel *et al.* (2009) under Gujarat conditions. The corresponding rabi peaks (Feb.-March) in the present study were reasonably high (more than the ETL, *i.e.,* 24.67 to 76.20 thrips / tapping of young shoots with at least 12 to 18 leaves - Std. week 10 in 2016; 15.20 to 44.53 thrips - Std. week 6 in 2017). This also necessitated our intervention for immediate control of thrips during this period of Feb.-March.

The present study generated data on the population fluctuation of thrips, *S. dorsalis* on staggered planting of chilli crop and the influence of ambient weather conditions on their build-up and activity. The chilli crop is being grown almost throughout the year but with varied planting time, the probable incidence of this major pest need to be addressed with appropriate management strategies, particularly on the middle aged crop more severely damaged coinciding with Nov.-Dec. (during kharif / rainy season) and Feb.-Mar. (during rabi).

References

AMIN, P. W., 1979, Leaf curl disease of chilli peppers in Maharashtra, India. *PANS*, **25** : 131-134.

ANANTHAKRISHNAN, T. N., 1993, Bionomics of thrips. *Ann. Rev. Entomol.*, **38** : 71-92.

ANONYMOUS, 2014-15, Revealing Agriculture in India, statistically an associate website of *indiastat.com.*

BAROT, B. V., PATEL, J. J. AND SHAIKH, A. A., 2012, Population dynamics of chilli thrips, *Scirtothrips dorsalis* Hood in relation to weather parameters. *AGRES – An International e-Journal,* **4**:480-485.

BHEDE, B. V., SURYAWANSHI, D. S. AND MORE, D. G., 2008, Population dynamics and bio efficacy of newer insecticide against chilli thrips, *Scirtothrips dorsalis* (Hood). *Ind. J. Ent.,* **70**(3) : 223-226.

BUTANI, D. K., 1976, Pests and diseases of chillies and their control. *Pesticides*, **10**:38-41.

DADASAHEB, S. T., 2013, Population dynamics, yield losses and management of thrips, *Scirtothrips dorsalis* Hood infesting chilli. *M. Sc. (Agri.) Thesis,* Department of Entomology, College of Agriculture, Junagadh Agricultural University.

KIRK, W. D., 1997, Distribution, abundance and population dynamics. *Thrips as Crop Pests*. *CABI,* UK., p. 217-258.

MISAL, S. S., SHAIKH, A. A. AND KHARBADEC, S. B., 2016, Correlations betweenWeather Parameters and Pests in Organic Green Chilli (*Capsicum annuum* L.). *Adv. Life Sci.,* **5**(1) 164-166.

MEENA, R. S., AMETA, O. P. AND MEENA B. L., 2013, Population dynamics of sucking pests and their correlation with weather parameters in chilli, *Capsicum annuum*. *The Bioscan,* **8**(1): 177-180.

PATEL, B. H., KOSHIY, D. J. AND KORAT, D. M., 2009, Population dynamics of chilli thrips, *Scirtothrips dorsalis* Hood in relation to weather parameters. *Karnataka J. Agric. Sci.,* **22**(1): 108-110.

PATEL, B. H., KOSHIYA, D. J., KORAT, D. M. AND VAISHNAV, P. R., 2009, Evaluation of some insecticides against chilli thrips *Scirtothrips dorsalis* Hood. *Karnataka J. Agric. Sci*., **22**(2): 327-330.

PATHIPATI, V. L., VIJAYALAKSHMI, T. AND NAIDU, L. N., 2014, Seasonal incidence of major insect pests of chilli in relation to weather parameters in Andhra Pradesh. *Pest Management in Horticultural Ecosystems*, **20**(1) :36-40.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 259-264, 2017

Abundance of Mesofauna in Guava *Psidium guajava* L. Ecosystem

NGUYEN THI KIM THOA AND N. G. KUMAR
Department of Agricultural Entomology, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail : ngkumar55@yahoo.co.in

ABSTRACT

The investigations on abundance of mesofauna in guava *Psidium guajava* L. ecosystem was carried out at Gandhi Krishi Vignana Kendra, University of Agricultural Scienses, Bengaluru. The samples (litter and soil) were collected from guava ecosystem from October, 2015 to September, 2016. The results indicated that litter samples harboured significantly higher abundance of mesofauna than soil samples and dominated by other invertebrates (11.53 / 100 g). The population in litter samples was significantly higher at June IIF (second fortnight) (20.27 / 100 g). Higher abundance other Acari (8.26 / 400 g) was recorded in soil samples. The population of mesofauna was significantly higher at July IF (first fortnight) (15.47 / 400 g) in soil samples. Higher total fauna abundance was recorded in litter sample (33.76 / 100 g) which was par on with soil sample (23.27 / 400 g).

Keywords : Mesofauna, ecosysyem, invertebrates, population

THE surface layer of soil is constantly receiving additions of organic matter, either as leaves or other debris of vegetation covering the ground, together with the droppings of animals or dung and other animal and vegetable residues supplied as manure to cultivated land. Soil fauna in general occupy an important position in the soil ecosystem and play a significant role in the complex process of organic matter decomposition, nutrient cycling and to improve the fertility status. The soil invertebrates play a crucial role in the terrestrial ecosystem as they control the rates of turnover and mineralization of organic substrate and accelerate the flow of energy and cycling of nutrient in soil (Reddy *et.al.,* 1994). In soil, most nutrients available for plant growth depend on complex interactions between plant roots, microorganisms and soil fauna (Bonkowski *et al*., 2000). Soil organisms contribute to a wide range of ecosystem services that are essential to the functioning of natural and managed ecosystems (Barrios, 2007). The soil ecosystem contains many less studied but often abundant groups of mesofauna, such as soil mites and other microarthropods (Coleman and Whitman, 2005). The present study was carried out to document the abundance of litter and soil mesofauna in guava (*Psidium guajava* L.) ecosystem.

MATERIAL AND METHODS

The investigations on the abundance of mesofauna in Guava (*Psidium guajava* L.) ecosystem were carried out at Division of Horticulture, Gandhi Krishi Vignana Kendra campus of the University of Agricultural Sciences, Bengaluru from October 2015 to September 2016. The experimental site is located at 13^0 05" North latitude and 77^0 35" East longitude. The soil belongs to Vijayapur series and is classified as Oxic Haplustalf. According to FAO classification, the soil is Ferric Luvisols. Soil is reddish brown, lateritic derived from granite gneiss under sub-tropical semi arid climate. Mean monthly values of different weather parameters at experimental location over the last 10 years (2006 - 2016) are 872.1 mm rainfall, 44 rainy days, 29.4 ^{0}C maximum temperature, 18.1 ^{0}C minimum temperature, 4.8 mm evaporation, 6.8 hours of sunshine hours with 90 and 47 per cent of maximum and minimum relative humidity, respectively.The guava ecosystem was established in the year 1977. The plants were planted at a distance of 7 m. Dry leaves were used as mulching material. Weeds were usually removed by shallow cultivation. Green manuring has been usually during the rainy season.

Sampling method : The samples were collected from litter and soil at fortnightly interval using the circular core sampler measuring 12 cm diameter and 10 cm height. The core sampler was placed on the soil surface and pressed downwards and turned in clockwise direction to a depth of 10 cm. The quantity of litter and soil sample collected was 100 and 400 g, respectively. Such collected samples were immediately transferred to aluminum cans (15 cm height and 6 cm diameter) and labels were placed into each can and closed with lid.

Extraction of mesofauna : The mesofauna was extracted from the soil and litter samples using Rothamsted modified McFadyen high gradient funnel apparatus in the soil biology laboratory. Soil samples were placed carefully along with the labels in canisters. The electric bulbs (25 W) fixed at the top in the baffle board served as the source of light and heat energy. The apparatus was allowed to run for 48 hours. The invertebrates including earthworms passing through 2×2 mm sieve of the sample holder were collected in vials containing 70 per cent ethyl alcohol fixed to the lower end of the funnel. These vials were periodically checked to keep the alcohol at desired levels. Labels were kept intact both in soil sample and fauna extracted vial.

Sorting procedure and preservation of mesofauna : A stereo binocular microscope (35 x magnifi-cation) was used for sorting the extracted soil invertebrates. They were separated into different taxonomic groups. The number in each group was recorded. Taxonomic groups encountered during the study period at fortnightly intervals were preserved in vials containing 75 per cent ethyl alcohol and labeled (date of collection, treatment etc.,) for further taxonomic identification.

Estimation of soil moisture : Measurement of soil moisture was made on soil samples of known weight. Soil sample was collected in airtight aluminum moisture can in each plot from desired depth. Fresh weight was recorded using electronic balance. Then it was dried in a hot air oven at 70 ^{0}C for 48 hours in the laboratory. Dry weight of the soil samples was recorded. The moisture content in percentage was calculated using the following formula.

$$\text{Moisture content (\%)} = \frac{\text{Fresh weight - Dry weight} \times 100}{\text{Dry weight}}$$

Estimation of soil temperature : Soil temperature was recorded by inserting a soil thermometer into the soil to a depth of 10 cm at the time of each sampling in each plot.

Data transformation : The data were transformed using $\sqrt{X+0.5}$ transformations, wherever necessary and statistically analyzed by adopting analysis of variance (Sundararaj *et al.,* 1972). SPSS 16 package was used for analyzing the data.

Abundance : The total number of individuals of all arthropods species, which appeared in each treatment at the time of observation, was recorded. The data were transformed using $\sqrt{X+0.5}$ transformations before statistical analysis (Sundararaj *et al.*, 1972).

Results and Discussion

Abundance of mesofauna in Guava litter sample

In the present study, significantly higher abundance of other invertebrates (11.53 / 100 g) was recorded in guava litter ecosystem. This was followed by other Acari (9.36 / 100 g). Collembola (5.12 / 100g), Cryptostigmata (4.29 / 100 g) and Mesostigmata (3.45 / 100 g) population was on par with each other (Table I). Significant difference in abundance of soil mesofauna in Guava litter samples was observed among the intervals. The population was significantly higher at June IIF (Second fortnight) (20.27) and was on par with October IF (16.33) and August IF (12.87). However, latter two samples exhibited no difference with the population ofJune IF (10.93), July IF (10.73), September IF (10.07), August IIF (9.80) and January IIF (9.47). Significantly least population was recorded in April IF (0.80) and found no difference in population from February IF to May IIF (Table I). There was significant difference among the mesofauna at peak activity stage (June IIF). Other Acari population was higher followed by Cryptostigmata, Collembola, Other invertebrates and Mesostigmata. No activity of Cryptostigmata, Mesostigmata and Collembola was observed at least activity stage (April IF). However, other Acari was dominated followed by other invertebrates.

Abundance of mesofauna in Guava soil sample

Significant differences in the abundance of mesofauna was noticed. Other Acari (8.26 / 400 g) was dominated and no difference in population of Collembola (5.47 / 400 g) and other invertebrates (5.27 / 400 g) was observed. Cryptostigmata (2.45 / 400 g) and Mesostigmata (1.82 / 400 g) population was on par with each other (Table II). Significant difference in abundance of soil mesofauna was documented in

TABLE I

The abundance of mesofauna in guava ecosystem (litter sample)

Meso-fauna	Mesofauna (#/100g litter)										
	Oct.IF	Oct.IIF	Nov.IF	Nov.IIF	Dec.IF	Dec.IIF	Jan.IIF	Feb.IF	Feb.IIF	Mar. IF	Mar.IIF
Cryptostigmata	9.00	0.67	6.33	4.00	1.00	0.00	1.67	0.00	0.00	0.00	0.00
	(2.97)	(1.05)	(2.52)	(1.91)	(1.09)	(0.71)	(1.35)	(0.71)	(0.71)	(0.71)	(0.71)
Mesostigmata	13.33	1.67	6.00	10.00	7.00	2.00	17.33	3.67	4.67	1.00	0.00
	(3.61)	(1.35)	(2.28)	(3.06)	(2.70)	(1.48)	(3.87)	(1.85)	(2.02)	(1.09)	(0.71)
Other Acari	0.00	0.00	0.00	0.00	4.67	0.67	8.67	0.00	0.00	0.67	1.67
	(0.71)	(0.71)	(0.71)	(0.71)	(2.06)	(1.00)	(2.97)	(0.71)	(0.71)	(1.00)	(1.46)
Collembola	16.00	0.33	14.00	10.33	4.67	8.00	5.00	0.00	0.00	0.33	0.00
	(3.81)	(0.88)	(3.76)	(3.12)	(2.22)	(2.70)	(2.16)	(0.71)	(0.71)	(1.00)	(0.71)
Other invertebrates	43.33	7.67	3.00	16.67	11.33	4.33	14.67	8.00	9.00	37.00	3.33
	(6.37)	(2.83)	(1.82)	(3.97)	(3.40)	(2.14)	(3.52)	(2.92)	(2.67)	(4.55)	(1.89)
Mean	**16.33**	**2.07**	**5.87**	**8.20**	**5.73**	**3.00**	**9.47**	**2.33**	**2.73**	**7.80**	**1.00**
	(3.49)^{ab}	**(1.36)**^{ef}	**(2.21)**^{de}	**(2.55)**^{cd}	**(2.29)**^{de}	**(1.60)**^{ef}	**(2.77)**^{bcd}	**(1.38)**^{ef}	**(1.36)**^{ef}	**(1.64)**^{ef}	**(1.09)**^{f}

TABLE 1 Continued

Meso-fauna	Mesofauna (#/100g litter)											
	Apr.IF	Apr.IIF	May.IF	May.IIF	Jun..IF	Jun.IIF	Jul.IF	Aug.IF	Aug.IIF	Sep. IF	Sep.IIF	**Mean**
Cryptostigmata	0.00	0.00	0.00	1.33	6.33	24.67	5.00	14.33	9.67	10.33	0.00	**4.29**
	(0.71)	(0.71)	(0.71)	(1.26)	(2.52)	(4.89)	(2.27)	(3.68)	(3.15)	(3.10)	(0.71)	**(1.73)**^{c}
Mesostigmata	0.00	1.00	0.00	0.00	1.33	2.33	0.67	1.33	1.00	1.67	0.00	**3.45**
	(0.71)	(1.09)	(0.71)	(0.71)	(1.18)	(1.67)	(1.05)	(1.18)	(1.17)	(1.25)	(0.71)	**(1.61)**^{c}
Other Acari	2.33	3.33	4.00	5.67	35.33	46.00	25.33	25.00	24.00	16.00	2.67	**9.36**
	(1.49)	(1.88)	(2.08)	(2.36)	(5.42)	(6.78)	(4.81)	(4.90)	(4.92)	(3.53)	(1.76)	**(2.39)**^{b}
Collembola	0.00	0.67	0.00	0.00	1.33	20.33	2.00	11.00	8.67	8.67	1.33	**5.12**
	(0.71)	(1.00)	(0.71)	(0.71)	(1.29)	(4.30)	(1.55)	(3.34)	(2.68)	(2.32)	(1.29)	**(1.89)**^{c}
Other invertebrates	1.67	2.67	8.67	4.00	10.33	8.00	20.67	12.67	5.67	13.67	7.33	**11.53**
	(1.46)	(1.61)	(2.83)	(2.08)	(3.14)	(2.76)	(4.43)	(3.54)	(2.35)	(3.46)	(2.58)	**(3.01)**^{a}
Mean	**0.80**	**1.53**	**2.53**	**2.20**	**10.93**	**20.27**	**10.73**	**12.87**	**9.80**	**10.07**	**2.27**	
	(1.01)^{f}	**(1.27)**^{f}	**(1.40)**^{ef}	**(1.42)**^{ef}	**(2.71)**^{bcd}	**(4.08)**^{a}	**(2.82)**^{bcd}	**(3.33)**^{abc}	**(2.85)**^{bcd}	**(2.73)**^{bcd}	**(1.41)**^{ef}	
										CV%	SEm ±	CD@5%
Treatment										51.71	0.13	0.25
Duration											0.28	0.55
Interaction											0.63	1.24

Note: Figures in the parentheses are $\sqrt{X+0.5}$ transformed values; IF: First fortnight; IIF: Second fortnight

TABLE II

The abundance of mesofauna in guava ecosystem (soil sample)

Meso-fauna	Mesofauna (#/100g litter)										
	Oct.IF	Oct.IIF	Nov.IF	Nov.IIF	Dec.IF	Dec.IIF	Jan.IIF	Feb.IF	Feb.IIF	Mar. IF	Mar.IIF
Cryptostigmata	8.67	3.00	3.33	1.00	0.00	0.00	2.00	1.00	0.00	2.67	0.00
	(3.02)	(1.67)	(1.79)	(1.09)	(0.71)	(0.71)	(1.47)	(1.09)	(0.71)	(1.64)	(0.71)
Mesostigmata	4.33	1.67	2.00	1.00	0.00	2.00	4.00	7.33	3.33	10.00	0.67
	(2.15)	(1.46)	(1.32)	(1.17)	(0.71)	(1.32)	(1.93)	(2.05)	(1.93)	(3.17)	(1.00)
Other Acari	0.00	1.00	0.00	4.33	0.00	2.33	11.33	15.67	2.33	0.00	0.67
	(0.71)	(1.17)	(0.71)	(2.15)	(0.71)	(1.49)	(2.82)	(3.94)	(1.38)	(0.71)	(1.00)
Collembola	1.33	0.67	1.67	8.00	0.00	9.00	4.33	1.67	0.67	2.00	0.00
	(1.34)	(1.00)	(1.44)	(2.39)	(0.71)	(2.73)	(1.98)	(1.38)	(1.00)	(1.32)	(0.71)
Other invertebrates	6.00	5.00	0.33	3.00	0.00	2.00	2.33	7.67	2.33	5.33	0.67
	(2.37)	(2.27)	(0.88)	(1.87)	(0.71)	(1.42)	(1.67)	(2.80)	(1.56)	(2.40)	(1.05)
Mean	**4.07**	**2.27**	**1.47**	**3.47**	**0.00**	**3.07**	**4.80**	**6.67**	**1.73**	**4.00**	**0.40**
	(1.92)^{cdef}	**(1.51)**^{cdefgh}	**(1.22)**^{efgh}	**(1.74)**^{cdefg}	**(0.71)**^{h}	**(1.53)**^{cdefgh}	**(1.97)**^{cde}	**(2.25)**^{bc}	**(1.31)**^{defgh}	**(1.84)**^{cdef}	**(0.90)**^{gh}

TABLE II Continued

Meso-fauna	Mesofauna (#/100g litter)											
	Apr.IF	Apr.IIF	May.IF	May.IIF	Jun..IF	Jun.IIF	Jul.IF	Aug.IF	Aug.IIF	Sep. IF	Sep.IIF	**Mean**
Cryptostigmata	0.00	0.00	5.67	4.33	5.67	8.33	6.33	0.00	0.67	1.00	0.33	**2.45**
	(0.71)	(0.71)	(2.16)	(1.99)	(2.04)	(2.87)	(2.52)	(0.71)	(0.99)	(1.17)	(0.88)	**(1.44)**^{b}
Mesostigmata	0.00	0.00	0.00	0.00	0.00	1.00	2.67	0.00	0.00	0.00	0.00	**1.82**
	(0.71)	(0.71)	(0.71)	(0.71)	(0.71)	(1.09)	(1.73)	(0.71)	(0.71)	(0.71)	(0.71)	**(1.25)**^{b}
Other Acari	3.00	2.67	14.33	2.67	32.67	36.00	24.33	3.33	1.00	1.33	22.67	**8.26**
	(1.87)	(1.44)	(3.49)	(1.55)	(4.87)	(5.95)	(4.26)	(1.84)	(1.09)	(1.18)	(4.73)	**(2.23)**^{a}
Collembola	1.00	0.00	4.33	24.33	2.67	12.00	27.67	6.00	1.00	4.00	8.00	**5.47**
	(1.09)	(0.71)	(1.82)	(4.37)	(1.77)	(3.30)	(5.27)	(2.41)	(1.17)	(1.84)	(2.48)	**(1.92)**^{a}
Other invertebrates	7.00	7.33	6.67	3.33	23.33	6.00	16.33	4.67	1.33	2.33	3.00	**5.27**
	(2.60)	(2.68)	(2.66)	(1.93)	(4.47)	(2.28)	(3.76)	(2.06)	(1.26)	(1.64)	(1.67)	**(2.09)**^{a}
Mean	**2.20**	**2.00**	**6.20**	**6.93**	**12.87**	**12.67**	**15.47**	**2.80**	**0.80**	**1.73**	**6.80**	
	(1.39)^{cdefgh}	**(1.24)**^{efgh}	**(2.17)**^{bcd}	**(2.11)**^{bcde}	**(2.84)**^{ab}	**(3.10)**^{a}	**(3.51)**^{a}	**(1.54)**^{cdefgh}	**(1.04)**^{fgh}	**(1.30)**^{defgh}	**(2.09)**^{bcde}	
										CV (%)	SEm ±	CD@5%
Treatment											0.12	0.23
Duration										56.66	0.26	0.51
Interaction											0.59	1.16

Note: Figures in the parentheses are $\sqrt{X+0.5}$ transformed values; IF: First fortnight; IIF: Second fortnight

Guava soil sample at different intervals. The population was significantly higher at July IF (first fortnight) (15.47) and found no difference with the population of June IF (12.87) and June IIF (12.67). Significantly least population was recorded in March IIF (0.40) and absent in December IF (Table 2II). There was significant difference among the mesofauna at peak activity stage (July IF). Collembola population was higher followed by Other Acari, Other invertebrates, Cryptostigmata and Mesostigmata in Guava soil samples.

Abundance of mesofauna in Guava litter and soil

The abundance of mesofauna varied among the litter and soil samples. Litter harboured more fauna compared to soil (Fig. 1). The abundance of mesofauna was more in the month of June IIF (101.33 / 100 g of litter) followed by October IF (81.67), August IF (63.44), Jun IF (54.67) and the lowest population of total fauna was observed in April IF (4.00) in litter samples. The population of total fauna was more in the month of July IF (77.33 / 400g of soil) followed by June I and IIF (64.33 and 63.33).The least population of total fauna was observed in Mar. IIF (2.00) and no activity of fauna was observed in December IF in soil samples (Fig. 2). Activity of both litter and soil mesofauna was more during rainy months (June to August month) which coincided with higher soil and litter moisture content with moderate soil temperature (Fig. 2). Similarly, the abundance of litter and soil mesofauna were lower from December to May month which coincided with higher soil temperature and lower moisture content in both litter and soil. This also due to higher atmosphere temperature,evaporation and

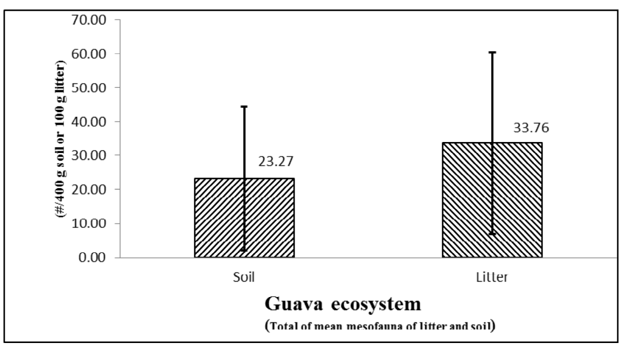


Fig.1 : Abundance of total fauna in Guava ecosystem

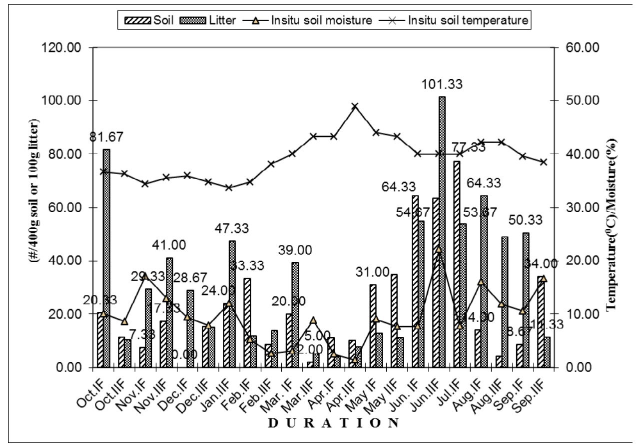


Fig. 2 : Abundance of total fauna in Guava litter and soil during October, 2015 to September, 2016

sunshine hours. Further, Cryptostigmata, Mesostigmata and Collembola were very sensitive to variation in above said weather parameter andfound no activities of these organisms during low soil moisture conditions. In support of the present investigations, Moitra (2013) collected soil samples from three different habitats at monthly intervals and documented. Order Oribatida as the highest numerically abundant group of acrarines followed by order Mesostigmata. Similarly, Postma-Blaauw *et al.* (2012) showed that in arable land the numbers, and the taxonomic diversity of mesostigmatid mites (which includes the predatory taxa) were low, while in grassland more taxa were found and in higher numbers. Rieff *et al.* (2010) and Borah and Kakati (2013) observed more soil biota abundance in natural forest or uncultivated ecosystems compared to agro ecosystem. Further, they also reported less cultivation practices helped to multiplication of soil fauna compared to short duration cropping system. However, Mahajan and Singh (1981) recorded higher collembolan populations during the monsoon months (July-September) when soil moisture was high and soil temperature was low.

The present study revealed that higher mesofaunal population activity both in litter and soil was noticed during early rainy season compared to later rainy and summer season, which may be due to variation in moisture content in soil and atmospheric temperature and light intensity in guava ecosystem.

References

BARRIOS, E., 2007, Soil biota, ecosystem services and land productivity. *Economic Entomology*, **64**: 269-285.

BONKOWSKI, M., GRIFFITHS, B. AND SCRIMGEOUR, C., 2000, Substrate heterogeneity and microfauna in soil organic hotspots as determinants of nitrogen capture and growth of ryegrass. *Appl. Soil Ecolo*., **14**: 37–53.

BORAH, M. AND. KAKATI, L. N., 2013, Abundance and distribution of soil Acarina in natural and degraded forest ecosystem at Pathalipam, Lakhimpur, Assam. An *International Journal of Scientific & Engineering Research*, **4**: 1694- 1709.

COLEMAN, D. C. AND WHITMAN, W. B., 2005, Linking species richness, biodiversity and ecosystem function in soil systems, *Pedologia*, **49**: 479-497.

MAHAJAN, S. V. AND SINGH, J., 1981, Seasonal variations of collembolan population in arable soil. (Eds: Veeresh, G.K.), *Progress in soil biology and ecology in India*. UAS Tech. Series, **37**:125-126.

MOITRA, M. N., 2013, On variation of diversity of soil oribatids (Acari, Oribatida) in three differently used soil habitats a waste disposal site, a natural forest and a tea garden in the northern plains of Bengal, India. *Int. J. Sci. Res. Pub.*, **3**(11): 1-12.

POSTMA, BLAAUW, M. B., DE, GOEDE, R. G. M., BLOEM, J., FABER, J. H. AND BRUSSAARD, L., 2012, Agricultural intensification and de-intensification differentially affect taxonomic diversity of predatory mites, earthworms, enchytraeids, nematodes and bacteria. *Appl. Soil Ecol*., **57**: 39–49.

REDDY, M. V., REDDY, V. R., YULE, D. F. AND GEORGE, P. J., 1994, Decomposition of straw in relation to tillage, moisture and arthropod abundance in a semi-arid tropical alfisol. *Biol. Fertil. Soils.*, **17**:45-50.

RIEFF, G. G., MACHADO, R. G. AND STROSCHEIN, M. R., 2010, Diversity of families of mites and springtails edaphic in growing eucalyptus and native areas. *Revista Brasileir de Agrociencia*, **16** (1/4): 57-61.

SUNDARARAJ, N., NAGARAJ, S., VENKATARAMU, M. N. AND JAGANNATH, M. K., 1972, Design and analysis of field experiments. *UAS, Bengaluru,* p.419.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 265-270, 2017

Diversity of Pollen Collected by the Indian Honey Bee (*Apis cerana* F.)

S. D. PRADEEPA AND V. V. BELAVADI
Department of Agricultural Entomology, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail : pradeep628@gmail.com

ABSTRACT

The present study was undertaken to delineate the foraging preferences of the Indian honey bee using palynological methods. This was done by comparing pollen spectra obtained from the selected hives at fortnightly intervals from August 2015 to December 2016 at three sampling locations within a confined landscape. The results revealed that, there were about 55 pollen taxa / types belonging to 50 dicotyledonous and five monocotyledonous species, encompassing 22 botanical families involving, trees, shrubs, epiphytes, herbs, climbers, grasses and sedges. Further, the diversity index for pollen collected by *Apis cerana* in 2015 was low (H= 0.78 to 1.85; D= 0.58 to 0.83) as compared to the 2016, the pollen diversity index was highest in the month of June (H= 2.49) and lowest in April (H=1.22). Pollen from species of Arecaceae, Myrtaceae, Fabaceae and Poaceae represented more than 70 per cent of all the pollen collected.

Keyword: Palynology, *Apis cerana,* pollen types

MORE than 70 per cent of flowering plants in the world depend on insects, mostly social and solitary bees, for pollination (Klein *et al.,* 2007; Gallai *et al.,* 2009 and Potts *et al.,* 2010). Variations in colour, shape and size of flowers we see around us is an indication that they have developed these adaptations for attracting pollinators. Plant-pollinator interactions play a significant role in maintaining the functional integrity of most terrestrial ecosystems (Ollerton *et al*., 2011).

The shared pollinators hypothesis suggests that plant species sharing pollinators segregate flowering temporarily to minimize interspecific overlap in flowering times and thus minimize ineffective pollination or competition for pollinators, indicating strong phylogenetic constraints in timing and variation of flowering. Comparison of phenology within and among forests species may help in understanding of phenological diversity (Sakai, 2001).

Since honey bees collect pollen both actively as well as passively, analyzing the diversity of pollen carried by the bees through sampling pollen from the nests in different times of the year may give an idea about the floral diversity and changes in flowering phenology in a given location. The present study aimed to understand this relationship among bee floral diversity, through replicability of pollen over months and to delineate the foraging preferences of bees with local floral diversity. We have used palynological methods (Ramanujan, 1992 and Bilisik, 2008) to compare the pollen collected by bees with the available flora in the study area.

MATERIAL AND METHODS

Study area : The study was conducted at the Gandhi Krishi Vignana Kendra (GKVK) campus of the University of Agricultural Sciences, Bengaluru, Karnataka state, India. The campus is spread over 526 ha (5.3 Km^2) (13^0 04' 37" N, 77^0 34' 39.99" E; 930 msl) and receives a mean annual rainfall of 915.8 mm. The study area comes under the eastern dry Agro-climatic zone of Karnataka state and it has diverse vegetation.

Three sampling sites were selected for the study: Agriculture College building (AB), Medicinal garden (MG) and National seed project unit (NSP) and in each site one colony of *Apis cerana* Fabricius was maintained from August 2015 till December 2016. The study area is characterized by diverse flora including cultivated crops (in agricultural fields), plantations (in horticultural blocks), medicinal plants, and several species of garden plants, wild trees, shrubs and weeds that would be sources of nectar and pollen for the bees.

Sampling and Identification of Pollen : Species of plants flowering in the study area was recorded at monthly intervals and reference pollen slides were prepared from pollen samples collected from freshly opened flowers. For each species a duplicate set of slides were prepared following Wodehouse (1953) and also by the standard acetolysis method (Erdtman, 1952, 1969, Kearns and Inouye, 1993). Photomicrographs of pollen were made using ZEISS Axio Scope A1 Trinocular Microscope (Fig. 1).

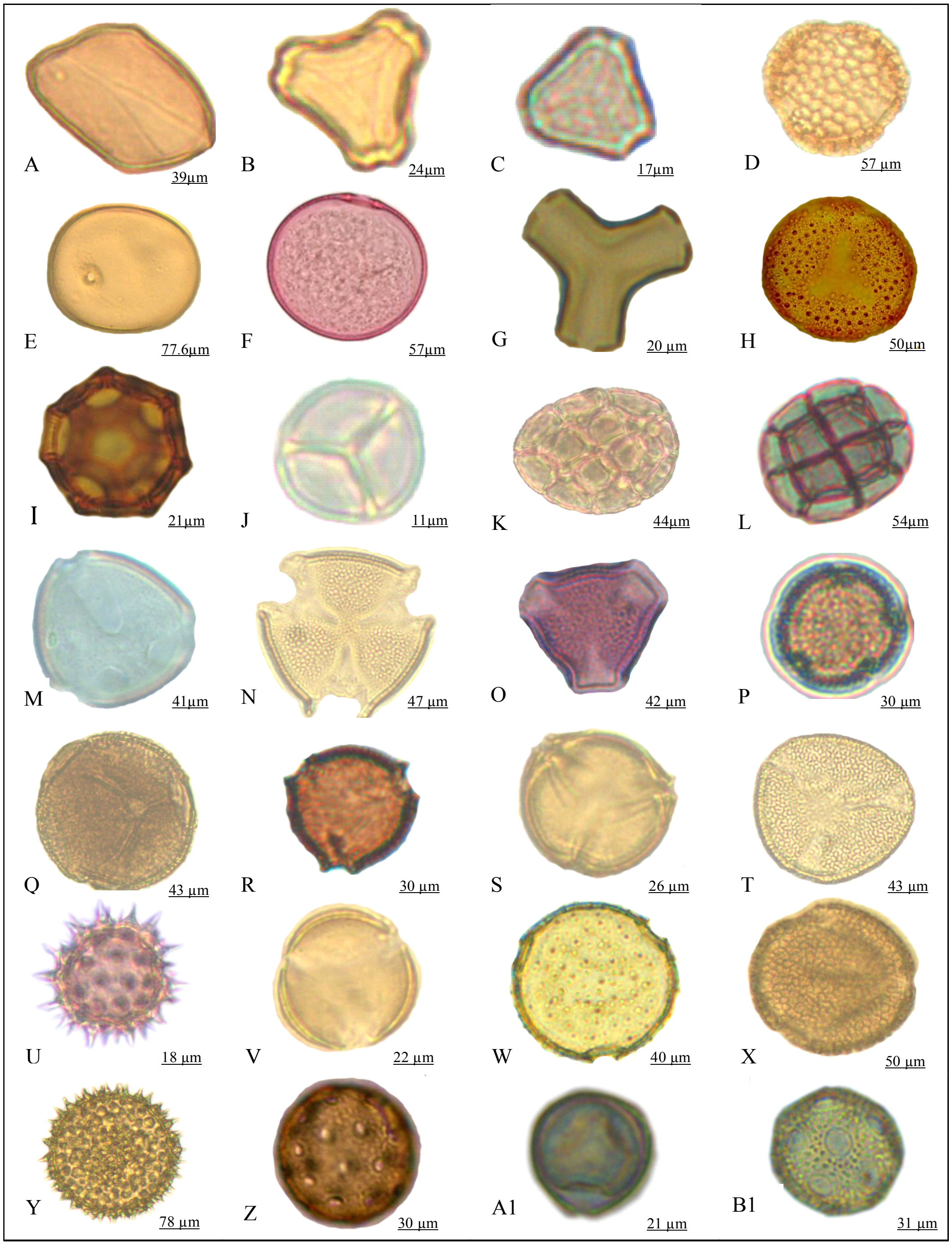


Fig.1: Photomicrographs Showing the predominant pollen types *i.e.,* **A** *Cocos nucifera,* **B** *Eucalyptusoblique,* **C** *Syzegium sp,* **D** *Pheltophoram ptreocarpum,* **E** *Zea maize,* **F** *Bouteloua dactyloides,* **G** *Dendropthoe falcate,* **H** *Portulaca* sp, **I** *Alternanthra bettzickiana,* **J***Mimosapudica*, **K** *Acacia sp,* **L** *Albezia* sp, **M** *Sennasiamea,* **N** *Tecoma* sp, **O** *Bauninia* sp, **P** *Phyllanthus emblica,* **Q** *Spathodea companulata,* **R** *Tamarindus indica,* **S** *Ricinus cummunis,* **T** *Millingtona hortensis,* **U** *Helianthus annus,* **V** *Tectonagrandis,* **W** *Clerodendrum* sp, **X** *Turnerasubulata,* **Y** *Malvestrum* sp, **Z** *Amaranthus* sp, **A1** *Flacourtia* sp, **B1** *Celosia argentia*

Bee collected pollen were sampled at fortnightly intervals from August 2015 to December 2016 using a pollen trap placed in front of the hive on the sampling day from morning till evening. Characterization and identification of bee pollen was done using pollen reference slides under a Olympus BX40 Trinocular Microscope. The major data collected in the course of this study was analysed using R statistics (R package RIOJA) and the pollen spectra were prepared.

RESULTS AND DISCUSSION

Pollen spectra

Analysis of 29 pollen samples drawn from August 2015 to December 2016 yielded 55 pollen taxa / types representing 50 dicotyledons and five monocotyledons encompassing 22 botanical families (Fig. 2a, 2b).

Three families such as Arecaceae (32%), Myrtaceae (21%), Fabaceae (13%) accounted for more than half the total number of pollen types (Fig. 3a,). A *Cocos nucifera* pollen was the most abundant which was recorded in all the months. Despite the year round presence of Apiacea, Convolulaceae, Passifloraceae, and Bignoniaceae, their proportion was found to be meager/low (Fig. 2a, 2b). Species of Phyllanthaceae, Cambritaceae and Sapindaceae and some species of Fabaceae exhibited seasonal representation (Fig. 2b).

The analysis of pollen spectra (Fig, 2a, 2b) also showed the species *Cocos nucifera*, remained available through all seasons and even during peak flowering of other taxa, the bees continued to visit and collect pollen from *Cocos nucifera*. Because, it was the only pollen available throughout the year and these results are in conformity with finding of Bhargava, *et al*., 2009 and Ramanujam, *et al*., 1992).

Frequency of pollen types

Among the 55 species, *C. nucifera* was the predominant one (28%) followed by *Eucalyptus* (14%), *Richordia* (6%), and *Peltophorum* (5%) and most of the other pollen were represented in lower frequencies (Fig. 3b). McCaughey (1980) suggested that several pollen types may be actually sought out

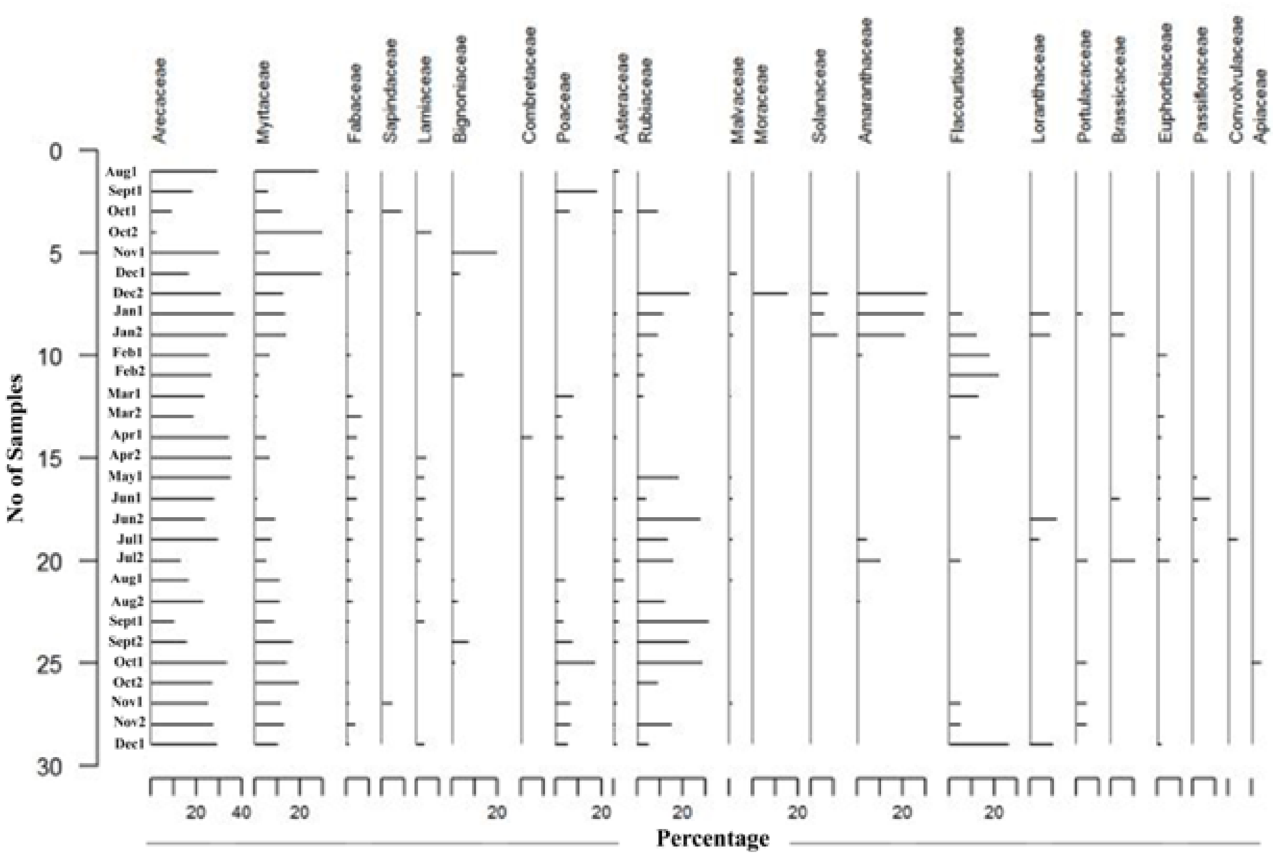


Fig. 2a: Pollen spectra showing the percentage of the family taxa.

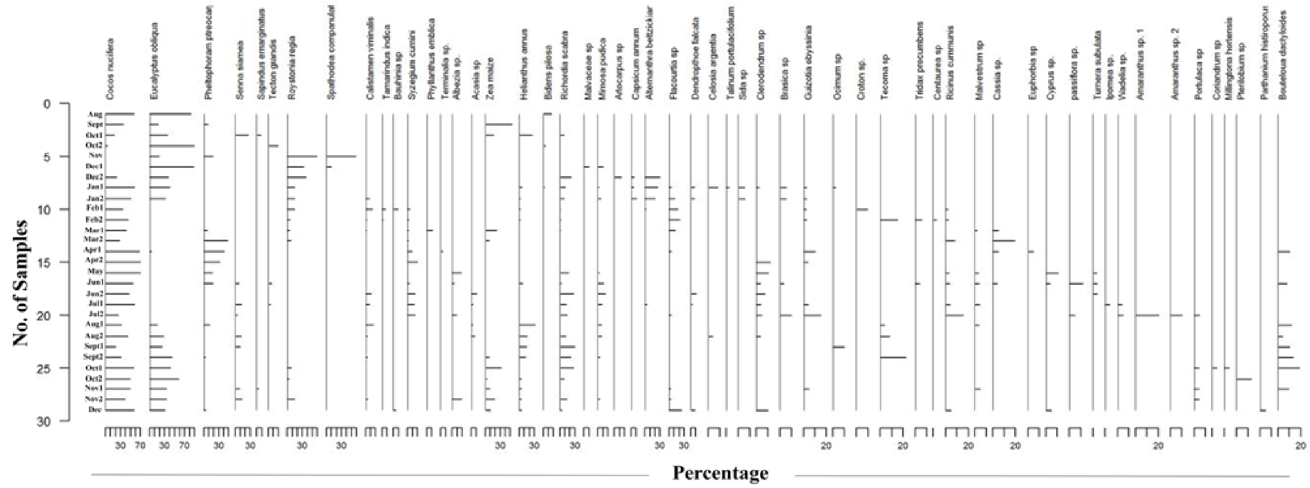


Fig. 2b: Pollen spectra showing the percentage of the main taxa

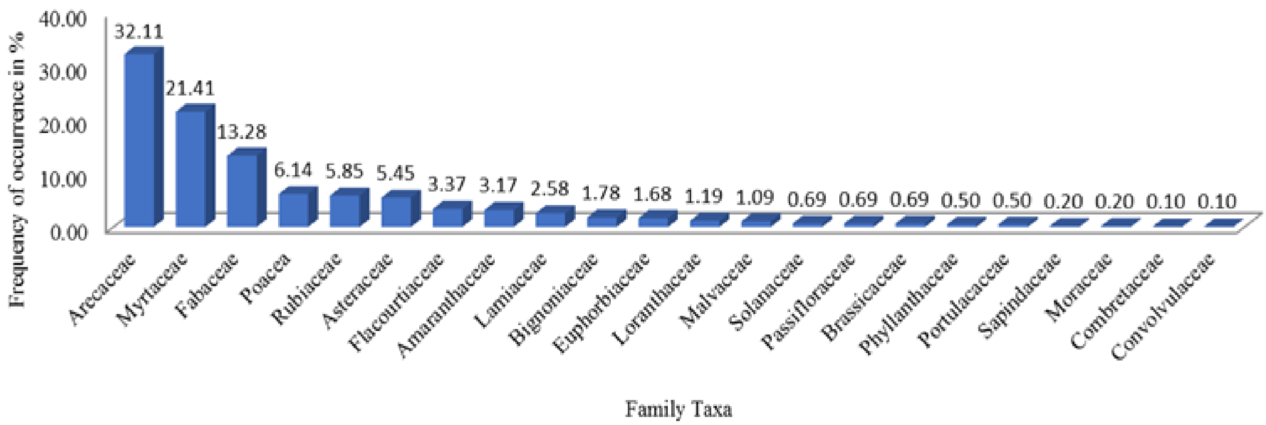


Fig. 3a: Frequency of pollen Family Taxa of GKVK

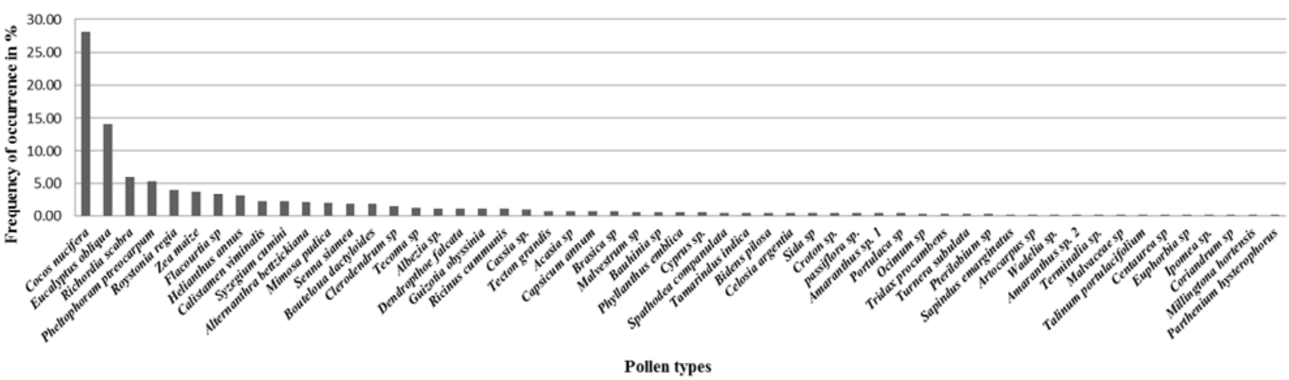


Fig. 3b: Frequency of pollen types in the pollen samples of GKVK

by bees for their nutritive value. Though the present study indicates that bees may largely depend on a few species, they also collect pollen from many other species.

Pollen Diversity Index

The diversity of pollen collected by *A. cerana* foragers in 2015 (August to December) was low (H= 0.78 to 1.85; D= 0.58 to 0.83) probably due to abiotic factors like low sunshine hours, cloudy weather and heavy rainfall. Gebremedhn, *et al.,* (2014) also observed a positive relation between peak bee activity and sunshine hours, and a negative association with relative humidity and cloudiness.

Interestingly, in 2016 the diversity was high (H=1.29 to 2.56; D=0.66 to 0.87) with greater (Table I) evenness (E= 0.77 to 0.95) and higher species

TABLE I

A. Cerana *pollen diversity collected at GKVK*

Year	Sampling Time	Species (S)	Evennes (E)	Simpson's index (D)	Shannon;s index (H)
2015	Aug-1	3	0.86	0.58	0.94
	Sept-1	4	0.87	0.66	1.20
	Oct-1	7	0.95	0.83	1.84
	Oct-2	4	0.56	0.41	0.78
	Nov-1	4	0.91	0.69	1.26
	Dec-1	5	0.76	0.61	1.22
	Dec-2	7	0.95	0.83	1.85
2016	Jan-1	18	0.82	0.86	2.36
	Jan-2	14	0.87	0.87	2.31
	Feb-1	13	0.86	0.86	2.21
	Feb-2	13	0.78	0.79	2.00
	Mar-1	11	0.81	0.81	1.95
	Mar-2	7	0.84	0.76	1.63
	Apr-1	10	0.77	0.76	1.77
	Apr-2	5	0.80	0.66	1.29
	May-1	10	0.79	0.76	1.81
	Jun-1	19	0.84	0.86	2.49
	Jun-2	9	0.90	0.83	1.98
	Jul-1	16	0.83	0.83	2.31
	Jul-2	15	0.94	0.91	2.56
	Aug-1	10	0.89	0.85	2.06
	Aug-2	12	0.87	0.85	2.16
	Sept-1	7	0.95	0.83	1.85
	Sept-2	10	0.89	0.84	2.04
	Oct-1	9	0.86	0.82	1.88
	Oct-2	7	0.75	0.70	1.45
	Nov-1	11	0.82	0.80	1.96
	Nov-2	12	0.90	0.87	2.23
	Dec-1	13	0.84	0.84	2.15
	Average	**9.83**	**0.84**	**0.78**	**1.85**

richness. Foragers of *A. cerana* were active throughout the study period. According to Pasquale *et al*., (2013) social bees keep a wide host range to meet high nutritional requirement of their colony since quality and diversity of pollen shapes their physiology and health. The present study also indicates that *A. cerana* is a generalist.

The result shows that, there is seasonal variation in the pollen types collected by honey bees. The delineation of pollen collected by bee gives valuable information for beekeeping and source of honey. Through periodical monitoring of pollen and analysis of honey pollen sample, one can map the local bee flora. The study also highlighted honey bees not only collected entamophilous pollen but also anemophilous pollen from Cyperaceae and Poaceae.

In addition, beyond their monetary value for sustaining our fragile food supply, bees also make an irreplaceable contribution to ecosystems around the world. Seeds, fruits and berries eaten by birds and small mammals are the result of pollination by bees, creating them custodians of the food chain and the biodiversity of our species.

References

Bhargava, H. R., Jyothi, J. V. A., Bhushanam, M. And Surendra, N. S., 2009, Pollen Analysis of Apis Honey, Karnataka, India. *Apiacta*, **44**: 14-19.

Bilisik, A., Cakmak, I., Blcakci, A. and Malyer, H., 2008, Seasonal variation of collected pollen loads of honeybees (*Apis mellifera* L. anatoliaca). *Grana,* **47**: 70–77.

Erdtman, G., 1969, Handbook of Palynology. Morphology, Taxonomy and Ecology. *Munksgaard Copenhagen*, p. 473.

Gebremedhn, H., Tadesse, A. and Belay, T., 2014, Flight intensity of honeybees (*Apis mellifera*) and its relationship with temperature, sunshine hours, cloudiness and relative humidity. *Livestock Research for Rural Development,* **26** (1): 1-4.

Kearns, C. A. and Inouye, D. W., 1993, Techniques for pollination biologists. *University Press of Colorado*, p. 583.

Klein, A. M., Vaissie'Re, B. E., Cane, J. H., Dewenter, I. S., Cunningham, S. A., Kremen, C. and Tscharntke, T., 2007, Importance of pollinators in changing landscapes for world crops. *Proc. R. Soc. B.*, **274**: 303–313

Mccaughey, W. F., Gilliam, M. and Standifer, L. N., 1980, Amino acid and protein adequacy for honey bees of pollens from desert plants and other floral sources. *Apidology*, **11**: 75-86.

Ollerton, J., Winfree, R. and Tarrant, S., 2011, How many flowering plants are pollinated by animals? *Oikos,* **120** : 321–326.

Pasquale, G. D., Salignon, M., Conte, Y. L., Belzunces, L. P., Decourtye, A., Kretzschmar, A., Suchail, S., Brunet, J. L. and Calaux, C., 2013, Influence of Pollen Nutrition on Honey Bee Health: Do Pollen Quality and Diversity Matter? *Plos one,* **8**:1-12.

Potts, S. G., Biesmeijer, J. C., Kremen, C., Neumann, P., Schweiger, O. and Kunin, W. E., 2010, Global pollinator declines: trends, impacts and drivers. *Trends in Ecology and Evolution*, **25** (6): 345-353.

Ramanujam, C. G. K., Kalpana, T. P. and Fatima, K., 1992, Melittopalynology and recognition of major nectar and pollen sources for honey bees in some districts of Andhra pradesh. In: Proceedings, Birbal Sahni Birth Centenary Palaeobotanical Conference. *Geophytology,* **22**: 261–271.

Sakai, S., 2001, Phenological diversity in tropical forests. *Popul. Ecol.,* **43** : 77–86.

Wodehouse, R. P., 1959, Pollen Grains their structure, identification and significance in science and medicine. *Hafner Publishing Co., New York*, p. 574.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 271-275, 2017

Field Evaluation of Sunflower (*Helianthus annuus* L.) Genotypes for their Reaction to Green Leaf Hopper, *Amrasca biguttula biguttula* (Ishida) (Hemiptera : Cicadellidae) infestation

Soumya M. Shettar and K. S. Jagadish
Department of Agricultural Entomology, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: soumyashettar23@gmail.com

Abstract

One hundred and sixty two sunflower (*Helianthus annuus* L.) accessions were screened under field conditions at the Main Research Station (MRS), Hebbal, Bengaluru, during *Rabi* season of 2015 for their reaction to leaf hopper, *Amrasca biguttula biguttula* Ishida infestation. The results revealed that, the ten accessions *viz*., RH-95-C-1, AHT 12, OPV 2, CMS 103 B, KBSH 53, KBSH 72, OPV3, NCP 198, KBSH 1 and AHT 13 showed resistance reaction, whereas, DRSF 108, RHA 284, EC 734840, EC 734844, NCP 22, NCP28, KBSH 41, Morden and UASB 560 were found to be highly susceptible. Among the remaining accessions, 101 accessions were moderately resistant and 43 accessions were in the susceptible category. The spatial distribution of the leafhopper studied on sunflower entries during two different phenological stages of the crop (45 and 75 DAS) revealed that the leafhopper confined maximum population to the middle portion of the plant canopy, followed by top portion during both growth stages in the level canopy of sunflower.

Keywords: *Amrasca biguttula biguttula, helianthus annuus,* field screening, resistance, canopy distribution

In Sunflower (*Helianthus annuus* L.) the work for the development ofinsect resistant cultivar / hybrid in particular reference to sucking pests, is still in its infancy. It is an elite oilseed crop of our country with high quality edible oil and wider adaptability and occupies an area of 7.21 lakh hectares with a production of 4.99 lakh tonnes and a productivity of 692 kg / ha. However, Karnataka occupies first position in India by accounting for an area of 3.84 lakh ha, a production of 1.93 lakh tonnes and productivity of 503 kg / ha (Anon., 2013). Although sunflower crop has the yield potential of 2.0 to 2.5 tonnes / ha under favourable conditions, its mean productivity levels are quiet low in India, mainly due to several biotic and abiotic stress factors. Among the bioticfactors, the attack of insect pests is the major limiting factor in its successful cultivation.

Of the 251 insect and acarine species that have been recorded on sunflower at the global level (Rajamohan, 1976), insect pests like Capitulum borer, *Helicoverpa armigera* (Hub.); Green semilooper, *Thysanoplusia orichalcea* (Fab.); Bihar hairy caterpillar, *Spilarctia obliqua* (Walker); tobacco caterpillar, *Spodoptera litura* (Fab.); cabbage semilooper, *Trichoplusia ni* (Hub.) and leaf hopper, *Amrasca biguttula biguttula* were considered to be of major economic importance in India (Basappa, 1995; Jagadish *et al*., 2004).

Leafhoppers, *A. biguttula biguttula* (Homoptera : Cicadellidae) are the important sucking pests of sunflower in India (Rana and Sheoran, 2004). Both nymphs and adults suck the plant sap and their severe infestation leads to curling of leaves and the characteristic "hopper burn" symptom. Crop loss due to insect pests in sunflower varies from region to region. As a result of severe outbreak of seedling pests, the plant stand of sunflower crop could be reduced by more than 30 per cent (Basappa and Bhat, 1998). The leaf hopper alone causes crop loss ranging from 18.5 to 46.3 per cent in Maharashtra (Anon., 1979).

Many insecticides are being used to control the pest complex of sunflower, which pose health and environmental hazards. Plant resistance is a potential alternate management strategy to reduce such pest damage, since it is eco-friendly, cost effective and can be integrated with cultural and biological control measures (Chirumamilla *et al*., 2010).

Since host plant resistance can be effectively exploited and utilized against sucking pests (Saritha *et al.*, 2008), the present investigation was undertaken to screen sunflower germplasm for resistance against leaf hopper under field conditions.

Material and Methods

The study was conducted at Main Research Station, Hebbal, Bengaluru, Karnataka falls under the eastern dry Agro-climatic zones of Karnataka state during *Rabi* season 2015. The experiment was sown on Nov. 13, 2015 in unreplicated rows of 4 m length.

The experiment was initiated in order to determine the sources of resistance to leaf hopper population, of which 162 germplasm lines and experimental hybrids were screened under field conditions for their reaction to the leaf hopper. Observations on mean leaf hoppers per plant and hopper burn injury were recorded on 45th and 75th DAS. All agronomic practices were followed as per the Package of Practices, UAS, Bengaluru (Anon., 2015).

For recording leaf hopper population, five plants of each entry were randomly selected and labelled for recording observations both at 45 and 75 DAS. The observations were recorded on two upper leaves, two middle leaves and two bottom leaves of plant canopy and later it was expressed as mean number per plant (*i.e.*, mean no. / six leaves / plant). Both nymphs and adults were counted.

Hopper burn injury was recorded on the same five labelled plants in each entry following a 0 to 5 scale (Anon, 2013) and expressed as mean injury grade per plant.

Based on the leaf hopper injury grade, the accessions were categorised as detailed below. In that ten entries were categorised as resistant and nine entries were highly susceptible. Germplasm entries of sunflower were screened for evaluating their resistance potential against *A. biguttula biguttula* and the same set of entries were used for studying canopy distribution pattern of sunflower by counting the number of leaf hoppers at two top, two middle and two bottom leaves.

Leaf hopper injury grade	Resistance category*
0-1	R
2	MR
3	S
4-5	HS

Note: R: Resistant, MR: Moderately Resistant, S: Susceptible, HS: Highly susceptible

Results and Discussion

The results revealed that mean population of leaf hoppers ranged from 0.50 to 2.66 and 0.83 to 5.66 the infestation at 45 DAS and 75 DAS, respectively, across the different genotypes and hopper burn injury grade ranged from 0.00-1.80 and 0.40-4.60 at 45 DAS and 75 DAS, respectively.

Based on the observations ten accessions *viz*., RH-95-C-1, AHT 12, OPV 2,CMS 103 B, KBSH 53, KBSH 72, OPV3, NCP 198, KBSH 1and AHT 13 had relatively lower leaf hopper population (< 1.0 hopper / plant) and hopper burn injury grade (0-1) than other accessions and were grouped as resistant, whereas, nine accessions *viz.,*DRSF 108, RHA 284, EC 734840, EC 734844, NCP 22, NCP28, KBSH 41, Morden and UASB 560 recorded the highest mean populations (>3 hoppers / plant) and hopper burn injury scale (>3 injury grade) and based on the mean injury grade these entries were rated as highly susceptible. Among the remaining accessions, 101 accessions were rated as moderately resistant and 43 accessions were rated as susceptible (Table I). Rana and Sheoran (2004) reported that the hopper population ranged from a minimum of 2 on HSFH 848 to a maximum of 4 per plant on KBSH 1. This result was contradictory with the present findings whereas, Bhat and Virupakshappa (1993) observed some hybrids such as KBSH 8 and KBSH 1 recorded the least damage. Morden recorded the highest leaf hopper population at both 45 and 75 DAS (2.66 and 5.66 per plant), respectively. Suganthy and Uma (2011) reported a maximum of 28 hoppers per plant in Morden and they consider Morden as susceptible check.

The present investigation has revealed that the genotypes RH-95-C-1, AHT 12, OPV 2,CMS 103 B,

TABLE 1

Categorization of sunflower genotypes for leafhopper resistance based on mean population of leafhoppers and hopper burn injury grade

Resistance category	Name of the genotypes
Resistant	RH-95-C-1, AHT 12, OPV 2,CMS 103 B, KBSH 53, KBSH 72, OPV3, NCP 198, KBSH 1, AHT 13 (10)
Moderately resistant	KBSH 44, S-207, RSFH 130, RHA 93, GKVK-2, M-17R, AHT 1, AHT 2, AHT 4, AHT 6, AHT8, AHT9, AHT 10, IHT 241, IHT 242, IHT 243, IHT 245, IHT 246, IHT 247, IHT 248, IHT 250, IHT 252, IHT 253, IHT 558, IHT 711, IHT 741, IHT 750, IHT 764, IHT 775, IHT 795, IHT 802, IHT 881, IHT 879, IHT 878, IHT 877, IHT 848, IHT 845, IHT 843, IHT 815, IHT 807, IHT 888, IHT 891, IHT 913, IHT 937, IHT 943, IHT 948, IHT 951, IHT 960, IHT 971, IHT 972, IHT 975, IHT 976, IHT 990, IHT 997, IHT 1061, IHT 1089, KBSH 71, KBSH 73, KBSH 75, KBSH 76, GMU 440, GMU 520, TCSH1, EC78484877, EC 734887, E17A,RHA 469, GMU 601, GMU 604, GMU 606, GMU 607, GMU 608, GMU 609, GMU 612, GMU 613, GMU 614, GMU 615, GMU 616, GMU 617, GMU 618, GMU 619, GMU 621, GMU 622, GMU 623, GMU 624, GMU 626, GMU 627, GMU 628, GMU 630, GMU 631, GMU 633, GMU 634, GMU 636, GMU 637, GMU 639, GMU 640, GMU 641, GMU 642, GMU 644 (101)
Susceptible	EC734846, RHA 378, X15WB, AHT 3, AHT 5, AHT 7, AHT 11, IHT 238, IHT 239, IHT 240, IHT 249, IHT 251, IHT 591, IHT 712, IHT 731, IHT 731, IHT 737, IHT748, IHT 752, IHT 753, IHT 754, IHT 837, IHT 821, IHT 936, IHT 952, IHT 956, IHT 980,IHT 981,IHT 995, KBSH 74, RHA 467, GMU602,GMU 603, GMU 605, GMU610, GMU 611, GMU 620, GMU 625, GMU 629, GMU 632, GMU 635, GMU 643, GMU 645 (43)
Highly susceptible	DRSF 108,RHA 284, EC 734840, EC 734844, NCP 22, NCP28, KBSH 41, Morden, UASB 560 (9)

KBSH 53, KBSH 72, OPV3, NCP 198, KBSH 1 and AHT 13 are resistant to *A. biguttula biguttula* by virtue of recording both relatively lower pest population and injury grade. Thus, the 19 entries (having extreme reactions to leaf hopper) (Table II) will be subjected to further tests both under field and artificial conditions, to confirm the resistance and susceptibility so that, it will help in further determination of morphological and biochemical basis for leaf hopper resistance in sunflower.

The results of the present investigation pertaining to the field screening were similar to the reports of Nagaraju *et al.* (2004), Anonymous (2006, 2007 and 2008) who screened several entries against leafhoppers, by the same methodology, however, their results cannot be compared with the present investigation as the entries / cultivars used by them differ and so also the seasonal variations.

Spatial distribution pattern of leafhopper in sunflower crop canopy

There was significant difference between the population of leafhopper within the crop canopy at both 45^{th} DAS (CD=0.071) and 75^{th} DAS (CD=0.42). During *rabi* 2015, leafhopper population (45^{th} DAS and 75^{th} DAS)was highest in the middle (3.58 / plant and 5.78 / plant), followed by top (2.95 / plant and 4.66 / plant) and least in the bottom (1.5 / plant and 2.11 / plant) at 45^{th} DAS and at 75^{th} DAS, respectively. However, there was no significant difference between top and middle crop canopy at 75 DAS (Table III). These finding however, do not agree with those of Jayaramaiah and Jagadish (1996) in case of *Myzus nicotianae* in tobacco probably due to differences in the host plant and pest species involved. Nevertheless, it indicates that middle level canopy is the most preferred site in sunflower for colonization by leafhopper.

TABLE II

Entries showing resistance and high susceptibility short listed for further studies.

A. Resistant entries

Entries	Mean no of leafhoppers / plant		Hopper burn injury grade	
	45 DAS	75 DAS	45 DAS	75 DAS
RH-95-C-1	0.50	0.83	0.20	1.00
AHT 12	0.66	0.83	0.00	0.80
OPV 2	0.66	0.66	0.00	1.00
CMS 103 B	0.50	0.83	0.20	0.60
KBSH 53	0.66	0.83	1.00	0.60
KBSH 72	0.66	0.83	0.00	1.00
OPV3	0.66	0.83	0.40	0.40
NCP 198	0.66	1.33	0.00	1.00
KBSH 1	0.50	0.66	0.80	0.60
AHT 13	1.33	1.00	1.00	1.00

B. Highly susceptible entries

DRSF 108	2.00	3.66	1.20	3.40
RHA 284	1.83	3.16	0.80	4.00
EC 734840	1.83	3.66	1.80	4.20
EC 734844	1.66	3.50	1.60	3.20
NCP 22	1.83	3.16	1.00	2.80
NCP28	2.16	3.50	0.60	3.00
KBSH 41	2.33	4.66	1.00	4.40
Morden	2.66	5.66	1.40	4.60
UASB 560	1.66	3.00	1.20	3.60

TABLE III

Spatial distribution pattern of leafhopper in sunflower crop canopy

	45days			75days		
	Bottom	Middle	Top	Bottom	Middle	Top
Mean leafhoppers per leaves	1.5 (1.08a)	3.58 (1.49c)	2.95 (1.37b)	2.11 (1.19a)	5.78 (1.81b)	4.66 (1.65 b)
±SD	1.31	1.48	1.52	1.63	2.48	1.89
SEM±		**0.032**			**0.15**	
CD at P=0.05		**0.071**			**0.42**	

The present findings are contradictory to those of Mahto (1990) who revealed that at lower canopy level of sunflower , leafhopper was significantly more in number than other two levels. He did not find significant difference in nymphal population between middle and upper leaves.

The overall incidence of leafhopper per six leaves and hopper burn injury grade recorded in sunflower during *rabi* 2015. Totally 19 entries (*i.e.,* resistant and 9 highly susceptible) were shortlisted and subjected to artificial screening to ascertain consistent reaction of these entries for leafhopper infestation. The spatial distribution of the leafhopper studied on sunflower entries during two different phenological stages of the crop (45 and 75 DAS) revealed that the leafhopper confined maximum population to the middle portion of the plant canopy, followed by top portion during both growth stages in the level canopy of sunflower.

REFERENCES

ANONYMOUS, 1979, Annual progress report of AICRP on Sunflower forthe year 1978-79, Directorate of Oilseeds Research, ICAR, Hyderabad, p. 109.

ANONYMOUS, 2006, Research achievement in sunflower, AICRP, (Sunflower) Directorate of Oilseeds Research, ICAR, Hyderabad, 117pp.

ANONYMOUS, 2007, Annual Progress Report of AICRP on sunflower for the year 2007-08, Directorate of Oilseeds Research, ICAR, Hyderabad, Pp. 197.

ANONYMOUS, 2008, Technical programme, AICRP on sunflower for the year 2007-08, Directorate of Oilseeds Research, ICAR, Hyderabad.

ANONYMOUS, 2013, Project Director's Report, Annual Group Meeting of Sunflower, Sesame and Niger, DOR, Hyderabad 8-10 April, 20pp.

ANONYMOUS, 2015, Package of practices of agricultural crops. University of Agricultural Sciences, Bengaluru, p. 357.

BASAPPA, H. AND BHAT, N. S., 1998, Pest management in sunflower seed production. In: Hybrid sunflower seed production technology (Eds.)

BASAPPA, H., 1995, Insect pest Management in sunflower-innovative approaches subject matter workshop cum seminar on integrated pest management in oil seeds, October 10-17, 1995, Directorate of oilseeds Research, Hyderabad.

BHAT, N. S. AND VIRUPAKSHAPPA, K., 1993, Integrated pest management in sunflower: Group discussion on IPM strategies in oilseeds in India. Punjab Agril. Univ., Ludhiana, India.

CHIRUMAMILLA, A., LAWRENCE, D., CHARLET, HULKE, H. C., SEILER, G. S., GROSS, T. A., KNODEL, J. J., ROBERT, K. AND AIKEN., 2010, Update on host plant resistance studies of banded sunflower moth and sunflower moth.www.ddr.nal.usda.gov/bitstream/10113/40225/1/IND44344428.pdf accessed on 19.02.11.

JAYARAMAIAH, M. AND JAGADISH, K. S., 1996, Spatial distribution of the tobacco aphid, *Myzus nicotianae* Blackman (Homoptera : Aphididae). Aphidologysymp., 1996. Dep. Zool., Univ. Gorakhpur, Gorakhpur, India.

JAGADISH, K. S., MANTUR, S. G., BHARATHI, S., JAGADEESH, B. N. AND CHANNAKRISHNAIAH,K. M., ANDNAGARAJU, 2004, Evaluation of sunflower genotypes for resistance to *Thripspalmi* - A vector of Necrosis Disease and its distribution in crop canopy. *Environ. Ecol.*, **22** (1) : 169-172.

MAHTO, Y., 1990, A note on population dynamics of *Amrasca biguttula biguttula* (Ishida) on sunflower. *Indian J. Ent.*, **52**(3) : 506-508.

NAGARAJU, JAGADISH, K. S. AND SHADAKSHARI, Y. G., 2004, Sunflower diseases and management (in Kannada). Extension brochure May 2004. AICRP sunflower, *Univ. Agri. Sci.*, Bangalore, p. 5.

RAJAMOHAN, N., 1976, Pest complex of Sunflower: a bibliography PANS, **20** : 546-563.

RANA, J. S. AND SHEORAN, R. K., 2004, Evaluation of sunflower (*Helianthus annuus* L.) hybrids against insect pests in semi arid tropics. *J. Oilseed res.,* **21**(2): 374-375.

SARITHA, R., K., DHARMA REDDY AND BASAPPA, H., 2008, Screening of sunflower varieties for resistance against sucking pests. *Indian J. Plant Prot.*, **36** (1) : 144-147.

SUGANTHY, M. AND UMA, D., 2011, Screening of Promising Sunflower Germplasm against Key Insect Pests. *Madras Agric. J.,* **98** (4-6) : 180-181.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 276-280, 2017

Population Dynamics of Grape Stem Borer *Celosterna scabrator* Fabr. (Cerambycidae : Coleoptera)

N. D. Sunitha and H. Khader Khan
Department of Agricultural Entomology, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail : drkhader@rediffmail.com

Abstract

Studies were conducted during 2015-16 and 2016-17 on the population dynamics of grape stem borer *Celosterna scabrator* Fabr. (Cerambycidae : Coleoptera) at three locations of Vijayapura district. Studies revealed variations in time of first occurrence, duration of occurrence and appearance of peaks in trap catches of beetles. First trap catches appeared between 26th and 28th standard weeks and recorded up to second standard week. Live tunnels appeared between 26th to 28th standard weeks and observed till 4th standard week. Neglected gardens without any prophylactic measures to trap adults on emergence presented maximum incidence of the pest to the tune of 90.00 per cent in terms of live tunnels.

Keywords : Diagonsis, necrosis, incidence, dynamics

Karnataka is the second largest grape growing state in India after Maharashtra with an area of 20.46 thousand ha with a production of 302.39 thousand MT and productivity of 14.78 tones / ha (www.nhb.gov.in/Horticulture%20Crops/Grape/Grape1.htm). Grape growing regions are located in the following two agro-climatic regions in the state *viz*., North Interior Karnataka and South Interior Karnataka. North Interior Karnataka comprises Vijayapura, Bagalkot, Belgaum, Koppal, Bidar and Gulbarga. In 2014-15, Vijayapura district contributed an area of 8906 ha, production of 1, 06,536 tons, with average productivity 20 t / ha. Large acreages of grape cultivation are quite evident in Basavana Bagewadi, Vijayapura, Indi, Muddebihal and Sindgi talukas of Vijayapura.

Soil and water salinity, acute water shortage, saturation in domestic raisin market and insect pests and diseases are the problems of viticulture in north interior Karnataka.

Grape being a perennial crop ravaged by number of insect pests. Total of 132 insects are known to attack grape vine in the world and as many as 100 insect mites have been reported to damage various parts of grape vine from different grape growing states of India. Of these only 15-20 species considered to cause losses in various regions and stem borer is one among them (Mani *et al.,* 2014). Stem borer, *Celosterna scabrator* F., (Coleoptera:Cerambycidae) is a pest of national significance and insect is a borer, the grub of which bores in to stem and branches and causes drying and withering of affected branches. The adult beetles start emerging from the vines during July to September by making a round hole on the vine. Female beetles make conspicuous slits on the bark of the trunk and arms of the vine (http://farmer.gov.in/imagedefault/ipm/IPM%20package%20for%20Grapes.pdf)

Stem borer *C. scabrator* makes holes on the main stem and arms. Leaves on affected parts turn yellow and mottled and ultimately dry and drop down. It is the pest found in major grape growing in India. It is an endemic pest and can cause up to 25 per cent loss. Its occurrence is maximum during the months of November-April. (http://nrcgrapes.nic.in/zipfiles/grape%20profile%20-%20nrc%20grapes.pdf). Adult beetles cause damage by scraping the young shoots and also by making slits on outer bark for egg laying. Larva makes damage by feeding inside the trunk and branches and by tunneling upward and downward. Stem borer affected plants show typical yellowing of leaves, followed by shedding of leaves, drying and dieback of branches. As a result affected vines get weakened; growth of vine is reduced leading to decrease in the yield. Maturity of the berries is also delayed ultimately influencing the quality of grapes. (Mani *et al.,* 2008). Systematic work on the population dynamics of *C. scabrator* is not done in northern Karnataka, which is much needed for the effective management of pest and also for developing forecasting modules. With this background, the present study was conducted on population dynamics of *C. scabrator*

MATERIAL AND METHODS

The studies were conducted during 2015-16 and 2016-17 at three locations of Vijayapura district (16° 50' 0" N, 75° 42' 0" E). *viz.,* Vijayapura (Location 1), Aliabad. (Location 2) and Tikota (Location 3). Vine orchards of same age (Six years) and same variety (Thompson seedless) were selected to study the population dynamics. Population dynamics of adults and grubs were studied in different vine orchards. Care was taken to maintain the isolation distance from other alternate hosts of the pest.

Population dynamics of adults

Solar light traps were installed @ one trap / acre to trap the adults and to assess their population and seasonality. Traps were installed at the centre of the vine orchard. Observations were recorded at weekly interval on the number of beetles trapped from first week of June 2015 to last week of January 2016 and first week of June 2016 to last week of January 2017. Orchards with no prophylactic measures for the management of adults during the study period were selected for the experiment. Observations were recorded thereafter under unprotected conditions.

Population dynamics of grubs

Grubs immediately after hatching tunnel into the trunk or branches of vines. Vines throwing fresh wood powder, frass and excretory pellets are considered as live tunnels. Observations were made at weekly intervals and vines ejecting fresh wood powder, frass and excretory pellets were recorded from hundred randomly selected vines from an orchard. After each observation vines with live tunnels were tagged for avoiding consideration of same vines during subsequent observations. Finally percent live tunnels were computed every week.

RESULTS AND DISCUSSION

Population dynamics of adults

During 2015-16, at location one and two, first trap catches of beetles were noticed during 26th standard week (June last week) whereas in location three, adult catches were noticed from 28th standard week (July second week) onwards. At all the three locations peaks were observed during different standard weeks. At location one, at 31st standard week (last week of July) maximum adults were caught in the trap / week (17.00). At location two maximum catches were recorded during 32nd standard week (August first week) (17.00 / trap / week). At location three, peaks were observed between 40th (Second week of October) and 42nd standard weeks (fourth week of October) (20.00/trap/week) (Fig 1).

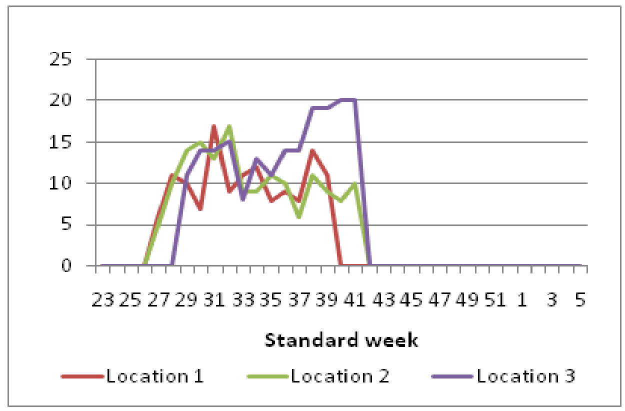


Fig 1: Light trap catches of *C. scabrator* during 2015-16

During 2016-17 first trap catches were observed during 32nd standard week (August second week) at location one and at locations two and three they were recorded during 34th standard week. (August fourth week) Maximum peak at first location was recorded during 40th standard week (October first week) (24.00

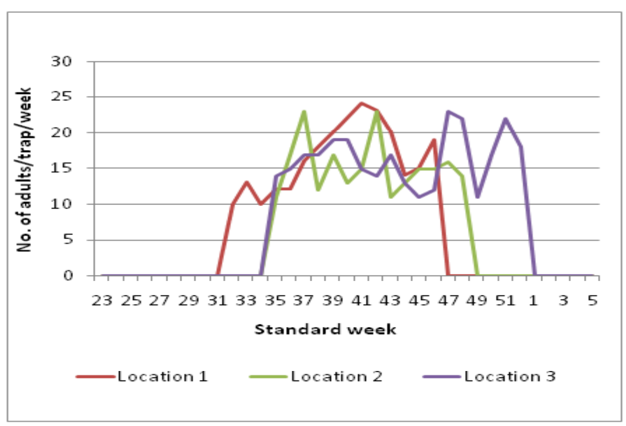


Fig 2: Light trap catches of *C. scabrator* during 2016-17

/ trap / week) whereas at location two peaks were recorded during 36th standard week (September first week) and 42nd standard weeks (October third week) (23.00 / trap / week). At location three peaks were observed during 47th standard week (November third week) (23.00 / trap / week) and 50th standard week (December second week). (22.00 / trap / week) (Fig 2).

Population Dynamics of grubs

Percent live tunnels (2015-16)

Live tunnels were first observed at location one during 27th standard week (first week of July) during which only 2.00 per cent live tunnels were observed. Incidence continued till 4th standard week (January fourth week).Peak incidence of 19.00 per cent was observed during 42nd standard week (Third week of October) and further no increase in incidence was observed till 4th standard week. (January fourth week) At location two live tunnels were observed from 30th

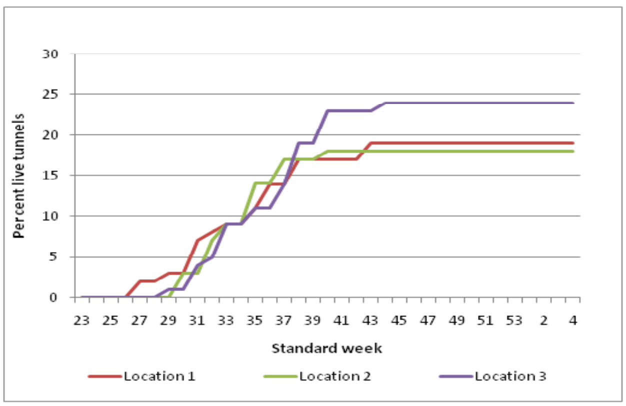


Fig 3: Percent live tunnels made by *C. scabrator* grubs at three locations during 2015-16

standard week (Third week of July) and maximum incidence of 17.00 per cent was recorded during 40th standard week (First week of October). There after no further increase in live tunnels was observed. At location three first incidences was observed during 28th standard week (July third week) and continued till 4th standard week (January fourth week) with maximum incidence of 23.00 per cent during 42nd standard week (Third week of October) (Fig 3).

Percent live tunnels (2016-17)

During 2016-17 live tunnels started appearing during 34th standard week (August fourth week) at all the three locations. Peak incidence at location one was recorded between 50th standard week (Second week of December) and 4th standard week (January fourth week). Incidence level was to the tune of 90.00 per cent. At location two, peak incidence was observed

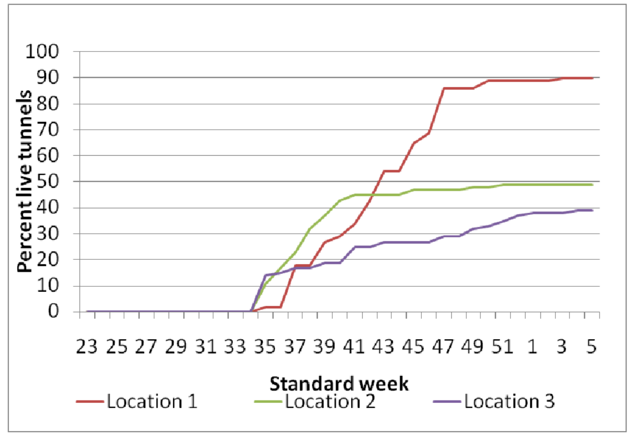


Fig 4: Percent live tunnels made by *C. scabrato*r grubs at three locations during 2016-17

between 52nd standard week (December fourth week) to 4th standard week (January fourth week) with incidence level of 50.00 per cent. Location three recorded maximum incidence of approximately 40.00 per cent between 52nd standard week (December last week) and 4th standard week (January fourth week) (Fig 4).

Present studies indicated the variations in the time of emergence of adults with peaks occurring at different standard weeks between different locations. During 2015-16 first trap catches were observed during 26th standard week (June) to 28th standard week (July) (Fig. 1) where as during 2016-17 first trap catches

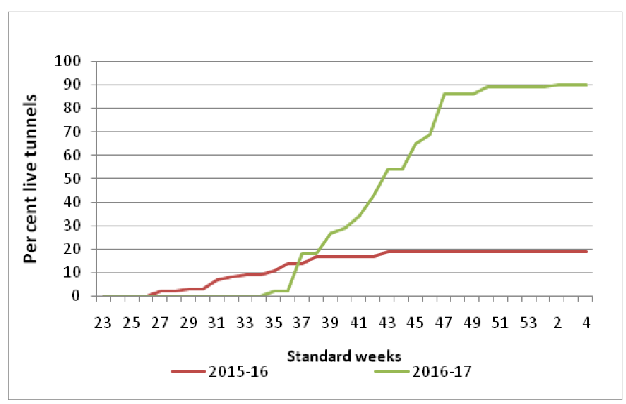


Fig 5: Percent live tunnels made by *C. scabrator* during 2015-16 and 2016-17 at Vijayapura

were found between the standard weeks 32 and 34 (August) (Fig 2). Similarly in the studies on occurrence of live tunnels at three locations revealed variations in the time of occurrence of first live tunnels and also magnitude of occurrence.

With respect to the appearance of live tunnels at location 1, incidence begun during 27th standard week (July) during 2015-16. At the same location during 2016-17 first live tunnels appeared during standard week 34 (August). Incidence level was 20.00 per cent during 2015-16. But greatest damage recorded during 2016-17 (90.00 per cent). Similar observations were recorded at location 2 (Fig 6). At location 3 first live

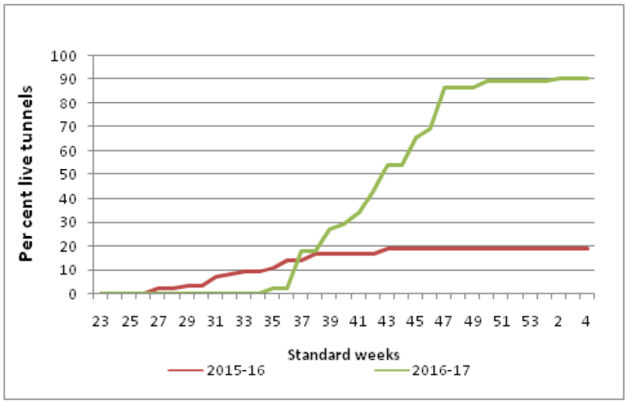


Fig 6: Percent live tunnels made by *C. scabrator* during 2015-16 and 2016-17 at Aliabad

tunnels appeared during 28th standard week (July) during 2015-16 whereas during 2016-17, incidences in the form of live tunnels appeared during 34th standard week (August). Similarly the severity of incidence ranged between 24.00 per cent during 2015-16 to 39.00 per cent during 2016-17 (Fig 7).

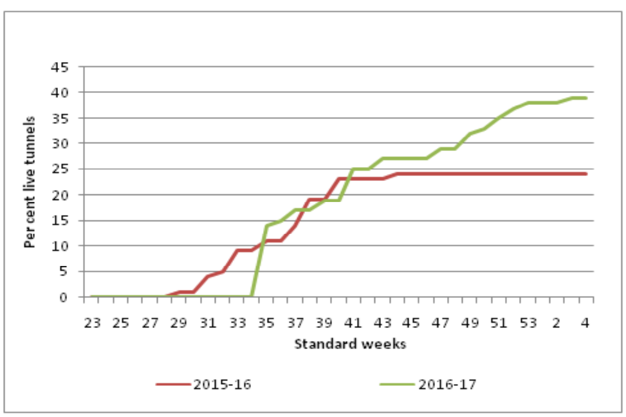


Fig 7: Percent live tunnels made by *C. scabrato*r during 2015-16 and 2016-17 at Tikota

Limited literature is available on the population dynamics of cerambycids in general and *C. scabrator* in particular. Mani *et al.* (2008) reported that adult beetles of *C. scabrator* emerge during July-August. Adult beetles start emerging from the vines during July to September by making a round hole on the vine. (http://farmer.gov.in/imagedefault/ipm/IPM%20package%20for%20Grapes.pdf). Bhawane *et al*. (2015) investigated that usually most of the longhorn beetles emerge after first shower of monsoon; the light traps were applied from 6. 00 pm to 10.00 pm.

The results of present investigation on population dynamics are not fully in agreement with the reports of earlier workers. The present study revealed that adults emerge not only between July-September but emergence continues throughout the months of October, November, December and January. Different emergence patterns of adults and appearance of live tunnels in grape ecosystem may be due to the fact that the pest has many alternate hosts like trees belonging to various families *viz.*, Casuarinaceae, Dipterocarpaceae, Leguminacae, Rhamnaceae, Verbenaceae, Myrtaceae, etc. (Choudhuri, 1963) on which the pest may complete its life cycle before attacking the grape vines.

Neglected gardens wherein no management practices were taken during the previous years for the management of pest are more susceptible to the attack of pest. This finding is in agreement with the findings of Mani *et al.* (2008) as the maximum incidence to the tune of 90.00 per cent was recorded at Vijayapura (Location one) which is totally a neglected garden.

First trap catches of beetles appear between 26th (June) and 28th standard weeks (July) and can be seen up to second standard week (January). Live tunnels appear between 27th (July first week) to 34th standard weeks (August fourth week) and are seen till 4th standard week (January fourth week). Emergence pattern of adults affects the formation of live tunnels. Neglected gardens are more susceptible to the attack of pest. Long term studies on the emergence pattern of stem borer adults, condition of vine orchards that influence the incidence of stem borer, life cycle on alternate hosts, climate effect on pest incidence and biology, influence of host plant factors (biophysical and biochemical) on pest will help in developing a forecast module for the pest *C. scabrator*

REFERENCES

BHAWANE, G. P., GAIKWAD, Y. B., GAIKWAD, S. M. AND MAMLAYYA, A. B., 2015, Longicorn beetles and their diet breadth from forest of Kolhapur District, Northern Western Ghats of Maharastra. *The Bioscan,* **10**(2): 679-684.

CHOUDHURI, J. C. B., 1963, New host plant of *Coelosterna scrabrator* Fabr. (Order: Coleoptera). *Current Science,* **9** : 434-435.

MANI, M., KULKARNI, N. S. AND ADSULE, P. G, 2008, Management of stem borer on grapes. *Extension folder No. 20.* National Research centre for grapes. Pune (India).

MANI, M., SHIVARAJU, C. AND KULKARNI, N. S., 2014, *The grape Entomology. S*pringer India. New Delhi.

http://farmer.gov.in/imagedefault/ipm/IPM%20package%20for%20Grapes.pdf)

www.nhb.gov.in/Horticulture%20Crops/Grape/Grape1.htm

www. http://nrcgrapes.nic.in/zipfiles/grape%20profile%20-%20nrc%20grapes.pdf

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 281-286, 2017

Species Diagnosis, Occurrence of Thrips and Bud Necrosis Virus Disease on Tomato

TIMMANNA AND MOHAN I. NAIK
Department of Agricultural Entomology, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: thimsento@gmail.com

ABSTRACT

The studies were carried out during *kharif* seasons of 2015-16 and 2016-17 at the Indian Institute of Horticultural Research, Hessaraghatta, Bengaluru to understand the role of thrips and impact of insecticide application on thrips and incidence of *Groundnut bud necrosis virus* (GBNV) on tomato var *Arka vikas*. Thrips collected in the experiment were identified as, *Thrips palmi* Karny, *Scirtothrips dorsalis* Hood and *Frankliniella schultei* Trybom and these three species were occurred together in tomato ecosystem. The results indicated that irrespective of thrips numbers, higher level of thrips incidence was observed at the flowering stage, 40 to 60 per cent of GBNV infection was observed from fourth week to till end of the crop.

Keywords :

TOMATO (*Solanum lycopersicum* L.) is one of the major and widely grown staple vegetable crop in both tropics and sub-tropics of the world and ranks second in importance among vegetables. In India tomato can be grown throughout the year. Though, the area under tomato cultivation is high but the productivity (15 t / ha) is low, due to various biotic and abiotic factors (Anonymous, 2016), Among the biotic factors, thrips transmitting tospovirus, *Ground Nut Bud Necrosis Virus* (GBNV) Disease having a greater negative impact on production of tomato.

Thrips are difficult to control due to their small size and ability to develop insecticide resistance and these attributes contribute to the success of this pathosystem and corresponding yield losses in agricultural systems. Thysanoptera is a diverse order includes more than 7700 species, among these 14 thrips species reported as vectors for tospoviruses worldwide, these viruses are exclusively transmitted by thrips in a circulative and propagative manner, and these viruses are not known to be existing in nature in absence of thrips vector. India hosts 700 species of thrips, of these five thrips species, suspected to be the tospovirus vectors *viz., Thrips palmi* Karny, and *Thrips tabaci* Lindeman, *Ceratothripoides claratris* (Shumsher), *Frankliniella schultzei* Trybom and *Scirtothrips dorsalis* Hood. They are transmitting five distinct tospoviruses *viz*., *Groundnut bud necrosis virus* (GBNV), *Watermelon bud necrosis virus* (WBNV), *Capsicum Chlorosis Virus* (CaCV), and *Iris Yellow Spot Virus* (IYSV) and *Peanut Yellow Spot Virus* (PYSV) in different vegetable and pulse crops. The losses due to GBNV disease in tomato depends mainly on the level of infection, stage of the crop, thrips population and severity of the disease. Early stage of the crop, *i.e.* 15-20 days after transplanting, flowering and fruit formation stage is susceptible to this virus. GBNV causes upto 100 per cent losses in tomato, chilli and groundnut and it was suspected to be transmitted by *T. palmi.* (Krishnareddy *et al.,* 2008; Kunkalikar *et al.,* 2011; Mandal *et al.,*2012), but the vector status and the virus transmissibility of all five thrips species need to be studied.

In India, meagre research efforts were made in respect of GBNV infecting tomato. Hence, this study has been formulated to understand the insights of thrips-virus pathosystem and their dynamics in different seasons.

MATERIAL AND METHODS

To study the occurrence of thrips and GBNV, tomato var. *Arka vikas* was planted for two consecutive growing seasons of *kharif* (June 15th 2015-2016 and 2016-2017) in two experimental plots, one without insecticide intervention (Control) and other treated with insecticide, Fipronil 5 SC (1.75ml/l) at 10 days interval till the harvest. In each treatment 15 replications were maintained.

One week after planting thrips number per plant and per cent disease incidence were recorded. Subsequent observations were made at weekly intervals till the end of the crop. During each sampling 15 plants were selected and tagged at randomly. Selected plant shoots were tapped on white paper and number of thrips were counted and recorded and per cent disease incidence was also recorded. During every sampling thrips individuals were collected and preserved in 70 per cent alcohol for taxonomic studies.

For morphological identification studies, the permanent microscopic slide mounts of thrips were prepared by maceration and dehydration protocol (modified protocol from Dr. J. S. Bhatti Delhi University), morphological key characters (Anon., 2012) of thrips were identified by using phase contrast microscope (Olympus BX) at the Department of Entomology, GKVK, Bengaluru.

Observations on mean number of thrips and disease incidence were subjected to statistical analysis using Analysis of variance (ANOVA) after suitable transformation.

Results and Discussion

Pooled data of two years indicated that the significant difference in thrips infestation and GBNV disease incidence was observed between fipronil and control plots (Fig. 1). Thrips infestation was lower in fipronil treatment at third week (1.53) to 6th week (1.67) after planting, and gradually decreases (0.93) as the crop matures. But higher level of thrips infestation was observed at 2nd week (8.07) to 6th week (9.40) after transplanting. Visual GBNV symptoms

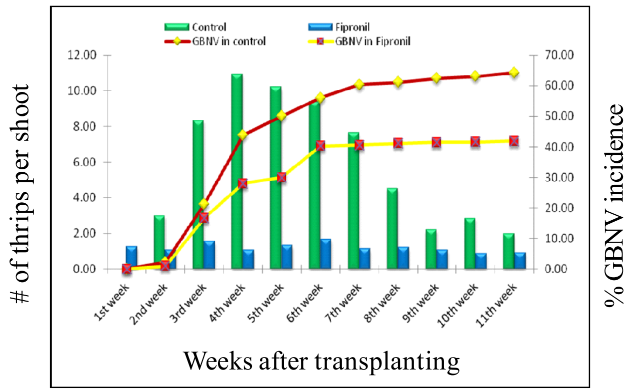
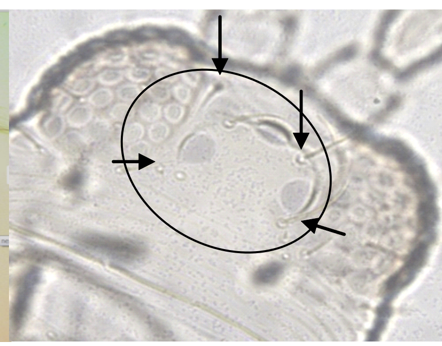
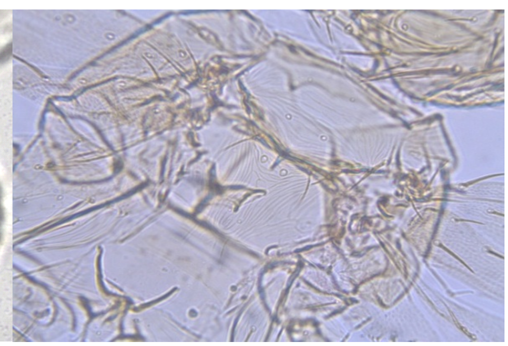


Fig.1: Mean incidence of thrips and GBNV during different weeks after transplanting

(i) Adult (@&)



(ii) 2 pairs of ocellar setae III pair is smaller



(iii) Campaniform sensillae present

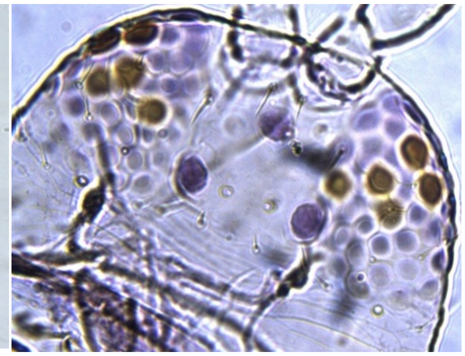
(iv) Ctenidia on tergite VIII is posterior to spiracle

(v) 3 distal setae with gap on forewing

Fig. A

(i) Adult (♀)

(ii) Antenna 7-8 segmented



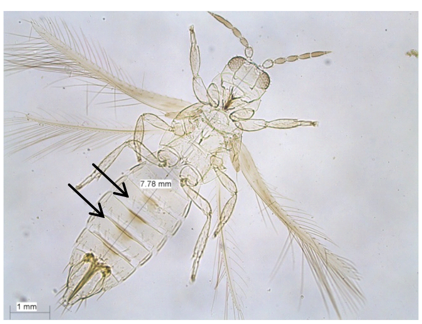
(iii) 3 pairs of ocellar setae

(iv) Campaniform sensilla absent

(v) Ctenidia on tergite VIII anterolateral to spiracle

(vi) Continuous 2 rows of setae on forewing

Fig. B

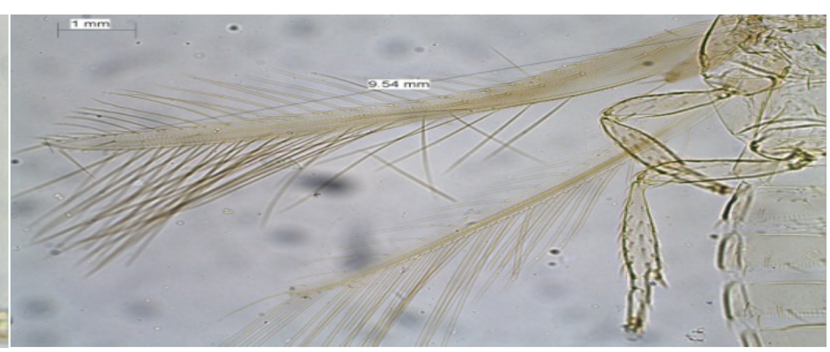


(i) Adult (♀) with dark brown patches anticostal ridges

(ii) Antenna 8 segmented

(iii) Closely spaced sculpture lines on pronotum

(iv) 4 pairs of posterior pronotal setae



(v) Long setae on both wings

Fig.C

TABLE I

Thrips and bud necrosis virus disease during different weeks after transplanting

Treatments	Thrips infestation and bud necrosis virus disease incidence in different weeks after transplanting (WAT)											
	1st WAT		2nd WAT		3rd WAT		4th WAT		5th WAT		6th WAT	
	No. Thrips	% GBNV	No. Thrips	% GBNV	No. Thrips	% GBNV	No. Thrips	% BNV	No. Thrips	% GBNV	No. Thrips	% GBNV
Fipronil 5 SC(1ml/l)	0.00	0.00	1.07	1.00	1.53	16.73	1.07	28.00	1.33	40.20	1.67	40.27
			(1.23)	(8.37)	(1.41)	(24.04)	(1.25)	(38.15)	(1.34)	(39.32)	(1.46)	(39.36)
Control	0.00	0.00	8.07	2.13	8.33	21.27	10.93	43.87	10.20	50.00	9.40	56.00
			(2.97)	(5.74)	(2.97)	(27.40)	(3.38)	(41.44)	(3.27)	(44.98)	(3.14)	(48.46)
SEM±	-	-	**0.29**	**0.06**	**0.14**	**0.73**	**0.18**	**1.29**	**0.22**	**1.23**	**0.19**	**1.12**
CD (0.05)	-	-	**0.89**	**0.19**	**0.43**	**2.22**	**0.55**	**3.92**	**0.66**	**3.75**	**0.57**	**3.38**

TABLE I (CONTD.)

Treatments	Thrips infestation and bud necrosis virus disease incidence in different weeks after transplanting (WAT)									
	7th WAT		8th WAT		9th WAT		10th WAT		11th WAT	
	No. Thrips	% GBNV	No. Thrips	% GBNV	No. Thrips	% GBNV	No. Thrips	% GBNV	No. Thrips	% GBNV
Fipronil 5 SC (1ml/l)	1.13	40.53	1.20	41.07	1.07	41.40	0.87	41.60	0.93	41.93
	(1.25)	(39.52)	(1.30)	(39.83)	(1.25)	(40.02)	(1.16)	(40.14)	(1.19)	(40.33)
Control	7.67	60.27	4.53	61.07	2.20	62.33	2.87	63.07	2.00	64.27
	(2.86)	(50.95)	(2.24)	(51.43)	(1.69)	(52.19)	(1.83)	(52.61)	(1.58)	(53.32)
SEM±	**0.17**	**1.06**	**0.11**	**1.12**	**0.06**	**1.22**	**0.07**	**1.13**	**0.05**	**0.99**
CD (0.05)	**0.51**	**3.23**	**0.34**	**3.40**	**0.19**	**3.71**	**0.21**	**3.44**	**0.14**	**2.99**

were not observed up to two weeks after planting. In contrast to thrips number the per cent disease incidence was higher in fipronil treatment, it increases from 3rd week (16.73%) after planting to the harvest (41.93%). The results indicated that more than the presence of thrips on tomato, there may be migrating adult thrips appear important in the spread of GBNV. It has been reported that inoculation access period for Western flower thrips, a vector of TSWV (Tomato spotted wilt virus) is few seconds to minutes (Ullman, 1997). It is likely that thrips successfully transmits the GBNV in a very short period possibly within few seconds to minutes. Thus, the fluctuating thrips population on tomato at any point of time may be less important compared to migrating adults. Further, our results indicated that the insecticide spray against thrips vectors to limit the spread the GBNV

Significant reduction of thrips numbers was observed in fipronil treated plot. In contrast to reduction in thrips number (following insecticide application), there was no significant reduction in GBNV infection (Table 4 and Figure D). GBNV incidence was higher in both the fipronil treated (41.40%) and control plots (64.27%). These results indicated that chemical control of thrips may not be an effective answer for management of GBNV, increased incidence of groundnut bud necrosis virus (GBNV) was observed due to the application of insecticide in groundnut (Amin *et al.,* 1980) as it facilitated higher dispersion of vector thrips.

The present study results are in conformity with the findings of Ullman *et al.* (1997) and Krishna Kumar *et al.*(2006), who reported that control of thrips transmitted plant pathogens can rarely be achieved using insecticides for several reasons. First, relatively a small number of vector thrips can result in high rate of pathogen spread. Second, many thrips species are intensely resistant to insecticides, so their populations are not well controlled. Third, inoculation of plant pathogen transmitted by thrips occurs quickly and the insects are not killed by the insecticide until after they have transmitted the pathogen. Finally, many epidemics are caused by dispersing thrips that are transient in the affected crop. Insecticides do not control this transient population unless applied at an unacceptable frequency. Our results fully support these findings.

Morphological identification of thrips species associated with tomato crop

During the present study, three thrips species were identified by morphological diagnostic key characters, which were prepared by using available resources (Mound and Kibby 1998; Thrips California website). Of these *Scirtothrips dorsalis* Hood was the predominant (60%) species followed by *Thrips palmi* Karny (30%) and *Frankliniella schultzei* Trybom (10%), these results are in agreement with the earlier reports, which stated that five thrips species were suspected to be the vectors of tospoviruses in India. but there was no particular study was carried out for the species specific thrips vector-virus interactions (Mandal *et al.,* 2012).

Key morphological diagnostic characters for identification of thrips

1. Terminal abdominal segment tubular, forewing (when present) without longitudinal veins, ovipositor represented by a small sclerotised eversible tube like opening on IX abdominal segment......................................2 (Tubulifera).
2. Terminal abdominal segment tubular, Forewing (when present) with longitudinal veins, ovipositor curved and serrated blades on IX abdominal segment ....3 (Terebrantia).
3. (2) Antennal segments III and IV with simple or forked sensory cones.....4(Thripidae)
4. (3) Legs covered with transverse rows of microtrichia.................Sericothripinae
   Legs covered without transverse rows of microtrichia......................................5
5. (4) Metathoracic endofurca elongated extending into mesothorax, terminal antennal segment not long and acute.. Dendrothripinae
   Metathoracic endofurca not elongated and usually not extending into mesothorax, terminal antennal segment variously shaped.........................6
6. (5) Head and legs usually with reticulate sculpture often body with heavy sculpture, terminal antennal segments long and acute.................................. Panchaetothripinae
   Head and legs are not reticulate but many have transverse lines of sculpture, terminal antennal segments not acute.................................7 (Thripinae)
7. (6) Abdominal tergites with rows of fine microtrichia S1 setae of abdominal sternites VII on posterior margin, ocellar setae III between posterior ocelli, posterior marginal cilia of fore wing straight ; lateral microtrichial fields of abdominal tergites with 3 discal setae; abdominal tergites usually with dark antero-medial shading......*Scirtothrips dorsalis* (Hood)
   Abdominal tergites with rows of fine microtrichia other characters are various............8
8. (7) Head with 3 pairs of ocellar setae(1 present), ctenidia of abdominal tergites VIII antero-lateral to the spiracle, forewing with two complete rows of vienal setae, antenna usually with 8 segments, pronotum usually with long setae on the anterior and posterior margin.............................. 9
   Head with 3 pairs of ocellar setae (1 absent), ctenidia of abdominal tergites VIII medial to the spiracle, forewing with gap in first row of vienal setae, antenna usually with 7 segments, pronotum usually with long setae only on the posterior margin...................13
9. (8) Pedicel antennal segment III simple (nearly parallel sided).................10
   Pedicel antennal segment III laterally expanded ....other *Frankliniella* spp.

10. (9) Head prolonged anterior of compound eyes..................other *Frankliniella* spp.
    Head not prolonged anterior of compound eyes..11.
11. (10) Compound eyes with 2-4 antero-lateral facets twice the diameter of other facets............. other *Frankliniella* spp.
    Compound eyes with antero-lateral facets not elongated............................12
12. (11) Ocellar setae III with in ocellar triangle and anterior of posterior ocelli, comb complete present on tergite VIII but short, metanotal companiform sensilla present....................*Frankliniella occidentalis* (Pergande)
    Ocellar setae III between the posterior ocelli, comb absent on tergite VIII, metanotal companiform sensilla absent......................... *Frankliniella schultzei* (Trybom)
13. (12) Abdominal sternites and pleurotergites without discal setae, comb on tergite VIII complete with long tines ....14.
    Abdominal sternites and pleurotergites with discal setae, comb various......other *Thrips* spp
14. (13) Tergite II with 3 lateral setae, abdominal pleurotergites with rows of microtrichia; metanotal companiform sensilla absent........... *Thrips tabaci* (Lindemann)
    Tergite II with 4 lateral setae, abdominal pleurotergites without rows of microtrichia; metanotal companiform sensilla present.............. *Thrips palmi* (Karny).

In conclusion, the present study indicated higher level of thrips incidence at the flowering stage and it reduces gradually after fruit setting. Insecticide fipronil was effective in reducing thrips load on tomato, but not effective in reducing GBNV infection. *T. palmi* was suspected to be the major vector of GBNV in groundnut, chilli and other vegetable crops, in our studies along with *T. palmi,* other species like *S. dorsalis* and *F. scultzie* were also observed and suspected to be the transmitters of GBNV. More basic research on virus-vector interactions and thrips migration, quick thrips identification techniques, screening of resistance sources are the needs of the hour for formulating the ecologically and economically viable management strategies for thrips and tospoviruses.

References

AMIN, P. W., REDDY, D. V. R., GHANEKAR, A. M. AND REDDY, M., 1980, Transmission of tomato spotted wilt virus, the causal agent of bud necrosis disease of peanut, by *Scirtothrips dorsalis* and *Frankliniella schultzei. Plant Disease,* **65** : 663-665.

ANONYMOUS, 2012, Thrips California 2012, website, (http://keys.lucidcentral.org/keys).

ANONYMOUS, 2016, Indian Horticulture Database, National Horticultural Board, Ministry of Agriculture, Government of India.

KRISHNA KUMAR, N. K., VENKATESH, N., KALLESHWARASWAMY, C. M. AND RANGANATH, H. R., 2006, Seasonal incidence of thrips and bud necrosis virus on watermelon. *Pest Management in Horticultural Ecosystems,* **12**(2): 85-92.

KRISHNA REDDY, M., USHA RANI, R., ANIL KUMAR, K. S., MADHAVI REDDY, K. AND PAPPU, H. R., 2008, *Capsicum chlorosis virus* (Genus: *Tospovirus*) infecting chilli pepper (*Capsicum annum*) in India. *Plant disease*, **92** (10) : 1469.

KUNKALIKAR, S. R., SUDARSANA, P., ARUN, B. M., RAJAGOPALAN, P., CHEN, T. C., YEH, S. D., NAIDU, R. A., ZEHR, U. B. AND RAVI, K. S., 2011, Importance and genetic diversity of vegetable-infecting tospoviruses in India. *Phytopathology.,* **101**: 367-376.

MANDAL, B., JAIN, R. K., KRISHNAREDDY, M., KRISHNA KUMAR, N. K., RAVI, K. S. AND PAPPU, H. R., 2012, Emerging problems of tospoviruses (Bunyaviridae) and their management in the Indian subcontinent. *Plant Disease*., **96**: 468-479.

MOUND, L. A. AND KIBBY, G., 1998, *Thysanoptera. An Identification Guide*. 2nd edition. Wallingford, UK, CAB International, p. 70.

ROTENBERG, D., JACOBSON, A. L., SCHNEWEIS, D. J. AND WHITFIELD, A. E., 2015, Thrips transmission of tospoviruses, *Current Opinion in Virology*., **15** : 80–89.

ULLMAN, D. E., SHERWOOD, J. L. AND GERMAN, T. L., 1997, Thrips as vectors of plant pathogens. In: *Thrips as crop pests.* Lewis, T. (Ed.) CAB International, New York, p. 695.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 287-296, 2017

Diversity of Scarab Beetles Attracted to Light Traps in Two Perennial Agro-ecosystems of Mudigere

M. H. Suchithra Kumari and A. R. V. Kumar
Department of Agricultural Entomology, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: mhsuchithra@gmail.com

Abstract

The activity pattern of scarabaeoid beetles was studied at Mudigere in two perennial crop ecosystems*viz*., Cardamom and coffee,for a period of two years from January 2015 to December 2016by setting up light traps fitted with 8 watt Philips Actinic BL UV tubes. The results indicated that the activity pattern of scarabaeoid beetles in both the ecosystems were highly scattered and distributed year round. However, moving averages indicated that two significant peaks of activity could be broadly identified within each year for the scarabs in the two locations. The most speciose family of the superfamily Scarabaeoidea attracted to light was Scarabaeidae. Scarabaeidae and Hybosoridae were common to both the ecosystems in both the years.By number of specimens, a total of 1235 (Mean= 8.64 ±15.22 per sample) and 1682 (13.57 ±26.53 per sample) were recovered from both the locations during 2015 and 2016, respectively that contributed to a total of 2917 specimens of scarabs distributed among 74 species.Activity and diversity parameters like abundance, species richness, Shannon-Weiner index and Simpson's reciprocal index were strongly inter-correlated. In both the years, cardamom was observed to be richer than coffee ecosystem, suggesting the potential impact of the differential management practices on the richness of the two ecosystems.

Keywords: Scarabaeidae, light trap, cardamom, coffee, abundance, species richness, diversity

Scarabaeoidea constitutes one of the largest cosmopolitan superfamily of Coleoptera consisting of ~31,000 species worldwide. Historically, scarabaeoids have served as objects of religion, culture, aesthetic appreciation and economic significance. In particular the dung beetles have attracted the attention of humans since the early Egyptian civilisation. But yet, surprisingly, little is known about the biodiversity and life histories of the majority of the world species. Scarabs also called as lamellicorn beetles are numerous, worldwide in distribution and both the phytophagous and non-phytophagous species are of significant economic importance, making them interesting subjects for ecological studies. The greatest diversity of scarabaeoid species occurs in the tropics, with the majority of known species represented by the family Scarabaeidae. Comprehensive research on scarab beetle diversity of central India was made by Chandra and Gupta (2012 a and b). However, their study was limited to central part of India and was largely an attempt to address the faunal composition from the taxonomic point of view. Studies on the diversity and abundance of scarabs were also attempted in Maharashtra (Thakare *et al*., 2011) especially in Kolkas region of Melghat Tiger Reserve and in Northeast India (Bhattacharya *et al*., 2017). Some work on the fauna of south India has been attempted by Sabu *et al.* (1995, 2006) and also on seasonality and community ecology (Anon., 2013-14; Aparna, 2015 and Kimondiu *et al*., 2017). Yet, none of these studies made attempts to assess the relative variability in the diversities of many of these groups at different locations.

Sampling is the basis of documenting the spatial distribution of species or assessing changes in ecosystem structure, composition and function. It is important to use simple and most effective methods to obtain an estimate of diversity and relative abundance of species. Different methods have been used for collecting beetles for research purposes and for preparing inventories depending on their biology and host range (Missa *et al*., 2009). Many groups of beetles are positively phototrophic and can be best sampled using light traps as is the case with scarabs. It has been reported that light source wave lengths (Viraktamath and Kumar, 2005) and hours of sampling influence scarab beetle catches (Lopez *et al*., 2011). The data provided by light trap catches could throw light on diversity and activity patterns of insects. In this study an attempt has been made to assess the diversity and abundance of scarabaeoid beetles supported by two perennial agro-ecosystems in Mudigere using light traps. Efforts have also been made to assess the impact of different abiotic factors on abundance, species richness and diversity of scarab beetles.

Material and Methods

The study was carried out in Mudigere, Chikkamagalur District, Karnataka State, India which is geographically located at 13°08' N latitude and 75°38' E longitude and at an altitude of 915 meters above sea level. Mudigere falls under the Hilly zone (Agro Climatic Zone 9) of Karnataka and receives an average annual rainfall of about 2500 mm.

Two perennial agro-ecosystems *viz*., cardamom and coffee were selected for sampling of scarab beetles. The samples were collected by setting up funnel and vane type of light traps fitted with two 8 watt Philips Actinic BL UV tubes (12" long- 16 % UVA) in each ecosystem, so that the light dispersed in all the 360 degrees, horizontally. These light traps were run at periodic intervals on specified dates for 12 hours from 6.00 p.m. to 6.00 a.m. next day morning. The light traps were run for a period of two years from January 2015 to December 2016. The insects attracted to light were collected in a container placed at the bottom of the light trap provided with salt water and soap solution as the killing agent. The trap catches were brought to the laboratory washed with fresh water, air dried and sorted to take out all scarabs. Larger scarabaeoid beetles were easily separated by handpicking and smaller ones were separated under a stereo-zoom microscope. All the specimens were further sorted into different morpho-types and assigned a code. Each morpho-type, in principle represented a taxonomic species. These morpho-types were identified by running the available keys and later the identified morpho-types were classified into their respective families, subfamilies and tribes and their numbers counted. The representatives of the morpho-types were pinned and the rest were stored in paper packets with proper labelling for further examination. Data on day wise catches were tabulated and analysed suitably to understand the patterns of activity, diversity, *etc*.

Results and Discussion

Patterns of activity of Scarabaeoids

The two agro-ecosystems were observed to differ in their ability to attract the scarab beetles to the light trap. As many as 143 and 124 nights of trapping was done during the year 2015 and 2016, respectively, in both cardamom and coffee ecosystems. A total of 1235 and 1682 individuals were collected during this period in the two ecosystems. Scarabs collected were 545 and 773 individuals in cardamom and 690 and 909 individuals in the coffee ecosystem during 2015 and 2016, respectively (Table I).

Considering the pattern of catches by individuals and numbers of species in the two ecosystems, it was observed that the trends were not clearly discernible. Therefore, three sample means were used to check for potential patterns. The three sample means for activity of scarabs in the two ecosystems could indicate roughly similar pattern across the years and across the two ecosystems. In all the cases, the two broad peaks could be made out. The first one roughly coincided with the beginning of the rainy season and the second one with the end of the rainy season (Figs. 1 to 4). However, in coffee ecosystem, the 2015 samples for individuals indicated an apparent single early monsoon peak. The trends were more or less similar across the years in both the systems held for both individuals and for the numbers of species. These patterns were similar to those observed earlier by Aparna (2015) in Bengaluru.

Abundance, Species Richness and Diversity of scarabaeoids in the two locations

As many as 545 (Mean = 8.93 ± 11.31 per sample) Scarabaeoidea specimens were recovered through light trap studies at the cardamom farm that also yielded 65 species (Mean = 4.38 ± 4.10 per sample) during 2015. At the coffee plantation during

TABLE I

Mean catches by numbers, species and diversity indices of scarabaeoid beetles collected at the two different locations of Mudigere during the year round light trapping in 2015 and 2016

Ecosystem	Year	Particulars	Total	Minimum	Maximum	Aver-age	SD
Cardamom	2015 (N=61)	No. of individuals	545	0	45	8.934	11.311
		No. of species	65	0	17	4.377	4.100
		Shannon-Weiner index	-	0	2.493	1.009	0.712
		Simpson's reciprocal index	-	0	10.256	3.078	2.175
	2016 (N=65)	No. of individuals	773	0	78	11.892	16.575
		No. of species	65	0	18	4.646	3.982
		Shannon-Weiner index	-	0	2.354	1.002	0.706
		Simpson's reciprocal index	-	0	7.813	3.113	2.074
Coffee	2015 (N=82)	No. of individuals	690	0	132	8.415	17.639
		No. of species	54	0	18	3.573	4.175
		Shannon-Weiner index	-	0	2.432	0.805	0.817
		Simpson's reciprocal index	-	0	10.667	2.509	2.669
	2016 (N=59)	No. of individuals	909	0	231	15.407	34.386
		No. of species	54	0	15	4.763	3.91
		Shannon-Weiner index	-	0	2.415	1.054	0.753
		Simpson's reciprocal index	-	0	10.256	3.263	2.206
Cardamom and Coffee together	2015 (N=143)	No. of individuals	1235	0	132	8.363	15.218
		No. of species	73	0	18	3.916	4.148
		Shannon-Weiner index	-	0	2.493	0.892	0.778
		Simpson's reciprocal index	-	0	10.256	2.752	2.478
	2016 (N=124)	No. of individuals	1682	0	231	13.565	26.526
		No. of species	74	0	18	4.702	3.932
		Shannon-Weiner index	-	0	2.415	1.027	0.773
		Simpson's reciprocal index	-	0	10.256	3.184	2.130

Note: SD = Standard deviation; N = No. of samples

the year 2015, 690 (Mean = 8.42 ± 17.64 per sample) scarabs were collected that accounted for 54 species (Mean = 3.57 ± 4.18 per sample). Similarly, during 2016, in cardamom, 773 (Mean = 11.89 ± 16.58 per sample) specimens were recovered that contributed 65 species (Mean = 4.65 ± 3.98 per sample). In coffee, during 2016, 909 (Mean = 15.41 ± 34.39 per sample) specimens were recovered that included 54 species (Mean = 4.76 ± 3.91 per sample) (Table I).

In all, 267 traps were run in the two locations over the two year period. This resulted in recovery of 2917 specimens of scarabs that were distributed among 74 species. By number of specimens, both the ecosystems were matching (mean values per trap) during 2015 while in 2016 more specimens were caught in coffee ecosystem. Nevertheless, the high standard deviation suggested a high degree of variability in trap catches in coffee ecosystem

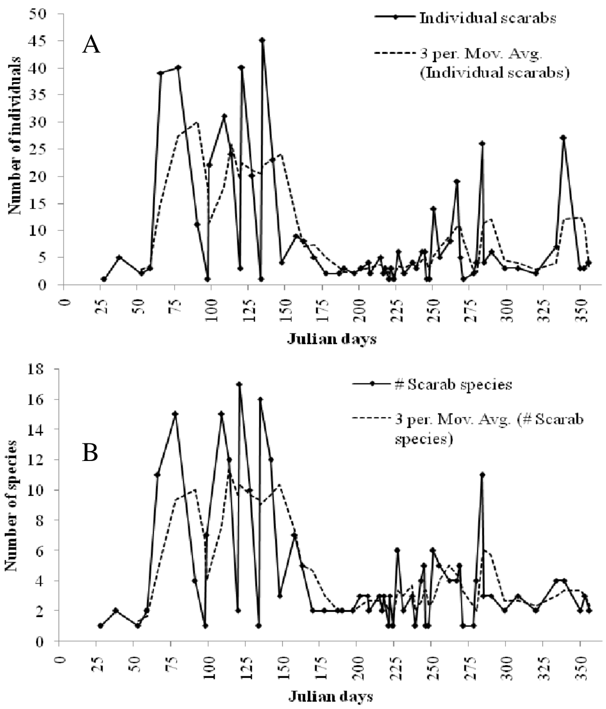


Fig. 1: Number of individuals (A) and number of scarab species (B) caught at light trap in cardamom during the year 2015 at Mudigere.

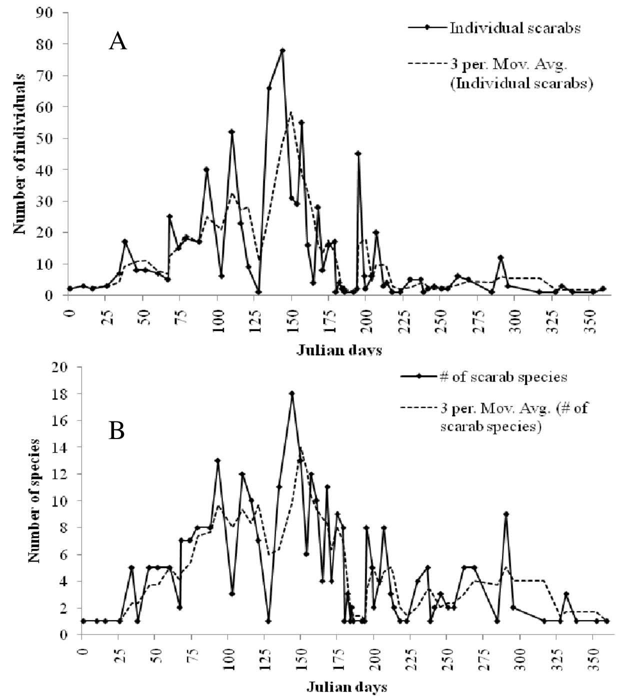


Fig. 3: Number of individuals (A) and number of scarab species (B) caught at light trap in cardamom during the year 2016 at Mudigere.

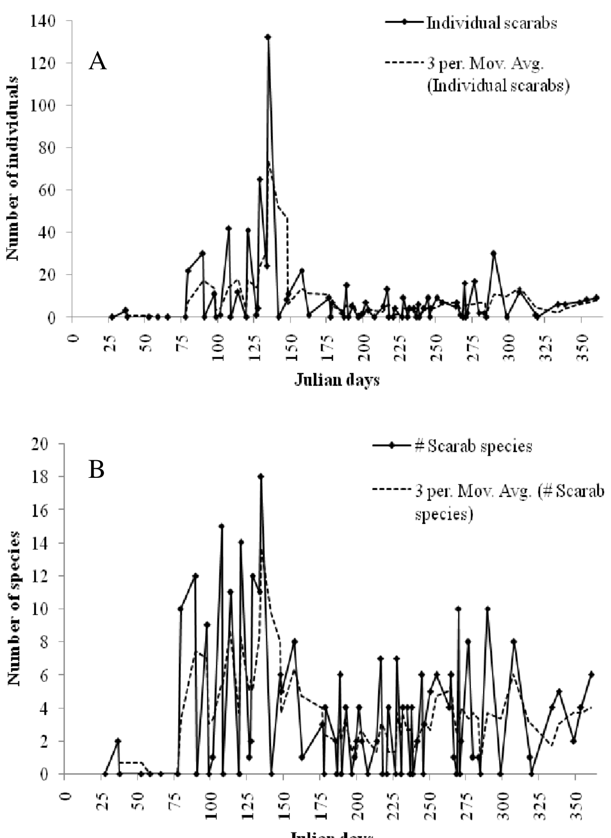


Fig. 2: Number of individuals (A) and number of scarab species (B) caught at light trap in coffee during the year 2015 at Mudigere.

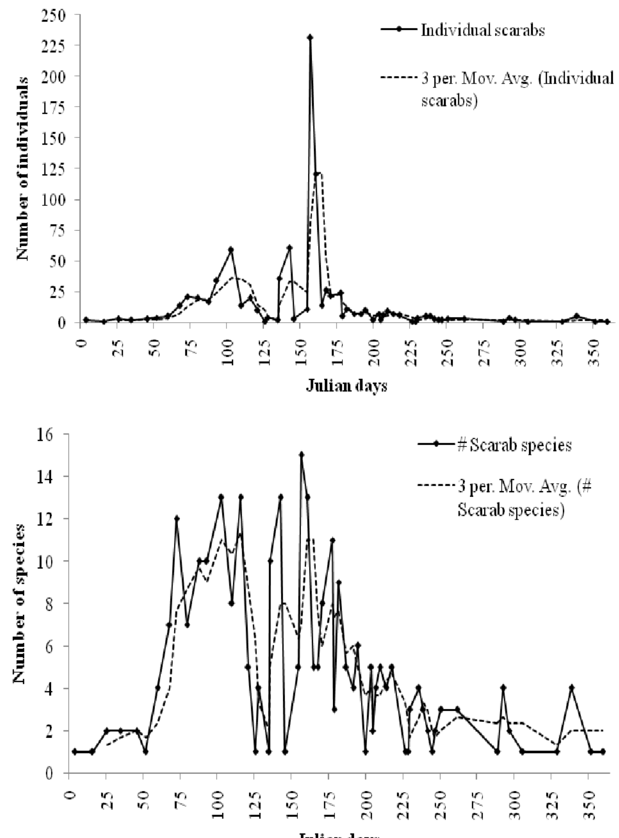


Fig. 4: Number of individuals (A) and number of scarab species (B) caught at light trap in coffee during the year 2016 at Mudigere.

compared to cardamom. Further interestingly, the number of species recovered remained constant for both the years across the two locations irrespective of the variable sample numbers and the mean abundances per trap. In both the years, the cardamom system accounted for higher species richness and greater species diversity compared to coffee system.

Species richness and taxonomic representation

In all 73 species were collected from the two ecosystems with 65 in cardamom and 54 in coffee ecosystem with 46 species being common to the two ecosystems. Nineteen species were unique to cardamom and eight unique to coffee system during 2015. While, 74 species were collected from the two ecosystems during 2016 with 65 in cardamom and 54 in coffee ecosystem with 45 species being common to the two ecosystems; 20 species were unique to cardamom and nine were unique to coffee ecosystem (Table I and II).

Diversity, species richness and abundance of many groups of insects are expected to remain stable or increase in agro-forestry systems, when supported by shade trees and relatively open canopy (Bos *et al.,* 2007). Both cardamom and coffee ecosystems fit this agro-forestry models, as in both the systems the shade trees are available. This aspect was not verified here in relation to forest system, but yet, it is intriguing to find significant differences between the numbers of species in the two systems. Generally non-phytophagous dung beetles are the ones that are expected to suit this idea of stability or increased diversity in systems where the shade trees are prevalent. Relative diversity of the two groups, phytophagous and non-phytophagous scarabs, was not studied here. But yet it is interesting to observe that two perennial, apparently similar agro-ecosystems, may not be similar in the scarab community composition despite being reasonably close (less than a km). The definitive reasons for this difference would

TABLE II

Taxonomic representation of scarabaeoid beetles collected at the light traps in cardamom and Coffee ecosystems of Mudigere during 2015 and 2016

Family	Cardamom								Coffee							
	2015				2016				2015				2016			
	No. of subfamilies	No. of tribes	No. of genera	No. of species	No. of subfamilies	No. of tribes	No. of genera	No. of species	No. of subfamilies	No. of tribes	No. of genera	No. of species	No. of subfamilies	No. of tribes	No. of genera	No. of species
Scarabaeidae	7	13	24	58	6	18	25	59	6	15	26	53	5	12	21	50
Bolboceratidae	1	1	1	1	1	1	2	2	0	0	0	0	0	0	0	0
Hybosoridae	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1
Lucanidae	1	1	1	1	1	1	1	1	0	0	0	0	1	1	1	1
Passalidae	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1
Trogidae	1	1	1	2	1	1	1	2	0	0	0	0	1	1	1	1
Total	**12**	**18**	**30**	**65**	**10**	**22**	**30**	**65**	**7**	**16**	**27**	**54**	**9**	**16**	**25**	**54**
Commom Sp.				46				45				46				45
Unique Sp.				19				20				8				9

be worth exploring through further analyses of the data in comparison with the ecosystem parameters.

A broad taxonomic representation of the scarabaeoid beetles attracted to light in cardamom and coffee during 2015 and 2016 are represented in Table II. It is evident that, the most speciose group was Scarabaeidae, while, other families were represented only in small numbers of species. Six and five families of scarabs were collected from cardamom ecosystem during the two years while only two and five families were collected from coffee ecosystem in both the years. Bolboceratidae was not recorded in coffee ecosystem during 2015 and 2016 while Scarabaeidae and Hybosoridae were common to both the ecosystems in both the years.

Interrelationships between weather parameters and the trap catch data

Using the data of abundance and species numbers caught over the sampling days, an attempt was made to understand the relationships between weather parameters and the various parameters of trap catches and diversity. The Pearson product moment correlation coefficients were worked out for daily catch abundances, species richness, Shannon-Weiner index, Simpson's reciprocal index and climatic variables for both the years (Tables III and IV).

In cardamom ecosystem, both during 2015 and 2016, all the activity parameters such as abundance, species richness, Shannon-Weiner index and Simpson's index were found to be strongly intercorrelated with high coefficients of determination (>70 % ; Table III). All the values were positive. However, the weather parameters considered such as rainfall, maximum daily temperature, minimum daily temperature, maximum daily relative humidity, minimum daily relative humidity were found to vary in their effect on the scarab activity parameters from year to year. The year to year variation was intractable and it was difficult to draw any strong conclusion on

TABLE III

Matrix for correlation between the weather parameters and abundance and diversity parameters in cardamom ecosystem of Mudigere during 2015 and 2016. (The upper triangle represents the data for 2015 and the lower triangle represents the data for 2016)

	Rainfall	Max. temperature	Min. temperature	Max. Relative humidity	Min. Relative humidity	Number of individuals	Number of species	Shannon-weiner index	Simpson's reciprocal index
Rainfall	1.00	-0.077	0.071	0.077	0.148	0.032	0.077	0.089	0.032
Max. temperature	-0.426*	1.00	-0.342*	0.00	-0.525*	0.481*	0.469*	0.314*	0.349*
Min. temperature	-0.134	0.374*	1.00	0.585*	0.699*	-0.044	0.00	0.063	0.031
Max. Relative humidity	0.088	-0.347*	-0.394*	1.00	0.418*	0.00	0.109	0.164	0.268*
Min. Relative humidity	0.281*	-0.723*	-0.170	0.554*	1.00	-0.300*	-0.202	-0.044	-0.126
Number of individuals	-0.054	0.317*	0.207	0.089	0.044	1.00	0.923*	0.723*	0.673*
Number of species	-0.161	0.317*	0.272*	0.070	0.070	0.863*	1.00	0.883*	0.870*
Shannon-Weiner index	-0.212*	0.219*	0.209	0.118	0.104	0.594*	0.880*	1.00	0.927*
Simpson's reciprocal index	-0.181	0.194	0.187	0.054	0.089	0.492*	0.837*	0.941*	1.00

Note: * Significance at 0.05 (No. of samples 2015 = 61 and 2016 = 65) the effect of any of the weather parameters on the activity and diversity parameters of the scarabs in cardamom ecosystem. Soil moisture is expected to be the single most influencing factor on the activity of scarabs. However, rainfall, anticipated to be the proxy for the soil moisture state was not found to be correlated with the activity of the scarabs in both the years in caradamom ecosystem (Table III).

In coffee ecosystem, although the various activity and diversity parameters considered were positively intercorrelated during the two years of survey, the coefficients of determination were highly variable and quite low. A case in point is the lack of good association between the abundance and the Simpson's reciprocal index during 2016. Considering the various weather parameters and their effect on the activity and diversity parameters in coffee ecosystem, the trends were unpredictable between the year. As was the case with caradamom system, the commonality in the effects of the weather parameters from year to year on the scarab activity was not possible to be clearly deduced. As a corollary, even in coffee ecosyetm it was noted that the rainfall had no effect on the activity of scarabs in both the years (Table IV).

The relationships between species abundance and factors driving the biodiversity are often largely unknown (Terradas *et al*., 2004). However, it has been proven that many variables are statistically related to species richness and distribution: *e.g.*, climate, altitude (Kessler, 2009), latitude (Andrew and Hughes, 2005), physical factors of the soil, disturbance degree (Davis and Philips, 2009) and temporal dynamics (Gobbi *et al*., 2007). Among these, rainfall is an important factor that influences variation in the insect activity in tropics (Wolda, 1988) and semi-arid ecosystems (Liberal *et al*., 2011). The activity of scarab beetles in tropical regions is often synchronized or maximized in line with rainfall (Aparna 2015; Bhattacharyya *et al*., 2017).

TABLE IV

Matrix for correlation between the weather parameters and abundance and diversity parameters in coffee ecosystem of Mudigere during 2015 and 2016. (The upper triangle represents the data for 2015 and the lower triangle represents the data for 2016)

	Rainfall	Max. temperature	Min. temperature	Max. Relative humidity	Min. Relative humidity	Number of individuals	Number of species	Shannon-weiner index	Simpson's reciprocal index
Rainfall	1.00	-0.151	0.054	0.089	0.228*	-0.054	-0.063	0.00	0.00
Max. temperature	-0.039	1.00	-0.386*	0.070	-0.508*	0.322*	0.316*	0.144	0.122
Min. temperature-	-0.044	0.368*	1.00	0.192	0.577*	-0.144	-0.077	0.044	0.054
Max. Relative humidity	0.288*	-0.407*	-0.192	1.00	0.408*	0.077	0.094	0.077	0.063
Min. Relative humidity	0.378*	-0.692*	-0.054	0.595*	1.00	-0.044	-0.031	0.031	0.063
Number of individuals	-0.063	0.00	0.209	0.054	0.189	1.00	0.802*	0.466*	0.316*
Number of species	0.00	0.192	0.519*	0.031	0.109	0.684*	1.00	0.876*	0.758*
Shannon-Weiner index value	0.114	0.154	0.498*	0.122	0.118	0.260*	0.824*	1.00	0.899*
Simpson's reciprocal index	0.054	0.240	0.475*	0.00	0.00	0.094	0.741*	0.904*	1.00

Note: * Significance at 0.05 (No. of samples 2015 = 82 and 2016 = 59)

Soil dwelling scarabs are expected to be greatly impacted by the soil moisture conditions. In particular, in tropical situations such as Mudigere, where clear cut dry seasons are followed by the rainy months, it was anticipated that the effect of rainfall would be strongly borne out on the scarb abundace and diversity (Wolda, 1988). Despite a two year long effort, the present study however, did not bear out any such strong effect. Several factors might contribute for this situation. Mudigere being a heavy rainfall area (>2500 mm per annum) the initial rains may sufficiently provide the wetness for a continued relatively stable wet conditions for the activity of the scarabs thus later rains may have slight impact. Such a situation is a possibility, as in studies carried out at Bengaluru clearly indicated two peaks of activity one during the beginning of the rainy season and later at the end of the rainy season (Aparna, 2015 and Anon., 2014). Broad similar trends were evident in the present study also for abundance and species richness. This could potentially be a possibility as scarabs as a community represents variable life history situations. Most phytophagous species require moisture for their activty during their larval periods. As a result, the adults may tend to remain active during the early part of the season allowing an extended activity period for the larvae. On the contrary, the non-phytophagous species may rely not just on soil moisture state but also on the moiture state of the available food or micro habitat such as dung. This might permit them to remain active for an extended period and further as these resources are likely to be ephemeral, they may be relatively smaller in size with shortened life cycle duration. An assessment of the relative body sizes of the two communities and their activity breadths would possibly provide an insight into this aspect.

Wolda (1978) proposed two general hypotheses to explain the variability in activity patterns of tropical insects: climatic predictability and seasonal variation of food resources. The former suggests that populations should fluctuate less in areas where the climate is more predictable. The latter argues that insect numbers should be directly related to seasonal variations depending on the availability of food resources. In tropics, among all climatic factors (temperature, photoperiod, rainfall and wind speed) rainfall and variation in the availability of food resources are the important factors in triggering seasonal activity of insects (Frolov and Akhmetova, 2013; Medina and Lope, 2014; Lopez *et al*., 2010). Temperature affects the insect activity and diversity on a long term basis than short term. Thus clearly the increasing temperatures of the globe are a concern in the context of climate change (Kimondiu *et al*., 2017). The seasonality of dung beetle assemblages constantly changes and the relative abundance of individual species changes along with change in the weather parameters (Kakkar and Gupta, 2009). Thus the general idea of variable activity of phytophagous and non-phytophagous species that revolves around the more predictable monsoon seems to be evident in the present study also. However, the non-phytohagous species such as the dung feeding scarabs are likely to remain affected by the prevailing weather factors. In the present study, the two communities are mixed up and thus clear cut conclusions are difficult to be drawn. Yet, further analyses of the data may help generate better ideas.

The present study indirectly suggests possibility of the scarab activity being controlled by the rainy season in Mudigere. The two generalized peaks observed for abundance and species richness fit the two ends of the monsoon period in Mudigere. A second important aspect that could be noted was the higher species richness in cardamom ecosystem. Potentially this reflects the relative impact of the management system between the coffee and the cardamom. Cardamom is more cared for and has greater degree of disturbance and soil enrichment while relatively coffee is less cared for and possibly promotes hardier species. It is felt that more detailed analyses of the data may help improve the ability to sort out the effects of various weather parameters, in particular the rainfall on the activity of various ecological guilds within the scarabs. Further, as many scarabs are pestiferous, it is suggested that monitoring the community would help improve the management practices.

References

Annonymous, 2013-14, *Annual Report,* Univ. Agric. Sci., Bengaluru, p. 96.

Andrew, L. R. and Hughes, L., 2005, Diversity and assemblage structure of phytophagous Hemiptera along a latitudinal gradient: predicting the potential impacts of climate change. *Global Eco. Biogeo.*, **14**: 249-262.

Aparna, S., 2015, Diversity and community structure of Scarabaeoidea (Coleoptera) attracted to light at GKVK, Bengaluru. *M.Sc. Thesis* (Unpub.), Univ. Agric. Sci., Bengaluru.

Bhattacharyya, B., Gautam, H., Pujari, D., Bhagawati, S., Mishra, H., Gogoi, D. and Debnath, H., 2017, Species diversity and relative abundance of scarab beetle fauna in Assam, northeast India. *J. Ent. Zoo. Studies*, **5**(1): 711-716.

Bos, Merijn ,M., Patrick H¨ohn, Shahabuddin Saleh, Boris B¨uche, Damayanti Buchori, Ingolf Steffan-Dewenter and Teja Tscharntke, 2007, Insect diversity responses to forest conversion and agroforestry management. In : Tscharntke T, Leuschner C, Zeller M, Guhardja E, Bidin A (eds), *The stability of tropical rainforest margins, linking ecological, economic and social constraints of land use and conservation*, Springer, Berlin 2007, p. 279-296.

Chandra, K. and Gupta, D., 2012a, Diversity and relative abundance of pleurostictScarabaeidae (Coleoptera) in Achanakmar-Amarkantak biosphere reserve, central India. *World J. Zoo.*, **7**(2): 147-154.

Chandra, K. and Gupta, D., 2012b, Diversity and composition of dung beetles (Scarabaeidae: Scarabaeinae and Aphodiinae) assemblages in Singhori Wildlife Sanctuary, Raisen, Madhya Pradesh (India). *Munis Ent. Zoo.*,**7**(2): 812-827.

Davis, A. L. V. and Philips, T. K., 2009, Regional fragmentation of rain forest in West Africa and its effect on local dung beetle assemblage structure. *Biotropica*, **41**: 215-220.

Frolov, A. and Akhmetova, L., 2013, A contribution to the study of the Lower Volga center of scarab beetle diversity in Russia: checklist of the tribe Aphodiini (Coleoptera, Scarabaeidae) of Dosang environs. *Biodiver. Data J.* 1: e979. doi: 10.3897/BDJ.1.e979.

Gobbi, M., Rossaro, B., Vater, A., Debernardi, F., Pelfini, M. and Brandmayr, P., 2007, Environmental features influencing carabid beetle (Coleoptera) assemblages along a recently deglaciated area in the Alpine region. *Ecol. Ent.*, **32**: 682-689.

Kakkar, N. and Gupta, S. K., 2009, Temporal variations in dung beetle (Coleoptera: Scarabaeidae) assemblages in Kurukshetra, Haryana, India. *J. Threatened Taxa*, **1**(9): 481-483.

Kessler, M., 2009, The impact of population processes on patterns of species richness: lessons from elevation gradients. *Basic Appl. Eco.*, **10**: 295-299.

Kimondiu, J. M., Gyneshwar Jha, Kumar, A. R. V. and Ganeshaiah, K. N., 2017, Temporal patterns of insect diversity in Bengaluru - A study using light traps. *Mysore J. Agric. Sci.*, **51** (1): 78-84.

Liberal, C. N., Isidro De Farias, A. M., Meiado, M. V., Filgueiras, B. K. C. and Iannuzzi, L., 2011, How habitat change and rainfall affect dung beetle diversity in Caatinga, a Braziliansemi-arid ecosystem. *J. Insect Sci.,* **11**: 1-11

Lopez, A. E., Mico, E. and Manuel, A., 2011, Sampling scarab beetles in tropical forests: the effect of light source and night sampling periods. *J. Insect Sci.,* **11**: 95-99.

Lopez, A. G., Catherine-numa, E. A. and Galante, E., 2010, Spatiotemporal variation of scarab beetle assemblages (Coleoptera: Scarabaeidae: Dynastinae, Melolonthinae, Rutelinae) in the Premontane rain forest in Costa Rica: a question of scale. *Ann. Entomol. Soc. America*, **103** (6) : 956-964.

Medina, A. M. and Lope, P. P., 2014, Resource Utilization and temporal segregation of Scarabaeinae (Coleoptera, Scarabaeidae) community in a Caatinga Fragment. *Neotropical Ent.,* **43**:127-133.

Missa, O., Basset, Y., Alonso, A., Miller, S. E., Curletti, G., Meyer, M. D., Eardley, C., Mansell, M. W. and Wagner, T., 2009, Monitoring arthropods in a tropical landscape: relative effects of sampling methods and habitat types on trap catches. *J. Insect Conser.*, **13**: 103-118.

SABU, K., JAYAKUMAR, K. AND ANANTHAKRISHNAN, T. N., 1995, Dynamics of insect communities at varying altitudes in Shola forests of Kodaikanal hills, in relation to the chemical diversity of litter. *Int. J. Eco. Environ. Sci.,* **21**: 109-129.

SABU, K., VINOD, K. V. AND VINEESH P. J., 2006, Guild structure, diversity and succession of dung beetles associated with Indian elephant dung in South Western Ghats forests. *J. Insect Science,* **6**: 17-20.

TERRADAS, J., SALVADOR, R., VAYREDA, J. AND LORET, F., 2004, Maximal species richness: An empirical approach for evaluating woody plant forest biodiversity. *Ecol. Monographs*, **189**: 241-249.

THAKARE, V. G., ZADE, V. S. AND CHANDRA, K., 2011, Diversity and Abundance of Scarab Beetles (Coleoptera: Scarabaeidae) in Kolkas Region of Melghat Tiger Reserve (MTR), District Amravati, Maharashtra, India. *World J. Zoo.,* **6** (1): 73-79.

VIRAKTAMATH, S. AND KUMAR, K. H. D., 2005, Efficacy of two types of light traps in attracting insect pests of economic importance. *Ins. Env.,* **10**(4): 162-164.

WOLDA, H., 1978, Seasonal fluctuations in rainfall, food and abundance of tropical insects. *J. Ani. Eco.*, **47**: 369–81.

WOLDA, H., 1998, Insect seasonality: Why? *Ann. Rev. Eco. Syst.*, **19**: 1-18

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 297-302, 2017

Development of Scale to Measure Attitude of Schedule Caste Farmers towards Integrated Farming System in Southern Karnataka and Its Application

S. Sujay Kumar and K. Narayanagowda
Department of Agricultural Extension, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: sujay.suji538@gmail.com

Abstrct

The present study was contemplated to develop and standardize the scale to measure attitude of SC farmers towards IFS in Sothern Karnataka. Based on the review of literature and discussion with the experts, 55 items were enlisted. Out of 55 statements, 17 statements were retained in the final scale. The scale developed was found reliable (0.8911) and valid (0.9439). The reliability and validity of the scale indicates its precision and consistency in assessing the attitude of SC farmers towards IFS. Majority of the respondents (35.00%) had most favourable attitude towards IFS followed by 35.00 per cent had favourable attitude and 30.00 per cent had least favourable attitude towards IFS.

Keywords: Integrated farming system, schedule caste, attitude, reliability and validity

India is an agricultural country where in more than 54.60 per cent of the population depends on agriculture for their livelihood and its contributes 13.70 per cent of Gross Domestic Product (GDP) in the country (2012-13). It has received the highest priority in the programmes of planned change, as it provides employment opportunity for the rural mass by maximizing the productivity in the field of agriculture and allied fields viz. animal husbandry, horticulture, sericulture, etc.

In India, 85 per cent of the land holding are small and marginal. The per capita availability of agriculture land has been decreased from 0.638ha in 1950-51 to 0.271ha by the end of the century and projected further decline to less than 0.10ha by 2020. This situation is further alarming among Scheduled Caste (SC) farmers. This decline trend in size of land holding with climatic changes possess a serious challenge to sustainability and profitability of farm. There is no scope for increasing the farm size, because of steady increase in population with shrinkage of cultivated land as a result of industrialisation and urbanization. Only vertical expansion is possible by integrating appropriate farming components requiring lesser space and time ensuring periodic income to the farmer. Hence, the Integrated Farming System (IFS) is the possible solution for assured regular income for a reasonable standard of living which includes agriculture and allied other enterprises. IFS is a judicious mix of one or more enterprise with cultivation of diversified crops in which there is a complementary effect through effective recycling of wastes/ residues and provide additional source of income. The IFS, therefore, assumes greater importance for sound management of farm resources to enhance the farm productivity, reduce the environmental degradation, improve the quality of life of resource poor farmers and to maintain the sustainability. IFS is not only reliable way of obtaining fairly high productivity with considerable scope for resource recycling, but also a concept of ecological soundness leading to sustainable agriculture.

An innovative action research project entitled Development of SC farm families in 17 districts of Southern Karnataka through Integrated Farming System approach was conceptualized and implemented by the University of Agricultural Sciences, Bengaluru (UASB) during 2009-10. The main objective of project is to improve the livelihood security, productivity, profitability and employment generation of SC farmers through IFS approach.With this background, the present study is taken up with the following specific objectives :

1) To develop and standardize a scale to measure the attitude of SC farmers towards IFS.
2) To analyse the attitude of SC farmers towards IFS.

METHODOLOGY

Attitude is an organized predisposition to think, feel, perceive and behave towards a cognitive object. Likert (1932) defined attitude is the degree of positive or negative disposition/association towards an innovation, objects, programme etc. Similarly, Thurstone (1946) also defined that attitude is a degree of positive or negative effects associated with some psychological object like symbol, person, institute, ideal or idea towards which people can differ in varying degrees.

Attitude in this study is operationally defined as the positive or negative mental predisposition of SC farmers towards IFS. The method of summated rating suggested by Likert (1932) was followed in the development of the scale. The following steps were considered for developing attitude scale to measure the attitude of SC farmers towards IFS.

Collection of Items

The objective of collection of items / statements for the attitude scale construction is to select the items in such a way that acceptance and rejection of each one will imply favourable or unfavourable attitude towards IFS. The items have been carefully edited and selected in accordance with set criteria as the items in any psychological test. The first step in the construction of attitude scale was to collect exhaustive number of statements / items pertaining to the IFS, accordingly, each one expressing some opinion about the psychological object under the study. A large number of items were collected from review of literature, informal discussion with agriculture extension personnel and experts from selected areas. Tentative list of 55 statements pertaining to the attitude of farmers towards IFS was prepared.

Editing of Item

The items collected were edited and modified as attitude statements as per the 14 criteria suggested by Thurstone and Chave (1929). Forty four statements were selected based on 14 criteria and the remaining 11 statements were eliminated.

Relevancy Analysis

Forty four statements were mailed to 105 experts comprising of Assistant Professors (those who had minimum of 3 years' experience), Associate Professors, Professors, Scientists, Extension personnel of State Agricultural Universities, Deemed Universities, National Institutes (NIRD and MANAGE) and ICAR institutes with appropriate instructions to critically judge the items for their relevancy in measuring the attitude of SC farmers towards IFS. They were asked to check each of the statements carefully for being relevant or not relevant using five point continuum *viz.,* Most Relevant (MR), Relevant (R), Somewhat Relevant (SWR), Less Relevant (LR) and Not Relevant (NR) with the score of 4,3,2,1 and 0, respectively. The judges were also requested to make necessary modifications and additions or deletion of components, if they desire so. The relevancy score for each item was found out by adding the relevancy scores of the rating given by 54 judges.

The relevancy score of each statement was ascertained by adding the scores on rating scale for all 54 judges responses. From this data, relevancy percentage and mean relevancy score were worked out for all the statements by using the following formulae :

$$\text{Relevancy Percentage} = \frac{(MRx4)+(Rx3)+(SWRx2)+(LRx1)+(NRx0)}{\text{No. of judges responded x Maximum score}} \text{ x100}$$

$$\text{Mean Relevancy Score} = \frac{R \text{ x } 4 + R \text{ x } 3 + SWR \text{ x } 2 + LR \text{ x } 1 + NR \text{ x } 0}{\text{No. of judges responded}}$$

Where,

MR= Most Relevant

R= Relevant

SWR= Somewhat Relevant

LR = Less Relevant and

NR= Not Relevant

Maximum possible score = 216 (54 x 4)

Number of Judges = 54

Accordingly, components having relevancy percentage of 70 and above and mean relevancy score of 2.40 and above were considered for further processing and suitably modified as per the comments of experts wherever applicable. Finally, thirty two components were selected for item analysis.

Item Analysis

To delineate the items based on the extent to which they can differentiate the attitude items about IFS as favourable or unfavourable, item analysis was carried out on the 32 items / statements selected after relevancy analysis. For item analysis, the respondents were arranged in ascending order based on attitude scores. Twenty five per cent of the subject with the highest of subjects total score and 25 per cent with the lowest total scores were selected. These two groups provided the criterion groups in terms of which item anaysis was conducted and critical ratio was calculated by using the following formula:

$$t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\dfrac{\sum(X_H - \bar{X}_H)^2 + \sum(X_L - \bar{X}_L)^2}{n(n-1)}}}$$

Where,

$$\sum(X_H - \bar{X}_H)^2 = \sum {X_H}^2 - \frac{(\sum X_H)^2}{n}$$

$$\sum(X_L - \bar{X}_L)^2 = \sum {X_L}^2 - \frac{(\sum X_L)^2}{n}$$

$\bar{X}_H$ = The mean score on a given statement for the highgroup

$\bar{X}_L$ = The mean score on a given statement for the low group

"X_H^2= Sum of squares of the individual score on a given statement for high group

"X_L^2= Sum of squares of the individual score on a given statement for low group

"X_H= Summation of scores on given statement for high group

"X_L= Summation of scores on given statement for low group

n= Number of judges in low and high groups

t= The extent to which a given statement differentiate between the high and low groups.

Σ = Summation

Based on the item analysis ('t' value), four items were significant at 5 per cent level and thirteen items were significant at 1 per cent level. Seventeen items which were statically significant at 5 per cent and 1 per cent level were finally retained in the scale to measure the attitude of SC farmers towards IFS.

Reliability and validity of the scale

Reliability: Reliability refers to the precision or accuracy of the measurement or scale. A well-made scientific instrument should yield accurate results both at present as well as over time (Ray and Mondal, 2011). Split half method was used for testing reliability scores of two halves and to find out the reliability co-efficient. The split half test reliability formula used is as follows:

$$\mathbf{r}_{1/2} = \frac{N(\sum XY - (\sum X)(\sum Y)}{(N\sum X^2 - (\sum X)^2)(N\sum Y^2 - (\sum Y)^2}$$

Where,

"X=sum of the socres of the odd number items

"Y=sum of the scores of the even numbers items

"X²= sum of the squares of the odd number items

"Y²= sum of the squares of the even number items

Split-half method of reliability is used with instrument that has many items and where pairs of items can be considered equivalent. Equivalence indicates the internal consistency of measuring device. The scale developed for the study was administered to 30 SC IFS beneficiary farmers in the non-sample area. Further, the scale was divided into two halves based on odd and even numbered statements and scores were found out from the same respondents for each half. The score of each respondent was calculated with a scoring pattern of 5, 4, 3, 2 and 1 for positive statements and for negative statements scores were reversed. The value of correlation co-efficient was 0.8036 and this was further corrected by using Spearman Brown formula and obtained the reliability co-efficient of the whole set. The 'r' value of the scale was 0.8911, which was highly significant at one per cent level indicating the high reliability of the scale.

Validity refers to the ability of the instrument to measure what it proposed to measure (Mulay and Sabarthanam, 1980). Validity of a scale is the property which ensures that the test scores obtained measure the variable they are supposed to measure. Content validity or construct validity and criterion validity are the methods generally followed to know the validity of the scale.

According to Kerlinger (1973), content validity is the representativeness or sampling adequacy of the content – the substance, the matter and the topics of a measuring instrument. He further stated that, content validation consists essentially in judgement. Alone or with others, one judges the representativeness of the item. The data was subjected to statistical validity, which was 0.9439, for attitude scale. Hence, the validity co-efficient was also found very high. Therefore, the scale developed is both reliable and valid. The delineation of statements at various steps of attitude scale construction is presented in Table I.

TABLE I

Delineation of statements at various steps of attitude scale construction

Steps in attitude scale construction	No. of Statements	
	Statements considered	Statements retained
Collection of items	55	55
Editing of items	55	44
Relevancy analysis	44	32
Item analysis	32	17
Reliability and validity	17	17

The final scale (Table II) consists of 17 statements of which, 12 are positive statements and the remaining five statements are negative. The

TABLE II

Statement considered to measure the attitude of scheduled cast farmers towards IFS

Statements	SA	A	UD	DA	SDA
Integrated farming system is an innovative approach					
Farmers view agriculture as a profitable venture due to IFS					
IFS is the best approach among the different farming systems					
Farm mechanization in IFS is very difficult due to integration of various enterprises					
The wastage of crop residues/by products is nil in IFS					
IFS improves the soil fertility status					
The labour requirement is more in IFS compared to other farming systems					
The social status of IFS farmers is better compared to non IFS farmers					
IFS demands more quantity of inputs than other farming systems					
Scope of adoption of Indigenous technical knowledge in IFS is more compared to other farming systems					
IFS requires more initial investment than other enterprises					
The IFS can be adopted by all categories of the farmers					
Management of different agriculture and allied component in IFS is very cumbersome					
There is more scope for organic farming in IFS than other farming systems					
The quantity of inputs required can be reduced due to recycling of the waste in the IFS farm					
The farm management in IFS requires specialized skills which are lacking among most of the farmers.					
IFS provides employment for all the members of the family					

SA= Strongly agree; A= Agree; UD= Undecided; DA= Disagree; SDA= Strongly disagree response could be collected on a five point continuum, namely, strongly agree, agree, undecided, disagree and strongly disagree with assigned scores of 5,4,3,2 and 1, for positive statements and vice versa for negative statements.The minimum and maximum score one could get is 17 and 85, respectively. The attitude score of a respondent can be calculated by adding up the scores obtained by him/her on all the items. The respondents will be categorized into less favourable, favourable and more favourable categories by considering mean and standard deviation. Higher the attitude score indicates the high favorableness of respondents towards IFS and lesser the attitude score indicates less favorableness towards IFS.

Results and Discussion

A perusal of Table III revealed the district-wise attitude of respondents towards IFS. In Chitradurga district, majority of the respondents (55.00%) had favourable attitude towards IFS followed by 28.33 per cent had most favourable attitude and 16.66 per cent had least favourable attitude towards IFS.

In Chickballapur district, half (50 %) of the respondents had favourable attitude towards IFS followed by 30.00 per cent had most favourable and 20.00 per cent had least favourable level of attitude towards IFS.

In Mandya district, more than one third of the respondents (38.33%) had most favourable attitude towards IFS followed by 31.66 per cent had favourable and 30.00 per cent had least favourable attitude towards IFS.

In Shimoga district, more than one third of the respondents (36.33%) had most favourable attitude towards IFS followed by 33.33 per cent had least favourable and 30.00 per cent favourable attitude towards IFS.

More than one third of the respondents (35.00%) had most favourable attitude towards IFS followed by 35.00 per cent favourable and 30.00 per cent least favourable level of attitude towards IFS (Table IV).

TABLE III

District-wise attitude of respondents towards IFS

Categories		Number	Per cent
Chitradurga			
Least Favorable		10	16.66
Favorable		33	55
Most Favorable		17	28.33
	Total	**60**	**100**
Chickballapura			
Least Favorable		12	20
Favorable		30	50
Most Favorable		18	30
	Total	**60**	**100**
Mandya			
Least Favorable		18	30
Favorable		19	31.66
Most Favorable		23	38.33
	Total	**60**	**100**
Shimoga			
Least Favorable		20	33.33
Favorable		18	30
Most Favorable		22	36.66
	Total	**60**	**100**

TABLE IV

Attitude of respondents towards IFS in Southern Karnataka

Categories	Number	Per cent
Least Favorable	72	30
Favorable	84	35
Most Favorable	84	35
Total	**240**	**100**

Favourable attitude act as a factor for selection of enterprises to stabilize the income, in addition to maximise input efficiency and higher rate of return.

It can be concluded that the attitude scale developed was found to reliable and valuable, therefore it can precisely measure the attitude of SC farmers towards IFS. Therefore, the scale can be used by researchers to measure the attitude of SC farmers towards IFS.

REFERENCES

KERLINGER, E. N., 1973, Foundations of Behavioural Research, New York: Holt, Rine Hart and Winston.

LIKERT, R. A., 1932, A Technique for the measurement of attitudes. *Archives of Psychology,* New York, p. 140.

MULAY, S. AND SABARTHANAM, V. E., 1980, Research methods in extension education. *Manasayan*, New Delhi.

RAY, G. L. AND MONDAL, S., 2011, Research methods in social sciences and extension education, Kalyani Publications, Calcutta, India.

THURSTONE. L. L, 1946, The measurement of attitude. *American J. Sociol.*, Chicago University Press, p. 39-50.

THURSTONE. L. L. AND CHAVE, E. C., 1929, The measurement of opinion. *J. Abnormal Social Psych.*, **22** : 415-430.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 303-308, 2017

Development of an Index on Sustainable Development of SHG Members and their Level of Sustainability

G. J. Chaithra and N. S. Shivalinge Gowda
Department of Agricultural Extension, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: chaithragj.gj@gmail.com

Abstract

Self Help Groups, as micro financial institutions emerged as an impetus for community action. An index of Sustainable development of SHG members was developed in this research study. The relevancy rating was obtained from 45 judges in the concerned area. All those components with the relevancy coefficient of 0.75 above were selected for the inclusion in the Sustainable development index. The level of sustainable development among members and non-members showed a significant difference at one per cent level of significance as indicated by chi-square analysis. The mean index value of SHG members among different components ranged from 7.65 to 12.66. While, among non-members the mean index value ranged from 4.25 to 8.10. The mean index values of all the components of sustainable development significantly differed among non-members at one per cent.

Keywords: Sustainable development, SHG members, relevancy, index

India is a country having vast population with persisting unemployment problem. In rural areas the poor are dependent on money lenders for their financial needs, either for social functioning, illness or any other emergency need in the family. Money lenders always exploit the situation. The formal credit system of banks by and large is beyond the reach of the poor, so rural employment generation is the greatest challenge for our country. Government has to make the rural people to realize that Self-help groups (SHGs) are facilitating rural employment generation. Encouragement and support by the government will solve the problem of rural unemployment which can be achieved by realizing the need for rural employment through SHGs.

The first initiative on the use of self-help groups (SHGs) concept for banking, finance and development was taken up by the National Bank for Agriculture and Rural Development (NABARD) in 1986-87 on a pilot basis, and since 1991 it is being implemented by the Reserve Bank of India. It is viewed as a good means from the perspective of SHG members, who do not have direct access to bank loans, and also from the viewpoint of financial institutions in terms of loan recovery success, since members with loans will experience neighborhood (group) pressure to repay the loans. In many of the cases, microcredit has helped the SHGs to start self-employment projects in groups.

Sreedhar (2012) reported that SHG-Bank linkage programme helped 167 lakh (45.21%) household members up to 2002-2003 then during the 2007-2008 it was only 130 lakh (22.41%) household members are benefited through the SHG-Bank linkage programme. The linkage programme helps the poor people to get micro-credit from formal financial institution to improve their standard of living and economic conditions.

A self-help group, is an informal association of individuals who come together voluntarily for promotion of economic and social objectives and it has been viewed as a major development tool for meeting the rural credit requirement and helping in poverty alleviation (Bi and Pandey, 2011). In India, the need for rural credit was recognized even before independence. Several efforts were made by the government to bring the rural sector under formal financial system and to meet its credit needs (Bharamappanavara, 2013).

Women Self-Help Group is an informal association of 15-20 women, who voluntarily come together for the business of saving and credit and it is a significant instrument in the process of empowerment. It is a homogeneous group of the poor voluntarily coming together to save whatever amount they can save conveniently out of their earnings, to mutually agree to contribute to a common fund and to lend to the members for meeting their productive and emergent needs. Self-help groups have been able to mobilize small savings either on weekly or monthly basis from persons who were not expected to have any savings. They have been able to effectively recycle the resources generated among the members for meeting the emergent credit needs of the members of the group. With this background the study is taken Development of an Index on Sustainable Development of SHG Members and their Level of Sustainability.

METHODOLOGY

Operationalization and measurement of Sustainable development of SHG members

Sustainable developement of SHG Members is operationally defined as the best combination of livelihood security, entrepreneurial behavior, women empowerment, group dynamics and standard of living of farm households.

Livelihood security: The livelihood security is operationally defined as the ability of the SHG members to spend income on all basic and other necessities which are essential to their livelihood, as per the requirement and thus by the attaining the secured livelihood.

*Entrepreneurial behavior:*The Entrepreneurial behavior is operationally defined as the ability of the SHG members to take risk, decisions and manage resources towards maximization of profit with an urge to excel others.

Group dynamics: It is the sum total of forces among the members of SHGs based on the sub-dimensions such as participation, membership, influence and style of influence, decision making procedure, group atmosphere, interpersonal trust, maintenance functions and empathy in SHG.

Measurement of different components of Sustainable development of SHG members

Sustainable development	Empirical measurement
Livelihood security	Scale developed by Mamathalakshmi (2013)
Entrepreneurial behaviour	Scale developed by Mahantesh Shirur (2015)
Group dynamics	Scale developed by Prasanna Kumar (2009)
women empowerment	Scale developed by Savitha (2005)
Standard of living	Scale developed by Vinaykumar (2008)

Women empowerment: Empowerment of women is operationally defined as the individual perceived sense of psychological power and actual change in power which leads to individual decision making.

Standard of living: It is operationally defined as it is the degree of wealth and material comfort available to SHG members.

The methodology in developing the procedure to measure the Sustainable development of SHG Members is based on the behavioral measurements procedure suggested by Guilford(1954). The steps followed for the development an index on sustanable development of SHG members is as follows ;

Identification of components

Based on a thorough review of literature, five components *viz.,* livelihood security, entrepreneurial behaviour, group dynamics, women empowerment and standard of living were identified to measure the sustainable development of SHG members.

Working out Relevancy weightage, Relevancy percentage and Mean relevancy score

The components were mailed to 100 experts in the agricultural extension and other related fields to critically evaluate the relevancy of each component viz., Most Relevant (MR), Relevant (R), Somewhat Relevant (SWR) and Not Relevant (NR) with the score of 4, 3, 2 and 1, respectively. A total of 45 judges returned the questionnaires duly completed were considered for further processing. From the data gathered, Relevancy Weightage, Relevancy percentage (RP) and Mean Relevancy Score (MRS) were worked out for all the components by using the formula.

$$\text{R.W.} = \frac{\text{MR x 4 + R x 3+ SWR x 2 + NR x 1}}{\text{No. of judges responded x Maximum score}}$$

$$\text{R.P.} = \frac{\text{MR x 4 + R x 3+ SWR x 2 + NR x 1}}{\text{No. of judges responded x Maximum score}} \text{ x 100}$$

$$\text{MRS} = \frac{\text{MR x 4 + R x 3+ SWR x 2 + NR x 1}}{\text{No. of judges responded}}$$

Components rated as relevant with a relevancy weightage (RW) of 0.75 or more, relevancy percentage of more than 75 per cent and Mean

TABLE I

Relevancy weightage of Sustainable development of SHG members index components

Components	Relevancy Percentage	Relevancy weight age	Mean Relevancy score
Livelihood security	87.14	0.87	3.48
Entrepreneurial behaviour	90.63	0.90	3.34
Group dynamics	87.63	0.87	3.50
Women empowerment	90.27	0.90	3.60
Standard of living	87.49	0.87	3.49

Relevancy Score of more than 2.25 were considered and retained for the next step. In this step, all the 5 components were retained for development of sustainable the development of SHG members p Table I.

Computation of Scale Values

In order to compute the scale values for each of the identified components, their relative importance in the Sustainable development of SHG members was worked out by adopting normalized ranking method recommended by Guilford (1954).

Responses of 45 experts in agricultural extension and other related fields' working in SAUs, ICAR institutions and Karnataka State Department of Agriculture was considered for analysis. The judges were requested to give rank order based on the relative importance of the component to the five selected indicators of sustainable development. After receiving ratings from the judges, they were used in calculation of scale values.

It is apparent that, all the five dimensions will not contribute equally towards the Sustainable development of SHG members. Hence, the variation in contribution of each dimension for the Sustainable development of SHG members must be represented by assigning different weightage to each of the dimension. Hence, the judges' rating was sought to calculate the scale values for each dimension of the Sustainable development of SHG members.

Rank values are a series, denoted by Ri, that are in exact reverse order to the ranks ri. Ranking the components based on their relative importance - Ranks were converted to rank values using the formula:

$$\mathbf{R_i = (n - r_i + 1)}$$

Where, Ri is the rank value

n is number of items ranked

ri is the rank given by the expert for each dimension

The calculation of scale values consisted of working out the centile position 'p' based on the formula recommended by Guilford (1954), working out 'c' scale values based on Hull (1928), calculating 'R_j' value and finally determining the scale of (R_c) (Table II and III).

$$\mathbf{P = \frac{(Ri - 0.5)100}{n}}$$

- P is essentially a centile value and represents the area under the normal distribution below the median of the interval assigned to the object.
- Where, Ri is the rank value and n is number of things ranked.
- The deduction of 0.5 from the rank value is simply to get the middle of the area for the dimension so ranked

$$\mathbf{R_c = 2.357{*}R_j - 7.01}$$

Schedule development, testing reliability and validity

For all the relevant five components, the questionnaire was prepared to elicit appropriate variability for Sustainable development of SHG Members. Pilot study was conducted among 30 respondents in non-sample area comprising five components in Sustainable development of SHG index to test the reliability and validity.

Testing for reliability

The coefficient of equivalence is the correlation between scores on parallel forms (P and Q) of the

TABLE II

Calculation of scale values for dimensions of Sustainable development of SHG members based on the judges rating

ri	Ri	C 1	C 2	C3	C4	C5	Total	P	C
1	5	26	5	6	7	1	45	90	6
2	4	7	12	3	13	10	45	70	5
3	3	6	11	8	12	8	45	50	4
4	2	6	11	8	8	12	45	30	4
5	1	0	6	20	5	14	45	10	3
Σfji		45	45	45	45	45			
Rj=Σfji C		239	196	175	202	178			
R=Rj/Σfji		5.31	4.36	3.89	4.89	3.96			
Rc *		5.51	3.26	2.16	3.57	2.31			

test, administered with a minimal time lag between testing. The responses for the odd (P) and even numbered items (Q) were obtained and the scores of both sets were used to calculate the coefficient of correlation (r).

r*(P)(Q)*= (XP)(XQ)/N – (XP) (XQ) / (SP) (SQ)

Where, P and Q are two different forms of the scale, X is the score of variable and S is the variance.

Spearman-Brown Prophecy formula was employed to know the reliability of the test of the original length from the values of split-half reliability.

rxx=2rhh/1+rhh

Where, rhh is the split-half reliability coefficientrxx is the estimate of the reliability of a test of the full length.

The rxx value of 0.9415 suggested high reliability of the scale.

Testing for validity

Validity of the scale was ensured by analyzing content validity. Since the items were based on extensive review of literature and relevancy analysis by the judges, the content validity was ascertained.Looking at the extensive literature and the nature of Sustainable development of SHG Members, five dimensions with suitable statements were finalized and were sent for relevancy analysis.

Then the ranking for each of the dimension were obtained from 45 judges to calculate scale values. Hence, the content validity was ascertained by using the following formula:

$$\text{Validity} = \sqrt{r_{11}}$$

Where

r_{11} =test reliability

The data were subjected for statistical validity, which was found to be 0.9703 for sustainable development index which is greater than the standard requirement of 0.75, hence the validity co-efficient was also found to be most appropriate and suitable for the tool developed.

The components of Sustainable development of SHG members were finalized based on the review of literature. The five components identified for the study assumed scale values ranging from 2.16 to 5.51indicating different weightage to be assigned to them based on the expert opinion arrived through judges rating. The scale values of respective components are given in Table III.

TABLE III

Sustainable development of SHG members and their respective scale values

Indicators of sustainable development of SHG Members	Final scale values
Livelihood security	5.51
Entrepreneurial behavior	3.26
Group dynamics	2.16
Women empowerment	3.57
Standard of living	2.31

Results and Discussion

The present study shows that livelihood security with a maximum scale value of 5.51 is the most important component contributing for Sustainable development of SHG members. Livelihood security helps to know the ability of the SHG members to protect their capabilities, assets and activities which are essential for their livelihood.

Women empowerment (scale value of 3.57) emerged as the second important components.In recent years, women empowerment has become a subject of great concern for the nations all over the world especially in poor and developing countries. The progress of any nation is inevitably linked with social and economic plight of women of the particular country.

Entrepreneurial behavior is the next important component with a scale value of 3.26. This is also an important factor contributing to successful entrepreneurship among the SHG members.

Standard of living and Group dynamics are the last two important components in the order of importance with a scale value of 2.31 and 2.16, respectively.

A glance of Table IV revealed that 44.45 per cent of SHG members belong to the high sustainable development followed by medium (31.11 %) and low (24.44 %) level. Whereas, 75.56 per cent of non-members had low level of sustainable development followed by medium (15.56%) and high (8.88 %) level of sustainable development. However, SHG members had more sustainable development than the non SHG members.

Table IV

Distribution of respondents according to sustainable development of SHG members and non-members (n= 180)

Categories	Sustainable development index				Chi-square
	SHG members (n_1= 90)		Non-members (n_2=90)		
	No.	%	No.	%	
Low	22	24.44	68	75.56	
Medium	28	31.11	14	15.56	49.51**
High	40	44.45	8	8.88	

Mean = 48.85 SD=13.14; ** Significant at 1% level

SHG members has exhibited relatively higher sustainable development, possible reasons might be their better education, more participation in group activities, maintenance of book for the savings details and constantly attending skill development trainings that helps in capacity building.

Non-members of SHG were less sustainably developed because they were less educated compared to SHG members and also e-literacy is less compared to SHG members. These are all the reasons for non-members were less in sustainable development. The findings were supported by the results of Lavanya (2010).

The chi-square test which was significant at 1 per cent level indicated that there was an association between SHG members and non-members with respect to their sustainability levels. The SHG members exhibited a higher level of sustainability when compared to non-members of SHG.

The data in Table V depicts the sustainable development indices obtained by the SHG members and non-members. As it is evident that, the SHG members had obtained a relatively higher mean livelihood security score 12.66 while non-members had a mean score of 8.10. In case of entrepreneurial behavior index, the SHG members had obtained a higher mean score of 7.65 followed by non-members who had scored 6.12. The SHG members had obtained a group dynamics mean score of 7.65 and non-members had a mean score of 4.25. Further, the SHG members had obtained relatively higher women empowerment mean score of 11.30 followed by 5.38. Whereas, standard of living got mean score in SHG members that is 8.13 and non-members had obtained 4.88 mean score

Further, the t-value showed a significant difference at 0.01 per cent level of probability, pointing to significant difference in the sustainable development indices between SHG members and non-members.

The present investigation revealed that SHG members had high indices score compare to non-members in all the five components.SHG members were relatively more stable in terms of higher education, getting good income, meeting and participating in social and political organization all these leads to SHG members more sustainably developed than the non-members.

TABLE V

Comparison of different components of sustainable development mean index value between SHG members and non SHG members

(n= 180)

Sustainable development components	No. of statements	Mean index value		't' test
		SHG members (n_1=90)	Non-members (n_2=90)	
Livelihood security	50	12.66	8.10	2.28**
Entrepreneurial behaviour	101	9.10	6.12	3.46**
Group dynamics	66	7.65	4.25	2.72**
Women empowerment	44	11.30	5.38	4.91**
Standard of living	40	8.13	4.88	3.32**

** Significant at 1% level; * Significant at 5% level

It can be concluded that the index developed on sustainable development of SHG members is found to be reliable and valid. The reliability value was found to be 0.9415 and validity value found to be 0.9703. livelihood security with a maximum scale value of 5.51 is the most important component contributing for sustainable development of SHG members followed by women empowerment (scale value of 3.57) and entrepreneurial behavior (scale value of 3.26). The sustainability level of members was significantly higher than non-members hence there is need to formulate more number of SHGs so that rural women derive the benefit and attain more sustainability. All the components of sustainable development were significantly differing between SHG members and non-members. Thus it could be concluded that SHGs have contributed for higher level of sustainable development among its members. SHGs are the viable institutions particularly among women folk in rural areas and need to be further strengthened to achieve overall development.

REFERENCES

BI, Z. AND PANDEY, L. S. D., 2011, Comparison of performance of microfinance institutions with commercial banks in India. *Australian J. Business and Management Res.,* **1**(6): 110-120.

BHARAMAPPANAVARA, S. C., 2013, Growth and outreach of Self-help groups microcredit models in India : Aliterature insight. *Int. J. Social and Econ. Res.,* **3** (1) : 1-14.

GUILFORD, J. P., 1954, Psychometric methods. Tata McGraw-Hill Publishing Co. Ltd., New Delhi.

HULL, C. L., 1928, Aptitude testing. Yonkers, NY; World.

LAVANYA, 2010, Assessment of farming system efficiency in Theni district of Tamil Nadu. *M.Sc. Thesis* (Unpub.), Univ. Agri. Sci., Bengaluru.

MAHANTESH SHIRUR, 2015, A study on mushroom entrepreneurship and consumer behavior in Karnataka. *Ph.D. Thesis* (Unpub.), Univ. Agric. Sci., Bengaluru.

PRASANNA KUMAR, R., 2009, A study on group dynamics and entrepreneurial behavior of women in SHGs. *Ph.D. Thesis* (Unpub.), Univ. Agric. Sci., Bengaluru.

SAVITHA, 2005, Women empowerment and decision making in agriculture – an economic study in Mysore district, Karnataka. *M.Sc. Thesis* (Unpub.), Uni. Agric. Sci., Bengaluru.

SREEDHAR, N., 2012, Self-help groups performance in India. *J. Econ. and Manag.,* **1** : 8.

VINAY KUMAR, R., 2008, impact of rural bio resource complex on Standard of living of its stakeholders in Karnataka. *Ph.D. Thesis* (Unpub.), Univ. Agric. Sci., Bengaluru.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 309-314, 2017

A Comparative Analysis of Livelihood Security among Beneficiaries and Non-Beneficiaries of Integrated Farming System Demonstration

K. S. Kowsalya and B. Krishnamurthy
Department of Agricultural Extension, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: kowshalyaks@gmail.com

Abstract

The present study was conducted during 2016-17 in Mandya district of Karnataka state for comparing to the livelihood security among beneficiaries and non-beneficiaries of Integrated Farming System Demonstration (IFSD) The study was carried out purposively in selected 14 villages of Mandya taluk and district. The results revealed that majority of the beneficiaries had higher medium to high level of livelihood security, whereas, majority of the non-beneficiaries had lower level of livelihood security. The results of the study revealed that there is a significant difference in the livelihood security of beneficiaries and non-beneficiaries of IFSD.

Keywords: Livelihood security, IFSD, beneficiaries, non-beneficiaries

Agriculture is the mainstay of our economy, a way of life for millions of farm families. Land is a primary source of livelihood and a critical factor that shapes the livelihood strategies and resultant outcomes. India lives in its villages - this axiom is as true today as it was when the country became independent 68 years ago. Agriculture and allied activities support livelihoods of nearly 70 per cent of India's rural population. In recent years, land-based livelihoods of small and marginal farmers are increasingly becoming unsustainable, since the land has not been able to support the family's food requirements and fodder for their cattle. As a result, rural households are forced to look at alternative means for supplementing their livelihoods. Livelihood is always more than just a matter of finding or making shelter, transacting money and preparing food to put on the table or exchange in the market place. It is equally a matter of the ownership and circulation of information, the management of social relationships, the affirmation of personal significance and group identity and the inter relationship of each of these tasks to the other. All these productive tasks together constitute a livelihood. For an anthropologist, livelihood is an umbrella concept, which suggests that social life is layered and that these layers overlap (both in the way people talk about themselves and the way they should be analyzed). This is an important analytical feature of the notion of livelihoods (Wallman, 1984).

Livelihood is the means for people use to support themselves, to survive, and to prosper. It is an outcome of how and why people organize to transform the environment to meet their needs through technology, labour, power, knowledge, and social relations. Livelihoods are also shaped by the broader economic and political systems within which they operate. In general, almost half of the world's population does not have the socio-economic and political means to realize their economic and social rights. One of the major causes of the poverty is the lack of viable livelihoods in the developing world.

Livelihood is also about creating and embracing new opportunities. While gaining a livelihood, or attempting to do so, people may, at the same time, have to cope with risks and uncertainties, such as erratic rainfall, diminishing resources, pressure on the land, changing life styles and kinship networks, exploitative markets, increasing food prices, inflation and national and international competition. These uncertainties, together with new emerging opportunities, influence how material and social resources are managed and used and on the choices people make.

Integration of various enterprises in a farm ensures recycling of farm wastes and utilizing all the available resources most economically and efficiently. It also aims at working out appropriate combinations of farm enterprises, resources, practices and methods.

Various subsidiary enterprises like crop husbandry, dairying, poultry, apiculture, sericulture, fisheries etc., have to be combined involving farmers in planning, implementation and evaluation of production plans to register a significant impact in terms of improving the standard of living in addition to sustained and stable income to rural poor. Hence, the present study is taken up with an objective to compare the livelihood security of beneficiaries and non-beneficiaries of IFSD.

Methodology

The study was conducted in 14 villages of Mandya taluk and district in Karnataka state during 2016-17. Out of fourteen villages, ten beneficiary villages (Kattedoddi, B. Yarahalli, Kagehalladadoddi, Javaregowdanadoddi,Mariyanadoddi, Mallaiahnadoddi, B. Gowdagere, Hadya, Machalli and Jayapura) and four non-beneficiary villages (Malligere, Gopalapura, Koppa and Guluru) were purposively selected for the study. Sixteen beneficiaries involved in IFSD were selected randomly from each of the ten villages and ten non-beneficiaries were selected randomly from each five villages selected for the study. Thus the total sample constituted 160 IFSD beneficiaries and 40 non-beneficiaries. Data was collected using a pre-tested interview schedule.

In the present study, livelihood security is operationalized as, the ability of the respondents to earn and spend their income on all basic and other development activities which are essential for decent living. Further, it refers to the ability of the beneficiaries and non-beneficiaries to protect their capabilities, assets and activities which are essential for their livelihood. The livelihood security was measured by using scale developed by Mamathalakshmi (2013) with slight modification. The scale consists of eight major dimensions *viz.,* Assets, Living Amenities, Economic Efficiency, Ecological Security, Social Equitability, Transformation over a period of time, Coping strategies against stress and Employment status, comprising of 50 statements. Responses of beneficiaries and non-beneficiaries was collected on five point continuum *viz.,* very great extent, to a great extent, to a moderate extent, to a least extent and to a very least extent by assigning scores of 5, 4, 3, 2, and 1, respectively. Minimum and maximum score a respondent could get 50 and 250, respectively. Based on the cumulated score, the respondents were categorized as low, medium and high level of livelihood security considering mean and half standard deviation. Ex-post facto research design was adopted for the study. The collected data was scored and analyzed using mean, standard deviation, frequency, percentage and t-test.

Results and Discussion

The results in Table I revealed that 51.88 and 65.00 per cent of beneficiaries and non beneficiaries were of middle aged. It was also noticed that 62.50 per cent of beneficiaries were having medium level of education and 72.50 per cent of non-beneficiaries possessed medium level of education. It is also observed that 67.50 and 75.00 per cent of beneficiaries and non-beneficiaries, respectively, were small farmers. With respect to extension participation, a little over half of the beneficiaries had high (51.25 %) level of extension participation, whereas, 80.00 per cent of the non-beneficiaries had low level of extension participation. Further, Table I revealed that 54.38 per cent of beneficiaries were having high level of risk orientation and 40.00 per cent of non-beneficiaries had low level of risk orientation.

The data in Table II presents the dimension-wise analysis of livelihood security among beneficiaries and non-beneficiaries of IFSD. The results showed that 48.75, 41.25 and 10.00 per cent of beneficiaries are having medium, high and low asset security, respectively. Whereas, 55.00, 27.50 and 17.50 per cent of the non-beneficiaries had low, medium and high asset security, respectively. More number of beneficiaries and non-beneficiaries belong to low level of asset security is due to the respondents living below the poverty line, one must possess assets like land, house, livestock etc. to lead a decent life. Similar findings were reported by Lavanya (2010).

With respect to the living amenities, 70.00 per cent of the beneficiaries had medium level of living amenities followed by high (20.00 %) and low (10.00 %) level of living amenities. Fifty per cent of non-beneficiaries had low, 47.50 per cent had medium and 2.50 per cent had high level of living amenities. The plausible reasons might be that drinking water is crucial for the survival of any living being, fuel is basic thing

TABLE I

Socio-economic characteristics of beneficiaries and non-beneficiaries of IFSD

Particulars	Criteria	Beneficiaries (n_1=160)		Non-beneficiaries (n_2=40)	
		No.	%	No.	%
Age	Young	24	15.00	7	17.50
	Middle	83	51.88	26	65.00
	Old	53	33.12	7	17.50
Education	Low	56	35.00	10	25.00
	Medium	100	62.50	29	72.50
	High	4	2.50	1	2.50
Land holding	Marginal farmers	52	32.50	10	25.00
	Small farmers	108	67.50	30	75.00
Extension	Low	9	5.63	32	80.00
Participation	Medium	69	43.12	5	12.50
	High	82	51.25	3	7.50
Risk Orientation	Low	12	7.50	16	40.00
	Medium	61	38.12	14	35.00
	High	87	54.38	10	25.00

in preparation of food items and savings is essential to buy required items during unforeseen or crisis situation. The study of Devarajaiah (2010) has favoured the present study findings.

Regarding economic efficiency, 48.75 per cent of the beneficiaries had medium level of economic efficiency, followed by high (39.38 %) and medium (11.87 %) level of economic efficiency. Fifty per cent of the non-beneficiaries had medium level of economic efficiency followed by low (40.00 %) and high (10.00 %) level of economic efficiency. The possible reason might be that even today unemployment is the major cause for poverty and migration. Employment is needed to earn money for living and also savings to meet the requirement of the self and family during emergencies. The study of Anand Rathod (2007) and Devarajaiah (2010) mirrored the present study findings.

In the context of ecological security, 40.00, 30.00 and 30.00 per cent of the beneficiaries had medium, high and low level of ecological security, respectively. Whereas, 45.00, 30.00 and 25.00 per cent of non-beneficiaries had low, medium and high level of ecological security, respectively. Due to uncertainty and unequal distribution of rainfall and dwindlling of forest resouses and drought situation prevalis in the study area. The result of present study were in consonance with the study of Rupak Goswami and Malay Paul (2012).

Table II also reveals that 40.62 per cent of the beneficiaries had medium level of social equitability, 30.00 per cent had low and 29.38 per cent had high social equitability. Whereas, 60.00 per cent of non-beneficiaries had low, 35.00 per cent medium and five per cent had high level of social equitability. The likely reasons might be that government and private sectors have created many schools primary health care centres, community halls etc. for the benefits of rural people. The finding of the study was consistent with findings of Lavanya (2010).

The results of transformation over a period of time revealed that 40.63 per cent of the beneficiaries had high level of transformation over a period of time. Whereas, 72.50 per cent had of the non-beneficiaries had low level of transformation over a period of time, 15.06 per cent had medium and 12.50 per cent had low level of transformation over a period of time. Opportunities of employment and number of earning members in the family has increased over a period of time. Further, government has taken interest in providing better health services by establishing more hospitals and extending many health coverage programmes to the rural people with a least cost. The

TABLE II

Dimension-wise analysis livelihood security among beneficiaries and non-beneficiaries of IFSD

Particulars	Criteria	Beneficiaries (n_1=160)		Non-beneficiaries (n_2=40)	
		No.	%	No.	%
Assets	Low	16	10.00	22	55.00
	Medium	78	48.75	11	27.50
	High	66	41.25	7	17.50
Living amenities	Low	16	10.00	20	50.00
	Medium	112	70.00	19	47.50
	High	32	20.00	1	2.50
Economic efficiency	Low	19	11.87	16	40.00
	Medium	78	48.75	20	50.00
	High	63	39.38	4	10.00
Ecological	Low	48	30.00	18	45.00
	Medium	64	40.00	12	30.00
	High	48	30.00	10	25.00
Social equitability	Low	48	30.00	24	60.00
	Medium	65	40.62	14	35.00
	High	47	29.38	2	5.00
Transformation over a period of time	Low	64	40.00	29	72.50
	Medium	31	19.37	6	15.00
	High	65	40.63	5	12.50
Coping strategies against stress	Low	60	37.50	24	60.00
	Medium	36	22.50	11	27.50
	High	64	40.00	5	12.50
Employment status	Low	32	20.00	30	75.00
	Medium	80	50.00	8	20.00
	High	48	30.00	2	5.00

finding of the study is not in the line with the finding of Kale *et al.* (2010).

Regarding the coping strategies against to stress, data results in Table II revealed that 40.00 per cent of beneficiaries had high, 37.50 per cent had low and 22.50 per cent had medium level of coping strategies. Whereas 60.00 per cent had low, 27.50 per cent had medium and 12.50 per cent had high level of coping strategies against stress, respectively. The possible reasons might be that savings gives safety and confidence to buy required things during crisis and kitchen gardens plays a crucial role in meeting the food and other requirements of the family during stress condition. The findings of the study conducted by Lavanya (2010) supported the results of present study.

In case of employment status, 50.00 per cent of beneficiaries had medium, 30.00 per cent high and 20.00 per cent low level of employment status. Whereas, 75.00 per cent of non-beneficiaries had low level of employment status, 20.00 per cent had medium

TABLE III

Overall livelihood security mean scores among beneficiaries and non-beneficiaries of IFSD

(n = 200)

Livelihood Security	Beneficiaries (n = 160)		Non-beneficiaries (n = 40)		't' value
	Mean	SD	Mean	SD	
Assets	26.00	2.73	22.65	3.32	5.98**
Living amenities	28.30	3.08	25.0	2.74	7.02**
Economic efficiency	17.10	1.93	15.43	1.91	5.06**
Ecological security	12.10	1.87	11.20	2.31	2.36**
Social equitability	20.40	2.16	17.90	2.80	5.55**
Transformation over a period of time	20.10	2.03	17.65	2.85	5.32**
Coping strategies	24.70	3.04	22.03	3.54	4.45**
Employment status	58.30	4.89	52.03	4.67	9.22**
Overall livelihood security	207.00	16.21	183.88	12.18	10.00**

t (0.01, 178df)= 2.58; **=Significant at 1% level

and 5.00 per cent had high level of employment status. The possible reason might be that because of difference in the type of work done by the men and women the wage differences exists. Government has initiated food for work programme and MGNREGA in order to provide employment opportunities and to create food security for the rural people. The study result was in line with the findings of Savitha *et al.* (2011).

The data in Table III presents the dimension wise livelihood security mean score of beneficiaries and non-beneficiaries of IFSD. It could be seen that the mean livelihood security of the beneficiaries was more in almost all the dimensions. The t-test was applied to compare the mean livelihood security of beneficiaries and non-beneficiaries and the value obtained under different dimensions are, 5.98, 7.02, 5.06, 2.36, 5.55, 5.32, 4.45 and 9.22 for assets, living amenities, economic efficiency, ecological security, social equitability, transformation over a period of time, coping strategies against stress and employment status, respectively. The results indicates that beneficiaries and non-beneficiaries significantly differ with respect to their livelihood security in all the dimensions.

The data on mean livelihood security score of beneficiaries and non-beneficiaries of IFSD is also presented in Table III. It was found that the mean livelihood security score of beneficiaries is 207.00 while it was 183.88 in the case of non-beneficiaries. The t-value obtained was 10.00 which is significant at one per cent level indicating a significant diffrence exists between the beneficiaries and non-beneficiaries in respect of their livelihood security. The IFSD beneficiaries had higher income, assets, education, extension partipation and risk beaing ablity than non-beneficiaries. Hence a significat diffrence exists between beneficiaries and non- beneficiaries in respect of livelihood security. The findings of the study is supported by Jayashree Datta (2013).

An examination of Table IV indicates the overall livelihood security of the beneficiaries and non-beneficiaries of IFSD. It is noticed that 46.87 per cent of the beneficiaries had medium level of livelihood security followed by high (33.75 %) and low (19.38 %) level of livelihood security. Whereas, 77.50 per cent of non-beneficiaries had low level of livelihood security followed by 15.00 per cent had medium and 7.50 per cent had high level of livelihood security. The results showed that there is large differences in livelihood security among beneficiaries and non-beneficiaries. The reasons quoted for the finding in Table III also holdsgood. The findings of the study is supported by Jayashree Datta (2013).

TABLE IV

Overall livelihood security of beneficiaries and non-beneficiaries of IFSD

(n = 200)

Particulars	Criteria	Beneficiaries (n_1=160)		Non-beneficiaries (n_2=40)	
		N	%	N	%
Livelihood Security	Low	31	19.38	31	77.50
	Medium	75	46.87	6	15.00
	High	54	33.75	3	7.50

Mean = 202.37 SD = 18.03

The study results revealed that 80.62 per cent of the IFSD beneficiaries had medium to high level of level hood security as against 77.50 per cent of non-beneficiaries having low level of livelihood security. A significant diffrence exist between beneficiaries and non-beneficiaries of IFSD in respect of livelihood security.The results implied the need of conducting more number of extension activities to motivate non-beneficiaries to adopt IFS activities for improving their livelihood security.

REFERENCES

ANAND RATHOD, 2007, A study on sustainable livelihoods of lambani farmers in Hyderabad Karnataka. *M.Sc. (Agri.) Thesis* (Unpub.), Univ. Agric. Sci., Dharwad.

DEVARAJAIAH, K., 2010, A study on livelihood diversification of small and marginal farmers in Kolar district of Karnataka. *Ph. D. Thesis* (Unpub.), The School of Agricultural Sciences Yashwantrao Chavan Maharashtra Open University, Nashik, Maharashtra.

JAYASHREE DATTA, 2013, Sustainability of jhum cultivation as perceived by the tribal people of Tripura and their livelihood status. *M.Sc. (Agri) Thesis* (Unpub.), Univ. Agric. Sci., Bengaluru.

KALE, N. M., KHONDE S. R. AND THAKARE, U. G., 2010, Antecedents of non-sustainable livelihood among suicidal farmers of Vidarbha. Karnataka state. *Karnataka J. Agri. Sci.,* **23** (2): 265 - 268.

LAVANYA, 2010, Assessment of farming system efficiency in Theni district of Tamil Nadu. *M.Sc. (Agri.) Thesis* (Unpub.), Univ. Agric. Sci., Bengaluru.

MAMATHALAKSHMI, N., 2013, An analysis of livelihood security among agricultural labourers in Karnataka, *Ph.D. Thesis* (Unpub.), Univ. Agric. Sci., Bengaluru.

RUPAK GOSWAMI AND MALAY PAUL, 2012, Using sustainable livelihoods framework for assessing the impact of extension programmes: An empirical study in the context of joint forest management. *Indian Res. J. Extn. Edu.*, **12** (3) : 28 – 36.

SAVITHA, M. G., MUNIDINAMANI, S. M., DOLLI, S. S., NAIK, B. K., PATIL, B. L. AND MEGERI, S. N., 2011, Livelihood systems for rural community in Chitradurga district of Karnataka state. *Karnataka J. Agri. Sci.*, **24** (3) : 325 - 330.

WALLMAN, S., 1984, Eight London households, London Tavistock.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 315-320, 2017

Development of a Scale to Measure the Attitude of Farmers towards Carbon Sequestration Technologies and Its Application in Rice and Sugarcane Based Farming System

D. K. Suresh and M. Shivamurthy
Department of Agricultural Extension, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: suri1775@gmail.com

Abstract

The present study was contemplated to develop and standardize the scale to measure farmer's attitude towards carbon sequestration technologies. Based on the review of literature and discussion with the experts, 40 statements were enlisted. Out of 40 statements, 20 statements were retained in the final scale. The scale developed was found reliable (0.8124) and valid (0.9013). As high as 43.44 per cent of the farmers had 'favourable' attitude towards carbon sequestration technologies in rice and sugarcane based farming system followed by 33.33 and 23.33 per cent of the farmers having 'more favourable' and 'less favourable' attitude towards carbon sequestration technologies in rice and sugarcane based farming system, respectively.

Keywords: Carbon sequestration, attitude, reliability, validity

Agriculture in India is contributing 17.9 per cent towards GDP (2016-17) and provides livelihoods to 50 per cent of the total population (Anon., 2016). Agriculture and food security are among the major casualties of climate change in India. The pace and extent of warming across India is wide spread and undisputed. Climate change is affecting India in a big way and its impacts are many such as serious-erratic monsoon, changes in agricultural zones, spread of tropical diseases, sea level rise, change in the availability of fresh water, floods, droughts, heat waves, storms, etc.

Accumulation of carbon dioxide in the atmosphere causes severe threat to health and survivability of leaving organisms, which leads to gradual extinction of fauna and flora on the earth. Therefore, there is a need to sequestering the carbon in to the soil which facilitates good crop growth and improves the environment. As agriculture is a major contributor of Green House Gases (GHGs) to the atmosphere, there is a need to mitigate carbon dioxide through the adoption of Carbon sequestration agricultural technologies. Studying farmer's attitude towards and adoption of carbons sequestration technologies would help in understanding the ground realities so as to formulate the programs and policies to promote carbon sequestration technologies among the farmers in Rice-sugarcane farming system.

Among the global common concerns, climate change has been identified as the most important environmental challenge faced by human beings. Emission of carbon dioxide, methane, nitrous oxide, chlorofluorocarbons and hydrocarbons are identified as green house gases causing warming of earth globally. Of these gases, CO_2 alone accounts for 60 per cent share. The most practical way of removing excess carbon from atmosphere and storing it in to a biological system is by absorption of atmospheric CO_2 into the physiological system, plant biomass and finally into the soil. Carbon is thus sequestered into the plants and then the animals. Studies have established that Carbon sequestration by trees and forest could provide relatively low cost net emission reduction. Carbon management in forest is therefore one of the most important agenda in India in during the 21st century in context of greenhouse gases effect and mitigation of global climate changes.

The success and failure of any improved technology mainly depends upon the people's mind-set or attitude towards a particular technology. Thus the attitude plays an important role in accepting or rejecting the technology at any stage of the adoption. Attitude scales provided to be useful tools to measure the attitude of large number of individuals towards specific ideas, person, programme, object etc. In this backdrop, the present study has been carried out with the following specific objectives :

1) To develop and standardize a scale to measure the attitude of farmers towards carbon sequestration technologies and its application in rice and sugarcane based farming system (RSBFS).
2) To analyze the attitude of the farmers towards carbon sequestration technologies in RSBFS and
3) To enlist the constraints of farmers in practising carbon sequestration technologies in RSBFS.

METHODOLOGY

Developing and standardizing attitude scale

Attitude is an organized predisposition to think, feel, perceive and behave towards a cognitive object. Likert (1932) defined attitude is the degree of positive or negative disposition/association towards an innovation, objects, programme etc. Similarly, Thurstone (1946) also defined that attitude is a degree of positive or negative effects associated with some psychological object like symbol, person, institute, ideal or idea towards which people can differ in varying degrees.

Attitude in this study is operationally defined as the positive or negative mental predisposition of farmers towards carbon sequestration technologies in rice and sugarcane based farming system. The method of summated rating suggested by *Likert* (1932) was followed in the development of the scale. The following steps were considered for measuring the attitude of farmers' towards carbon sequestration technologies in rice and sugarcane based farming system.

Collection of statements

Statements related to carbon sequestration were collected by reviewing the journals, books and discussion with experts from Agronomy, Genetics and Plant Breeding and Horticulture. As many as 40 statements related to carbon sequestration were listed and each items was carefully scrutinized to avoid duplication.

Editing of statements

The items collected were edited and modified as per the 14 criteria suggested by Edwards (1969) and Thurstone and Chave (1929). Finally, out of 40 statements, 30 statements were retained as attitude statements and 10 were rejected. These statements were found to be non- ambiguous and non- factual.

Relevancy analysis

The 30 statements were mailed to 90 experts in the Agricultural field of Agricultural Extension, Agronomy, Soil Science and Agricultural field. Chemistry, Environmental science and other related fields working in SAUs, ICAR institutions and Karnataka State Department of Agriculture to critically evaluate the relevancy of each statement on a five point continuum viz., Most Relevant (MR), Relevant (R), Some What Relevant (SWR), Least Relevant and Not Relevant (NR) with the score of 5, 4, 3, 2, and 1, respectively. The judges were also requested to make necessary modifications and additions or deletion of components, if they desire so. A total of 40 judges returned the questionnaires duly completed were considered for further processing. The relevancy score of each statement was ascertained by adding the scores on rating scale for all 40 judges' responses. From this data 'relevancy percentage' and 'mean relevancy score were worked out for all the statements by using the following formulae as below :

$$\text{Relevancy Percentage} = \frac{(\text{MR} \times 5) + (\text{R} \times 4) + (\text{SWR} \times 3) + (\text{LR} \times 2) + (\text{NR} \times 1)}{\text{Maximum Possible score}} \times 100$$

$$\text{Mean Relevancy Score} = \frac{(\text{MR} \times 5) + (\text{R} \times 4) + (\text{SWR} \times 3) + (\text{LR} \times 2) + (\text{NR} \times 1)}{\text{Number of Judges responded}}$$

MR = Most relevant
R = Relevant
SWR= Some What relevant
LR = Least relevant
NR = Not relevant
Maximum possible score = 200 (40x5)
Number of Judges = 40

Relevancy percentage was calculated out by summing up the scores of most relevant and not relevant categories, which were converted into percentage. Accordingly statements having relevancy percentage of 80 and above, mean relevancy score of 4.0 and above were considered for further processing and suitably modified as per the comments of experts wherever applicable. Twenty three statements were isolated in the first stage for development of attitude scale.

Item analysis

These 23 statements were subjected to item analysis to delineate the statements based on the extent to which they can differentiate the respondent with high attitude than the respondent with low attitude towards carbon sequestration technologies. Thirty farmers were selected from non-sample area and the respondents were asked to indicate their degree of agreement or disagreement with each statement on a five point continuum ranging from 'strongly agree" to "strongly disagree". The scoring pattern adopted was 5 to 1, in which 5 score to strongly agree response, 4 to agree response, 3 score to undecided response, 2 to disagree response and 1 to strongly disagree response for the positive statement in case of the negative statement scoring pattern was reversed.

Based upon the total scores, the respondents were arranged in descending order. The top 25 per cent of the respondents with their total scores were considered as high group and the bottom 25 per cent as low group. These two groups provide criterion groups in terms of evaluating the individual statements suggested by Edwards (1969). 't' value was calculated for each of the statement by using the following formula:

$$t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\dfrac{\sum(X_H - \bar{X}_H)^2 + \sum(X_L - \bar{X}_L)^2}{n(n-1)}}}$$

Where

$$\sum(X_H - \bar{X}_H)^2 = \sum {X_H}^2 - \frac{(\sum X_H)^2}{n}$$

$$\sum(X_L - \bar{X}_L)^2 = \sum {X_L}^2 - \frac{(\sum X_L)^2}{n}$$

$\bar{X}_H$ = The mean score on a given statement for the high group

$\bar{X}_L$ = The mean score on a given statement for the low group

“X_H^2=Sum of squares of the individual score on a given statement for high group

“X_L^2= Sum of squares of the individual score on a given statement for low group

“X_H=Summation of scores on given statement for high group

“X_L= Summation of scores on given statement for low group

n= Number of judges in low and high groups

t= the extent to which a given statement differentiate between the high and low groups.

“= Summation

After computing the 't' value for all the 23 statements, 20 statements with highest 't' value equal to or greater than 2.04 were finally selected and included in the attitude scale.

Standardization of scale

The reliability and validity was ascertained for standardization of the scale.

Reliability and validity of the scale

Reliability refers to the precision or accuracy of the measurement or scale. A scientific instrument should yield accurate and similar results both at present as well as over time, even after repeating the experiment/ study several times (Ray and Mondal, 2011). Pre-testing of the attitude scale was done by interviewing 30 farmers in an non sample area. The split half method was employed to test the rehability of the attitude scale. Spear man brown formule was used to to obtain the reliability co-efficient of the whole set. The reliability co-efficient attitude scale was found to be 0.8124, which is higher than the standard of 0.70 indicating higher reliability of the scale, indicating the constructed attitude scale was highly reliable and dependable in its measurement. The data were subjected to statistical validity, which was found to be 0.903, for attitude scale, which is higher than the standard of 0.70. Hence, the validity co-efficient was found to be high and it seemed reasonable to accept the scale as a valid measure of the attitude.

The final attitude scale consists of 20 statements that could be administred to the farmers along a five point continuum representing strongly agree undecided, disagree and strongly disagree with weightage of 5, 4, 3, 2 and 1, respectively, for positive statments. In case of negative statements the scaring pattern follwed is vice-versa. The attitude score of each respondent can be calculated by summating the scores obtained by each farmers's on all the items. The attitude score on this scale ranges from 20 to 100. The higher score towards attitude indicates that respondent had more favourable attitude towards carbon sequestration technologies and vice-versa.

RESULTS AND DISCUSSION

Attitude of farmers towards carbon sequestration technologies

The reliability and validity of the scale indicated the precision and consistency of the results. The scale can also be used to measures the farmers' attitude towards carbon sequestration beyond the study area with suitable modifications (Table I).

It is observed from Table II that more number (43.34%) of the farmers had favourable attitude towards carbon sequestration technologies in rice and sugarcane based farming system followed by 33.33 and 23.33 per cent of the farmers having more favourable and less favourable attitude, respectively.

The probable reason for over majority of farmers having favourable and more favourable attitude towards carbon sequestration technologies in rice and sugarcane based farming system is due to the farmers' interest to mitigate the dangerous climate change, reduce the emission of more carbon dioxide and other Green House Gases (GHG'S) to the atmosphere in rice and sugarcane based farming system. Increasing

TABLE I

Statement considered to measure the attitude of farmer towards carbon sequestration technologies in rice and sugarcane based farming system

Attitude Statements	SA	A	UD	DA	SDA
Aerobic rice cultivation helps in reduction of Green House Gas emission from rice field					
Application of FYM helps to increase in soil carbon in rice and sugarcane based farming system					
Crop rotation with pulses is not benefit in improving carbon seque stration in rice and sugarcane based farming system					
Green manuring improves the soil fertility					
Stubble incorporation in sugarcane improves the soil health condition					
Trash incorporation (sugarcane) reduces the CO_2 emission to atmosphere					
Practicing of SRI (System of Rice Intensification) method of paddy cultivation is not helps the farmers to reduce the climate change					
Micro irrigation techniques improves the irrigation efficiency in rice and sugarcane based farming system					
Organic Farming is highly useful to increase the carbon sequestration					
Integrated Nutrient Management may fails to results in better Bio-mass production rice and sugarcane based farming system					
Reduced tillage sustain the soil fertility in rice and sugarcane based farming system					
Adoption of Agro-Forestry improves the carbon sequestration					
Mulching of Rice straw reduces the carbon emission to the atmosphere					
Straw burning in paddy and thrash burning in the sugarcane releases more CO_2 to atmosphere					

Attitude Statements	SA	A	UD	DA	SDA
Water stagnation throughout the season in the paddy field releases more amount of methane to atmosphere					
Weed management through cover crops in sugarcane helps in better carbon sequestration					
Site Specific Nutrient Management helps in carbon sequestration in rice and sugarcane based farming system					
Mulching may not beresults better carbon sequestration in rice and sugarcane based farming system					
Excessive application of Nitrogenous fertilizers in the paddy and sugarcane based farming system induces the climate change					
Introduction of Earthworms improves the health condition					

SA: Strongly agree; A: Agree; UD: Undecided; DA: Disagree; SDA: Strongly disagree

TABLE II

Distribution of farmers based on their attitude towards carbon sequestration technologies in rice and sugarcane based farming system

(n=30)

Attitude category	Number	Per cent
Less favourable	7	23.33
Favourable	13	43.34
More favourable	10	33.33
Total	30	100.00

Mean = 81.66; S.D = 2.77

the carbon sequestration in the rice and sugarcane based farming system also helps in the improving the soil fertility leads higher productivity of crops. These results are conformity with the studies of Shankar (2011), Muttanna (2012) and Vinay Kumar (2015).

Low technical knowledge about the carbon sequestration technologies in rice and sugarcane based farming system and difficulty to practice the technologies like aerobic rice and System of Rice Intensification (SRI) due to excess availability of water in command area etc were the reasons for 23.33 per cent of the farmers having less favourable towards carbon sequestration technologies in Rice and Sugarcane based farming system.

Constraints faced by the farmers in practicing carbon sequestration technologies

The data in the Table III revealed that, major constraints faced by farmers to practice carbon sequestration technologies were, non-availability of labours in the village (Rank I), followed by low price for the produce in the market (Rank II). Difficult to practice technologies with low knowledge level (Rank III), absence of water management techniques (Rank

TABLE III

Constraints of farmers in practicing of carbon sequestration technologies in rice and sugarcane based farming system.

Constraints	Rank
Non availability of labours	I
Low price for their produce in the market	II
Difficult to practice technologies with lower knowledge level	III
Absence of water management techniques	IV
Non – availability of inputs	V
Lack of awareness about carbon sequestration	VI
No subsidies on promoting of new carbon sequestration technologies	VII

IV), non- availability of inputs (seeds, agro-chemicals, etc) (Rank V), lack of awareness about carbon sequestration (Rank VI) and no subsidies on promoting of new carbon sequestration technologies (VII). These results are in line with Shankar (2011) and Vinay Kumar (2015).

The reliability and validity of the scale indicated the precision and consistency of the results. Farmers have favourable attitude towards carbon sequestration technologies in rice and sugarcane based farming systems, as they knew about the application of carbon sequestration and impact of climate change on cropping system and human health. High wage rate and the non-availability of laborers were the major problems of farmers.

References

ANONYMOUS, 2016, *Annual Report*. Statistical information. Official website of the Govt. of India.

EDWARD, A. L., 1969, Techniques of attitude scale construction. Vakils, Feffer and Simons Pvt. Ltd., Bombay.

LIKERT, R. A., 1932, A technique for the measurement of attitudes. *Archives of Psychology*. New York, p. 140.

MUTTANNA, 2013, A study on Perception of climate change among farm women and its impact on production of red gram. *M.Sc. (Agri.) Thesis* (Unpub.), Univ. Agri. Sci., Bengaluru.

RAY, G. L. AND MONDAL, S., 2011, Research methods in social sciences and extension education, Kalyani Publications, Calcutta, India.

SHANKARA, M. H., 2010, A study on understanding the perception of farmers about climate change and their adaptation measures in Eastern Dry Zone of Karnataka, *M.Sc. (Agri.) Thesis* (Unpub.), Univ. Agri. Sci., Bengaluru.

THURSTONE, L. L., 1946, The measurement of attitude, *American J. Sociology*, Chicago University Press, p. 39-50.

THURSTONE, L. L. AND CHAVE, E. C., 1929, The measurement of opinion. *J. Abnormal Social Psychology*, **22** : 415-430.

VINAY KUMAR, H. M., 2015, Management of climate induced crisis by the farmers of coastal region of Karnataka state - A critical analysis. *Ph.D. Thesis* (Unpub.), Univ. Agri. Sci., Bengaluru.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 321-325, 2017

Technological Gap of Bt *(Bacillus thuringiensis)* Cotton Growers in Northern Dry Zone of Karnataka

Prabhu Iliger and N. Narasimha
Department of Agricultural Extension, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: ipbu4158@gmail.com

Abstract

The focus of the study was to identify the technological gap of Bt cotton growers in Northern Dry Zone of Karnataka during 2016-17. The study was conducted in four Bt cotton growing districts of Karnataka, *viz.,* Dharwad, Haveri, Gadag and Koppal. It was observed that 35.00 per cent of the respondents belonged to low level of technological gap category followed by 33.75 and 31.25 per cent of the respondents belonged to high and medium technological gap category, respectively. In case of selected Bt cotton cultivation practices, crop protection measures, physiological disorder management, cotton based cropping system and integrated nutrient management (INM) practices were found medium to high level of technological gap. The low level of technological gap was observed in practices such as Bt hybrid selection, agronomic practices, sowing methods, post sowing operations and picking of cotton practice. The variable age had positive and significant relationship with technological gap.

Keywords: Technological gap, Bt cotton growers, integrated nutrient management

Bt cotton is a transgenic variety of cotton genetically modified to contain a gene of *Bacillus thuringiensis* (Bt) foreign to its genome. Bt cotton was first developed by Monsanto – a US registered Multinational Corporation. The company claimed that the seeds are resistant to bollworm infestations. Though some of the top cotton-growing countries are adopting Bt cotton, still there is an international debate regarding the sustainability of the crop. Along with certain benefits, there are various risks and uncertainties regarding Bt Cotton. These may be categorized according to the three pillars of sustainability – environmental, economical and social issues. The most significant environmental risks of Bt cotton use are a loss of biodiversity, the development of pest resistance, impacts on non target beneficiaries and human risks, such as toxicity and allerenecity. The economic risks mainly accrue from the high seed costs. Negative social impacts may arise indirectly through these economic risks – where higher levels of investment are lost as a result of crop failures (Iyengar and Lalitha, 2002). On the other hand, supporters argue that Bt Cotton is beneficial as it has pest resistance. This means that pesticides are not required – reducing costs and giving higher yields, resulting in increasing farmers' profit, as well as increasing food security in developing countries.

The world cotton production was estimated at 105.72 million bales of 480 lb in 2016 17 (USDA, March, 2017), around 9.3 per cent more than last year. It is also indicated that the area under cotton declined to the tune of 1.28 million ha (4.18%) as compared to 2015-16. The estimates of USDA indicate that India continued to be the leading producer of raw cotton followed by China and the United States. India also maintains the largest area under cotton in the world and it is second largest exporter of cotton next to the United States. In India, the cotton production during 2016-17 is expected to produce 351 lakh bales of 170 kg from 105 lakh hectare with a productivity of 568 kg lint/ha. In Karnataka, during 2016-17, the area under cotton crop was 4.64 lakh ha with production of 19.90 lakh bales (Anon., 2016-17).

India has the largest cotton area in the world with 90 lakh hectares accounting for one-fourth of the global cotton area. Cotton contributes 29.90 per cent of the Indian agricultural gross domestic product and provides livelihood to nearly six crore people (Pratiyogitha Darpana, 2010). In Karnataka, cotton is grown on an area of 5.34 lakh hectares with the production of 10.00 lakh bales and productivity of 318 kg per hectare (Pratiyogitha Darpana, 2010). Since the introduction of hybrids, pest menace in cotton is severe resulting in indiscriminate use of insectiside, increase in crop losses and reduction in productivity and income to farmers. In some of the area the Bt cotton cultivation was discontinued due to severe attack of insect pests.

The technological gap is the major problems in efforts to increase agricultural production in the country. A need of the day is to reduce technological gap between agricultural technology recommended by the scientists and its ultimate acceptance of the farmers on their field. Bt cotton crop as an economic venture, supports and improves the economics of farmers and helps in providing raw materials needs of the prestigious textile industry. Hence, the present study is taken up with the following specific objectives :

1) To analyse the technological gap in Bt cotton cultivation.

2) To find out the relationship between the farmers characteristics with technological gap.

Methodology

The study was conducted in Northern dry zone (Zone-3) of Karnataka. In this zone, four districts namely, Dharwad, Haveri, Gadag and Koppal and two talukas in each district were selected. From each taluka, two villages and from each village ten rainfed farmers were selected. Thus, the total number of respondents for the study was 160. The ex-post facto research design was employed. The data was collected with the help of structured interview schedule.

Technological gap is the gap between the technology or inputs being recommended by the agronomists or by research stations and the inputs being used in the farmers field. Technological gap was conceived as the gap between the level of recommendation and the extent of adoption (against recommendation) Tripathy (1977) and Sadamate (1978). The recommended technologies for the study have been selected by using the reports published by Central Institute for Cotton Research (CICR) and in consultation with research scientists and extension personnel working on Bt cotton crop. The Bt cotton cultivation practices were selected from the package of practices recommended by Central Institute for Cotton Research (CICR) for Karnataka state.

Results and Discussion

Practice-wise Technological Gap of Bt Cotton Growers

Table I depicts about practice wise technological gap. It was observed that 75.00 per cent were having low technology gap in selection of Bt hybrid followed by 15.63 and 6.37 per cent of the respondents belonged to high and medium technological gap category, respectively. Majority of the farmers were not aware about suitable Bt cotton in their locality that might be the reason for falling under low level of technological gap.

In case of agronomic practices, 53.75 per cent of the respondents were having low technological gap followed by 35.00 and 11.25 per cent of the respondents belong to high and medium technological gap category, respectively. Regarding sowing methods, 48.12 per cent of the respondents belong to low technological gap category followed by 43.13 per cent and 8.75 per cent of the respondents belong to high and medium technological gap category, respectively.

In case of Integrated Nutrient Management (INM) practices, 71.88 per cent of respondents were having medium level of technological gap followed by low (17.50%) and high level (10.62%) of technological gap.

Regarding post sowing operations, it was found that 68.75 per cent of respondents were having low level of technological gap followed by 20.00 per cent and 11.25 per cent of the respondents had high and medium technological gap, respectively. In case of cotton based cropping system, the crop rotation practice, 83.75 per cent of the respondents were having medium level of technological gap followed by 8.75 and 7.50 per cent respondents having high and low technological gap, respectively. With respect to intercropping practices, 76.25 per cent of the respondents were in medium level of technological gap followed by 18.13 and 5.62 per cent of the respondents belongs to high and low technological gap category, respectively. In the physiological disorder management practice, 64.38 per cent respondents belong to medium technological gap category followed by 21.25 and 14.37 per cent of the respondent belong to high and low technological gap category, respectively. The data

TABLE I

Practice-wise technological gap of Bt cotton growers

(n=160)

Practices	Category	Bt cotton growers	
		Frequency	Per cent
Hybrids of Bt cotton	Low	120	75.00
	Medium	15	9.37
	High	25	15.63
Agronomic practices	Low	86	53.75
	Medium	18	11.25
	High	56	35.00
Sowing method	Low	77	48.12
	Medium	14	8.75
	High	69	43.13
INM	Low	28	17.50
	Medium	115	71.88
	High	17	10.62
Post sowing operations	Low	110	68.75
	Medium	18	11.25
	High	32	20.00
Cotton based cropping system			
a) Crop rotation	Low	12	7.50
	Medium	134	83.75
	High	14	8.75
b)Intercropping	Low	9	5.62
	Medium	122	76.25
	High	29	18.13
Physiological disorder	Low	23	14.37
	Medium	103	64.38
	High	34	21.25
Crop protection measures			
a) Diseases	Low	14	8.75
	Medium	116	72.50
	High	30	18.75
b) Pests	Low	9	5.63
	Medium	105	65.62
	High	46	28.75
Picking of cotton	Low	69	43.13
	Medium	52	32.50
	High	39	24.37

further revealed that most of the respondent's *i.e.,* 43.13 per cent possessed low level of technological gap about picking of cotton followed by 32.50 per cent and 24.37 per cent respondents having medium and high level of technological gap, respectively. It was found that out of nine practices four practices such as crop protection measures, physiological disorder management, cotton based cropping system and Integrated Nutrient Management (INM) practices were found medium to high level of technological gap. This reflects that there is scope for improvement by reducing the technological gap in Bt cotton growers by educating the Bt cotton farmers about recommended practices and improve their economic level.

In case of crop protection measures, it was found that majority (72.50%) of respondents had medium level of technological gap followed by high (18.75%) and low (8.75%) level of technological gap with respect to diseases management. Regarding pest management practices, it was observed that 65.62 per cent of the farmers belong to medium level of technological gap followed by 28.75 and 5.63 per cent had high and low technological gap, respectively.

The technological gap in major cultivation practices, especially in crop protection measure deserves attention. It was found that farmers are using over dose or under dose of plant protection chemicals than the recommended. This resulted in pest resurgence. The results are in close agreement with the findings of Jaiswal and Duboliya (1994), and Ray *et al*. (1995), Jaiswal and Rathore (1985), Mahawer *et al*. (1995), Patil and Deshmukh (1995) and Singh and Chauhan (1996). In some cases the respondents are not aware of proper time of application. This was mainly due to lack of knowledge on use of chemicals. The results and observations of the study point to the need for better education of farmers in this regard.

Distribution of farmers based on their technological gap in Bt cotton cultivation

The results in Table II revealed that over one third of the respondents (35.00 %) were found in the low category of technological gap. There were 33.75 per cent of the respondents who had high level of technological gap and 31.25 per cent of the respondents had medium level of technological gap. The probable reasons for technological gap among Bt cotton growers is due to lack of knowledge about technical know-how and they could not get the information on improved recommended practices intime The findings are conformity with the findings of Bhairamkar *et al.* (2005).

TABLE II

Distribution of farmers based on their technological gap in Bt cotton cultivation

(n=160)

Category	Bt cotton growers	
	Frequency	Per cent
Low	54	33.75
Medium	50	31.25
High	56	35.00
Total	160	100.00

Mean = 31.40; S.D= 9.17

TABLE III

Relationship between personal, psychological and socio-economic characteristics of Bt cotton growers and their technological gap

Variables	Correlation co-efficient (r)
Age	0.241**
Family size	0.082 NS
Education	0.116 NS
Land holding	0.145 NS
Annual income	0.125 NS
Innovative Proneness	0.025 NS
Risk orientation	-0.125 NS
Scientific orientation	-0.014 NS
Market orientation	-0.062 NS
Economic motivation	-0.068 NS
Mass media participation	-0.135 NS
Cosmopoliteness	0.032 NS
Extension contact	0.086 NS
Extension participation	0.010 NS

** Significant at 0.01 per cent level;
* Significant at 0.05 per cent level; NS: Non-significant

Relationship between personal, psychological and socio-economic characteristics with their technological gap

The data in Table III revealed that variables such as family size, education, land holding, annual income, innovative proneness, risk orientation, scientific orientation, market orientation, economic motivation, cosmopoliteness, mass media participation, extension contact and extension participation had non-significant relationship with the technological gap of Bt cotton cultivation. Whereas, variable age of the respondents had positive and significant relationship at one per cent level with the technological gap. With increase in age there was corresponding increase in technological gap. The findings are similar with the findings of Anchule (2000).

The study revealed that medium to high level of technological gap was observed in Bt cotton cultivation practices such as integrated nutrient management (INM), crop rotation, inter cropping, physiological disorder management and crop protection measures needs attention. The extension personnel should conduct educational activities to increase the respondents knowledge on improved Bt cotton cultivation practices to minimise the technological gap for getting sustainable yield and income.

REFERENCES

ANONYMOUS, 2016-17, Annu. Rep. All India Coordinated Cotton Improvement Project. CICR, Nagpur, p. 2.

ANCHULE, M. M., 2000, Critical analysis of technological gap in use of pulse production technology. *Ph.D. Thesis* (Unpub.), MAU, Parbhani.

BHAIRAMKAR, M. S., SAWANT, P. A. AND TAWADE, N. D., 2005, Technological gap in cashew cultivation. *Int. J. Extn. Edu.,* **1**: 73-75.

IYENGAR, S. AND LALITHA, N., 2002, Bt Cotton in India: Controversy Visited. *Indian J. Agric. Econ.,* **57** (3): 459-466.

JAISWAL, D. K. AND RATHORE, A. K., 1985, Technological gap in adoption of recommended technology in wheat among farmers growing irrigated and unirrigated wheat. *Maharshtra J. Extn. Edu.,* **4**: 147-149.

JAISWAL, P. K. AND DUBOLIYA, S. R., 1994, Adoption gap in wheat technology. *Maharashtra J. Extn. Edu.,* **13** : 63-68.

MAHAWER, S. K., PUNJABI, N. K. AND DASHARA, P. K., 1995, Technological gap between beneficiaries and non-beneficiaries of schedule caste area research project. *Maharashtra J. Extn. Edu.,* **14**: 51-64.

PATIL, H. N. AND DESHMUKH, M. K., 1995, Impact of Training and Visit System on Rice Economy. *Indian J. Extn. Edu.,* **31** (4) : 98-101.

PRATIYOGITHA DARPANA, 2010, General Studies of Indian Economy, Upkar Prakashan Publication, New Delhi .

RAY, G. L., CHATTERJEE, P. AND BANERJEE, S. N., 1995, Technological Gap and Constraints in Agricultural technology Transfer, Naya Prakash, Calcutta, p.27.

SADAMATE, V. V., 1978, A study of tribal farming system and technological gaps. *Ph.D. Thesis* (Unpub.), Division of Agricultural Extension, IARI, New Delhi.

SINGH, BHAGAVAN AND CHAUHAN, K. N. K., 1996, Technological gap recommended mustard production technology. *Agri. Extn. Rev.,* **8** (3) : 29-30.

TRIPHATHY, A., 1977, A study on technological gap in adoption of new rice technology in coastal Odissa and their constraints. *M.Sc. (Agri.) Thesis* (Unpub.), IARI, New Delhi.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 326-330, 2017

Development of Readability Formula for Kannada Language

A. MADHUSHREE AND D. NANJAPPA
Department of Agricultural Extension, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: madhushree819@gmail.com

ABSTRACT

An attempt has made to develop readability formula for Kannada language in the present study using text books (2nd to 10th standard) of kannada and science state syllabus in which 141 sample criterion passages were selected. The samples have been analyzed with reference to readability variables like Word length (WL), Average sentence length (ASL) and Percentage technical words (PTW). The three readability variables had positive and significant relationship with respect to grade level. The correlation values of the variables corresponding to the grade level were ASL(0.74), WL(0.46) and PTW(0.47). Hence, these variables were considered in the development of readability formula. The readability formula obtained on the basis of regression analysis reads as GL=-4.45+1.425(WL)+ 0.7262(ASL)+0.0437(PTW). Where, GL= grade level estimated, x_1= WL, x_2= ASL and x_3= PTW. The variation in the grade level was explained to the extent of 63 per cent by these three independent variables (R^2=0.63). The developed formula be used by the communicators, writers and authors to know the grade level of the writing and it could be also used as a guideline in modifying their writing to make it readable to the intended audience.

Keywords: Readability, agricultural publications, feature article, agricultural journalism

IN a country where agriculture is predominant occupation, communication of scientific information to farmers is a vital element in the process of agricultural development. Print media serve as potential source of information to the audience in terms of accuracy, preservability, timeliness and understanding of the message by reader. In view of increased literacy over the last few decades, the print media have acquired greater importance in the education of farmers. The increase in literacy level to 75.60 per cent in Karnataka during 2011 implies that three fourth of the farming population can make use of print media effectively. Hence, the print media has greater potentials in the present situation. Besides newspapers and farm magazines, the agricultural universities publish a large number of books, booklets, bulletins and brochures related to farming on a regular basis. These publications are published in local language so that they can reach and have an impact on the rural readers. The present day writers have a challenge of presenting the information in the most simplest and understandable form to reach the audience. A piece of writing is said to be readable if it could be read and understood by the readers for whom it is intended (Anon., 1963).

Readability is the indication of level of comprehension of a written or published material as measured by any method of measuring readability (Klare, 1984). The readability is expressed in terms of reading difficulty or reading ease of a written or published material. Readability formula is a predictive device to determine the extent of readability of selected written material. It is useful to know the readability levels of agricultural publications in particular and other publication in general. It recognises the elements in writing that are related to reader's success. Readability formula provides an estimate of the difficulty of writing without requiring the reader to read it and undergo tests on it (Klare, 1963). In this context readability formula is considered as a diagnostic and clinical tool in the pathology of communication (Flesch, 1951). Readability formulas are the only objective method for determining the difficulty of written texts and studies have shown that readability formulas correlate well with comprehension difficulty as measured by reading tests (Du Bay, 2004). Eventhough, a lot of research has been made to measure readability in English language, only a beginning is made in this direction in Kannada language. The aforesaid preamble emphasized the need for developing readability formula for Kannada language. With this background, the present study was conducted with the following specific objectives :

1) To develop and standardize readability formula for kannada language and
2) To measure the reading is of agricultural publications of the university using the developed formula.

METHODOLOGY

In the present study the kannada and science text books prescribed by the Government of Karnataka from 2nd to 10th standards were selected as criterion passages for the study. From each of the 15 text books considered, every 10th page was selected as sample for the measurement of readability variables. The total number of passages selected were 141. The readability variables constituted were Word length (WL), Average sentence length (ASL), and Percentage technical words (PTW).

Word length : This refers to the number of letters or alphabets contained in a word. e.g. the word 'I' has one letter and the word 'you' has three letters.

Calculation of word length : This variable was measured by adopting the following formula

$$Word\ length = \frac{Number\ of\ letters\ in\ a\ passage}{Number\ of\ words\ in\ that\ passage}$$

Calculation of Average sentence length:

This variable was measured by adopting the following formula.

$$Percentage\ Tech.words(PTW) = \frac{Number\ of\ technical\ words\ in\ a\ passage}{Total\ number\ of\ words\ in\ a\ passage} \times 100$$

Technical word: Technical words are operationally defined asthe wordsrelating to a particular subject, art, or craft, or its techniques which requires special knowledge to understand.Each of the technical word occurred in the passage should be counted separately and recorded even when it appeared more than once (Dale and Tyler, 1934)

Calculation of Technical words per 100 words: This variable was measured by adopting the following formula

$$Percentage\ Technical\ words(PTW) = \frac{Number\ of\ technical\ words\ in\ a\ passage}{Total\ number\ of\ words\ in\ a\ passage} \times 100$$

At the first instance the data were subjected to correlation analysis. The variables showing positive and significant relationship with respect to grade level were considered for the development of readability formula. The three variables WL, ASL and PTW were selected to develop readability formula for the present study as they exhibited higher 'r' values. In the next step, regression analysis was employed to ascertain the extent of variation caused by the three independent variables and also to obtain the values of constant and the regression coefficients. Based on the values pertaining to the constant and the regression coefficients in the results the readability formula was developed for predicting the grade level of the passages.In order to serve as an illustration of use of the formula developed, the readability formula developed in the current study was applied to the farm journal published by UAS, Bengaluru and reading ease of the selected articles were measured.

It was decided to apply correlation test to know the nature and extent of relationship. The three readability variables selected for analysis and development of readability formula were: (i) Average Sentence Length, (ii) Word Length and, (iii) Percentage of Technical Words (PTW). In accordance with the guidelines of using present readability formula, 10 samples from 'KrishiVignana' journal and five farm folders were drawn and readability variable were analysed. The WL, ASL and PTW were measured.

Directions for the application of readability formula

Readability formula is being applied by variety of people in different fields of communication and education. In this situation it is essential to use guidelines or the directions for the application of the formula.

While selecting samples, take about 100 words from every tenth page in case of books. Never begin or end a sample in the middle of sentence. In methodology the procedures involved in measurement of variables using the formula have been explained.

*Counting of words :*A word consisting letters or alphabets, denotes a specific meaning of its own. One word is separated from the other usually by one more type spaces in the typed or printed passage. Word is any single symbol used in writing and classifiable among parts of speech. The following procedure need to be used in counting the words.

1. Count all noun forms as one word.
2. All the hyphenated words were counted as one word.
3. In counting the words, an abbreviation is counted as one word. U.S.A is counted as one word
4. The words relating to numbers were written as they are usually pronounced before counting. *e.g.,* Nineteen forty seven for 1947.

*Counting of sentences :*A sentence is a group of words, which is marked off by periods like full stop, exclamatory mark and question mark. Small headings, which do not have the quality of a sentence, are not considered for counting of sentence.

Counting of Technical words: Technical words are the words relating to a particular subject, art or craft or its techniques which requires special knowledge to understand. *e.g.,* Nitrogen fixation, infiltration, transplanting *etc.* each of the technical word occurred in the passage should be counted separately and recorded even when it appeared more than once. After analysing the readability variables occurred in the passages it should be simplified in the developed formula by multiplying with regression co-efficients. Further, round off the obtained fractional value to the nearest whole number to attain the grade level of the sample passages.

Results and Discussion

As revealed from the data in the Table I, the value of correlation coefficient between grade level and WL was 0.46, while that between PTW and grade level was 0.47. Grade level and ASL had shown highest correlation coefficient value of 0.74. All these three variables were positively and significantly related to grade level. Inter correlation between ASL and PTW was 0.38, while ASL and WL was 0.46 and between PTW and WL was 0.46, which was significant at 0.01 level of probability.Hence, they were considered in the development of readability formula.

Table I

Correlation between grade level and readability variables (n=141)

	Grade level	WL	ASL	PTW
Grade level	1			
WL	0.4645**	1		
ASL	0.7474**	0.4696**	1	
PTW	0.4761**	0.4674**	0.3844**	1

Using the readability variables, the readability formula was developed with regression formula.

$$Y = a + b_1x_1 + b_2x_2 + b_3x_3 \ldots\ldots\ldots bnxn$$

Where, Yis the dependent variable to be estimated

'a' is the constant

b_1, $b_2$and b_3 are the estimted regression coefiicients

x_1, x_2 and x_3 are the independentvariables

Regression weights presented in Table II were utilized for fitting regression equation.The coefficient of determination indicates the amount of variation in the grade level explained by WL, ASL and PTW combined with the regression weights used. The value of R^2 was 0.63.Higher value of multiple correlation in the present study indicates the strength of relationship between readability variables and grade level.

Table II

Regression analysis of grade level with independent variables (n=141)

Variable	Regression Coefficient b)	SE of Regresco effient(Seb)	t' value	A	R^2	F
WL	1.425	0.377	3.78			
ASL	0.7262	0.0743	9.78			
PTW	0.0437	0.0183	2.39	-4.45	0.63	80.58

TABLE III

Grade level of articles published in Krishi Vignana published by UAS, Bengaluru

Article No	WL	ASL	PTW	Readability value	Grade level	Range of readability
1	3.83	10.8	0.92	8.89	9	High school
2	3.86	16.71	5.98	18.30	18	>PUC
3	3.66	19.01	2.25	14.64	15	>PUC
4	3.58	8.30	0.00	6.67	7	Middle school
5	3.31	15.10	3.67	11.38	11	PUC
6	3.81	12.21	0.81	9.85	10	High shool
7	4.03	22.16	2.25	17.38	17	>PUC
8	3.70	14.01	0.00	10.98	11	High school
9	4.16	14.10	0.00	11.65	12	PUC
10	3.83	13.75	0.00	10.98	11	High school

TABLE IV

Grade level of farm folders published by UAS, Bengaluru

Article No	WL	ASL	PTW	Readability value	Grade level	Range of readability
1	3.69	15.20	0.00	11.83	12	PUC
2	3.51	13.51	1.63	10.42	10	High school
3	3.43	15.00	0.83	11.35	11	PUC
4	3.38	9.36	1.94	7.23	7	Middle school
5	3.15	9.90	1.01	7.25	7	Middle school

Using these values, the following readability formula was obtained:

$GL= -4.45+ 1.425X_1+ 0.7262\ x_2 +0.0437\ x_3$

Where, GL= Grade level

x_1= Word length (WL)

x_2=Average Sentence Length (ASL)

x_3= Percentage Technical words (PTW)

In order to measure the grade level of any passages, there is a need to measure the WL, ASL and PTW of the intended passage and substitute the figures in the formula.

Application of the formula on agricultural publication

The data on this aspect are denoted in Table III and Table IV. The results specified that among 10 articles in the journal 40 per cent of articles belonged to 8th to 10th standard, 30 per cent belonged to more than 12th standard followed by nearly 20 per cent of articles belonged to 11th and 12th standard and only 10 per cent of articles belonged to middle school level difficulty. Majority of the articles in farm folders belonged to below college level (60%) and 40 per cent of the articles belonged to middle school level. This indicates that majority of the articles belonged to high school level of difficulty.

Majority of the articles published in Krishi Vignana are below to High School level of readability. The readability formula developed has direct application in the field of education, mass communication, journalism and agricultural extension. The developed formula can be used by the communicators, writers and authors to know the grade level of any written or published material. By using the readability formula developed, it is possible to analyse the already published extension literature and other publications to determine their suitability to the intended readers. This work will provide the required feedback for communicators and writers to appropriately modify the writings for the benefit of intended readers.

References

Anonymous, 1963, Simple reading materials for adults and youth education, 3, UNESCO, Paris.

Du Bay, W., 2004, The principles of readability. Impact Information, p. 1–76.

Flesh, R. F., 1951, Reply to Criticism by Jenkins and Jones, *J. Appl. Psychol.,* **35**: 69.

Klare, G. R., 1963, The Measurement of Readability, IOWA State University Press, Ames.

Klare, G. R., 1984, Readability. Handbook of reading research, ed. P. D. Pearson. New York: Longman, p. 681-744.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 331-338, 2017

A Scale to Measure Climate Resilience Management Level among Farmers and Its Application

M. A. Murthy and K. Nagabhushanam
Department of Agricultural Extension, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: murthy526.mudd@gmail.com

Abstract

An attempt is made in the study to construct a scale to measure climate resilience management level among farmers. The method of summated rating procedure was followed in the construction of climate resilience management scale. All those items with the relevancy weightage of 0.75 and above were selected for the inclusion in the climate resilience management level scale. Sixty items retained in the scale to measure the climate resilience management level. The scale developed was found reliable (0.9223) and valid (0.9603). The results revealed that 43.33 per cent of farmers belonged to medium level of climate resilience management followed by 38.34 and 18.33 per cent had low and high level of climate resilience management level, respectively.

Keywords: Climate change, resilience management level, item analysis, reliability, validity

Climate change is posing biggest challenges facing the world today. The problems of human induced climate change first came into force and drew the attention of the scientist and policy makers when Inter Governmental Panel on Climate change was established. Agriculture in entire world and particularly in India mostly depend on the persisting weather conditions. The alteration in global warming has dramatically affected on agriculture and it's productivity, through serious-erratic monsoon, micro level changes in agricultural zones, spread of tropical diseases, sea level rise, change in availability of fresh water, floods, droughts, heat waves and storms, etc. Analysis of different metrological data from weather stations in the country shows that there is an upward trend in mean temperature and downward trend in relative humidity (RH), annual rainfall and number of wet days in a year. With unpredictable weather, farmers keep changing crop management practices by growing suitable crops, varieties and be prepared for constant change in the farming practices.

Impacts of climate change are diversified and need to be understood, so as to workout pragmatic strategies to mitigate ill-effects of climate change. There is no scale available to measure climate resilience management level; hence, the present study was taken up with following objectives :

1) Developing a scale to measure the climate resilience management level among the farmers.
2) To measure the climate resilience management level among the farmers in eastern dry zone.
3) To document the climate resilience management practices followed by farmers to mitigate climate change.
4) To know the association between Climate resilience management and farmers profile characteristics and.
5) To enlist the constraints faced by farmers due to climate change and their suggestions.

Methodology

The study was conducted in Chikkamagalur district of Karnataka state during 2016-17. Study area was purposively selected because it represents both rainfed and irrigated conditions. Randomly 60 farmers were personally interviewed using the scale developed to measure the Climate resilience management level among the farmers. The collected data was scored and analyzed using frequency and percentage.

Development of scale to measure the Climate Resilience Management level among farmers

Climate Resilience Management level is operationally defined as the capacity for a socio-ecological system to absorb stresses and maintain functional in the face of external stresses imposed by climate change and adopt, reorganize and evolve into more desirable management practices that improve the sustainability of the system and better prepared for future climate change impacts. The method suggested by Likert (1932) and Edward (1969) in developing scale was followed in construction of climate resilience management level among farmers. The procedure followed in construction of the scale is depicted in the following steps.

Table I revealed that 21 dimensions were identified from the literature and discussion with experts in the selected fields. It is apparent that, all

TABLE I

Steps to develop and standardize a scale to measure the climate resilience management level among farmers

Steps	Management level	
	Considered	Retained
Collections of Dimensions	21	4
Collection of items	110	110
Editing of items	110	81
Relevancy Analysis	81	70
Item Analysis	70	60
Reliability and Validity	60	60
Administrating the scale	60	60

the 21 dimensions will not contribute equally towards the climate resilience management level among farmers. Hence, the variation in contribution of each dimension for the resilience management must be represented by assigning different weightage to each of the dimension. Judgment ratings for all the 21 dimensions were obtained and the relevancy weightage were worked out. Based on relevancy weightage more than 0.90 is considered, accordingly four dimensions, namely natural resource degradation management, agriculture resource /non agriculture resource management, environmental protection and ecological security management were identified and included to develop the scale. 130 statements pertaining to Climate Resilience Management level was prepared based on the available literature and discussion with experts from selected areas.

Further, the statements were edited as per the 14 criteria suggested by Edwards (1969), Thurstone and Chave (1929). As a consequence 29 statements were eliminated and the remaining 81 statements were included for the study. Eighty one statements were mailed to experts in the Agricultural Extension and other related fields working in SAUs, ICAR institutions in Karnataka State Department of Agriculture to critically evaluate the relevancy of each component viz., Most Relevant (MR), Relevant (R), Somewhat Relevant (SWR), Less Relevant (LR) and Not Relevant (NR) with the score of 5, 4, 3, 2 and 1, respectively. The 'relevancy weightage' and 'mean relevancy score' were worked out for 81 statements. The statements were analyzed for their relevancy using the following formulae.

$$\text{Relevancy Weightage} = \frac{(MR\times5)+(R\times4)+(SWR\times3)+(LR\times2)+(NR\times1)}{\text{Maximum Possible score}}$$

$$\text{Mean Relevancy Score} = \frac{(MR\times5)+(R\times4)+(SWR\times3)+(LR\times2)+(NR\times1)}{\text{Number of Judges responded}}$$

The results on the relevancy weightage and mean relevancy weightage score obtained after analysis. Accordingly statements having 'relevancy weightage' of more than 0.75 and above and 'mean relevancy score' of 3.65 and above were considered for final selection. Sixty statements were retained after relevancy test and these statements were suitably modified and written as per the comments of the judges wherever applicable.

$$t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\dfrac{\left[\Sigma x^2_H - \frac{(X_H)^2}{n}\right] \left[\Sigma x^2_L - \frac{(X_L)^2}{n}\right]}{n\,(n-1)}}}$$

where

Σx^2_H= sum of the square of the individual scores (high group)

Σx^2_L= sum of the square of the individual scores (Low group)

x_H=mean score for the given item for high group

x_L=mean score for the given item for low group

Item analysis

To delineate the statements based on the extent to which they can differentiate the Climate Resilience

Management level as lower or lower management level, item analysis was carried on the statements selected in the first stage. For item analysis, statements were arranged in ascending order based on relevancy score. The 't' value of the statements were calculated by using following formula.

Based on the item analysis (t value), 60 statements which were statistically significant at 5 per cent and 1 per cent were finally retained in the scale to Climate Resilience Management level.

Reliability and validity of the scale

The value of correlation coefficient was 0.8595 and this was further calculated by using Spearman brown formula and obtained the reliability coefficient of the whole test. The value of the scale was 0.9223 which was highly significant at 1 per cent level indicating high reliability of the scale. The validity of coefficient of the scale was 0.9603 which was also statistically significant at 1 per cent level of probability indicates the higher validity of the developed scale. Hence, the scale is said to be valid. Thus the developed scale to measure the Climate Resilience Management level was feasible and appropriate.

Table II indicates that 60 statements which determines the Climate Resilience Management level consist of both positive and negative statements. The

TABLE II

Statement consisted to measure the climate resilience management level among the farmers

Statement	Measurement				
	Fully in Vogue	In Vogue	Un decided	Partially in vogue	Not in Vogue
1	2	3	4	5	6
I Natural resource degradation management					
1. Sustainable and equitable use of resources for meeting the basic needs of the present and future generations without causing damage to the environment					
2. Non-adoption of soil-conservation management practices leads to desertification of the agricultural land					
3. Steps for restoration of ecologically degraded areas and for environmental improvement in our rural settlements					
4. Cost effective and efficient methods of water conservation and use					
5. Encouraging crop rotation patterns					
6. Environmental consciousness through education and mass awareness programs which can reduces the natural resource degradation.					
7. Prevent and control the future deterioration in land, water and air which constitute our life-support systems					
8. Ensure that development projects are correctly sited so as to minimize their adverse environmental consequences					
9. Ensuring land for different uses based upon land capability and land productivity					
10. Encouragement for improvement in traditional methods of rain water harvesting and storage					
11. Developing coping mechanisms for future climatic changes as a result of increased emission of carbon dioxide and greenhouse gases					

1	2	3	4	5	6
12. Development and promotion of methods of sustainable farming, especially organic and natural farming					
13. Raising of green belts with pollution tolerant species can protect the natural resources.					
14. Efficient use of inputs including agro-chemicals with minimal degradation of environment					
15. Inorganic fertilizer ,insecticides and other chemicals used in non-organic farming cause long term harmful effects to the environment					
II Agricultural resource / Non agricultural resource management					
1. Organic farming is effective in increasing the texture and fertility of soil.					
2. Integrated pest management is a boon to reduce the chemical use for plant protection.					
3. Integrated farming system is one of the best method to use the agricultural resource management.					
4. Measures for increasing the efficiency of water-use, water conservation and recycling					
5. Setting up of biogas plants based on cow-dung and vegetable wastes					
6. Restoration and protection of grazing lands					
7. A movement toward greater efficiency in resource use including recycling					
8. Protection and sustainable use of plant and animal genetic resources through appropriate laws and practices					
9. Development of integrated pest management and nutrient supply system					
10. Afforestration on common lands by the local communities through government schemes					
11. Improvement in genetic variability of indigenous population					
12. Incentives for environmentally clean technologies, recycling and conservation of natural resources					
13. Concerted efforts for development and propagation of non-conventional renewable energy generation systems					
14. Improvement of infra-structural facilities such as water supply, sewerage, solid waste disposal, energy recovery systems					
15. Encouraging efficient utilization of forest produces					

1	2	3	4	5	6
III Environmental protection					
1. Environmental change causes negative effect on people health and animals					
2. Organic farming can improve soil fertility and soil structure					
3. Willing to give up part of my profit for environmental conservation					
4. Create environmental consciousness through education and mass awareness programs					
5. Climate resilience reduces environmental degradation					
6. Environmental factors play an important role in climate change					
7. Crop cover may protect the soil climate					
8. Climate resilience efficient in mitigating climate change effects					
9. Less risk of pollution in climate resilience practices					
10. Raising of green belts with pollution tolerant species					
11. Increasing temperature and variation in rain fall are the main indicators of environmental change and modify the cropping pattern					
12. Inorganic fertilizers and pesticides cause long term harmful effects to the environment					
13. Pesticides and chemical fertilizers will reduce the number of soil micro organisms					
14. Practicing the afforestration activities helps in increasing environmental conditions					
15. Climate change reduces mineral output to the environment					
IV Ecological security management					
1. Conservation of natural and domesticated ecosystems, and of wild and domesticated species, to the fullest extent possible and the restoration and regeneration of degraded ecosystems					
2. Protection of domesticated species/varieties of plants and animals in order to conserve indigenous genetic diversity					
3. Bringing together the representatives of village institutions, civil society groups, academics and government functionaries on a common platform, so as to achieve better stewardship of the area					

1	2	3	4	5	6
4. Concentrating on Common Property Resources as these offer a single platform to collectively address issues of social justice, ecological restoration and poverty alleviation					
5. Development and promotion of methods of sustainable farming, especially organic and natural farming					
6. Development of methodologies to multiply, breed and conserve the threatened and endangered species through modern techniques of tissue culture and biotechnology					
7. Encouraging private individuals and institutions to regenerate and develop their wastelands					
8. Support for protecting traditional skills and knowledge for conservation of resources					
9. Conservation of micro-fauna and micro-flora which help in reclamation of wastelands and revival of biological potential of the land					
10. Protection and sustainable use of plant and animal genetic resources through appropriate laws and practices					
11. Restriction on introduction of exotic species of animals without adequate investigations					
12. Discouragement of monoculture and plantation of dominating and exotic species, in areas unsuited for them and without sufficient experimentation					
13. Taking measures to increase the production of fodder and grasses to bridge the wide gap between supply and demand					
14. Reorientation of the development process, ensuring that ecological and livelihood security become central concerns and that the conservation of biodiversity receives the highest priority					
15. Development and strengthening of formal education efforts for awareness of biodiversity promoting action for sustainable use and biodiversity conservation					

response collected on a five point continuum, namely, fully in vogue, in vogue, undecided, partially in vogue, and not in vogue with assigned score of 5, 4, 3, 2 and 1, respectively for positive statements and vice versa for negative statements. Thus, the minimum and maximum score one could get is 60 and 300, respectively. Higher the score indicates the high management level of farmers towards Climate Resilience Management level and lesser the score indicates low management level.

Results and Discussion

Dimension wise analysis climate resilience management level among farmers in Eastern Dry Zone

The results in Table III revealed that the irrigated situation, natural resource degradation management (62.00%) and Agriculture / non agricultural resource management (60.00%) were ranked I and II, respectively. Where in rainfed situation, environmental

TABLE III

Dimension wise analysis climate resilience management level among farmers in eastern dry zone

Dimensions	Scores	Per cent	Rank
Irrigated (n=30)			
Natural resource degradation management	93.43	62.00	I
Agriculture / non agricultural resource management	90	60.00	II
Environmental protection	88.25	58.84	III
Ecological security management	87.85	58.56	IV
Rainfed (n=30)			
Environmental protection	128	85.34	I
Ecological security management	84	56.00	II
Agriculture / non agricultural resource management	71.22	47.48	III
Natural resource degradation management	62.14	41.42	IV
Pooled (n=60)			
Environmental protection	216.25	72.00	I
Ecological security management	171	57.00	II
Agriculture / non agricultural resource management	161	53.67	III
Natural resource degradation management	155	51.66	IV

TABLE IV

Climate resilience management level of the farmers different situations in eastern dry zone

Management level	Irrigated		Rainfed	
	No.	%	No.	%
High	8	26.67	5	16.67
Medium	15	50.00	11	36.67
Low	7	23.33	14	46.66
Total	**30**	**100**	**30**	**100**

TABLE V

Distribution of farmers according to their climate resilience management level in eastern dry zone

Management level	No.	%	Mean	SD
High	13	18.33		
Medium	26	43.33	249.56	9.49
Low	21	38.34		
Total	**60**	**100**		

protection (85.34%) ecological security management (56.00%), were ranked I and II, respectively. In pooled situation, environmental protection (72.00 %) and ecological security management (57.00 %) were ranked I and II, respectively. The probable reason for above findings might be environmental protection is the prime factor which determine climate change. Ecological security management determine the life of all creatures on this earth and ecological resource supports the living beings. The findings are conformity with the findings with Mamathalakshmi *et al.* (2013).

Climate resilience management level among the farmers in Eastern Dry Zone

An examination of Table IV indicates the levels of climate resilience management of farmers in different situations. In irrigated situation, half of the respondents (50.00 %) belongs to medium climate resilience management subsequently 26.67 and 23.33 per cent under high and low climate resilience management, respectively. Due to irrigation facilities, the irrigated farmers harvests two to three crops in a year leading to increased opportunities. In the rainfed situation, 46.66 per cent respondents had low level of climate resilience management followed by 36.67 and 16.67 per cent of them fall under medium and low climate resilience management level, respectively. As it is rainfed situation only one crop can be harvested per year was the possible reason for this type of results. The findings are conformity with the findings of Vinay Kumar *et al.* (2010).

Distribution of farmers according to their climate resilience management level in Eastern Dry Zone

A critical look at the Table V shows that 43.33 per cent of farmers belonged to medium level of climate resilience management followed by 38.34 and 18.33 per cent of them belong to low and high climate resilience management level, respectively. It can be inferred that majority (62 %) of farmers had medium level to high level of climate resilience management level. Most of the respondents have availed the benefits of government initiated programmes and also majority of the respondents depends on-farm and off-farm activities for their livelihood security. The results are in close agreement with findings of Shankar (2010).

It can be concluded that the scale developed is useful to measure the climate resilience management level beyond the study area with suitable modifications. The reliability and validity of the developed scale indicated the precision and consistency of results. The study revealed that majority (62 %) of farmers had medium to high level climate resilience management practices.

References

EDWARDS, A. L., 1969, Techniques of Attitude scale construction. *Vikils, Feger and Simons Pvt. Ltd.,* Bombay.

LIKERT, R., 1932, A technique for the management of attitude. *Psych. Stud.,* **5** : 106-107.

MAMATHALAKSHMI, N., 2013, An analysis of Livelihood security among Agricultural labourers in Karnataka. *Ph.D. Thesis*, (Unpub.), Univ. Agri. Sci., Bengaluru.

SHANKARA, M. H., 2010, A study on farmers perception of climate change and their adaptations. *M.Sc. (Agri.) Thesis* (Unpub). Univ. Agric. Sci., Bengaluru.

THURSTONE, L. L. AND CHAVE, E. J., 1992, The measurement of attitude. *Chicago University Press,* USA, p. 39-40.

VINAY KUMAR, C. T. AND UMESH, K. B., 2015, Perception and adaptation of the famers to climate change. *Karnataka J. Agric. Sci.*(Spl. Issue), **28**(5):822-827.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 339-346, 2017

Development of Scale to Measure the Attitude of Farmers towards different Audio-Visual Electronic Media and Its Application

S. Sowjanya and N. R. Gangadharappa
Department of Agricultural Extension, College of Agriculture, UAS, GKVK, Bengaluru - 560 065
E-mail : souju.janya@gmail.com

Abstract

The present study was contemplated to develop and standardize a scale to measure the attitude of farmers towards audio-visual electronic media. The attitude scale developed was found to be reliable and valid. Among the different treatments, Mobile (Whats App) treatment has got highest significance compared to television and agriportal. When compare to control group it can be clearly noticed from the results that treatment area has got more favourable attitude towards different audio-visual electronic media. The results revealed that as high as 43.33 per cent of the farmers had favourable attitude, whereas 33.33 and 23.33 per cent of the farmers had most favourable and least favourable towards Audio-visual electronic media, respectively.

Keywords: Attitude scale, electronic media, likert's summated rating, item analysis, reliability, validity

Agricultural Extension in the current scenario of rapidly changing world has been recognized as an essential mechanism for delivering knowledge (information) and advices as an input into modern farming (Jones ,1997). Present day agriculture and Indian farming community is facing a multitude of problems to maximize crop productivity. In spite of successful research on new agricultural practices related to crop cultivation, majority of farmers are not getting upper bound yield due to several reasons. One of the reasons that expert / scientific advice regarding crop cultivation is not reaching farming community in a timely manner. Farmers need expert advice well on time to make them more productive and competitive. For this, extension agency plays a major role in bridging this gap to make available the latest technologies at the door step of the farmers. Agricultural extension which depends to a large extent on information exchange between and among farmers on the one hand and a broad range of other actors on the other, has been identified as one area in which electronic media can play a significant role.

Electronic media are technologies offering new ways for communicating and exchanging information and knowledge. Modern electronic media when applied to conditions in rural areas can help to disseminate information, improve farmer's knowledge, increase their participation and share knowledge with others. It is said that cyber extension would be the major form of information technology, since farmers still have the difficulty in accessing accurate information to make timely decisions. It is essential that information availability is demand - driven rather than supply - driven. The challenge is not only to improve the accessibility of communication technology to farmers, but also to improve its relevance to local conditions and specific situations. There is a great need to utilize electronic media for the advancement of the agricultural sector by involving all the partners in the process. The three important partners in agriculture development are researchers, farmers, and extension workers. They need to interact in the context of the problems faced by the farmers. The extension workers have to provide solutions to the problems faced by farming community. Information may come to farmers from various sources. It may be from personal, impersonal, institutional, localite, cosmopolite or mass media sources. The appropriateness of these sources varies from enterprise to enterprise, situation to situation and from time to time. Further, the credibility of information sources also varies with respect to the competency and trustworthiness of the source. Hence, it becomes quite important to channelize the right information at the right time and through the right channel. For this, knowledge of different information sources consulted by farmers under different situations and at different times is required by all those concerned. It is the field of agriculture that knowledge networking through electronic media is going to make a big difference in the life of people in the developing world.

Electronic media could provide farmers, the farm related information such as package of practices, weather forecasting, access to credit, prices and availability of farm inputs, market information, etc., the unrestricted flow of information through the electronic media process opens an avenue for the people to view other from a different perspective. Advancement in scientific research has given rise to the most sophisticated new technology in electronic media fields that are now drastically changing the concept of a large size, diversified world to a global village. All we need to do is exploit the resources of electronic media and intertwine it with yield of crops, thereby enhancing quality and quantity of crops in India. The extension organizations all over the country are engaged in designing new methods of communication and information dissemination to reach the farmer at a rate. The agricultural change agents are using electronic media for providing this extension services. Therefore, it is time to understand the existing feeling of the farmers towards the electronic media. As of now, there are no scales available to measure farmers' attitude towards audio-visual electronic media. Hence, the present study is taken up with the following specific objectives

1. To develop a scale to measure the attitude of farmers towards audio-visual electronic media
2. To analyze the attitude of farmers towards different audio-visual electronic media.

METHODOLOGY

In this study, Likert (1932) method of summated rating has been utilized for the construction of attitude scale. The present study was conducted in the Shivamogga district of Karnataka state. Bhadravathi taluk in Shivamogga district was selected for the study. From Bhadravathi taluk, four villages were selected namely Arahatholalu, Attigunda, Dasarakalallahalli, Bilaki for the study.

In the present study, the communication tools like television, Agri-portal and Mobile message (Whatsapp) were used for the treatment. The "Before and after" and Randomized group control research designs were used to study the attitude behaviour of farmers who belong to similar age group, land holding and education level.

Operationalization of Attitude

Attitude in this study was operationalized as the degree of positive or negative feeling of farmers towards electronic media based extension services. The following points were considered for measuring the attitude of farmers towards electronic media based extension services.

The steps followed in the construction of scale to measure the attitude of farmers towards electronic media have been discussed below:

Collection of items

The objective of collection of items for the attitude scale construction is to select the items in such a way that acceptance and rejection of each one will imply favourable or unfavourable attitude towards the electronic media. The items have been carefully edited and selected in accordance with set criteria as the items in any psychological test. The first step in the construction of attitude scale was to collect exhaustive statements/items pertaining to the electronic media accordingly each one expressing some opinion about the psychological object under the study. A large number of items were collected from literature, informal discussions with agriculture extension and the other experts from selected areas .Tentative list of 70 statements pertaining to the attitude of farmers towards the electronic media was prepared.

Editing the statements

These statements were edited as per the 14 criteria enunciated by Edwards (1969), Thurstone and Chave (1929). As a consequence, 15 statements were eliminated. The remaining 55 statements were included in the schedule. These statements were found to be non-ambiguous and non-factual.

Response to raw statements

It is possible all the statements collected may not be relevant equally in measuring the attitude of farmers towards electronic media related to extension services. Hence, the schedule containing these statements on a five point continuum were mailed by post and also handed over personally to the judges. Judges comprised experts in the field of extension education of University of Agricultural Sciences, Bangalore, University of Agricultural Sciences, Dharwad, Extension Education Institute, Hyderabad, National Institute of Agriculture Extension Management (MANAGE), Hyderabad and Extension Education Institute, Anand. The judges were requested to examine each statement and place them on a five point continuum indicating the degree of strength of these statements from strongly agree to strongly disagree. The judges were also requested to make necessary modifications and additions or deletion of statements, if they desire so.

The respondents were asked to indicate their degree of agreement or disagreements with each statement on a five point continuum ranging from strongly agree, agree, neutral, disagree and strongly disagree. The scoring for positive statements was done with 5, 4, 3, 2, and 1 and the scoring pattern was reversed i.e. 1, 2, 3, 4 and 5 for negative statements; respectively.

Out of 100 judges, 50 respondents responded in a time span of one month. The relevancy score of each item was ascertained by adding the sores on rating scale for all the 50 judges' responses. From this data Relevancy Percentage (RP), Relevancy Weightage (RW) and Mean Relevancy Scores (MRS) were worked out for all the 55 statements by using the following formulae.

$$R.W = \frac{MR\,X\,5 + R\,X\,4 + N\,X\,3 + SWR\,X\,2 + NR\,X\,1}{\text{No. of judges responded x Maximum score}}$$

$$R.P = \frac{MR\,X\,5 + R\,X\,4 + N\,X\,3 + SWR\,X\,2 + NR\,X\,1}{\text{No. of judges responded x Maximum score}}\ x100$$

$$MRS = \frac{MR\,X\,5 + R\,X\,4 + N\,X\,3 + SWR\,X\,2 + NR\,X\,1}{\text{No. of judges responded}}$$

Using these three criteria the statements were screened for their relevancy. Accordingly, statements having relevancy per centage >80, relevancy weightage >0.80 and mean relevancy score >4.0 were considered for further processing. Totally 20 statements were retained in the scale based on t test to measure the attitude towards electronic media. It indicates that the judges do not differ among themselves in their relevancy ratings.

Item analysis

To delineate the items based on the extent to which they can differentiate the attitude items about electronic media as favourable or unfavourable. Item analysis was carried out on the items selected in the first stage. For item analysis, the responses were arranged in ascending order based on scores. Twenty five per cent of the subjects with the highest total score and 25 per cent with the lowest total scores were selected. These two groups provided the criterion groups in terms of which item analysis was conducted and critical ratio was calculated by using the following formula:

$$t = \frac{\bar{X}_H - \bar{X}_L}{\sqrt{\sum \bar{X}_H^2 - \left(\frac{\sum \bar{X}_H^2}{n}\right) \sum \bar{X}_L^2 - \left(\frac{\sum \bar{X}_L^2}{n}\right)}}$$

Where,

X_H = The mean score on given statement of the high group

X_L = The mean score on given statement of the low group

“x^2_H = Sum of squares of the individual score on a given statement for high group

“x^2_L = Sum of squares of the individual score on a given statement for low group

n = Number of respondents in each group

“ = Summation

t = The extent to which a given statement differentiate between the high and low group.

Based on the item analysis (‘t’ value), 18 statements with‘t’ value equal to or greater than 1.75 were finally selected and included in the attitude scale.

Standardization of the scale by testing reliability and validity

Reliability: The split-half method was employed to test the reliability of the attitude scale. The value of correlation co-efficient (‘r’) was 0.9103 which was highly significant at one per cent level indicating the high reliability of the scale. It was concluded that the attitude scale constructed was reliable. The split half test reliability formula used in the present study is as follows:

$$r_{1/2} = \frac{\Sigma (XY - (\Sigma X)(\Sigma Y)}{(N\Sigma X^2 - (\Sigma X)^2 \; (N\Sigma Y^2 - (\Sigma Y)^2}$$

Where,

“X = sum of the socres of the odd number items

“Y = sum of the scores of the even numbers items

“X^2 = sum of the squares of the odd number items

“Y^2 = sum of the squares of the even number items

Validity : It refers to how well a scale measures what it is purported to measure. The validity of the scale was tested by content and statistical validity methods, which was ensured during judges rating and statistical formula.

Content validity: According to Kerlinger (1966), it is the representatives or sampling adequacy of the content – the substance, the matter and the topics of a measuring instrument. The item included in the scale was based on extensive review of literature and experts judgments. Therefore, it was assumed that the scale developed was valid with reference to inclusion of relevant contents of concepts under study.

Statistical validity: While construction of the scale, statistical validity was worked out by relating attitude score of 50 respondents. The validity co-efficient for the scale was 0.95409, which was also statistically significant at one per cent level of probability indicating the higher validity of the developed scale. Thus, the developed scale was confined of its validity to use in the sample area. The validity formula is as follows :

$$V=\sqrt{r}$$

The number of attitude statements retained during various steps of scale construction is presented in Table I.

TABLE I

Number of attitutde statements retained during various steps of scale construction

Steps	No. of Attitude statements	
	Statements considered	Statements retained
Collection of items	70	70
Editing of items	70	55
Relevancy Analysis	55	38
‘t’ analysis	38	20
Item Analysis	20	18
Reliability and Validity	18	18

Administering the scale

The final scale consists of 18 statements (Table-II) for determining the attitude of farmers towards electronic media. Of which, ten are positive statements and the remaining eight statements are negative. The response was collected on a five point continuum, namely, strongly agree, agree, undecided, disagree and strongly disagree with assigned score of 5, 4, 3, 2, and 1, respectively for positive statements and vice versa for negative statements. Thus the minimum and maximum score one could get is 18 and 90, respectively. Higher the attitude score indicates the high favourableness of respondents towards electronic media and lesser the attitude score indicates less favourableness towards electronic media. The total attitude score for each respondent was obtained by adding the weights of individual responses made to the total scale items.

TABLE II

Statements considered to measure the attitude of farmers towards audio-visual electronic media

Statements	SA	A	UD	DA	SDA
I would like to use electronic media.					
Electronic media plays an important role for exploring agricultural information.					
Electronic media usage is socially and economically acceptable.					
Electronic media will lead to modernization.					
Use of electronic media will build social capital among farmers.					
Electronic media is an essential part of present day life					
Electronic media can bridge the wide ratio of farmers and extensionist (1000:1)					
Electronic media helps to improve the knowledge, attitude and skill of farmers.					
Electronic media can attract people towards agriculture.					
Electronic media will fasten the adoption of new technologies.					
Electronic media are suitable only to literate people.					
Electronic media is expensive.					
Use of electronic media is more accessible to rich people only.					
Accuracy of the available information on electronic media is questionable.					
Electronic media cannot provide information suitable to a particular culture.					
Watching/ listening to electronic media is a waste of productive time.					
Electronic media are not offering anything new to their users.					
Electronic media are not efficient without electricity.					

Strongly Agree (SA); Agree (A); Undecided (UD); Disagree (DA); Strongly Disagree (SDA)

RESULTS AND DISCUSSION

Overall gain in attitude level of farmers in the television treated village

A close perusal of Table III revealed that mean knowledge score of the respondents in the television treated village increases from 52.41 (before) to 55.38 (after). Value of 't' (3.042) obtained by undertaking the paired t-test shows that there is a significant difference between the two mean attitude scores in the television treated village infer that television brings about a positive change in the attitude level of the farmers. Television has became our part and parcel of farmer life, which transmit information very fast about agricultural technology among the farmers community are the reason for increased favourable attitude of farmers towards television.

TABLE III

Overall attitude level of farmers towards Television

(n=30)

Scores	Before	After	t-value
Mean	52.41	55.38	3.042 **
SD	8.24	9.06	

Min. score =18; Max. score =90; ** Significant at 1% level

Comparison of attitude level of farmers before and after the television treatment in the experimental and control villages

Table IV shows that the 't' value (2.047) is significant, thus proving that the enhancement in attitude level of the farmers in the television treated

TABLE IV

Comparison of attitude of farmers before and after the television treatment in the experimental and control villages

(n=60)

Villages	Difference of Means	SD	t-value
Experimental (n=30)	2.97	0.82	2.047 *
Control (n=30)	2.00	1.97	

* Significant at 5% level; 't' (0.05, 29df) = 2.045

village after the treatment is due to the television programme. Thus, it helps us to infer that television brings about a positive change in the attitude level of the farmers.

Overall gain in attitude level of farmers in the mobile treated village

A close perusal of Table V revealed that the mean knowledge score of the respondents in the mobile treated villages increases from 56.87 (before) to 63.41 (after). Value of 't' (5.96) obtained by undertaking the paired t-test shows that there is a significant difference between the two mean attitude scores in the mobile treated village. Mobile (WhatsApp) is now-a-days become more popular; here the farmer can upload his problems through photographs, video and find solution to their problems immediately from the experts at the quickest possible time which is the reason behind the increased favourable attitude of farmers towards mobile (WhatsApp).

TABLE V

Overall attitude level of farmers towards mobile

(n=30)

Scores	Before	After	t-value
Mean	56.87	63.41	5.96 **
SD	13.83	14.98	

Min. score =18, Max. score =90, ** Significant at 1% level, 't' (0.01, 29df) =2.462

Comparison of attitude level of farmers before and after the mobile treatment in the experimental and control villages

Table VI shows the 't' value (2.97) is significant, thus proving that the enhancement in attitude level of the farmers in the mobile treated villages after the treatment is due to the Mobile (WhatsApp) message. Thus, it helps us to infer that mobile brings about a positive change in the attitude level of the farmers.

TABLE VI

Comparison of attitude of farmers before and after the Mobile treatment in the experimental and control villages

(n=60)

Villages	Difference of Means	SD	t-value
Experimental (n=30)	6.54	1.15	2.97 **
Control (n=30)	2.00	1.97	

** Significant at 1% level; 't' (0.05, 29df) = 2.045

Overall gain in attitude level of farmers in the agriportal treated village

A close perusal of Table VII revealed that the mean knowledge score of the respondents in the agriportal treated villages' increases from 53.70 (before) to 57.96 (after). Value of 't' (3.57) obtained by undertaking the paired t-test shows that there is a significant difference between the two mean attitude scores in the agriportal treated village. Agriportal is slowly penetrating in rural India, but it has huge option of crop specific solutions by which farmer can get information related to his area of interest is the possible reason for increased favourableness of farmers towards agriportal.

TABLE VII

Overall attitude level of farmers towards agriportal

(n=30)

Scores	Before	After	t-value
Mean	53.7	57.96	3.57 **
SD	10.09	13.04	

Min. score =18; Max. score =90; ** Significant at 1% level 't' (0.01, 29df) =2.462

Comparison of attitude level of farmers before and after the agriportal treatment in the experimental and control villages

Table VIII shows the 't' value (2.509) is significant, thus proving that the enhancement in attitude level of the farmers in the agriportal treated villages after the treatment is due to the Agriportal message. Thus, it helps us to infer that agriportal brings about a positive change in the attitude level of the farmers.

TABLE VIII

Comparison of attitude of farmers before and after the agriportal treatment in the experimental and control villages

(n=60)

Villages	Difference of Means	SD	t-value
Experimental (n=30)	4.26	2.95	2.509 **
Control (n=30)	2.00	1.97	

** Significant at 1% level; 't' (0.01, 29df) =2.462

Overall Relative effectiveness of attitude level of farmers before and after the treatment.

The results in the Table IX revealed that the overall relative effectiveness of different treatments in attitude level. The paired 't' test was calculated to find out the mean difference before and after the treatments. ANOVA was calculated to find out the F-value to know the significance among the different treatments. It was observed that the mean score before the television treatment was 52.41 and it was increased to 55.38 after the television treatment. The paired 't' value is 3.042 which is significance at 1 per cent level. In case of mobile treatment the mean score before the treatment was 56.87 and it was increased to 63.41 after the mobile treatment. The paired 't' value is 5.96 which is significant at 1 per cent level. Further with respect to agriportal treatment the mean score before treatment was 53.70 and it was enhanced to 57.96 after the agriportal treatment. The paired 't' value is 3.57 which is significant at 1 per cent level. The possible reason for the above result may be due to the fact that when compare to television programme and agriportal information, mobile (WhatsApp) message has got highest significance as it creates a huge platform for farmers to interact directly with the experts, and can easily obtain solution. Even it has got the advantage of uploading PDF files, photos, videos, text message, and voice message.

The reliability and validity of the scale indicated the precision and consistency of the results. Hence, it can be used to measure the attitude of farmers towards

TABLE IX

Overall Relative effectiveness of attitude level of farmers before and after the treatment

(n=90)

Treatments	Sample	Before		After		Difference		Paired 't' value
		Mean	SD	Mean	SD	Mean	SD	
T1Television	30	52.41	8.24	55.38	9.06	2.97	0.82	3.042 **
T2Mobile	30	56.87	13.83	63.41	14.98	6.54	1.15	5.96 **
T3Agriportal	30	53.70	10.09	57.96	13.04	4.26	2.95	3.57 **
F-value		0.65 ^{NS}		0.24 ^{NS}		3.16 **		

** Significant at 1% level; 't' (0.01, 29df) =2.462; NS=Non-significant audio-visual electronic media. The scale developed is useful to measure the farmers' attitude beyond the study area with suitable modifications. Further, the study revealed that the mobile (WhatsApp) has more significant role in increasing the favourable attitude of farmers, because it has got a wide advantage of uploading PDF files, photos, videos, text message and voice message.

References

EDWARDS, A. L., 1969, Techniques of Attitude scale construction. *VIkils, Feger and simons Pvt. Ltd., 9,* Sport Road, Ballard Estate, Bombay.

JONES GWYN, E., 1997, The history, development and future of agricultural extension in improving agricultural extension - a reference manual. *Food and Agricultural Organization*, Rome.

KERLINGER, F. N., 1966, Foundations of behavioural research, *Holt Rinehart and Winston Inc.,* New York, p. 379.

LIKERT, R., 1932, A technique for the management of attitude. *Psych. Stud.,* **5**: 106 - 107.

THURSTONE, L. L. AND CHAVE, E. J., 1929, The measurement of attitude. *Chicago University Press,* USA, p. 39 - 40.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 347-353, 2017

Effect of Biocontrol Agents and PGPRs on Growth and Yield of Okra under *in vitro* Condition

A. Anantha Rama and L. Krishna Naik
Department of Agricultural Microbiology, College of Agriculture, UAS, GKVK, Bengaluru -560 065
E-mail : ananthramboss4@gmail.com

Abstract

The aim of this study was to evaluate the efficiency of bioagents (*Trichoderma viride, Pseudomonas fluorescens*) and PGPRs (*Bacillus megaterium, Azotobacter chroococcum*) for the control of root rot pathogen (*Fusarium solani*) and its influence on growth and yield of okra plants under greenhouse conditions. Among all the treatments, T_{21} showed significant increase in plant height (135.67^{a} cm) compared to T_{25} (133.33^{b} cm), co-inoculation of *Trichoderma viride* 1 + *Pseudomonas fluorescens* 1 + *Bacillus megaterium* 1, significantly, increased number of fruits per plant T_{25} (28.33^{a}) compared to untreated control T_1 (1.67^{p}), fruit length and fruit diameter also significantly increased in the treatment which received *T.v* 1 + *P.f* 1 + *B.m* 1 compared to all other treatments under green house conditions.

Keywords: Okra root rot, *fusarium solani, trichoderma viride*, *bacillus megaterium*

Okra (*Abelmoschus esculentus* L.) belongs to the family Malvaceae, genus *Abelmoschus* and species *esculentus*. It has many vernacular names *viz., Bhindi, Bhendi, Tori, Dhenrosh, Venda, Sapaid lori, Okra or Bende kayi* or Lady's finger. Okra plants are infected by a number of diseases caused by different fungi for example root (collar) rot and damping-off, root / stem rot; angular leaf spot and powdery mildew. According to reports, root rot is one of the most destructive diseases caused by *Fusarium solani* (Rahim *et al*., 2006). Its incidence ranges between 10-80 per cent with a maximum of 55-80 per cent in the crop grown in kitchen gardens and minimum of 10-45 per cent in the crop sown on large scale under field conditions. Abused use of chemical pesticides leads to ill effect on environment, with this concern there is a need to develop biological techniques to maintain fragile ecosystem. Many biological control agents such as *Trichoderma* spp., *Pseudomonas* spp., *Bacillus* spp. and *Azotobacter* spp. could be effectively used in suppressing diseases caused by *Fusarium* spp. (Hashem and Hamada, 2002; Soleimani *et al*., 2005; Nourozian *et al.,* 2006; Abdel-Monaim, 2010).

With this concern the objective was setup to evaluate the effectiveness of isolated microorganisms under greenhouse conditions as bio-control and PGPR agents against the incidence of root rot disease caused by *Fusarium solani* and its impact on growth and yield of okra.

Material and Methods

Isolation of root rot pathogen of okra: Samples of okra plants exhibiting root rot and uninfected okra rhizosphere soils were collected from different fields in southern parts of Karnataka. Root rot infected samples were washed thoroughly with tap water. Small portions of the root rot diseased samples were surface sterilized with 1 per cent sodium hypochlorite solution for 5 min, rinsed in sterilized water and dried between folds of sterilized filter papers. The portions were placed on potato dextrose agar (PDA) and incubated at 25±1 °C. The fungal colonies were purified using single spore or hyphal tip technique. Identification of the fungi was made according to the procedure given by Booth (1985) and Gilman (1998). Stock cultures were maintained on PDA slants and kept in a refrigerator at 5 °C for further studies.

Isolation of potential antagonists and PGPRs: The antagonists against *Fusarium solani* were isolated and based on morphological, biochemical and molecular studies the organisms were identified as *Trichoderma viride*, *Pseudomonas fluorescens,* and PGPRs such as *Bacillus megaterium* and

Azotobacter chroococcum. Based on the different *in vitro* studies the potential antagonists and PGPRs were selected and used under greenhouse conditions.

Greenhouse experiment: Potential antagonist and PGPRs obtained from the *in vitro* evaluation studies were selected against *Fusarium solani* under green house condition to study the effect of these bioagents and plant growth promoting rhizobacteria in suppressing the root rot pathogen and influence on the growth and yield of okra.

Treatment Details

T_1 – Control (100 % RDF)
T_2 – *T.v* (ATV8)
T_3 – *T.v* (Std)
T_4 – *P.f* (APF19)
T_5 – *P.f* (Std)
T_6 – *B.m* (ABM6)
T_7 – *A.c* (AAC2)
T_8 – *T.v* (ATV8) + *P.f* (APF19)
T_9 – *T.v* (Std) + *P.f* (Std)
T_{10} – *T.v* (ATV8) + *P.f* (Std)
T_{11} – *T.v* (Std) + *P.f* (APF19)
T_{12} – *B.m* (ABM6) + *A.c* (AAC2)
T_{13} – *T.v* (ATV8) + *B.m* (ABM6)
T_{14} – *T.v* (Std) + *B.m* (ABM6)
T_{15} – *P.f* (APS19) + *B.m* (ABM6)
T_{16} – *P.f* (Std) + *B.m* (ABM6)
T_{17} – *T.v* (ATV8) + *A.c* (AAC2)
T_{18} – *T.v* (Std) + *A.c* (AAC2)
T_{19} – *P.f* (ATV8) + *A.c* (AAC2)
T_{20} – *P.f* (Std) + *A.c* (AAC2)
T_{21} – *T.v* (ATV8) + *P.f* (APF19) + *B.m* (ABM6)
T_{22} – *T.v* (Std) + *P.f* (Std) + *B.m* (ABM6)
T_{23} – *T.v* (ATV8) + *P.f* (Std) + *B.m* (ABM6)
T_{24} – *T.v* (Std) + *P.f* (APS19) + *B.m* (ABM6)
T_{25} – *T.v* (ATV8) + *P.f* (APF19) + *A.c* (AAC2)
T_{26} – *T.v* (Std) + *P.f* (Std) + *A.c* (AAC2)
T_{27} – *T.v* (ATV8) + *P.f* (Std) + *A.c* (AAC2)
T_{28} – *T.v* (Std) + *P.f* (APF19) + *A.c* (AAC2)

Plant growth and yield parameters: The plant growth parameters such as, Plant height (cm), Number of branches, plant and yield parameters like number of fruits, Fruit length (cm), Fruit diameters (cm) were measured and the data obtained from the green house experiments were subjected to CRD statistical analysis, the analysis of variance and interpretation of data were done as per procedures given by Fisher and Yates (2008).

Results and Discussion

Effect of Bioagents and PGPRs on plant height: In the greenhouse, the seedlings inoculated with the consortia of the antagonist and PGPR organisms grew better and showed higher plant height than uninoculated seedlings during the growth period. The treatment which received all the three inoculants *viz., T. viride, P. fluorescens* and *B. megaterium* showed significantly highest plant height (135.67^{a} cm) (Table I) at harvesting stage, whereas, the uninoculated control showed less plant height (96.33^{q} cm) compared to all other treatments.

Effect of Bioagents and PGPRs on Number of fruits / plants: Application of triple inoculants T_{21} (*T. viride, P. fluorescens* and *B. megaterium*) proved their efficacy in increasing the number of fruit set on plants, and it also resulted in significant increase in fruit yield per plant over the control (Table II).

Effect of Bioagents and PGPRs on Fruit Length: Among all the treatments, T_{21} (15.40^{a} cm) showed maximum fruit length followed by T_{25} (14.90^{ab} cm) and the least fruit length was recorded in the treatment T_1 (5.83^{o} cm). This shows that the treatment containing inoculants like *T. viride, P. fluorescens* and *B. megaterium* have positive influence on the fruit length compared to other treatments (Table II).

Effect of Bioagents and PGPRs on Fruit diameter: Fruit diameter of the okra also increased with the application of *T. viride* + *P. fluorescens* + *B. megaterium* (1.67^{a} cm) in combination, followed by the treatment which received *T. viride* + *P. fluorescens* + *A. chroococcum* (1.43^{ab} cm) and the treatment in which only pathogen (*Fusarium solani*) was inoculated showed significantly less fruit diameter compared to all other treatments (Table II).

TABLE I

Influence of biocontrol agents on plant height in okra

Treatments	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
T_1 – Control (100 % RDF)	5.33 r	36.33 q	65.00 s	96.33 q
T_2 – *T.v* (ATV8)	15.33 m	48.33 l	81.67 m	109.33 l
T_3 – *T.v* (Std)	13.33 n	46.33 m	77.67 n	106.67 m
T_4 – *P.f* (APF19)	15.00 m	48.00 l	80.67 m	109.00 l
T_5 – *P.f* (Std)	13.00 n	46.00 m	75.67 o	106.33 m
T_6 – *B.m* (ABM6)	9.33 p	42.00 o	70.00 q	101.67 o
T_7 – *A.c* (AAC2)	7.33 q	39.67 p	67.33 r	98.33 p
T_8 – *T.v* (ATV8) + *P.f* (APF19)	28.33 g	60.33 g	97.67 g	122.67 g
T_9 – *T.v* (Std) + *P.f* (Std)	27.33 h	59.33 g	96.33 h	121.67 g
T_{10} – *T.v* (ATV8) + *P.f* (Std)	28.00 gh	60.00 g	97.33 gh	122.33 g
T_{11} – *T.v* (Std) + *P.f* (APF19)	27.67 gh	59.67 g	96.67 gh	122.00 g
T_{12} – *B.m* (ABM6) + *A.c* (AAC2)	11.33 o	44.33 n	72.67 p	104.33 n
T_{13} – *T.v* (ATV8) + *B.m* (ABM6)	25.33 i	57.33 h	94.00 i	118.67 h
T_{14} – *T.v* (Std) + *B.m* (ABM6)	20.33 k	53.33 j	88.00 k	114.33 j
T_{15} – *P.f* (APS19) + *B.m* (ABM6)	24.67 i	57.00 h	93.67 i	118.33 h
T_{16} – *P.f* (Std) + *B.m* (ABM6)	20.00 k	53.00 j	87.67 k	114.00 j
T_{17} – *T.v* (ATV8) + *A.c* (AAC2)	22.33 j	55.33 i	90.67 j	116.33 i
T_{18} – *T.v* (Std) + *A.c* (AAC2)	18.00 l	51.00 k	84.67 l	111.33 k
T_{19} – *P.f* (ATV8) + *A.c* (AAC2)	22.00 j	55.00 i	90.33 j	116.00 i
T_{20} – *P.f* (Std) + *A.c* (AAC2)	17.67 l	50.67 k	84.33 l	111.00 k
T_{21} – *T.v* (ATV8) + *P.f* (APF19) + *B.m* (ABM6)	39.33 a	71.33 a	109.67 a	135.67 a
T_{22} – *T.v* (Std) + *P.f* (Std) + *B.m* (ABM6)	36.00 c	67.33 c	105.33 c	131.33 c
T_{23} – *T.v* (ATV8) + *P.f* (Std) + *B.m* (ABM6)	31.33 e	63.33 e	101.33 e	126.33 e
T_{24} – *T.v* (Std) + *P.f* (APS19) + *B.m* (ABM6)	31.00 ef	63.00 ef	101.00 ef	126.00 ef
T_{25} – *T.v* (ATV8) + *P.f* (APF19) + *A.c* (AAC2)	37.67 b	69.33 b	107.33 b	133.33 b
T_{26} – *T.v* (Std) + *P.f* (Std) + *A.c* (AAC2)	33.67 d	65.67 d	103.33 d	129.33 d
T_{27} – *T.v* (ATV8) + *P.f* (Std) + *A.c* (AAC2)	30.67 ef	62.33 ef	100.67 ef	125.67 ef
T_{28} – *T.v* (Std) + *P.f* (APF19) + *A.c* (AAC2)	30.33 f	62.00 f	100.00 f	125.00 f
S.Em±	0.223	0.280	0.286	0.275
CD at 1%	0.842	1.055	1.080	1.035

Note : *T.v – Trichoderma viridae, P.f – Pseudomonas fluorescens, B.m – Bacillus megaterium, A.c – Azotobacter chroococcum,* Std – Standard culture

TABLE II

Influence of biocontrol agents on growth and yield parameters in okra

Treatments	Number of fruits / plan	Fruit Length (cm)	Fruit Diameter (cm)
T_1 – Control (100 % RDF)	5.33 [r]	36.33 [q]	65.00 [s]
T_1 – Control (100 % RDF)	1.67 [p]	5.83 [o]	0.93 [f]
T_2 – *T.v* (ATV8)	9.67 [k]	8.27 [jk]	1.13 [bcdef]
T_3 – *T.v* (Std)	8.33 [l]	7.83 [kl]	1.10 [cdef]
T_4 – *P.f* (APF19)	9.67 [k]	8.23 [k]	1.30 [bcd]
T_5 – *P.f* (Std)	8.00 [l]	7.80 [kl]	1.10 [cdef]
T_6 – *B.m* (ABM6)	4.67 [n]	6.73 [mn]	1.00 [def]
T_7 – *A.c* (AAC2)	3.33 [o]	6.27 [no]	0.97 [ef]
T_8 – *T.v* (ATV8) + *P.f* (APF19)	19.67 [f]	12.33 [f]	1.27 [bcde]
T_9 – *T.v* (Std) + *P.f* (Std)	19.00 [f]	12.13 [f]	1.23 [bcdef]
T_{10} – *T.v* (ATV8) + *P.f* (Std)	19.33 [f]	12.23 [f]	1.27 [bcde]
T_{11} – *T.v* (Std) + *P.f* (APF19)	19.33 [f]	12.20 [f]	1.27 [bcde]
T_{12} – *B.m* (ABM6) + *A.c* (AAC2)	6.33 [m]	7.17 [lm]	1.00 [def]
T_{13} – *T.v* (ATV8) + *B.m* (ABM6)	17.33 [g]	11.67 [f]	1.23 [bcdef]
T_{14} – *T.v* (Std) + *B.m* (ABM6)	13.67 [i]	9.83 [h]	1.13 [bcdef]
T_{15} – *P.f* (APS19) + *B.m* (ABM6)	17.00 [g]	11.63 [f]	1.20 [bcdef]
T_{16} – *P.f* (Std) + *B.m* (ABM6)	13.33 [i]	9.77 [h]	1.13 [bcdef]
T_{17} – *T.v* (ATV8) + *A.c* (AAC2)	15.67 [h]	10.63 [g]	1.17 [bcdef]
T_{18} – *T.v* (Std) + *A.c* (AAC2)	11.67 [j]	9.00 [i]	1.13 [bcdef]
T_{19} – *P.f* (ATV8) + *A.c* (AAC2)	15.33 [h]	10.60 [g]	1.13 [bcdef]
T_{20} – *P.f* (Std) + *A.c* (AAC2)	11.33 [j]	8.97 [ij]	1.13 [bcdef]
T_{21} – *T.v* (ATV8) + *P.f* (APF19) + *B.m* (ABM6)	28.33 [a]	15.40 [a]	1.67 [a]
T_{22} – *T.v* (Std) + *P.f* (Std) + *B.m* (ABM6)	25.33 [c]	14.43 [bc]	1.40 [abc]
T_{23} – *T.v* (ATV8) + *P.f* (Std) + *B.m* (ABM6)	22.00 [e]	13.33 [de]	1.33 [bc]
T_{24} – *T.v* (Std) + *P.f* (APS19) + *B.m* (ABM6)	21.67 [e]	13.20 [e]	1.37 [abc]
T_{25} – *T.v* (ATV8) + *P.f* (APF19) + *A.c* (AAC2)	26.67 [b]	14.90 [ab]	1.43 [ab]
T_{26} – *T.v* (Std) + *P.f* (Std) + *A.c* (AAC2)	23.67 [d]	14.00 [cd]	1.37 [abc]
T_{27} – *T.v* (ATV8) + *P.f* (Std) + *A.c* (AAC2)	21.33 [e]	13.10 [e]	1.33 [bc]
T_{28} – *T.v* (Std) + *P.f* (APF19) + *A.c* (AAC2)	21.00 [e]	13.07 [e]	1.30 [bcd]
S.Em±	0.284	0.189	0.081
CD at 1%	1.072	0.712	0.304

Note : *T.v – Trichoderma viridae, P.f – Pseudomonas fluorescens, B.m – Bacillus megaterium, A.c – Azotobacter chroococcum,* Std – Standard culture

TABLE III

Influence of biocontrol agents on number of branches of okra

Treatments	No. of branches / plant	Treatments	No. of branches / plant
T_1 – Control (100 % RDF)	0.00 [i]	T_{15} – *P.f* (APS19) + *B.m* (ABM6)	1.33 [efg]
T_2 – *T.v* (ATV8)	0.67 [ghi]	T_{16} – *P.f* (Std) + *B.m* (ABM6)	1.00 [fgh]
T_3 – *T.v* (Std)	0.67 [ghi]	T_{17} – *T.v* (ATV8) + *A.c* (AAC2)	1.00 [fgh]
T_4 – *P.f* (APF19)	0.67 [ghi]	T_{18} – *T.v* (Std) + *A.c* (AAC2)	1.00 [fgh]
T_5 – *P.f* (Std)	0.67 [ghi]	T_{19} – *P.f* (ATV8) + *A.c* (AAC2)	1.00 [fgh]
T_6 – *B.m* (ABM6)	0.33 [hi]	T_{20} – *P.f* (Std) + *A.c* (AAC2)	1.00 [fgh]
T_7 – *A.c* (AAC2)	0.33 [hi]	T_{21} – *T.v* (ATV8) + *P.f* (APF19) + *B.m* (ABM6)	4.00 [a]
T_8 – *T.v* (ATV8) + *P.f* (APF19)	1.67 [def]	T_{22} – *T.v* (Std) + *P.f* (Std) + *B.m* (ABM6)	2.67 [bc]
T_9 – *T.v* (Std) + *P.f* (Std)	1.67 [def]	T_{23} – *T.v* (ATV8) + *P.f* (Std) + *B.m* (ABM6)	2.00 [cde]
T_{10} – *T.v* (ATV8) + *P.f* (Std)	1.67 [def]	T_{24} – *T.v* (Std) + *P.f* (APS19) + *B.m* (ABM6)	2.00 [cde]
T_{11} – *T.v* (Std) + *P.f* (APF19)	1.67 [def]	T_{25} – *T.v* (ATV8) + *P.f* (APF19) + *A.c* (AAC2)	3.00 [b]
T_{12} – *B.m* (ABM6) + *A.c* (AAC2)	0.67 [ghi]	T_{26} – *T.v* (Std) + *P.f* (Std) + *A.c* (AAC2)	2.33 [bcd]
T_{13} – *T.v* (ATV8) + *B.m* (ABM6)	1.33 [efg]	T_{27} – *T.v* (ATV8) + *P.f* (Std) + *A.c* (AAC2)	2.00 [cde]
T_{14} – *T.v* (Std) + *B.m* (ABM6)	1.00 [fgh]	T_{28} – *T.v* (Std) + *P.f* (APF19) + *A.c* (AAC2)	2.00 [cde]

Note : *T.v – Trichoderma viridae, P.f – Pseudomonas fluorescens, B.m – Bacillus megaterium, A.c – Azotobacter chroococcum,* Std – Standard culture

Effect of Bioagents and PGPRs on Number of branches per plant: Number of branches per plant of the okra also increased with the application of *T. viride* + *P. fluorescens* + *B. megaterium* (4.00[a]) in combination, followed by the treatment which received *T. viride* + *P. fluorescens* + *A. chroococcum* (3.00[b] cm) and the treatment in which only pathogen (*Fusarium solani*) was inoculated showed significantly less number of branches per plant compared to all other treatments (Table III)

Generally, treatments involving, *T.v* + *P.f* + *B.m* recorded the highest reduction of root rot incidence and increased the growth and yield components of crop plants especially in soil application method. The results obtained are in good accordance with previous studies which have been concluded that *Trichoderma viride, Pseudomonas fluorescens* and *Bacillus megaterium* can effectively protect many plant species against root rot diseases (Hashem and Hamada, 2002; Soleimani *et al*., 2005; Nourozian, *et al.,* 2006; Atef, 2008; Abdel-Monaim, 2010). According to Harman (2001) natural factors limiting the number of soil borne pathogens occur through a combination of antagonism by other soil fungi and bacteria, natural release of antibiotics from other bacteria and fungi and by competitive exclusion of habitat in the root zone or rhizosphere. The mechanism of *Trichoderma* and *Bacillus* acts on pathogens may be by attacking and binding the pathogenic organisms by sugar linkage and begins to secrete extracellular protease and lipase (Soleimani *et al*., 2005; Zaghloul *et al.,* 2007), produce siderophores and hydrogen cyanide (Soleimani *et al*., 2005), production of secondary metabolites such as Phenazine-1-Carboxilic acid (PCA), 2, 4-Pyrrolnitrin, Oomycin.

Such enhancement may be due to induced plant resistance, production extracellular enzymes and antifungal or antibiotics, which decrease biotic stress on plant, and produce growth promoting substances

(Szczech and Shoda, 2004). In addition, Egamberdiyeva (2007) hypothesized that there are several mechanisms by which rhizosphere bacteria and fungi may stimulate plant growth, such as production of plant growth substances, nitrogen fixation, phytohormones, vitamins, solublizing minerals besides, their role in direct inhibition of pathogen growth and suppression of diseases and increased plant growth and yield.

The obtained results are in harmony with that obtained by Zahoor *et al*. (2012); Siddiqui *et al.,* 2000 on okra**.** The inoculation of bioagents and PGPRs showed effective control on root rot disease of okra and influenced the growth and yield of okra plants.

Specific antagonist can influence disease suppression and could be considered as part of disease control strategy under an integrated pest management which offers a successful approach for the deployment of both agro-chemicals and biocontrol agents. This study suggest that effective screening of bioagents for growth and yield promotion under greenhouse experiment is a good tool to select efficient antagonist for biocontrol agent development.

References

Abdel-Monaim, M. F., 2010, Integrated management of damping-off, root and/or stem rot diseases of chickpea with sowing date, host resistance and bioagents. *Egypt. J. Phytopathol*., **38** (1-2) : 45 - 61.

Atef Nagwa, M., 2008, *Bacillus subtilits* and *Trichoderma harzianum* as wheat inoculants for biocontrol of *Rhizoctonia solani*. *Australian J. Basic Appl. Sci.,* **2** (4) : 1411 - 1417.

Booth, C., 1985, The genus *Fusarium*. Kew, Surrey Commonwealth Mycological Institute, 2nd Ed., p. 237.

Chauhan, D. V. S., 2010, Vegetable Production in India. 3rd ed. Ramprasad and Sons, Agra.

Egamberdiyeva, D., 2007, The effect of plant growth promoting bacteria on growth and nutrient uptake of maize in two different soils. *Appl. Soil Eco*., **36** : 184 - 189.

Fisher, R. A. and Yates, F., 2008, Statistical Tables for Biological, Agricultural and Medical Research, Sixth edition, Oliver and Boyd, Edinburgh.

Gerhardson, B., 2002, Biological substitute for pesticides. *Trends Biotech*., **20** : 338 - 343.

Gilman, J. C., 1998, A manual of soil fungi: Iowa. State. Univ. Press. Ames. Iowe., U.S.A.

Gravel, V., Martinez, C., Antoun, H. and Tweddel, R. J., 2004, Evaluation of antagonistic microorganisms as bio-control agents of root rot (*Pythium ultimum*) of greenhouse tomatoes in rock wool. *Can. J. Plant Pathol*., **26** : 152 - 159.

Harman, G. E., 2001, *Trichoderma* spp., including *T. harzianum, T. viride, T. koningii, T. hamatum* and other spp. Deuteromycetes, Moniliales (asexual classification system) In: Biological Control: A Guide to Natural Enemies in North America. (C.R. Weeden, A.M. Shelton, M. P. Hoffman eds.), Cornell University, USA.

Hashem, M., Hamada Afaf, M., 2002, Evaluation of two biologically active compounds for control of wheat root rot and its causal pathogens. *Microbiol*., **30** (4) : 233 - 239.

Hausbek, M. K. and Lamour, K. H., 2004, *Phytophthora capsici* on vegetable crops: research progress and management challenges. *Plant Dis*., **88** : 1292 - 1303.

Nadkarni, K. M., 2002, *Indian Meteria*, Nadkarni and Co., Bombay, p. 104.

Nourozian, J., Etebarian, H. R. and Khodakaramian, G., 2006, Biological control of *Fusarium graminearum* on wheat by antagonistic bacteria. *Nutraceutical and Functional Food,* **28** (1) : 29 - 38.

Rahim, A. M., Aziza, K. D., Tarabeih, A. M. and Hassan, A. A. M., 2006, Damping-off and root rot of okra and table beet with reference to chemical control. *Assiut J. Agric. Sci*., **23** : 19 - 36.

Riungu, G. M., Muthomi, J. W., Narla, R. D., Wagacha, J. M. and Gathumbi, J. K., 2008, Management of *Fusarium* head blight of wheat and deoxynivalenol accumulation using antagonistic microorganisms. *Plant Pathol. J.,* **7** : 13 - 19.

SIDDIQUI, I. A., HAQUE, S. E., ZAKI, M. J. AND GHAFFAR, A., 2000, Greenhouse evaluation of Rhizobia as biocontrol agent of root-infecting fungi in okra. *Acta Agrobotanica*, **53** : 13 - 22.

SOLEIMANI, M. J., SHAMSBAKHSH, M., TAGHAVI, M. AND KAZEMI, S. H., 2005, Biological control of stem and root rot of wheat caused by *Bipolaris* spp. by using antagonistic bacteria, fluorescent Pseudomonas and *Bacillus* spp. *J. Biological Sci*., **5** (3) : 347 - 353.

SZCZECH, M. AND SHODA, M., 2004, Bio-control of *Rhizoctonia* damping-off of tomato by *Bacillus subtilis* combined with *Burkholderia cepacia*. *J. Phytopathol*., **152** : 549 - 556.

ZAFARI, D., KOUSHKI, M. M. AND BAZGIR, E., 2008, Biocontrol evaluation of take-all disease by *Trichoderma* screened isolates. *African J. Biotechnol*., 7 : 3653 - 3659.

ZAGHOUL, R. A., HANAFY EHSAN, A., NEWEIGY, N. A. AND KHALIFA NEAMAT, A., 2007, Application of biofertilization and biological control for tomato production. 12th Conference of Microbiology; Cairo, Egypt (18-22) March, p. 198 - 212.

ZAHOOR AHMAD, SAIFULLAH, FAZLI RAZIQ, HAKIM KHAN AND MUHAMMAD IDREES, 2012, Chemical and biological control of *Fusarium* root rot of okra. *Pak. J. Bot.,* **44** (1) : 453 - 457.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 354-358, 2017

Evaluation of Liquid Bio-inoculants for Production of Plant Growth Promoting Hormones and their Effect on Growth of Amaranthus *(Amaranthus cruentus)*

H. Gurumurthy and M. K. Shivaprakash
Department of Agricultural Microbiology, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail : gurumurthyh.8031@gmail.com

Abstract

An investigation was carried out to assess the ability of liquid bio-inoculants *viz*., *Azotobacter chroococcum, Bacillus megaterium, Frateuria aurentia, Psuedomonas fluorescens, Bacillus subtilis* and *Trichoderma viridae* for production of plant growth hormones and study their effect on growth of Amaranthus (*Amaranthus cruentus*). Bio-assay was conducted for production of GA, IAA and Cytokinin. It was noticed to be significantly highest in *Psuedomonas fluorescens* (4.75µg, 180.07 µg and 4.94 µg of GA, IAA and Cytokinin, respectively) and least was recorded in *Trichoderma viridae* (1.43 µg, 9.32 µg, 0.88 µg of GA, IAA and Cytokinin, respectively). The results of green house studies revealed that the plants inoculated with a consortia of *A. chroococcum* + *B. megaterium* + *F. aurentia* + *P. fluorescens* + *B. subtilis* + *T. viridae* recorded significantly highest plant height (8.82 cm, 29.00 cm and 40.87 cm), highest number of leaves (6.23, 9.13 and 12.57) at 15 DAS, 21DAS and 30 DAS, respectively, maximum root and shoot length (7.80 cm and 40.87 cm, respectively) as well as root and shoot fresh weight and dry weight at harvest.

Keywords: Liquid bio-inoculants, GA, IAA, cytokinin, *amaranthus cruentus*

Amaranthus (*Amaranthus* sp.) popularly known as chouli, is a nutritive and highly suitable crop for kitchen gardening and commercial cultivation. Rapid growth, quick rejuvenation after each harvesting and high yield of edible matter per unit area in limited time and the most unique benefits includes its ability to stimulate growth and reduce inflamation (Belanger *et al.,* 2004). Plant hormones are signal molecules acting as chemical messengers that control plant growth and development. Aside from their role in plant response to changes in environmental conditions, hormones are also the principal agents that regulate expression of the intrinsic genetic potential of plants. Numerous soil bacteria and fungi are also able to produce phytohormones. The commonly recognized classes of phytohormones are *viz.,* auxins, gibberellins, cytokinins, abscisic acid and ethylene (Gabriele Berg, 2009).

Liquid bio-inoculants are the promising and updated technology in spite of many advantages not only over agrochemicals but also carrier based biofertilizer several reasons major being the viability of organism. Shelf life is the first and foremost problem with carrier based inoculants and does not retain throughout the crop cycle. Liquid bio-inoculants on the other hand facilitate long survival of organism by providing the suitable growth medium which is sufficient for entire crop cycle (Uma Maheswari and Elakkiya, 2014). Keeping in view of the advantages of liquid bio-inoculants, this study aims to evaluate the plant growth hormones production by liquid bio-inoculants and its effect on growth of Amaranthus under greenhouse condition.

Material and Methods

The present investigation was conducted at the Department of Agricultural Microbiology, University of Agricultural Sciences, G.K.V.K, Bengaluru.

Estimation of phytohormone production by bio-inoculants under In-vitro condition: Bioassay for GA and IAA production by bioinoculants was done by using Starch agar halo test and Cucumber root elongation method, respectively (Loper and Schroth, 1986). Bioassay for cytokinins determined by using Cucumber cotyledon greening bioassay (Fletcher *et al*., 1982).

Determination of efficacy of bio-inoculants under green house condition: Experiment was conducted under green house conditions with the application of bio-inoculants in different treatment combinations are given below. :

T_1- Control; T_2 - A.c + B.m + F.a, T_3 - A.c + B.m + F.a + B.s; T_4 - A.c + B.m + F.a + T.v; T_5 - A.c + B.m + F.a + T.v + P.f + B.s; T_6 - A.c + B.m + F.a + P.f; T_7 - A.c + B.m + F.a +T.v+ B.s; T_8 - A.c + B.m+ P.f + T.v

Note: A.c - *Azotobacter chroococcum;* B.m - *Bacillus megaterium;* F.a – *Frateuria aurantia;* P. f - *Pseudomonas fluorescens;* B.s- *Bacillus subtilis* and T.v -*Trichoderma viridae*.

Crop and statistical design: Amaranthus cruentus crop was taken up following Complete Randomised Design (CRD) and each treatment replicated thrice.

Plant height and Number of leaves per plant: Plant height was measured from the base of plant to the terminal growing point of the main stem at 7, 21 and 30 Days After Sowing (DAS). The average plant height was expressed in centimeters (cm). The leaves which were fully opened, matured and not senescent were counted for each plant and recorded as number of leaves per plant (5 plants/treatment) at 7, 21 and 30 DAS.

Shoot length and Root length: Five normal plants were selected randomly from each treatment at harvest. The shoot length was measured from collar region to the tip of the seedling with the help of a scale and the mean shoot length was expressed in centimeter (cm). Five normal randomly selected plants used for the measurement of root length. The root length measured from collar region to the tip of primary root with the help of a scale and the mean root length was expressed in cm.

Root and shoot dry weight (g): The root and shoot of the same five seedlings selected for measurement were kept in butter paper bag and dried in an oven maintained at 85 ± 2^{o}C for 24 hours. After drying, the butter paper bags were removed and kept in desiccators for cooling. The weight of shoot and root was recorded and mean dry weight of seedlings was calculated and expressed in grams.

RESULTS AND DISCUSSION

Production of Plant growth promoting hormones by bio-inoculants

*Production of Gibberellic Acid (*GA): The concentration of GA in the liquid bio-inoculants was determined by the starch agar halo test and presented in Table-I. The highest GA was recorded in *Pseudomonas fluorescens* (4.75 µg) followed by *Bacillus subtilis* (2.57 µg) and *Bacillus megaterium* (2.29 µg). The least was recorded with *Trichoderma viridae* (1.43 µg). Lenin and Jayanthi (2012) have also isolated and purified GA3 and GA like compounds from genera *Azotobacter*, *Bacillus* and *Pseudomonas* isolated from soil in the range of 6.45 to 7.10 µg

TABLE I

Bioassay for Plant growth hormones production by liquid inoculants

Liquid inoculants	Gibberellic Acid (GA)		Indole Acetic Acid (IAA)		Cytokinin	
	Diameter of Zone (mm)	GA (µg)	Root Length (mm)	IAA (µg)	Chl µg/ml	Cytokinin (µg)
Azotobacter chroococcum	16.32	1.91	1.15	130.96	0.97	1.19
Bacillus megaterium	15.10	2.29	1.38	173.41	1.62	3.56
Frateuria aurantia	14.47	1.47	1.13	127.37	0.86	0.94
Pseudomonas fluorescens	23.04	4.75	1.44	183.07	2.12	4.94
Bacillus subtilis	18.85	2.57	1.27	160.67	1.39	2.69
Trichoderma viridae	14.22	1.43	0.86	91.32	0.55	0.88
SEM±	0.19	0.05	0.03	0.73	0.02	0.05
CD @ 5%	0.59	0.14	0.09	2.24	0.06	0.17

25 ml^{-1} broth whereas, in our findings gibberellins production was in the range of 25-60 µg ml^{-1}. So the selected *Pseudomonas* isolates were quite efficient for the production of gibberellins like substances.

*Production of Indole Acetic Acid (*IAA): The IAA bioassay is based on the inhibition of root growth in cucumber by IAA. As the concentration of IAA increases the root elongation of germinating seedlings is inhibited. The results of the bioassay are presented in Table-I. The liquid bio-inoculants containing *Pseudomonas fluorescens* showed highest production of IAA (183.07 µg) which was followed by *Bacillus megaterium* (173.41 µg) and *Trichoderma viridae* (91.32 µg) recorded least IAA production. Karnwal (2009) isolated pseudomonad strains from rhizosphere soils and observed that the *Pseudomonas fluorescens* AK1 and *Pseudomonas aeruginosa* AK2 showed the best plant growth-promoting activity. These isolates were tested for their ability to produce IAA in pure culture for both strains, indole production increased with increases in tryptophan concentration . *P. aeruginosa* AK2 was less effective in production of indole acetic acid than *P. fluorescens* AK1.

*Production of Cytokinins:*The cucumber cotyledon greening bioassay is frequently used for detecting cytokinins and the results of the test are shown in Table I. Cytokinins accelerate chloroplast differentiation as well as regulate and stimulate chlorophyll (Chl) production in etiolated cucumber cotyledons. The increase in Chlorophyll production is proportionate to the concentration of cytokinins and this response provides a sensitive yet rapid bioassay for cytokinins. The significantly highest cytokinin production was observed in *Pseudomonas fluorescens* (4.94 µg) and the least was recorded in *Trichoderma viridae* (0.88 µg). Yildirim (2011) demonstrated that heads of cabbages inoculated with the three strains and tested strains have higher chlorophyll content than controls (14.7 %, 14.0 %, and 13.7 %, respectively, in plants inoculated with *B. cereus, R. rubi*, or *B. reuszeri*).

Effect of liquid bio-inoculants on growth parameters of *Amaranthus* crop under greenhouse condition.

Plant height: The plant height was recorded at different intervals and it is presented in Table II. At 15 DAS, treatment T_5 (8.82 cm) showed significantly highest plant height and it was statistically on par with treatments T_8 and T_6 (8.70cm and 8.63 cm), respectively. The least plant height was noticed in

TABLE II

Effect of liquid bio-inoculants on growth parameters of Amaranthus crop under greenhouse condition

Treatments	Plant height (cm)			Number of leaves		
	15 DAS	21 DAS	30 DAS	15 DAS	21 DAS	30 DAS
T_1- Control	5.45	14.60	23.37	4.93	7.53	10.13
T_2- A.c + B.m + F.a	6.85	18.33	27.53	5.27	8.10	10.80
T_3- A.c + B.m + F.a + B.s	7.50	22.47	28.97	5.00	8.03	11.50
T_4- A.c + B.m + F.a + T.v	8.40	23.23	38.23	5.90	8.53	11.43
T_5- A.c + B.m + F.a + T.v + P.f + B.s	8.82	29.00	40.87	6.23	9.13	12.57
T_6- A.c + B.m + F.a + P.f	8.63	25.77	40.53	6.13	8.50	11.83
T_7- A.c + B.m + F.a +T.v+ B.s	7.82	25.53	36.43	6.10	8.27	11.40
T_8- A.c + B.m+ P.f + T.v	8.70	28.70	39.07	5.83	8.13	11.77
SEM±	0.15	0.35	0.25	0.34	0.15	0.16
CD @ 5%	0.44	1.05	0.76	1.03	0.45	0.48

Note : *A.c- Azatobacter chroococcum, B.m - Bacillus megaterium, F.a – Frateuria aurantia, P. f- Pseudomonas fluorescens, B.s- Bacillus subtilis* and *T.v -Trichoderma viridae* control (5.45 cm). At 21 DAS, treatment T_5 (29 cm) showed significantly highest plant height followed by treatment T_8 (28.70 cm) and T_6 (25.77 cm). The least plant height was noticed in the control (5.45 cm). At 30 DAS the highest plant height was recorded in the treatment T_5 (40.87) which was on par with T_6 (40.53 cm). The efficacy of three species microbial consortium of *Bacillus* sp, *Azotobacter* sp and *Frauteria* sp. for its plant growth promoting efficacy in black gram (*Vigna mungo* (L.) Hepper has been reported by Maiyappan *et al*. (2010).

Number of leaves: Application of bio-inoculants have positive effect on number of leaves and the results pertaining to number of leaves at different days after sowing were interpreted in Table II. At 15 DAS, Treatment T_5 recorded higher number of leaves per plant (6.23) compared to other treatments. The treatments T_6, T_7 and T_4 recorded 6.13, 6.10 and 5.90 respectively. Control (T_1) recorded least number of leaves (4.93). At 21 DAS, Treatment (T_5) recorded highest number of leaves of 9.13 compared to treatments T_6 (8.53), T_4 (8.50), T_7 (8.27), T_8 (8.13). At 30 DAS, T_5 recorded maximum number of leaves (12.57) followed by T_6 (11.83) which was on par with T_8 (11.77), T_3 (11.50), T_4 (11.43) and T_5 (11.40). Control (T_1) recorded least number of leaves (10.13). Uma Maheswari and Elakkiya (2014) studied the application of liquid biofertilizers on *Vigna mungo* and observed for number of leaves which were increased in combined inoculation of liquid biofertilizer treatments such as *Rhizobium* + *Azospirillum* + *Azotobacter* on 60th day showed maximum response in leaves (27.6) followed by other treatments and control.

Root and Shoot Length: The results pertaining to root and shoot length of Amaranthus plants are presented in Table III. Maximum root length (7.80 cm) was recorded in T_3. Least root length is noticed in Control (T_1). Similarly the shoot length of treatment T_5 recorded maximum shoot length (40.87 cm) compared to other treatments. Treatment T_6 (40.53cm) was on par with T_5. Least shoot length was recorded in control (23.37cm). Uma Maheswari and Elakkiya, (2014) their study was clearly highlighted that combined inoculation of liquid biofertilizers such as *Rhizobium Azospirillum, Azotobacter* (Treatment T_7) could enhance the morphological parameters such as height of the plant (31.62cm), number of leaves (27.6), Shoot length (20.5 cm), Root length (15.6 cm), number of roots (21.8), root nodules(15.4) at 60th day compared to individual inoculation and control.

TABLE III

Effect of liquid bio-inoculants on plant biomass of Amaranthus under greenhouse condition

Treatments	Root length (cm)	Shoot length (cm)	Root & Shoot Fresh weight (cm)	Root & Shoot Dry weight (cm)
T_1- Control	3.40	23.37	2.48	0.94
T^2- A.c + B.m + F.a	5.30	27.53	4.60	1.47
T_3- A.c + B.m + F.a + B.s	6.30	28.97	5.71	1.73
T_4- A.c + B.m + F.a + T.v	6.50	38.23	7.59	1.93
T_5- A.c + B.m + F.a + T.v + P.f + B.s	7.80	40.87	7.87	3.07
T_6- A.c + B.m + F.a + P.f	7.00	40.53	7.77	2.83
T_7- A.c + B.m + F.a +T.v+ B.s	6.70	36.43	7.71	2.68
T_8- A.c + B.m+ P.f + T.v	6.17	39.07	7.19	2.93
SEM±	0.07	0.25	0.06	0.08
CD @ 5%	0.21	0.76	0.17	0.24

Note : *A.c- Azatobacter chroococcum, B.m - Bacillus megaterium, F.a – Frateuria aurantia, P. f- Pseudomonas fluorescens, B.s- Bacillus subtilis* and *T.v -Trichoderma viridae*.

Root and Shoot Fresh Weight: There was significant difference among the treatments in Root and shoot fresh weight and the highest root and shoot fresh weight was recorded in T_5 (7.87g) which was on par with T_6 (7.77g) and T_7 (7.71g). Control (T_1) recorded least root and fresh weight (2.48g). Singaravel *et al*., 2008 reported the application of liquid bio-fertilizer both Symbion N and Symbion P significantly increased the growth character, yield character and yield of okra. Among various treatments, Symbion N and Symbion P both applied in soil was significantly superior in increasing the growth and yield of okra. This treatment recorded the highest okra yield of 6280 Kg ha^{-1}.

Root and Shoot dry weight: The Root and shoot dry weight of Amaranthus crop was recorded at harvest stage and the highest was recorded in treatment T_5 (3.07g). The treatments T_8 (2.93g) and T_6 (2.83g) were on par with each other. Uninoculated control (T_1) recorded least root and shoot dry weight (1.47g). The efficacy of three species microbial consortium of *Bacillus* sp., *Azotobacter* sp. and *Frauteria* sp. for its plant growth promoting efficacy in black gram (*Vigna mungo* L.) has been reported by Maiyappan *et al*. (2010).

The study indicated that application of consortia of liquid bio-inoculants enhance the growth and biomass of Amaranthus which can be attributed to the plant growth promoting ans biocontrol activity of the organisms.

References

Belanger, J., Balakrishna, M., Latha, P., Katumalla, S., and Johns, T., 2004, Contribution of selected wild and cultivated leafy vegetables from South India to lutein and â-carotene intake. *Asia Pacific J. Clinical Nutri.*, **46** (4) : 221 - 227.

Fletcher, R. A., Kallumbil, V. and Steele. P., 1982. An improved bioassay for cytokinins using cucumber cotyledons. *Plant Physiol.,* **69** : 675 - 677.

Gabriele Berg, 2009, Plant - microbe interactions promoting plant growth and health: perspectives for controlled use of microorganisms in agriculture. *Appl. Microbiol. Biotechnol*., **84** : 11 - 18.

Karnwal, A., 2009, Production of indole acetic acid by fluorescent pseudomonas in the presence of l - tryptophan and rice root exudates. *J. Plant Pathol.*, **91** (1) : 61 - 63.

Lenin, G. and Jayanthi, M., 2012, Indole acetic acid, gibberellic acid and siderophore production by PGPR isolates from rhizospheric soils of *Catharanthus roseus. Int. J. Pharm. Biol. Sci. Arch.,* **3** : 933 - 938.

Loper, J. E. and Schroth, M. N. 1986, Influence of bacterial sources of Indole -3- Acetic acid on root elongation of sugarbeet. *Phytopathol.*, **76** : 386 - 389.

Maiyappan, S., Amalraj, E. L. D., Santhosh, A. and John P. A., 2010, Isolation, Evaluation and Formulation of Selected Microbial Consortia for Sustainable Agriculture. *J. Biofert. Biopest*., **2** : 2 - 6

Singarvel, R., Suhatiya, K,, Vembu, G., and Kamaraj, S., 2008, Effect of liquid formulation of Symbion - N (*Azospirillum*) and Symbion - P (*Phosphobacter*) on the growth and yield of okra. *Asian J. Soil Sci.,* **3** (2) : 261 - 263

Umamaheswari, N. and Elakkiya, T., 2014, Effect of Liquid Biofertilizers on Growth and Yield of *Vigna mungo* L. *Int. J. Pharm. Sci. Rev. Res.,* **29** (2) : 42 - 45.

Yildrim, E., 2011, Promotion of broccoli by plant growth promoting rhizobacteria. *Horti. Sci.,* **46** : 932 - 936.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 359-365, 2017

Screening of Wild Mushrooms for Antiviral Property and Their Molecular Characterization

R. Manoj and N. Earanna
Department of Agricultural Microbiology, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail : earanna7@gmail.com

Abstarct

Five wild mushrooms were collected from Nettana village of Dakshina Kannada district of Karnataka, India. One of the mushroom was identified as *Ganoderma lucidium*based on its phenotypic characters and the other four mushrooms were identified as *Lentinus* sp. *Pleurotus djamour, Pluteus cervinus*and *Micromphale foetidum*by Internal Transcribed Spacer (ITS) sequence homology. Crude extract (1:1 w/v) was made from these mushrooms in sterile distilled water and screened for antiviral property against *Bovine herpes virus-1*(BoHV-1) and *Morbili virus* grown on madin derby bovine kidney cells (MDBK cells) and Vero-cells respectively. The crude extract of the mushrooms except *P. djamour* showed cytotoxic effect on the host cells before dilutions. The diluted extract of *G. lucidium* and *Lentinus* sp. at 10^{-6} and 10^{-4} dilutions respectively inhibited both the BoHV-1 and *Morbilli viruses* without affecting host cells. However, *P. djamour, P. cervinus* and *M. foetidum* did not affect the viruses and found non cytotoxic once after dilutions were made. This study reveals that the *G. lucidum* and *Lentinus* sp. as potential antiviral mushrooms.

Keywords: Mushroom extract, antiviral property, *bovine herpes virus-1*, *morbilivirus*

Many mushrooms were described under traditional medicine to set right the disorders and to cure the diseases. Mushroom extracts were reported to have antibacterial, hematological, antiviral, antitumor, hypotensive, antioxidental, anticancerous and hepatoprotective effects (Barros *et al*., 2007). The isolated active compounds appeared to play a direct role by acting as inhibitors of viral enzymes, synthesis of viral nucleic acids or absorption and uptake of viruses into cells. The direct antiviral effects were exhibited in particular by small molecules and the indirect antiviral effects (Santoyo *et al*., 2012)

Herpes viruses contain DNA as their genetic material and are important pathogens in humans as well as animals. *Bovine herpes virus-1* (BoHV-1) is an important pathogen of cattle causing significant economic losses to the livestock industry worldwide. The virus has been associated with a variety of clinical disease manifestations including rhinotracheitis, vulvovaginitis, balanoposthitis, abortions, conjunctivitis, neurological disorders and generalized systemic infections (Benoit *et al*., 2007). Similarly, the *Morbilli virus* is an RNA virus belonging to the family *Paramyxovirdae* is a causative agent of highly fatal disease called Peste *des* petits ruminant's (PPR) in Sheep and Goats (Harish *et al.,* 2009). Both of these causes major diseases in livestock. Since there were no specific drugs to control the viral diseases directly so far in the modern medicine, exploitation of the plant and fungi resources is very much essential in *bioprospecting*.

Characterization of mushroom species requires basic knowledge on the structure of the fungi. The phenotypic characters used for identification of mushroom species are shape, size, texture, colour and odour of the fruiting body (Arora, 1986). However, in recent years, molecular tools well supported the mushroom taxonomy. Molecular markers, particularly DNA based techniques are quick and reliable to establish identities of wild mushrooms.Identification of mushroom species using ITS (Internal Transcribed Spacers) region sequence not only provides appropriate information to classify the organism up to species level but useful in identification of young fruit bodies. Several researchers have been reported characterization of fungi based on ITS sequence analysis. Oyetayo (2014) identified the *Trametes* species collected from Nigerian forest by using Internal Transcribed Spacer

(ITS) region of the rDNA. In the present study, five mushrooms were screened for antiviral property and characterized.

Material and Methods

Collection of wild mushrooms and preparation of mushroom extract: Mushrooms were collected in a paper cover bags during rainy seasonat forest, Nettana village area of Dakshina kannada district located in Western Ghats (WG) of Karnataka, India. Field characters, such as season, soil type, vegetation, *etc.*, were recorded at the time of collection.These mushrooms were brought to the laboratory and designated as WG-1, WG-2, WG-3, WG-4 and WG-5 (Fig.1). One gram of fresh mushroom tissue was ground with one milliliter of sterile water and centrifuged at 10,000 rpm for 10 min. The supernatant was filtered through sterile micron syringe fixed with 0.45 µm membrane filter and stored in -20^{o}C.

Collection of viruses:Two viruses *viz*., *Bovine herpes virus-1* (DNA virus) and *Morbili virus* (RNA virus) were collected from the Department of Virology, Institute of Animal Husbandry and Veterinary Biological, Hebbal, Bengaluru-560024, India. The experiment was conducted in Molecular Microbiology laboratory, Department of Agricultural Microbiology, UAS, GKVK, Bengaluru-560065, India.

Screening of mushroom extract for antiviral property against DNA virus (Bovine herpes virus-1): *Bovine herpes virus-1* adapted to grow in madin derby bovine kidney cells (MDBK) was used to study antiviral property of the mushroom extracts. The antiviral activity was analysed by virus neutralization test using mushroom extracts, in 96 well cell culture plates, as per the procedure described by Rovozzo and Burke (1974). Serial dilution of mushroom extract (1:10) was made in a sterile water. 0.5 ml from each dilution was dispensed in eight cryovials. In to this, 0.5 ml of diluted *Bovine herpes virus-1*was added and incubated for 1 hr at 37°C.After incubation, 200 µl of this neutralized mushroom extract-virus mixture was added to the corresponding well of 24 hrs grown MDBK cells and incubated for one hour at 37°C for viral adsorption. Then these cultures were added with 200 µl of Dulbecco's modified eagle's medium (DMEM) maintenance media at 37°C and five per cent CO_2. The monolayers were observed for production of cytopathic changes at 24 hours intervals till the seventh day post of inoculation and the inhibition of virus was recorded.

Fig 1: Wild mushrooms collected from nettana village of Dakshina kannada district located in Western Ghats of Karnataka

Screening of mushroom extracts for antiviral property against RNA virus (Peste des petits ruminants virus): The *Morbilli virus* adopted to grow in Vero cell (African green monkey kidney cell) line was used to study antiviral property of the two mushroom extracts.The antiviral property was determined using the same procedure mentioned above for*Bovine herpes virus-1* (Rovozzo and Burke, 1974).

Molecular identification: Total genomic DNA from the cap tissue of the mushroom fungus was extracted using CTAB lysis buffer. Then 0.2 gram of dried mushrooms sample was ground into fine powder using liquid nitrogen and sample was transferred into 2 ml of extraction buffer containing CTAB and incubated at 65°C for 30 minutes. After incubation the tubes were centrifuged at 10,000 rpm for 10 minutes. The supernatant was transferred into a fresh centrifuge tube and equal volume of chloroform and Iso-amyl alcohol (24:1 V/V) was added, it was mixed by inverting the tubes and centrifuged at 10,000 rpm for 10 minutes. The above step was repeated till no white interface is seen. Clear supernatant was collected and DNA was precipitated by adding 0.6 volumes of chilled Isopropanol and placed in -20ºC for 2 hours. After incubation the mixture was centrifuged and the pellet was washed with 70 per cent ethanol, further air dried, dissolved in Tris-EDTA (10:1) buffer and stored at -20°C.

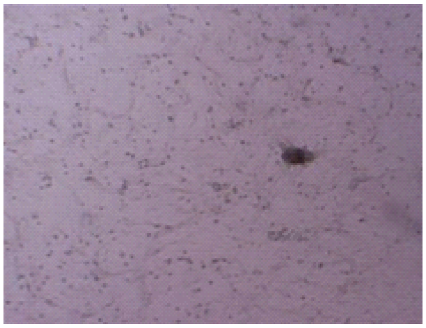
The DNA thus extracted was checked for purity using UV spectrophotometer at 260 / 280 nm wave length. Concentration was measured using nano drop (ependorff). Then 50-100 ng DNA was used for PCR amplification in a 20 µl reaction mixture containing 2.0 µl of 10 x PCR Taq. Buffer, 2.0 µl of 10 mM dNTP's mix, 1.0 µl of ITS primers, 0.3 µl of Taq. DNA polymerase, 1.0 µl of Template DNA, 13.7 µl of Sterile distilled water in Sterile PCR tubes. ITS-1 (5' TCCGTAGGTGAACCTGCGG 3') as a forward primer and ITS-4 (5' TCCTCCGCTTATTGATA TGC 3') as a reverse primer were used as a primer. The reaction was carried out in a Thermal Cycler (Applied biosystems).

The PCR programme was standardized with initial denaturation at 96°C for 4 min, 40 cycles of denaturation of 94°C for 1 min, annealing at 60°C for 30 seconds and extension at 72°C for one min and final extension at 72°C for 10 min. The amplified products were separated by agarose gel electrophoresis. The gel was visualized under UV light and documented using Alpha innotech Gel documentation unit. The visualized band was excised and purified by using the Gene Jet™ Gel Extraction Kit. The DNA thus eluted was sequenced by Sci Genom Labs Private Ltd. Kerala, India using ITS-1 forward and ITS-4 reverse primers. The sequence homology was searchedat NCBI GenBank (*http// www.Ncbi.nlm.nih.gov/BLAST/*).

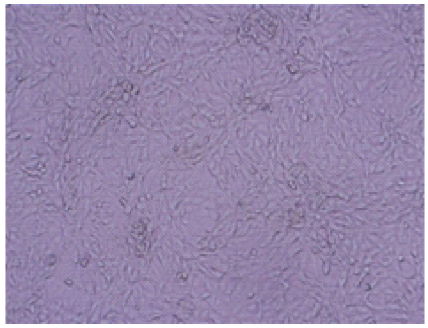
Screening of mushroom extracts for antiviral property against DNA virus (Bovine herpes virus-1) and RNA virus (Peste des petits ruminants virus or Morbili virus): *Bovine herpes virus-1* (BoHV-1) is an important pathogen of cattle causing significant economic losses to the livestock industry worldwide. This virus causes variety of diseases such as neurological disorders and generalized systemic infections in livestock. Similarly, the *Morbilli virus* causes highly fatal disease called Peste *des* petits ruminant's (PPR) in Sheep and Goats. Hence both the viruses contribute to major economic losses in livestock industry. Therefore, present study is focused on the identification of potential antiviral mushroom against both the viruses. Screening of antiviral properties of mushrooms against BoHV-1 (DNA virus) andPeste *des* petits ruminants virus (RNA virus) was done by using extracts of *G. lucidium, Lentinus* sp. *P. djamour, P. cervinus*and *M. foetidum* mushrooms by using 96 well cell culture plates containing MDBK and Vero cells separately. The observations were recorded up to seven days.

RESUL'TS AND DISCUSSION

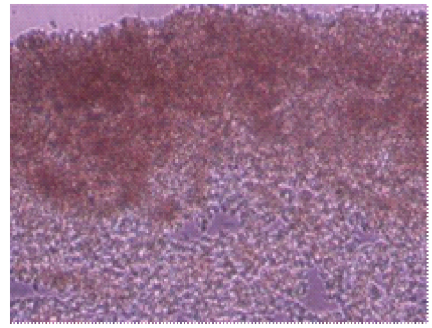
The *Ganoderma lucidium* and *Lentinus* sp.inhibited the viral activity of *Bovine herpes virus-1* (DNA virus) in MDBK cell culture plate at 10^{-6} and 10^{-4} dilution, respectively and *Morbilli virus* (RNA virus) in Vero cell culture plate at 10^{-6} and 10^{-4} dilution, respectively. Both the mushrooms exhibited the potential antiviral properties at 10^{-6} and 10^{-4} dilutions respectively. Mushroom extracts of *G. lucidium* and *Lentinus* sp. up to dilutions of 10^{-5} and 10^{-3} affected the cell growth respectively. But dilutions above 10^{-6} of *G. lucidium* and above 10^{-4} of *Lentinus* sp., did not



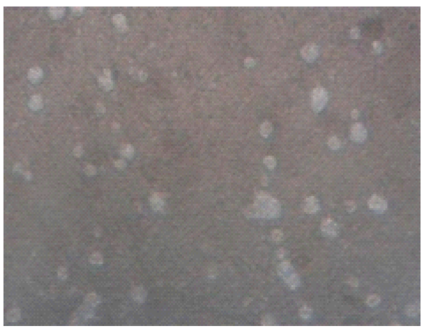
Ganoderma lucidium Mushrooms extract alone on MDBK cells



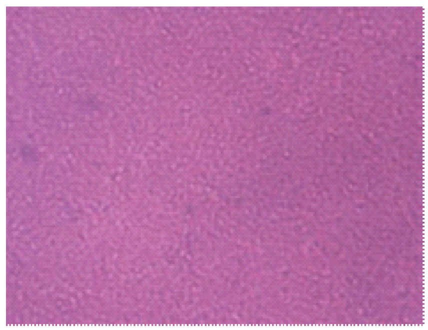
Ganoderma lucidium extract and BoVH-1 on MDBK cells (Inhibition of viral activity at 10^{-6} dilution)



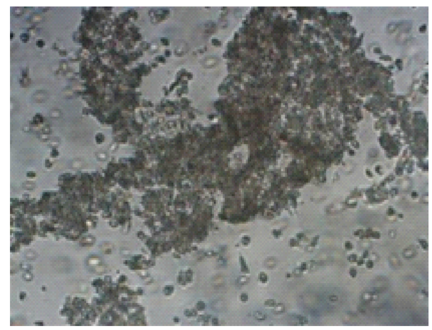
Cytopathic effect of virus control on MDBK cells



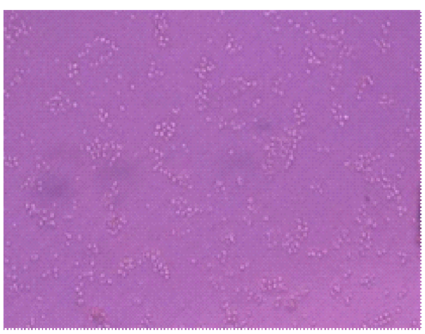
Lentinus sp.mushroom (WG 80) extract alone on MDBK cells



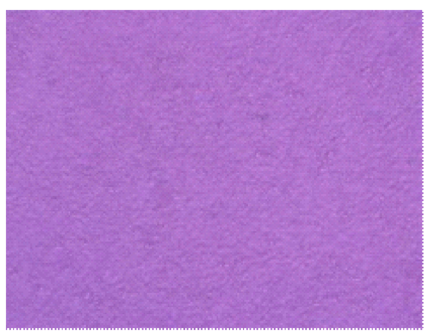
Lentinus sp.+ BoHV-1 on MDBK cells (at 10^{-4} dilution)



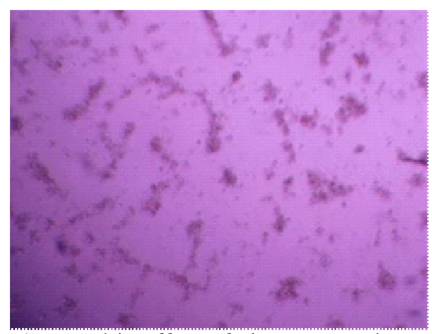
Cytopathic effect of Virus control on MDBK cells



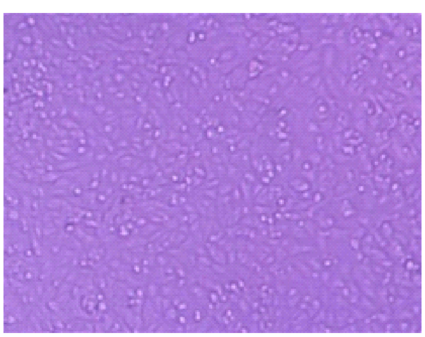
Ganoderma lucidium mushroom extract alone on Vero cells



Ganoderma lucidium extract + *Morbili virus* on Vero cells (Inhibition of viral activity at 10^{-6} dilution)

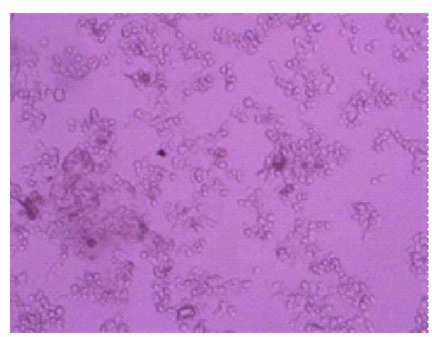


Cytopathic effect of virus control on Vero cells



Lentinus sp.mushrooms (WG 78) extract alone on Vero cells

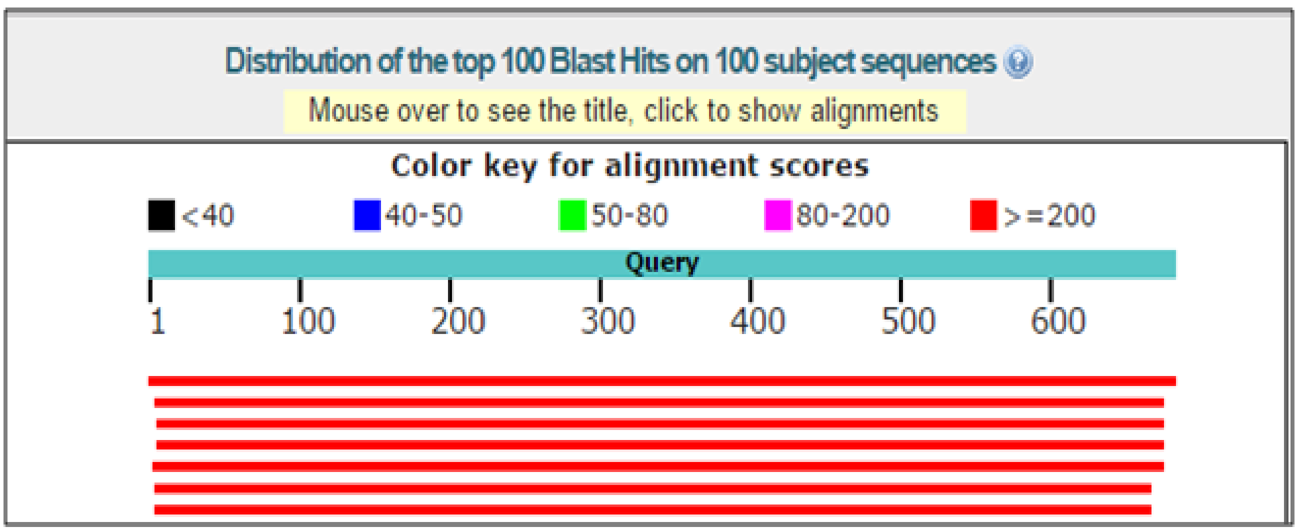
Sample W 78 + *Morbilli virus* on Vero cells (Inhibition of viral activity10^{-4} dilution)



Cytopathic effect of Virus control on Vero cells

Fig 2: Mushrooms which are showing antiviral properties

CCTCTTCCGTAGGTGAACCTGCGGAAGGATCATTATCGAGTTTTGAAACGGGTTG
TAGCTGGCCTTCCGAGGCATGTGCACGCCCTGCTCATCCACTCTACACCTGTGCA
TTTACTGTGGGTTTCAGGAGCTTCGAAAGCGAGAAAGGGGCCTTCACGGGCTTTT
TCTTGCGTAGTTGTTACTGGGCCTACGTTTCACTACAAACACTTATAAAGTATCA
GAATGTGTATTGCGATGTAACGCATCTATATACACTTTCAGCAACGGATCTCTTG
GCTCTCGCATCGATGAAGAACGCAGCGAAATGCGATAAGTAATGTGAATTGCAG
AATTCAGTGAATCATCGAATCTTTGAACGCACCTTGCGTCCTTGGTATTCCGAGG
AGCATGCCTGTTTGAGTCATGAAATTCTCAACCTAACGGGTTCTTAACGGGACTT
GCTTAGGCTTGGACTTGGAGGTTCTTGTCGGCTTGCTTCAATGTCAGGTCGGCTC
CTCTTAAATGCATTAGCTTGGTTCCTGTGCGGATCGGCTCACGGTGTGATAATTGT
CTACGCCGCGACCGTTGAAGCGTTTTATAGGCCAGCTTCTAGTCGTCTCTACGAG
ACAATAATCATCGAACTCTGACCTCAGATCAGGTAGGACTACCCGCTGAACTTAA
GCATATCAATAGGCGGGGGAAAA



Sequences producing significant alignments:

Select: All None Selected 0

Alignments Download GenBank Graphics Distance tree of results

Description	Max score	Total score	Query cover	E value	Ident	Accession
Lentinus sp. S3007 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete seq	1236	1236	100%	0.0	99%	JQ868746.1
Lentinus squarrosulus strain 7-4-2 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2,	1186	1186	98%	0.0	98%	GU001951.1
Lentinus sp. GZMS-25 small subunit ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, co	1184	1184	98%	0.0	98%	KX377592.1
Lentinus squarrosulus strain WCR1201 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spa	1164	1164	98%	0.0	98%	KT956127.1
Lentinus sp. BAB-5060 18S ribosomal RNA gene, partial sequence; internal transcribed spacer 1, 5.8S ribosomal RNA gene, and internal transcribed spacer 2, complete s	1164	1164	98%	0.0	98%	KR155105.1

Fig 3: Full length sequence and homology search of Lentinus sp. (WG 2)

TABLE I

Field information and phenotypic character of mushrooms

Designated samples	Habitat	Character of Pileus		Character of Gills	Annuals	Character of Stipe	Name of identified mushrooms	Family
		Colour	Shape					
WG 1	Soil	Reddish brown	Kidney shape	Absent	Absent	Equal	*Ganoderma lucidum*	Ganodermataceae
WG 2	Wood	White	Uplifted	Absent	Absent	Tapering upwards	*Lentinus* sp.	Polyporaceae
WG 3	Wood	Creamy white	Round	Present	Absent	Tapering downwards	*Pluteus cervinus*	Pluteaceae
WG 4	Wood	White	Irregular	Present	Absent	Tapering downwards	*Pleurotus djamour*	Pleurotaceae
WG 5	Soil	Brown	Convex	Present	Absent	Tapering downward	*Micromphalefoetidum*	Marasmimaceae

have lytic effects on the cells and these dilutions when inoculated on the cells along with the virus, yielded effective antiviral effects as evidenced by absence of cytopathic changes by mainly inhibiting intracellular replication of BoHV-1 in MDBK cell culture and *Morbili virus* in Vero cell culture and they were also able to disrupt the virus adsorption step in MDBK (Fig. 2) and Vero cells (Fig. 2), respectively. In this study, *G. lucidum and Lentinus* sp. mushroom extracts might have interfered with the BoHV-1 and *Morbili virus* infection process at the initial infection steps perhaps by blocking virus attachment or adsorption to MDBK and Vero cells, respectively. This indicating that these species might be an interesting source of antiviral compounds. However, the extract of the *P. djmour* did not show any inhibitory effect neither on virus nor on the host cell. In contrast, the extracts of *P. cervinus*and *M. foetidum* have inhibitory effect on host cells but not on targeted viruses indicating that these mushrooms are not producing antiviral compounds. Similar results were obtained by Santoyo *et al.* (2012) by using aqueous extract and methonal extract of *Ganoderma lucidium* and *Lentinus edodes* against *Herpes simplex virus-1*. Crude dichloromethane, ethanol, water and polysaccharide extracts of *Ganoderma lucidum* all suppressed HPV 16 E6 (Lai *et al*., 2010).

Identification of mushrooms by phenotypic / ITS region sequence: Mushrooms are the objects of much curiosity, speculation since time immemorial and also one of the most important components of the ecosystem. Their edibility, poisonous nature psychotropic properties, medicinal properties draw the attention of the researchers. The WG-1 was identified by its phenotypic characterswhile consulting the book *Mushroom Demystified* (Arora, 1986). The pileus of this mushroom was reddish brown in colour, kidney shaped and the border surrounded by white tissue. Stipe was brown in colour, off centric and tapered upward. Texture of the fruiting body was corky and tough. Thus, the mushroom was identified as *Ganoderma lucidum* (Table I). Identification of mushrooms through morphological characters in the field is advantageous for mushroom collection. Similarly Meera and Veena, (2012) identified 45 species of mushrooms from Kodagu district of Western ghats by studying their phenotypic characters.

The other four mushrooms were identified by ITS region sequence homology available at NCBI Gen Bank. The ITS sequence of the mushroom designated as WG-2 (684bp) showed 99 per cent homology with *Lentinus* sp., (Fig.3) WG-3 (622bp) showed 99 per cent sequence homology with *Pluteus cervinus*, WG-4 (683bp) showed 99 per cent sequence homology with *Pleurotus djamour* and WG-5 (715bp) showed 97 per cent sequence homology with *Micromphale foetidum.* Molecular identification has precise and avoid confusion while speciation. Therefore, in this study, four mushrooms were identified by ITS region sequence. Ranjaratnam and Thiagarajan (2012) identified *Perenniporia* sp. by amplification of ITS region and aligned by using Jukes-Cantor Corrected Distance model. Similarly, eighteen species of Termitomyces collected from Ondo and Ekiti States of Nigeria were identified using ITS region of rDNA (Oyetayo, 2012).

This study revealed antimicrobial property of two mushrooms on two bovine viruses *viz*., DNA and RNA viruses. The other three mushrooms did not possess the antimicrobial propertybut characterized for reporting. However, further study required to isolate and identify the antiviral compound.

References

Arora, D., 1986, Mushrooms Demystified : A comprehensive guide to the fleshy fungi. *Ten Speed Press*., p. 8 - 28.

Barros, L., Baptista, P., Correia, D. M., Morais, J. S. and Ferreira, 2007, Effects of conservation treatment and cooking on the chemical composition and antioxidant activity of portuguese wild edible mushrooms. *J. Agril. Food Chem*., **55** : 4781 - 4788.

Benoit, M., Julien, T., Philippe, K., Frederic, S. and Etienne, T., 2007, *Bovineherpesvirus* 1 infection and infectious bovine rhinotracheitis. *Vet. Res*., **38** : 181 - 209.

Harish, B. R., Chandranaik, B. M., Shivraj, Venkatesh, M. D. and Renukaprasad, C., 2009, Epidemiology of PPR outbreaks in Karnataka.*Ind. Vet.J.,* **86** (8) : 773 - 775.

Lai, C. Y., Hung, J. T., Lin, H. H., Alice, L. Y., Chen, S. H., Tsai, Y. C. and Yu, J., 2010, Immounomodulatory and adjuvant activities of a polysaccharide extract of *Ganoderma lucidum in vivo* and *in Vitro. Vaccine*, **25** (31) : 4945 - 4954.

Meera, P. and Veena, S. S., 2012, Characterization and conservation of edible and medicinal mushrooms of Western Ghats of India. *Indian. J. Trop. Biodiv*., **20** (1) : 37 - 44.

Oyetayo, V. O., 2014, Molecular identification of *Trametes* species collected from Nigeria. *Jordan . J. Biol. Sci.,* **7** : 165 - 169.

Oyetayo, V. O., 2012, Wild *Termitomyces* species collected from Ondo and Ekiti states are more related to African species as revealed by ITS region of rDNA. *The Sci. World.,* p. 1 - 5.

Rajaratnam, S. and Thiagarajan, T., 2012, Molecular characterization of wild mushroom. *Eur. J. Exptl. Biol*., **2** (2) : 369 - 373.

Rovozzo, G. C. and Burke, C. N., 1974, *A manualof Basic Virological Techniques*. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

Santoyo, S., Ramirez - Anguiano, A. C., Aldars - Garcia, L., Reglero, G. and Soler - Rivas, C., 2012, Antiviral activities of *Boletus edulis, Pleurotus ostreatus* and *Lentinus edodes* extracts and polysaccharide fractions against *Herpes simplex virus type 1*. *J. Food Nutr. Res.,* **51 :** 225 - 235.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 366-372, 2017

Molecular Characterization of *Gluconacetobacter diazotrophicus* Isolated from Maize (*Zea mays* L.) and Its Interaction with Microbial Consortia on Growth and Yield

G. B. Santosha Gowda and N. Earanna
Department of Agricultural Microbiology, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: santhugowdagb@gmail.com

Abstract

Gluconacetobacter diazotrophicus is an endophytic, Gram-negative, rod shaped, associative nitrogen fixing bacterium. The bacterium was isolated from roots of maize using LGI-P medium. The bacterium formed orange colour colonies on LGI-P medium. The genomic DNA was isolated and amplified using 16S rRNA primers. The results of the sequence obtained were BLAST searched at NCBI GenBank. The bacterium showed 98 per cent sequence homology with the *G. diazotrophicus* 263-A available in NCBI GenBank. The consortia of *G. diazotrophicus* MZ-01 + *B. megaterium* + *G. fasciculatum* showed significant increase in plant height, number of leaves, number of cob per plant, number of rows per cob, number of grains per cob, test weight, grain yield per plant, cob length, cob diameter, shoot and root biomass contents compared to single inoculation treatments. The un-inoculated maize plants (control) produced least growth and yield indicating the superiority of consortial inoculation.

Keywords: *G. diazotrophicus,* LGI-P medium, *b. megaterium, g. fasciculatum*

Maize (*Zea mays* L.) is one of the important staple food crop of the world and ranks next only to wheat and rice. Maize has been an important cereal because of its great production potential and adaptability to wide range of environment. Maize occupies an important place in Indian economy, like rice, wheat and millets. Besides, being a potential source of food for human being, it is used for feeding cattle, poultry and industries for the production of starch, syrup, alcohol, acetic acid, lactic acid *etc*. In India, maize is grown over an area of 9.18 million ha with a production of 24.17 million tonnes and the productivity is 2.63 t / ha (www.indiastat.com). In Karnataka, it is cultivated in an area of 1.34 million ha with production of 3.98 million tonnes and the productivity is 2.99 t / ha. (www.indiastat.com). Nitrogen gas comprises 78 per cent in the atmosphere. Despite its abundance in the atmosphere, the paradise of nature can't be assimilated by plants unless it is reduced to ammonia by special group of prokaryotic organisms called nitrogen fixers. The group of diazotrophs capable of colonizing the roots of non-legumes gained importance and the association has been termed as associative symbiosis or diazotrophic biocoenosis. *Gluconacetobacter diazotrophicus* (previously known as *Acetobacter diazotrophicus*) is a strict aerobe and a nitrogen fixing endophyte originally isolated from sugarcane roots and stems by Dobereiner (Bertalan *et al.,* 2009).

Gluconacetobacter diazotrophicus is found to live freely in the intercellular spaces of roots, stems and leaves of the sugarcane plant. This endophytic bacterium does not form any specific structures (like the nodules of legume plants) within plant tissues (Oliveira *et al.,* 2009). *Gluconacetobacter diazotrophicus* appears to grow in a wide spectrum of conditions (Bhavanath *et al.*, 2009). The association between *G. diazotrophicus* and plants is not species specific, like Rhizobia. In fact, *G. diazotrophicus* has been found in a number of unrelated plant species (Boddey *et al.,* 2013). The discovery that *G. diazotrophicus* associates as a free-living organism in plants, fixes nitrogen, and supplies nitrogen to plants, has attracted a broad interest in plant science (Oliveira *et al.,* 2009). Since *G. diazotrophicus* lives freely in plant tissues and does not form any special structures (like nodules) in plants and the bacterium appears to be non-species specific in its associations (unlike rhizobia), there is a possibility that the bacterium can be introduced into other plants for nitrogen fixation.

In this study, we isolated *G. diazotrophicus* from maize and studied its interaction effect with P solubilizer and arbuscular mycorrhizal fungus to influence the growth and yield of maize.

Material and Methods

Isolation of *G. diazotrophicus* from Maize roots

Roots were collected from Maize plant and cut into 2-3 cm bits. These root bits were surface sterilized by sodium hypochlorite solution (5%) for 5 minutes and was washed repeatedly using sterile water. Thus sterilized root bits were transferred in to test tubes containing LGI-P medium and incubated at 30º C for 7 days. After incubation, change of the medium to orange colour as well as formation of pellicles on the surface was observed for *G. diazotrophicus*. The bacterium was further purified by repeated streaking on fresh LGI-P agar plates. The pure culture so obtained was preserved on LGI-P agar slants in refrigerator for further use.

Molecular identification of the Bacterium using 16S rRNA gene sequence

Extraction of genomic DNA and PCR amplification : Total genomic DNA of the bacterium was extracted by alkaline lysis method (Nandhini *et al.,* 2014). The bacterium was grown in LGI-P broth for 48 hours at 30°C and 3 ml of bacterial culture was pelleted by centrifugation at 12,000 rpm. The bacterial pellet was re-suspended in 650 µl of extraction buffer (10mM Tris HCl pH 8.0, 20 mM EDTA and 250 mM NaCl) and incubated at 65°C for 30 minutes for lysis. To the extract, 100 µl of 5M Potassium acetate solution was added and placed on ice for 15 minutes for precipitation of protein and carbohydrates and clear supernatant was collected by centrifugation. DNA was precipitated by adding equal volume of ice cold Isopropanol and the DNA pellet was collected by centrifugation at 12,000 rpm. The pellet was twice washed with 70 per cent ethanol, air dried, and dissolved in 10mM TE (10:1) buffer stored in aliquots at -20°C. The quality and quantity of the isolated DNA was checked with 0.8 per cent agarose gel electrophoresis and spectrophotometrically.

Primer designing and PCR amplification using 16S rRNA : The primers already reported 16S rRNA sequences from the NCBI database (http://www.ncbi.nlm.nih.gov) were custom synthesized by Sigma-Aldrich (Sigma, USA) and diluted accordingly for the PCR reactions (A 26 bp of forward primer 5' GTTAGATCTTGGCTCAGGACGAACGC3' and 24 bp of reverse primer 5' GATCCAGCCGCACCTTCCGATACG 3'). PCR was performed in a 40µl reaction volume containing 1X buffer with $MgCl_2$ (1.5mM), dNTPs (200µM), forward and reverse primers (0.5µM each), *Taq* DNA polymerase (3U Genei Bangalaore) and template DNA (50ng). Amplification was carried out with an initial denaturation at 96°C for 3 minutes followed by 35 amplification cycles consisting of 94°C for 1 minute, 50°C for 30 seconds and 72°C for 1 minute and a final extension step at 72°C for 12 minutes. PCR products were separated on 1.0 per cent agarose gel and documented using gel documentation system Hero Lab, Germany (Nandhini *et al.,* 2014).

Pot experiment : Pot experiments were conducted in glass house of Department of Agricultural Microbiology, University of Agricultural Sciences, GKVK campus, Bengaluru. Soil and FYM were filled to 10 kg pot with 2:1 ratio, respectively, treatment details are as follows. T_1 = Soil (Control), T_2 = FYM (Control), T_3 = *G. diazotrophicus* MZ-01, T_4 = *Azotobacter chroococcum* (N_2 fixer ref. strain), T_5=*Bacillus megaterium* (PO_4 solubilizer ref. strain) T_6 = *Glomus fasiculatum* (Arbuscular mycorrhiza), T_7 = *G. diazotrophicus* MZ-01 + *B. megaterium* + *G. fasiculatum* and T_8 = *A. chroococcum* + *B. megaterium* + *G. fasiculatum*. In pot experiment growth and yield observations were recorded *viz*., plant height, number of leaves per plant, seed yield per plant, shoot dry weight and root dry weight.

Results and Discussion

Isolation and molecular identification of Gluconacetobacter diazotrophicus

The 16S rRNA partial gene sequence having 1089bp showed 98 per cent homology with *Gluconacetobacter diazotrophicus* strain 263-A available in the NCBI data base. Thus, the bacterium was identified as *Gluconacetobacter* *diazotrophicus*. Phylogenetic tree constructed with sequence of 10 *Gluconacetobacter diazotrophicus* species present in NCBI showed that the new isolate *Gluconacetobacter diazotrophicus* MZ-01 as similar to *Gluconacetobacter diazotrophicus* strains (strain 232, Ac-C2.5, 176-B2-1, 165, 263-A, 202 and Ac-CF2.2) Fig. 1(a) and 1(b) available at NCBI GenBank.

GTCGCGGGCGCATGCTTACACATGCAGTCGCACGAACCTTTCGGGGTTAGTGGCGGACGGGTGAG
TAACGCGTAGGGATCTGTCCATGGGTGGGGGATAACTCCGGGAAACTGGAGCTAATACCGCATGA
CACCTGAGGGTCAAAGGCGCGAGTCGCCTGTGGAGGAACCTGCGTTCGATTAGCTAGTTGGTGGG
GTAAAGGCCTACCAAGGCGATGATCGATAGCTGGTCTGAGAGGATGATCAGCCACACTGGGACTG
AGACACGGCCCAGACTCCTACGGGAGGCAGCAGTGGGGAATATTGGACAATGGGCGCAAGCCTG
ATCCAGCAATGCCGCGTGTGTGAAGAAGGTCTTCGGATTGTAAAGCACTTTCGACGGGGACGATG
ATGACGGTACCCGTAGAAGAAGCCCCGGCTAACTTCGTGCCAGCAGCCGCGGTAATACGAAGGGG
GCTAGCGTTGCTCGGAATGACTGGGCGTAAAGGGCGCGTAGGCGGTTTGGACAGTCAGATGTGAA
ATTCCTGGGCTTAACCTGGGGGCTGCATTTGATACGTATAGACTAGAGTGTGAGAGAGGGTTGTGG
AATTCCCAGTGTAGAGGTGAAATTCGTAGATATTGGGAAGAACACCGGTGGCGAAGGCGGCAACC
TGGCTCATAACTGACGCTGAGGCGCGAAAGCGTGGGGAGCAAACAGGATTAGATACCCTGGTAGT
CCACGCTGTAAACGATGTGTGCTGGATGTTGGGTGGCTTAGCCCCTCAGTGTCGTAGTTAACGCGA
TAAGCACACCGCCTGGGGAGTACGGCCGCAAGGTTGAAACTCAAAGGAATTGACGGGGGCCCGCA
CAAGCGGTGGAGCATGTGGTTAATTTCGAAGCAACGCGCAGAACCTTACCAGGGCTTGACATGGG
GAGGGCTGCAGTCAGAAGATGGCTGTTTCCCGGCAAAGGGACCTCCTGCACAGGTGCTGCATGAC
TGTCGTCAACTCGTGTCGTGAAGAATGTTGAGTAAGTCCCGCAACGAGCGCACCCTCGCCCTTTAG
TTGCAGCATGATGGGTGGACATCTAAGGAAACTGCCGGATGAACAGC

Select: All None Selected:0

Alignments Download GenBank Graphics Distance tree of results

	Description	Max score	Total score	Query cover	E value	Ident	Accession
	Gluconacetobacter diazotrophicus strain 263-A 16S ribosomal RNA gene, partial sequence	1989	3850	97%	0.0	98%	KP969074.1
	Gluconacetobacter diazotrophicus strain 232 16S ribosomal RNA gene, partial sequence	1989	3850	97%	0.0	98%	KP969072.1
	Gluconacetobacter diazotrophicus strain 176-B2-1 16S ribosomal RNA gene, partial sequence	1989	3850	97%	0.0	98%	KP969070.1
	Gluconacetobacter diazotrophicus strain 165 16S ribosomal RNA gene, partial sequence	1989	3850	97%	0.0	98%	KP969069.1
	Gluconacetobacter diazotrophicus strain PAI 5 16S ribosomal RNA gene, complete sequence	1989	3850	97%	0.0	98%	NR_074284.1
	Gluconacetobacter diazotrophicus PAI 5 complete genome	1989	15402	98%	0.0	98%	AM889285.1
	Gluconacetobacter diazotrophicus strain PAI 5 16S ribosomal RNA gene, complete sequence	1984	3839	97%	0.0	98%	NR_074292.1

Fig. 1(a): *G. diazotrophicus* MZ-01 showing 98 per cent sequence homaology with 16S rRNA sequence present in NCBI database

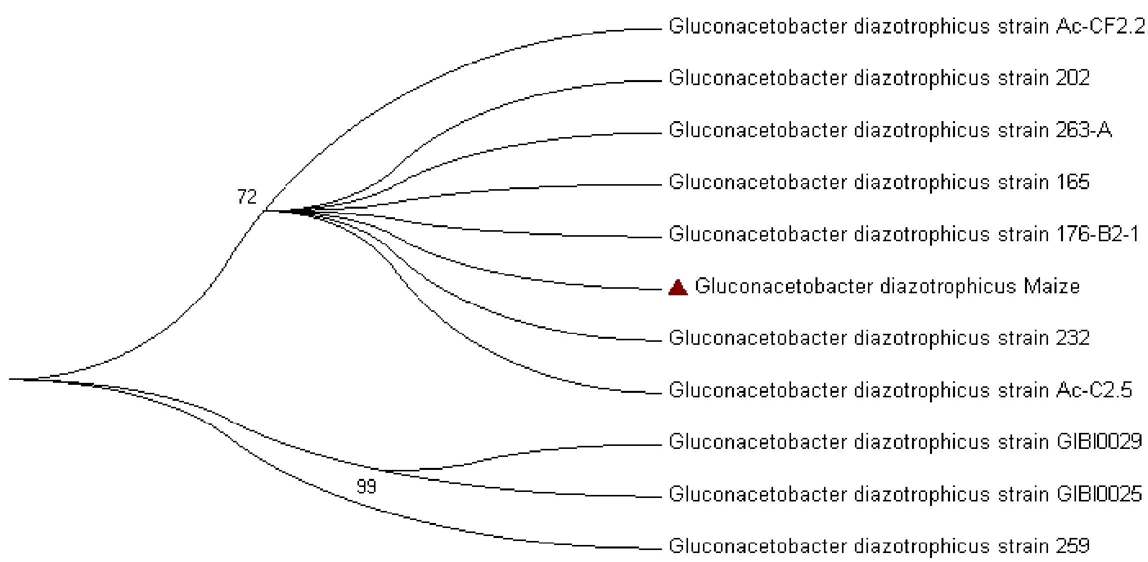


Fig. 1 (b): Molecular Phylogenetics of *G. diazotrophicus* with ten different species available at NCBI GenBank.

Microorganisms can be identified using both classical methods and molecular tools. The genes encoding for 16S rRNA in prokaryotes are most widely used in molecular phylogenetic. The small sub unit of 30S ribosomal RNA (SSU rRNA) genes have been used extensively for sequence based evolutionary analysis because they are 1) Universally distributed, 2) Functionally constant, 3) Sufficiently conserved and 4) Have adequate length to provide a view of evolution encompassing all living microorganisms (Madigan *et al*., 2009). Tian *et al.* (2009) studied colonization of *Gluconacetobacter diazotrophicus* in corn (*Zea mays*), the presence of the bacterium in plant tissues was evaluated via polymerase chain reaction using specific primers. The bacterium was detected in 11 grain corn lines, 9 sweet corn varieties and the overall colonization in corn was 74.1 per cent. This indicates that corn can be a potential new host plant for *G. diazotrophicus*.

Effects inoculation of *G. diazotrophicus, B. megaterium* and *G. fasiculatum* on plant growth and yield

The plant height of maize at different growth stages were significantly higher in the treatment number T_7 (*G. diazotrophicus* MZ-01 + *Bacillus megaterium* + *Glomus fasciculatum*) as compared to the T_8 (*A. chroococcum* + *B. megaterium* + *G. fasciculatum*). Among the signal inoculation treatments the highest plant height was recorded in the treatment T_4 (*G. diazotrophicus* MZ-01). The treatment T_1 (Control) is the least recorded of plant height in all the growth stages. Similarly, observation recorded on number of leaves per plant was significantly higher in treatment that received *G. diazotrophicus* MZ-01 + *B. megaterium* + *G. fasciculatum* (8.33, 12.67, 13.67 and 12.67 at 30 DAS, 60 DAS, 90 DAS and 110 DAS, respectively) and the lowest number of leaves per plant was recorded in the treatment soil control (5.00, 8.00, 9.33 and 6.67 at 30 DAS, 60 DAS, 90 DAS and 110 DAS respectively) in all the stages of growth (Table I).

The production of growth hormones by diazotrophs plays a vital role in enhancing the growth of grasses. It has also been shown that *G. diazotrophicus* is beneficial to sugarcane through production of growth promoting factors. Khan and Pariar (2012) reported that combined inoculation of *Azospirillum brasilense*, VAM (*Glomus fasciculatum*) and P-solubilizing *Pseudomonas striata* and *Serratia* spp. increased the plant height, top root length, stem girth and weight of coffee seedlings at all stages of growth as compared to un-inoculated control. The increased cell elongation and multiplication due to enhanced nutrient uptake by plants following inoculation of Nitrogen fixer and P solubilising bacteria may have caused the increased plant height **(**Laheurte and Berthelin., 2013**).** Iman (2008) reported that the inoculation of the efficient PSB strains significantly increased the plant height up to 81 per cent. The obtained results in our studies is agreed with those of Mohod *et al.* (2012) who mentioned that phosphate dissolving bacteria posses the ability to bring insoluble phosphate in soluble forms by secreting organic acids which lower the pH and bring about the dissolution of bonds of phosphate.

Shoot and root dry weight of maize were significantly higher in treatment T_7 (shoot 118.41 g and root 18.73 g) as compared to treatment T_8 (shoot 110.33 g and root 16.67 g). Among the single inoculation treatment T_3 (shoot 104.27 g and root 16.54 g) were recorded maximum (Table II). Similarly, Meenakshisundaram and Santhaguru (2011) reported that the combining ability of *G. diazotrophicus* with AM fungi on *Sorghum bicolour*, where in fresh weight, dry weight, soluble sugars and photosynthetic pigments in leaves was significantly higher in dual inoculated plants. The highest values were recorded with *Glomus fasciculatum* + *G. diazotrophicus* combination. AM fungal infection was significantly higher in dual inoculated plants. Nitrogen concentration was significantly increased by *G. diazotrophicus* even more in association with the efficient fungal strains.

Treatment T_7 (*G. diazotrophicus* MZ-01 + *B. megaterium* + *G. fasiculatum*) were recorded significantly higher seed yield per plant (152.50 g per plant) as compare to treatment T_8 (*A. chroococcum* + *B. megaterium* + *G. fasiculatum*) (134.05 g per plant), Among the single inoculation treatments T_3 (*G. diazotrophicus* MZ-01) recorded maximum to yield (117.75 g per plant) and treatment T_1 (Control) recorded the lowest yield (89.19 g per plant) (Table II). Kaeppler *et al.* (2013) studied and identified maize

TABLE I

Effect of inoculation of G. diazotrophicus, B. megaterium *and* G. fasciculatum *on plant height and number of leaves*

Treatments	Average plant height (cm) at different growth intervals				Average number of leaves per plant at different growth intervals			
	30 DAS	60 DAS	90 DAS	110 DAS	30 DAS	60 DAS	90 DAS	110 DAS
Control (Soil)	33.00 d	90.67 g	125.00 g	126.00 h	5.00 c	8.00 e	9.33 e	6.67 d
Control (Soil FYM)	33.67 d	94.00 f	134.17 f	135.17 g	5.00 c	8.00 e	10.67 d	8.33 c
G. diazotrophicus MZ-01	37.50 c	116.67 c	150.17 c	154.67 c	6.67 b	10.33 c	12.33 bc	9.67 b
Azotobacter chroococcum	34.67 d	103.33 d	141.33 d	143.33 d	5.33 c	8.67 de	11.33 cd	8.67 c
Bacillus megaterium	34.25 d	101.67 de	139.58 e	141.08 e	5.67 c	9.00 d	11.00 cd	9.00 c
Glomus fasciculatum	34.00 d	100.00 d	138.33 e	139.33 f	5.33 c	8.33 de	11.00 cd	8.67 c
G. diazotrophicus MZ-01 + Bm + Gf	44.17 a	146.00 a	172.33 a	178.33 a	8.33 a	12.67 a	13.67 a	12.67 a
A. chroococcum + Bm + Gf	40.67 b	120.33 b	160.33 b	162.33 b	7.00 b	11.67 b	12.67 b	10.00b
SEm±	0.62	0.63	0.46	0.46	0.26	0.26	0.29	0.29
LSD	1.863	1.90	1.37	1.37	0.79	0.79	0.87	0.87

Note : Means with same superscript, in a column do not differ significantly at P=<0.05 as per Duncan Multiple Range Test. DAS: Days After Sowing. Bm: *Bacillus megaterium,* Gf: *Glomus fasciculatum*

TABLE II

Effect of inoculation of G. diazotrophicus, B. megaterium *and* G. fasciculatum *on yield*

Treatments	Seed yield per plant (g)	Shoot dry weight (g/plant)	Root dry weight (g/plant)
Control (Soil)	89.19 e	95.87 g	14.34 e
Control (Soil FYM)	92.93 e	97.50 f	14.47 e
G. diazotrophicus MZ-01	117.75 c	104.27 c	16.54 b
Azotobacter Chroococcum	105.50 d	99.33 e	15.31 d
Bacillus megaterium	103.33 d	99.67 de	15.57 cd
Glomus fasciculatum	102.21 d	101.00 d	16.14 bc
G. diazotrophicus MZ-01 + Bm + Gf	152.50 a	118.41 a	18.73 a
A. chroococcum + Bm + Gf	134.05 b	110.33 b	16.67 b
SEm±	1.46	0.50	0.16
LSD	4.38	1.50	0.59

Note : Means with same superscript, in a column do not differ significantly at P=<0.05 as per Duncan Multiple Range Test. Bm: *Bacillus megaterium,* Gf: *Glomus fasciculatum*

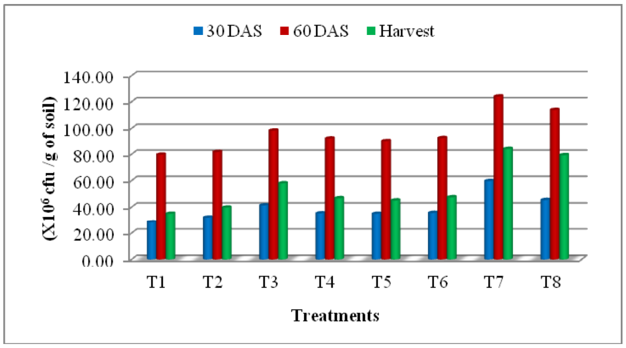


Fig. 02: Bacterial population in the rhizosphere soil of maize at different growth intervals

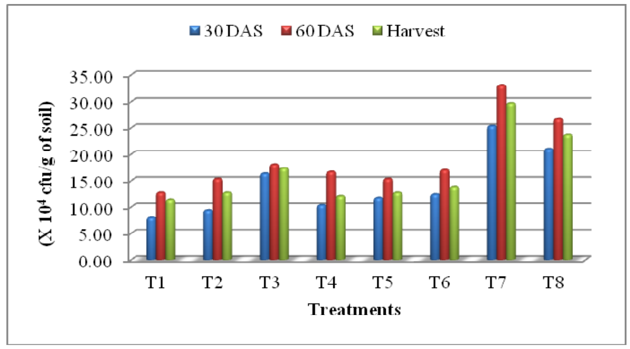


Fig. 03: Fungal population in the rhizosphere soil of maize at different growth intervals

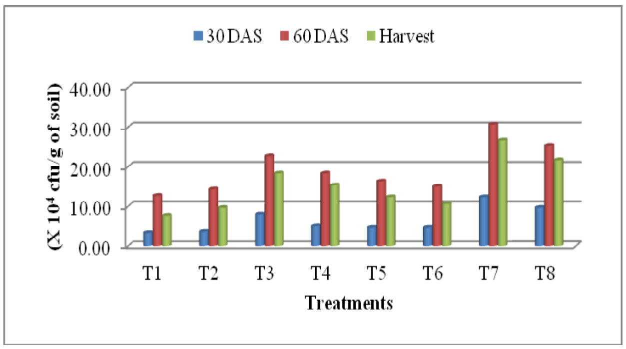


Fig. 04: Actinomycetes population in the rhizosphere soil of maize at different growth intervals

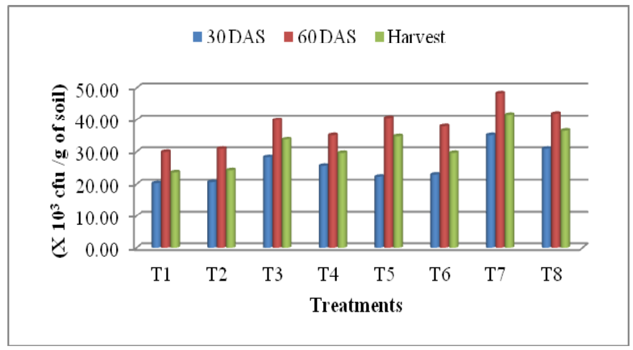


Fig. 05: *Azotobacter* population in the rhizosphere soil of maize at different growth intervals

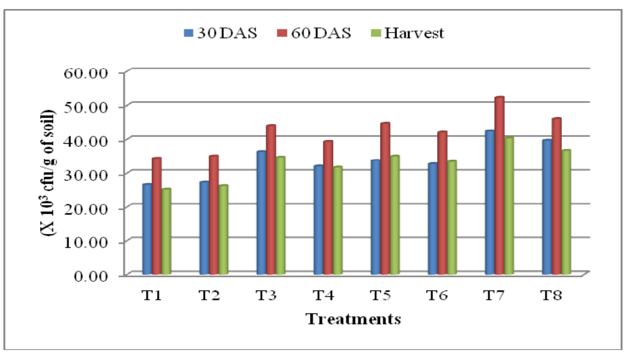


Fig. 06: PSB population in the rhizosphere soil of maize at different growth intervals

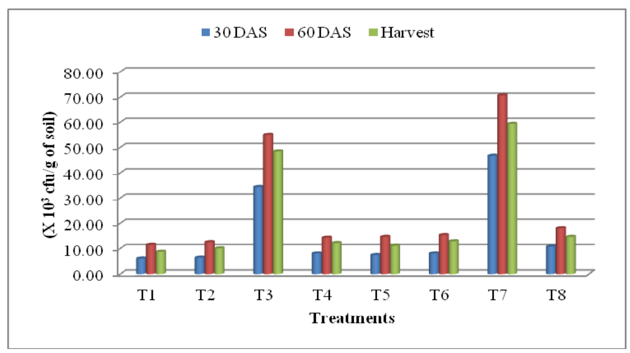


Fig. 07: *G. diazotrohicus* population in the rhizosphere soil of maize at different growth intervals

endophyte associations with increased plant productivity compared with un-inoculated control, where they used a collection of endophytes isolated by several groups. Significant yield enhancements of N-fertilized maize were obtained with bacterial endophytes isolated from N-efficient lines of maize (such as *Klebsiella pneumonia* 342) or Switch grass (*Pantoea agglomerans* P101 and P102). Several other strains from other groups were also tested with best yield enhancements from two Brazilian strains, *Gluconacetobacter diazotrophicus* PAl5 and *Herbaspirillum seropedicae* Z152. No strains were capable of relieving the N-deficiency symptoms of unfertilized maize either in field or in greenhouse.

Microbial population in the rhizosphere soil after inoculation

All treatments were showed maximum microbial populations at flowering stage as compared to vegetative and harvest stage. However, maximum microbial population were at harvest stage as compared to vegetative stage (Fig. 2-7). The higher bacterial population followed by fungal and actinomycetes populations were found at flowering stage (Jachson and Ilamurugu, 2014).

So far, studies on the occurrence of *G. diazototrophicus* have shown that it has a restricted host range. The study support the hypothesis that in nature, there are many more nitrogen-fixing bacteria to be identified and also strongly suggest that endophytic diazotrophicus bacteria are more prevalent than previously thought. In view of the economic importance of maize to this region and the difficulties of obtaining nitrogen fertilizers, maize-associated nitrogen-fixing *G. diazototrophicus* may be agronomically important because they could supply part of the nitrogen that the crop requires.

References

Bertalan, M., Albano, R., Pa´Dua, V., Rouws, L., Rojas, C., Hemerly, A., Teixera, K. and Schwab, S., 2009, Complete genome sequence of the sugarcane nitrogen-fixing endophyte Gluconacetobacter diazotrophicus Pal5. *Genomics,* **10** : 450.

Bhavanth Jha, Mukund C. Thakur., Iti Gontia, Valerie Albrecht, Marion Stoffels, Michael Schmid and Anton Hartmann, 2009, Isolation, partial identification and application of diazotrophic rhizobacteria from traditional Indian rice cultivars. *Eur. J. Soil Biol*., **45** : 62 - 72.

Boddey, R. M., Urquiaga, S., Reis, V. and Dobereiner, J. 2013, Biological nitrogen fixation associated with sugarcane. *Dev. Plant Soil Sci*., **48** : 105 - 111.

Iman, M., 2008, Effect of phosphate solubilising fungi on growth and nutrient uptake of Soybean (*Glycine max* L.) plants. *J. Appl. Sci. Res*., **4** (6) : 592 - 598.

Jachson, M. K. and Illamurugu, K., 2014, Metabolic profiling of rice root exudates and its impact on rhizosphere microbial dynamics under aerobic conditions. *Res. J. Agric. Sci*., **5** (4) : 777 - 781.

Kaeppler, S. M., Riggs, P. J., Chelius, M. K., Iniguez, A. L. and Triplett, E. W., 2013, Enhanced maize productivity by inoculation with diazotrophic bacteria. *Aust. J. Plant Physiol*. 28 : 829 - 836.

Khan, S. and Pariar, P., 2012, Effect of n- fixing biofertilizers on growth, yield and quality of chilli (*Capsicum annum* L.). *Int. J. Life Sci.,* **7** (3) : 481 - 482.

Laheurte, F. and Berthelin, J., 2013, Effect of phosphate solubilising bacteria on maize growth and root exudation over four levels of labile phosphorus. *Plant Soil,* **105** : 11 - 17.

Madigan, M. T., Martinco, J. M., Dunlap, P. V. and Clark, D. P., 2009, Microbial evolution and systematic In brock biology of microorganisms. Pearson *Benjamin cummings*, San Franscisco, p. 358 - 393.

Meenakshisundaram, M. and Santhaguru, K., 2011, Studies on association of Arbuscular Mycorrhizal fungi with *Gluconacetobacter diazotrophicus* and its effect on improvement of *Sorghum bicolor* (L.). *Int. J. Cur. Sci. Res*., **1** (2) : 23 - 30.

Mohod, S. P., Gupta, D. N. and Chavan, A. S., 2012, Enhancement of phosphate availability and phosphorus uptake in rice by phosphate solubilising culture. *J. Maharashtra. Agric. Univ*., 14 : 178 - 181.

Nandhini, K., Preethi, U. and Earanna, N., 2014, Molecular identification of phosphate solubilizing bacterium (*Alcaligenes faecalis*) and its interaction effect with *Bradyrhizobium japonicum* on growth and yield of Soybean (*Glycine max* L.). *Afr. J. Biotechnol*., 13 : 3450 - 3454.

Oliveira, A. L. M., Stoffels, M., Schmid, M., V. M. Reis., Baldani, J. I. and Hartmann., 2009, Colonization of sugarcane plantlets by mixed inoculations with diazotrophic bacteria. *European J. Soil Biolo*., 45 : 106 - 113.

Sherif, Sakit, J. and Chiru, S., 2010, Influence of PSB on plant parameters. *Plant Soil,* **24** : 231 - 239.

Tian, G., Pauls, P., Dong, Z., Reid, L. M. and Tian, L., 2009, Colonization of the nitrogen fixing bacterium *Gluconacetobacter diazotrophicus* in a large number of Canadian corn plants. *Can. J. Plant Sci*., **89** : 1009 - 1016.

www.indiastat.com

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 373-384, 2017

Development and Standardization of Effervescent Biofertilizer Consortial Tablets for French Bean (*Phaseolus vulgaris* L.)

SNEHA S. NAIR AND G. P. BRAHMAPRAKASH
Department of Agricultural Microbiology, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail : snehasasidharan05@gmail.com

ABSTRACT

A new formulation of effervescent tablets containing microbial consortium was prepared for french bean with an objective to improve its survival and effectiveness. Three agriculturally beneficial micro organisms *viz. Rhizobium phaseoli* (dinitrogen fixer), *Pseudomonas fluorescens* (plant growth promoter), and *Bacillus megaterium* (phosphate solubilizer) were used in consortium. Tablets were prepared using wet granulation method with talc or compost as diluents. Enhancement in nitrogen content, phosphorus content and dry weight was observed from triple inoculant consortium followed by dual, single and control. Plant growth in inoculated treatments was robust when supplied with NPK fertilizers, but effect of inoculation was pronounced in plants not receiving chemical fertilizers. However, performance of plants receiving triple inoculants consortium without nutrients (-NPK) was on par with un-inoculated plants with nutrients (+NPK).

Keywords : Biofertilizer, consortium, effectiveness

FRENCH BEAN (*Phaseolus vulgaris* L.) is one of the most important leguminous crops in the world owing to its nutritional value and rich source of proteins and carbohydrates. It has an added advantage of being a short duration crop there by yielding more profit to the farmers. The demand for the crop has increased significantly, leading to an extensive use of chemical fertilizers without any consideration for soil health and quality, which is a critical factor for realizing sustainable yield (Zahida *et al*., 2016).

Addition of beneficial microorganisms in the form of biofertilizers to soil will help replenish soil health. Biofertilizers are preparations containing beneficial microorganisms which enhance plant growth. They are an integral part of organic farming and their application has shown to enhance soil fertility thereby increasing plant growth and crop yield. Besides accessing nutrients, they also provide growth-promoting factors in plants and control soil borne diseases.

Being a legume, french bean performs best in combination with the bacterium *Rhizobium phaseoli.* Poor crop stands and low yields in dry bean have been reported to be associated with lack of inoculation of seeds prior to planting which also results in little nitrogen contributed to the crop (Atemkeng *et al*., 2011). *Rhizobium* inoculation also serves as a cheaper and usually more effective agronomic practice for ensuring adequate nitrogen nutrition of legumes than the application of nitrogen fertilizer (Wange, 1989).

Biofertilizers manufactured in India presently are carrier based which generally suffer from short shelf life, poor quality, high contamination, low and unpredictable field performances (Vendan and Thangaraju, 2006). Therefore, the commercial use of microbial inoculants requires a good formulation that retains high cell viability and ease in transportation and applicability. Developing efficient formulation and its application is a challenging step in commercialization of microbial inoculants. Several available forms like powder, liquid and granular formulation have immensely contributed to the use of these beneficial microbial inoculants in crop production but effervescent tablets are a noval approach. Effervescent biofertilizer tablets are designed to be dissolved or dispersed in water before administration and helps in easy release of microorganisms into the soil. In this context, effervescent tablet formulations appear to be promising due to their better viability and survivability in adverse soil conditions.

Material and Methods

Preparation of effervescent biofertilizer tablets: Tablets were prepared using different excipients *viz.,* diluents, binders, glidants and disintegrants. Talc and compost were selected as diluents. The tablets were prepared following wet granulation method and a rotary tablet press was used for the purpose of tablet making. These formulations were made in nine treatment combinations- T_1 (Absolute control), T_2 (conventional control) T_3 (*Rhizobium phaseoli*), T_4 (*Pseudomonas fluorescens*), T_5 (*Bacillus megaterium*), T_6 (*Rhizobium phaseoli* + *Pseudomonas fluorescens*), T_7 (*Rhizobium phaseoli* + *Bacillus megaterium*), T_8 (*Pseudomonas fluorescens* + *Bacillus megaterium*) and T_9 (*Rhizobium phaseoli* + *Pseudomonas fluorescens* + *Bacillus megaterium*).

A pot experiment was conducted in green house of University of Agricultural Sciences, GKVK, Bengaluru using nine different treatments to study the performance of the inoculants on the growth of french bean (cv Arka Komal). The experiment comprised nine treatments with two levels of fertilizers (with and without NPK), two levels of effervescent tablets (talc and compost based) and three replications each. Un-inoculated pots were kept as absolute control and pots treated with talc based powder formulation were kept as conventional control.

Soil processing: Soil sample used for experiment was collected from uncultivated field at GKVK, Bengaluru, which was red sandy loam soil, classified as kandic paleustalfs soils. Five kilograms of soil was filled into 10 kg capacity polythene bags. Homogenization was done by row and column randomization. The soil samples were subjected to three cycles of wetting and drying and its moisture content was raised to field capacity at the end of each cycle. Recommended dose of fertilizers were provided to +NPK pots.

Sowing and maintenance: Seeds were sown in poly bags containing five kilograms soil and effervescent tablets (Talc or compost based) were placed one per poly bag. The poly bags were uniformly watered regularly to maintain moisture at field capacity and other routine care was taken to protect the plants from pests and diseases.

Chlorophyll content: Chlorophyll content was recorded at maximum vegetative growth. Estimation of chlorophyll was done by method suggested by Witham *et al*. (1971). One gram of leaf sample was crushed in pre-chilled 80 per cent acetone and filtered to extract all the chlorophyll present in the leaf. Final volume was made up to 100 ml with 80 per cent acetone as blank and absorbance was recorded at 663 and 645 nm wavelength.

Dry weight of plant: Harvesting was done at 50 per cent flowering. Shoot and root dry weight was recorded after drying the samples at 60 ÚC to a constant weight. Shoots were harvested by separating stem at the collar region from roots. Roots were washed free of soil particles by a slow jet of water.

Nitrogen estimation in plant samples: Concentration of nitrogen in root and shoot was estimated by micro kjeldahl method as outlined by Jackson (1973). Finely ground plant samples (200 mg each) were digested with digestion mixture (100:20:1 of K_2SO_4: $CuSO_4$: Se) and 10 ml of concentrated sulfuric acid at 400°C till solution became clear. The digested samples were then distilled with 40 per cent sodium hydroxide and ammonia evolved was trapped in boric acid (4 per cent w/v) solution with mixed indicator (bromocresol green+ methyl red). After completion of distillation, boric acid solution containing trapped ammonia was titrated against 0.09 N sulfuric acid and volume of acid required to neutralize the alkalinity (ammonia) was recorded. The end point was indicated by change in color of solution from green to pink. Nitrogen content in plant sample was calculated using standard formula.

Phosphorus estimation in plant samples: The procedure outlined by Black (1965) was used to determine the phosphorus concentration in shoots and roots of french bean. Powdered plant samples (0.2 g each) were digested with 10 ml of di-acid mixture (concentrated nitric acid: perchloric acid at the ratio of 9: 4 v/v) on a hot plate. After digestion the volume of the samples were made up to 100 ml with distilled water.

Ten ml of this aliquot was taken in a 50 ml volumetric flask and to this 10 ml of vanadomolybdate reagent (25 g of ammonium molybdate and 1.25 g of ammonium metavanadate in 1000 ml of 2N HNO_3) was added and volume was made to 50 ml. The intensity of yellow colour developed was read at 430 nm using spectrophotometer. The amount of phosphorus present in plant sample was calculated by comparing with a standard graph developed using KH_2PO_4 as phosphorus source.

Statistical analysis: Statistical analysis of the data from green house investigation was done by using factorial complete randomized design (FCRD) and means were separated by Least Significant Difference (LSD) (Little and Hills, 1978).

Results and Discussion

Plants supplied with NPK fertilizers showed robust growth irrespective of the inoculants and the diluents used in the study but effect of inoculation was pronounced in plants not receiving chemical fertilizers. However, performance of plants receiving triple inoculants consortium without nutrients (-NPK) was on par with un-inoculated plants with nutrients (+NPK).

Nitrogen content: The results revealed a significant difference in the nitrogen content of shoots treated with consortial tablets when compared to absolute (1.30%) and conventional control (1.81%). An interaction effect was observed within the plants treated with tablets with two different diluents as well as plants treated with and without fertilizers (Table I). Plants treated with compost based tablets containing triple inoculants recorded maximum nitrogen (3.69%) in shoots showing a significant difference from those treated with talc based tablets containing triple inoculants (3.57%).

Plants inoculated with dual inoculants showed significantly higher nitrogen content, with tablets containing *Rhizobium phaseoli* and *Bacillus megaterium* recording higher nitrogen content with and without NPK (3.07% and 2.85%, respectively) irrespective of the diluent when compared to single inoculants (Table II). All treatments showed significant differences in nitrogen content when treated with and without NPK except control. The same pattern of result was observed in root nitrogen content and total nitrogen content with maximum nitrogen recorded in compost based tablets containing triple inoculants (1.41 %) followed by talc based tablets (Fig. 1). Enhancement in the plants ability to take up nitrogen might be due to the effective colonization of *Rhizobium phaseoli* and the synergistic effect of *Bacillus megaterium* and *Pseudomonas fluorescens* might be the reason for an increased uptake (Tilak *et al*., 2006).

Highest root phosphorus was observed in compost based triple inoculants (0.193 %) followed by composed based tablets containing dual inoculants, *R. phaseoli* and *B. megaterium* when compared to conventional (0.133 %) and absolute control (0.199%) (Table III).Treatments containing *Bacillus megaterium* recorded higher root phosphorus content when compared to all other treatments. This may be due to its phosphorus solubilization and plant growth promotion by producing growth hormones which helps the plant in nutrient uptake and building up its biomass as discussed by Kang *et al*. (2009). All treatments treated with NPK yielded significantly higher phosphorus content when compared to those without NPK (Fig. 2).

Phosphorus content: Highest phosphorus content was recorded in shoots of plants treated with triple inoculant formulation and NPK (0.78%) followed by dual inoculation with *R. phaseoli* and *B. megaterium* and NPK (0.63%) irrespective of the diluent used (Table IV). The least nitrogen in shoots were observed in absolute control (0.24%) followed by conventional control (0.34%). A two way interaction effect was observed between treatments, diluents and fertilizers which denote that different diluents and application of NPK affects the inoculants thereby resulting in significant difference between the treatments.

Chlorophyll content: Chlorophyll content was recorded highest in plants treated with compost based tablets containing triple inoculants (4.39 mg/g of leaf) followed by compost based tablets containing dual inoculants, *R. phaseoli* and *B. megaterium* (4.20 mg / g of leaf) when compared to conventional (3.76 mg / g of leaf) and absolute control (3.40 mg / g of leaf)

TABLE I

Effect of effervescent tablets on shoot nitrogen content in french bean

Treatments	Root nitrogen (per cent)								
	Talc		Compost		Main effect of T	- NPK		+ NPK	
	- NPK	+ NPK	- NPK	+ NPK		Talc	Compost	Talc	Compost
Absolute control	1.28	1.32	1.29	1.34	1.30	1.28	1.29	1.32	1.34
	(1.30)^{Lh}		(1.30)^{Li}			(1.27)^{Qi}		(1.33)^{Qg}	
Conventional control	1.69	1.86	1.76	1.91	1.81	1.69	1.76	1.86	1.91
	(1.78)^{Kg}		(1.84)^{Kh}			(1.73)^{Oh}		(1.89)^{Pf}	
Rhizobium phaseoli	2.59	2.63	2.66	2.86	2.65	2.59	2.66	2.63	2.86
	(2.61)^{Ie}		(2.78)^{je}			(2.64)^{Me}		(2.74)Nd	
Pseudomonas fluroescens	2.26	2.31	2.21	2.37	2.28	2.26	2.21	2.31	2.37
	(2.28)^{Hf}		(2.29)^{Hg}			(2.23)^{Kg}		(2.34)^{Le}	
Bacillus megaterium	2.53	2.75	2.55	2.81	2.61	2.53	2.55	2.75	2.81
	(2.56)^{Fe}		(2.66)^{Gf}			(2.47)^{If}		(2.75)^{jd}	
R. Phaseoli + P. fluorescens	2.90	3.04	2.95	3.11	2.98	2.90	2.95	3.04	3.11
	(2.97)^{Ec}		(3.00)^{Ec}			(2.85)^{Gc}		(3.07)^{Hc}	
R. phaseoli + P. megaterium	3.05	3.15	3.07	3.20	3.10	3.05	3.05	3.15	3.20
	(3.06)^{Cb}		(3.13)^{Db}			(3.06)^{Eb}		(3.14)^{Fb}	
B. megaterium+B. fluorescens	2.75	3.03	2.76	3.00	2.88	2.75	2.76	3.03	3.00
	(2.89)^{Bd}		(2.88)^{Bd}			(2.76)^{Cd}		(3.01)^{Dc}	
R. phaseoli+P. fluorescens+ B. megaterium	3.30	3.64	3.40	3.75	3.52	3.30	3.40	3.64	3.75
	(3.47)^{Aa}		(3.57)^{Ba}			(3.35)^{Aa}		(3.69)^{Ba}	
	Main effect of NPK					Pooled effect of NPK			
	2.47a	2.62b	2.50a	2.70b		2.49		2.66	
CV					2.26				

	F calc.		S.Em±	LSD at 5%
D	28.50	*	0.008	0.022
N	242.65	*	0.008	0.002
T	1655.37	*	0.017	0.047
DxN	5.37	*	0.011	0.032
DxT	3.06	*	0.024	0.067
TxN	8.80	*	0.024	0.067
DxTxN	0.94		0.033	-

Note : Means with same superscript are statistically on par at P d" 0.05 by DMRT.
D-Diluent , N- Nutrient, T- Treatment with different inoculants

TABLE I1

Effect of effervescent tablets on root nitrogen content in french bean

Treatments	Root nitrogen (per cent)				
	Talc		Compost		Main effect of T
	- NPK	+ NPK	- NPK	+ NPK	
Absolute control	0.56	0.68	0.61	0.66	0.63 ^{g}
Conventional control	0.73	0.82	0.78	0.83	0.79 ^{f}
Rhizobium phaseoli	1.44	1.50	1.45	1.52	1.47 ^{a}
Pseudomonas fluorescens	0.82	0.95	0.88	0.95	0.90 ^{e}
Bacillus megaterium	0.96	1.06	0.95	1.10	1.02 ^{d}
R. phaseoli + P. fluorescens	1.13	1.16	1.19	1.24	1.18 ^{c}
R. phaseoli + B. megaterium	1.35	1.06	1.35	1.38	1.37 ^{b}
B. megaterium + P. fluorescens	0.95	1.06	0.97	1.06	1.01 ^{d}
R. phaseoli + P. fluorescens + B. megaterium	1.30	1.40	1.31	1.41	1.35 ^{b}
	Mean values				
Talc	1.07 ^{a}		-NPK		1.04 ^{a}
Compost	1.09 ^{b}		+NPK		1.12 ^{b}
CV			4.33		
	F calc.		S.Em±		LSD at 5 %
D	5.27 *		0.060		0.018
N	72.74 *		0.060		0.018
T	442.21 *		0.014		0.038
DxN	0.16		0.009		-
DxT	0.72		0.019		-
NxT	1.39		0.019		-
DxNxT	0.50		0.027		-

Note : Means with same superscript are statistically on par at P d" 0.05 by DMRT.
D-Diluent , N- Nutrient, T- Treatment with different inoculants

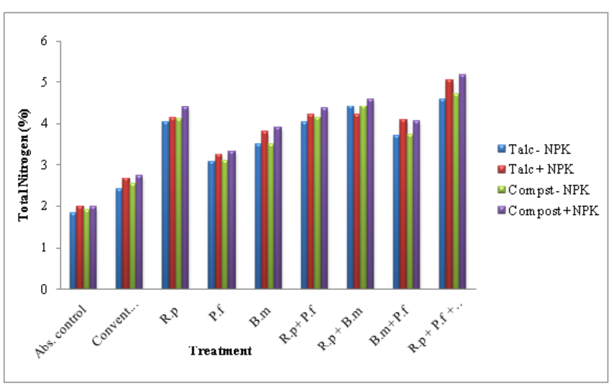


Fig. 1: Total nitrogen (per cent) as influenced by inoculation of effervescent biofertilizer tablets in french bean (*Phaseolus vulgaris* L.)

Note: R.p: *Rhizobium phaseoli,* P.f: *Pseudomonas fluorescens,* B.m: *Bacillus megaterium*

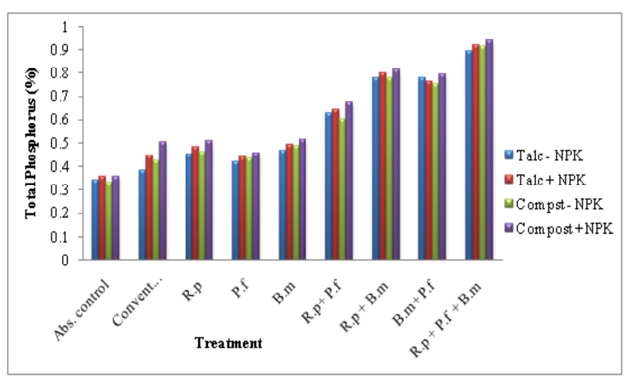


Fig. 2: Total phosphorus (per cent) as influenced by inoculation of effervescent biofertilizer tablets in french bean (*Phaseolus vulgaris* L.)

Note: R.p: *Rhizobium phaseoli,* P.f: *Pseudomonas fluorescens,* B.m: *Bacillus megaterium*

TABLE I1I

Effect of effervescent tablets on root phosphorus content in french bean

Treatments	Root nitrogen (per cent)				
	Talc		Compost		Main effect of T
	- NPK	+ NPK	- NPK	+ NPK	
Absolute control	0.113	0.118	0.111	0.119	0.116 [f]
Conventional control	0.132	0.128	0.127	0.133	0.130 [e]
Rhizobium phaseoli	0.139	0.141	0.140	0.141	0.140 [cd]
Pseudomonas fluorescens	0.130	0.132	0.136	0.138	0.134 [de]
Bacillus megaterium	0.149	0.151	0.150	0.152	0.150 [c]
R. phaseoli + P. fluorescens	0.157	0.152	0.150	0.155	0.153 [c]
R. phaseoli + B. megaterium	0.160	0.172	0.171	0.176	0.169 [b]
B. megaterium + P. fluorescens	0.158	0.143	0.141	0.145	0.146 [c]
R. phaseoli + P. fluorescens + B. megaterium	0.162	0.188	0.183	0.193	0.181 [a]
CV			6.45		
	F calc.		S.Em±		LSD at 5 %
D	0.81		0.001		0.004
N	3.59		0.001		0.004
T	53.01 *		0.003		0.008
DxN	0.51		0.002		0.005
DxT	1.25		0.004		0.011
TxN	1.46		0.004		0.011
DxTxN	0.87		0.005		0.011

Note : Means with same superscript are statistically on par at P d" 0.05 by DMRT.
D-Diluent, N- Nutrient, T- Treatment with different inoculants

(Table V) (Fig. 3). A two way interaction effect was observed between diluents, nutrient and inoculants which depicts that the diluents used and fertilizers (+/-) have a prominent effect on the inoculants and their interaction with the plants. Higher chlorophyll content in triple inoculants may be due to the synergistic effects of *Pseudomonas fluorescens* and *B. megaterium* on *R. phaseoli* which resulted in higher uptake of nitrogen (Samavat *et al*., 2012).

Total dry weight of plants: Highest shoot dry weight, irrespective of the nutrient level, was observed in plants receiving triple inoculation (16.48 g) followed by plants treated with dual inoculants, *Rhizobium phaseoli* and *Bacillus megaterium* (16.31 g) when compared to conventional (13.93 g) and absolute control (11.24 g) (Table VI). All treatments receiving NPK yielded significantly higher shoot dry weight when compared to those without NPK (Fig. 4). The same pattern of result was recorded in root dry weight of plants receiving triple inoculation recording highest root dry weight (1.52 g) followed by plants treated with dual inoculants, *Rhizobium phaseoli* and *Bacillus megaterium* (1.32 g) when compared to conventional (0.90 g) and absolute control (0.61 g) (Table VII).

There was no significant difference in the root dry weight of plants with and without NPK. This might be because of more number of nodules on the roots of –NPK plants when compared to +NPK plants. Various

TABLE IV

Effect of effervescent tablets on shoot phosphorus content in french bean

Treatments	Shoot phosphorus (per cent)								
	Talc		Compost		Main effect of T	-NPK		+NPK	
	-NPK	+NPK	-NPK	+NPK		Talc	Compost	Talc	Compost
Absolute control	0.23	0.24	0.22	0.24	0.23	0.23	0.22	0.24	0.24
	(0.23)^{Lf}		(0.23)^{Lf}			(0.23)^{Lf}		(0.24)^{Lf}	
Conventional control	0.25	0.32	0.30	0.37	0.31	0.25	0.30	0.32	0.37
	(0.29)^{Je}		(0.33)^{Ke}			(0.33)^{Kd}		(0.34)^{Kd}	
Rhzobium phaseoli	0.31	0.34	0.32	0.37	0.34	0.31	0.32	0.34	0.37
	(0.33)^{Hd}		(0.35)^{Id}			(0.32)^{Kd}		(0.35)^{Kd}	
Pseudomonas fluorescens	0.29	0.31	0.30	0.32	0.30	0.29	0.30	0.31	0.32
	(0.30)^{Ge}		(0.31)^{Gf}			(0.29)^{Ie}		(0.31)^{Je}	
Bacillus magaterium	0.32	0.34	0.34	0.36	0	0.32	0.34	0.34	0.36
	(0.33)^{Ed}		(0.35)^{Fd}		34	(0.33)^{Gd}		(0.35)^{Hd}	
R. phaseoli + P. fluroescens	0.47	0.49	0.45	0.52	0.48	0.47	0.45	0.49	0.52
	(0.48)^{Dc}		(0.48)^{Dc}			(0.46)^{Ec}		(0.50)^{Fc}	
R. phaseoli + B. megaterium	0.62	0.63	0.61	0.64	0.62	0.62	0.61	0.63	0.64
	(0.62)^{Cb}		(0.62)^{Cb}			(0.61)^{Cb}		(0.63)^{Dh}	
B. megaterium + P. fluorescens	0.62	0.62	0.61	0.65	0.62	0.62	0.61	0.62	0.65
	(0.62)^{Cb}		(0.63)^{Cb}			(0.61)^{Cb}		(0.63)^{Db}	
R. *phaseoli + p. fluorescens B. megaterium*	0.73	0.73	0.78	0.79	0.76	0.73	0.73	0.73	0.75
	(0.73)^{Aa}		(0.7)^{Bb}			(0.73)^{Aa}		(0.78)^{Ba}	
	Main effect of NPK					Pooled effect of NPK			
	0.430^{a}	0.45^{b}	0.434^{a}	0.476^{b}		2.49		2.66	
CV					3.43				

	F calc.		S.Em±	LSD at 5%
D	18.60	*	0.003	0.006
N	122.37	*	0.003	0.006
T	1703.81	*	0.006	0.013
DxN	8.61	*	0.005	0.008
DxT	2.69	*	0.009	0.018
TxN	4.73	*	0.009	0.018
DxTxN	0.65		0.001	-

Note : Means with same superscript are statistically on par at P d" 0.05 by DMRT. D-Diluent, N- Nutrient, T- Treatment with different inoculant

TABLE V

Effect of effervescent tablets on total chlorophyll content in french bean

Treatments	Total chlorophyll (mg / g of leaf)								
	Talc		Compost		Main effect of T	- NPK		+ NPK	
	- NPK	+ NPK	- NPK	+ NPK		Talc	Compost	Talc	Compost
Absolute control	3.10	3.36	3.13	343	3.25	3.10	3.13	3.36	3.43
	(3.23)^{Hd}		(3.28)^{Hf}			(3.11)^{Jf}		(3.40)^{Ke}	
Conventional control	3.60	3.73	3.60	3.80	3.68	3.60	3.60	3.73	3.80
	(3.66)^{Gc}		(3.70)^{Ge}			(3.60)^{He}		(3.76)^{Id}	
Rhizobium phaseoli	4.10	4.13	4.03	4.13	4.10	4.10	4.03	4.13	4.13
	(4.11)^{Fb}		(4.08)			(4.06)^{Gb}		(4.13)^{Ec}	
Pseudomonas fluorescens	3.96	4.10	3.80	4.00	9.97	3.96	3.80	4.10	4.0
	(4.03)^{Fd}		(3.91)^{Fd}			(3.90)^{Fd}		(4.05)^{Ec}	
Bacillus magaterium	4.03	4.13	3.93	4.03	4.03	4.03	3.90	4.13	4.03
	(4.08)^{Cb}		(3.98)^{Ec}			(3.98)^{Fc}		(4.08)^{Ec}	
R. phaseoli + P. fluroescens	4.13	4.16	4.00	4.16	4.11	4.13	4.00	4.16	4.16
	(4.15)^{Cb}		(4.08)^{Db}			(4.06)^{Cb}		(4.16)^{Ebc}	
R. phaseoli + B. megaterium	4.1	4.2	4.03	4.20	4.13	4.1	4.03	4.2	4.20
	(4.15)^{Cb}		(4.11)^{Cb}			(4.06)^{Cb}		(4.20)^{Db}	
B. megaterium + P. fluorescens	4.1	4.0	4.00	4.20	4.07	4.1	4.00	4.0	4.20
	(4.05)^{Cb}		(4.10)^{Cb}			(4.05)^{Cb}		(4.10)^{Cb}	
R. phaseoli + P. fluorescens B. megaterium	4.36	4.4	4.2	4.38	4.33	4.36	4.2	4.4	4.38
	(4.38)^{Aa}		(4.29)^{Ba}			(4.28)^{Aa}		(4.39)^{Ba}	
	Main effect of NPK					Pooled effect of NPK			
	2.47^{a}	2.62^{b}	2.50^{a}	2.70^{b}		2.49		2.66	
CV					1.91				

	F calc.	S.Em±	LSD at 5%
D	5.58 *	0.010	0.029
N	78.22 *	0.010	0.029
T	210.72 *	0.031	0.062
DxN	10.43 *	0.021	0.041
DxT	2.23 *	0.044	0.087
TxN	2.48 *	0.044	0.087
DxTxN	1.08	0.043	-

Note : Means with same superscript are statistically on par at P d" 0.05 by DMRT. D-Diluent, N- Nutrient, T- Treatment with different inoculants

TABLE V1

Effect of effervescent tablets on shoot dry weight in french bean

Treatments	Shoot dry weight (g)				
	- NPK		+ NPK		Main effect of T
	Talc	Compost	Talc	Compost	
Absolute control	10.80	11.13	11.53	11.50	11.24
	(10.96)^{Gd}		(11.51)^{He}		
Conventional control	14.06	13.56	14.03	14.06	13.93
	(13.81)^{Fc}		(14.05)^{Fcd}		
Rhizobium phaseoli	14.03	13.96	14.26	14.73	14.25
	(14.00)^{Fc}		(14.50)^{Gc}		
Pseudomonas fluorescens	13.86	13.36	13.76	13.53	13.63
	(13.61)^{Fc}		(13.65)^{Fd}		
Bacillus magaterium	14.63	14.53	15.28	15.06	14.87
	(14.58)^{Cb}		(15.17)^{Eb}		
R. phaseoli + P. fluroescens	14.90	15.20	16.60	16.26	15.74
	(15.05)^{Cb}		(16.43)^{Da}		
R. phaseoli + B. megaterium	15.56	16.30	16.78	16.60	16.31
	(15.93)^{Aa}		(16.69)^{Ba}		
B. megaterium + P. fluorescens	15.26	16.26	16.50	16.43	16.11
	(15.76)^{Aa}		(16.46)^{Ba}		
R. phaseoli + P. fluorescens B. megaterium	15.93	16.23	16.83	16.93	16.48
	(16.08)^{Aa}		(16.88)^{Ba}		
Pooled effect	14.70		14.76		
Cv			2.85		

	F calc.	S.Em±	LSD at 5%
D	0.511 *	0.057	-
N	58.40 *	0.057	0.161
T	194.38 *	0.121	0.341
DxN	1.82 *	0.081	-
DxT	1.23 *	0.171	-
TxN	2.46 *	0.171	0.482
DxTxN	1.48	0.241	-

Note : Means with same superscript are statistically on par at P d” 0.05 by DMRT.
D-Diluent, N- Nutrient, T- Treatment with different inoculants.

TABLE VII

Effect of effervescent tablets formulations on root dry weight in french bean

Treatments	Shoot dry weight (g)					
	- NPK			+ NPK		Main effect of T
	Talc	Compost		Talc	Compost	
Absolute control	0.51 (0.51)[Ie]	0.51		0.69 (0.72)[Je]	0.75	0.61
Conventional control	0.84 (0.83)[Gd]	0.83		0.92 (0.96)[Hd]	1.01	0.90
Rhizobium phaseoli	1.31 (1.30)[Fc]	1.30		1.33 (1.33)[Fb]	134	1.32
Pseudomonas fluorescens	1.13 (1.13)[Dc]	1.13		1.20 (1.20)[Ec]	1.20	1.16
Bacillus magaterium	1.18 (1.17)[Dc]	1.16		1.18 (1.18)[Dc]	1.19	1.18
R. phaseoli + P. fluroescens	1.21 (1.21)[Dc]	1.20		1.22 (1.22)[Dc]	1.23	1.21
R. phaseoli + B. megaterium	1.31 (1.30)[Bb]	1.30		1.35 (1.34)[Cb]	1.33	1.32
B. megaterium + P. fluorescens	1.20 (1.19)[Bb]	1.18		1.20 (1.20)[Bc]	1.19	1.19
R. phaseoli + P. fluorescens B. megaterium	1.50 (1.50)[Aa]	1.51		1.51 (1.53)[Aa]	1.55	1.52
Pooled effect	1.15			1.16		
Cv				3.17		
	F calc.		S.Em±	LSD at 5%		
D	1.10 *		0.005	-		
N	72.43 *		0.005	0.014		
T	603.46 *		0.011	0.030		
DxN	2.95 *		0.007	-		
DxT	0.828 *		0.015	-		
TxN	10.21 *		0.015	0.482		
DxTxN	0.582		0.02	-		

Note : Means with same superscript are statistically on par at P d" 0.05 by DMRT.
D-Diluent, N- Nutrient, T- Treatment with different inoculants.

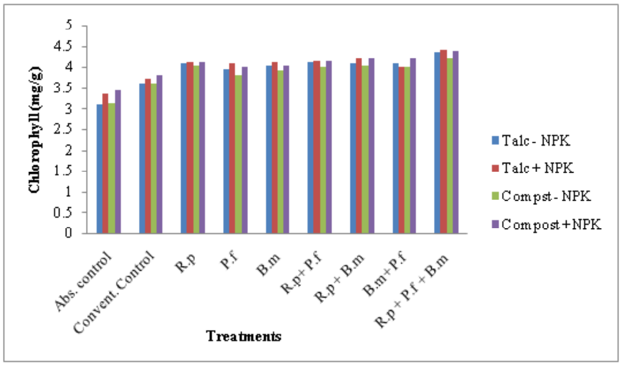


Fig. 3: Chlorophyll content (mg/g of plant) as influenced by inoculation of effervescent biofertilizer tablets in french bean (*Phaseolus vulgaris* L.)

Note: R.p: *Rhizobium phaseoli,* P.f: *Pseudomonas fluorescens,* B.m*: Bacillus megaterium*

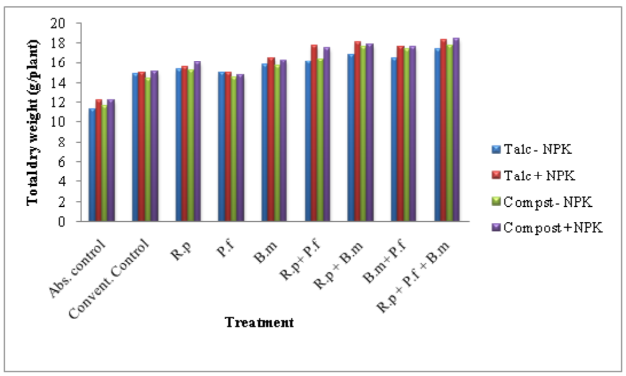


Fig. 4: Total dry weight (g) as influenced by inoculation of effervescent biofertilizer tablets in french bean (*Phaseolus vulgaris* L.)

Note: R.p: *Rhizobium phaseoli,* P.f: *Pseudomonas fluorescens,* B.m*: Bacillus megaterium*

direct and indirect mechanisms of the inoculants such as atmospheric nitrogen fixation, insoluble phosphate solubilization and production of growth hormones might have contributed to the high plant dry matter content in plants treated with consortia (Dutta *et al.*, 2014).

The study revealed that all plants treated with effervescent biofertilizer consortial tablets showed a pronounced and significantly higher nutrient uptake, chlorophyll content and total dry matter when compared to absolute control. The effervescence from the tablet might have positively affected the early and quick release of microorganisms into the rhizosphere thereby resulting in effective colonization by the inoculants.

Plants treated with compost based tablets recorded maximum nutrient uptake and dry matter content when compared to those treated with talc which suggests that the diluent used has an influence on the microbial population in the tablet. The granular nature of compost might have helped in easy compression of the formulation into a tablet by applying less force, thereby increasing the viability of inoculants in it and performed better when compared to talc based tablets.

The results also revealed a significantly higher plant dry matter and nutrient content in plants treated with tablets when compared to conventional control (talc based powder formulation) which assures a high microbial load in the tablet when compared to the powder formulation and their effective release into the rhizosphere. Tablet formulation not only gives stability in their performance but also reduce contaminants to a permissible level due to its low water content. These findings have opened up a new and better option of formulation that can even be applied to soils under stress.

References

Atemkeng, F. M., Remans, R., Michiels, J., Tagne, A. and Ngonkeu, M. L. E., 2011, Inoculation with *Rhizobium etli* enhances organic acid exudation in common bean (*Phaseolus vulgaris* L.) subjected to phosphorus deficiency. *African J. Agric. Res.,* **6** (10) : 2235 - 2243.

Black, C. A., 1965, Method of soil analysis part II Agronomy Monograph No. 9. *Am. Soc. Agron.*, Madison, Wisconsin, p. 219-221.

Dutta, S., Gupta, S. and Meena, M. K., 2014, Isolation, characterization of plant growth promoting bacteria from the plant *Chlorophytum borivilianum* and in-vitro screening for activity of nitrogen fixation, phosphate solubilization and IAA production. *Int. J. Curr. Microbiol. Appl. Sci*., **3** (7) : 1082 - 1090.

Jackson, M. L., 1973, Soil chemical analysis. Prentice Hall of India Pvt. Ltd., New Delhi, India, p. 498.

Kang, S. M., Joo, G. J., Muhammad, H., Shin, D. H. and Kim, H.Y., 2009, Gibberellin production and phosphate solubilization by newly isolated strain of *Acinetobacter calcoaceticus* and its effect on plant growth. *Biotechnol. Lett.*, **31** : 277 - 281.

LITTLE, T. M. AND HILLS, J. F., 1978, Agricultural experimentation. John Wiley and sons, New York, USA.

SAMAVAT, S., SAMAVAT, S., MAFAKHERI, S. AND JAVAD, S., 2012, Promoting common bean growth and nitrogen fixation by the co-inoculation of *Rhizobium* and *Pseudomonas fluorescens* isolates. *Bulg. J. Agric. Sci.,* **18** (3) : 387 - 395.

TILAK, K. V. B. R., RANGANAYAKI, N. AND MANOHARACHARI, C., 2006, Synergistic effects of plant-growth promoting rhizobacteria and *Rhizobium* on nodulation and nitrogen fixation by pigeon pea (*Cajanus cajan*). *Eur. J. Soil. Sci.*, **57** (1) : 67 - 71.

VENDAN, R. T. AND THANGARAJU, M., 2006, Development and standardization of liquid formulation for *Azospirillum* bioinoculant. *Indian J. Microbiol.*, **46** (4) : 379 - 387.

WANGE, S. S., 1989, Response of groundnut (*Arachis hypogaea* L.) to inoculation with strains isolated from wild arboreal legumes. *J. Appl. Microbiol. Biotechnol.*, **5** : 135 - 141.

WITHAM, F. H., BLAYDES, B. F. AND DEVLIN, R. M., 1971, Experiments in plant physiology. Van Nostrand Reinhold, New York, USA.

ZAHIDA, R., SHAHID B. D., MUDASIR, R. AND INAMULLAH, S., 2016, Productivity and quality of french bean (*Phaseolus vulgaris* L.) as influenced by integrating various sources of nutrients under temperate conditions of Kashmir. *Int. J. Food Agric. Vet. Sci.,* **6** (1): 15-20.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 385-391, 2017

Growth, Yield and Quality of Groundnut as Influenced by Organic Nutrient Management in Groundnut (*Arachis hypogaea* L.) – Finger Millet (*Eleusine coracana* L.) Cropping System

M. R. Ananda and Sharanappa
Department of Agronomy, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: anandmruas@gmail.com

Abstract

A field experiment was conducted during *kharif* 2015 and *kharif* 2016 in Chintamani taluk, Chickballapur district coming under eastern dry zone Karnataka to study the effect of bio-digested liquid manures on growth, productivity and quality of groundnut (*Arachis hypogaea* L.). Application of enriched biodigested liquid organic manure (EBDLM) at 25 kg N equivalent ha^{-1}+ 3 sprays of panchagavya (PG) at 3 per cent produced significantly higher pod yield, kernel yield, number of pods plant^{-1}, 100 kernal weight and shelling per cent (2232 kg ha^{-1},1608 kg ha^{-1}, 36g plant^{-1}, 43.1 g,72.1 per cent, respectively), LAI, total dry matter production plant^{-1}, SPAD and nodules plant^{-1} (1.5, 9.4 g plant^{-1}, 28.1 and 138.0, respectively). Further, higher protein and oil yield of groundnut (430.6 kgha^{-1} and 799.6 kg ha^{-1}) was recorded with EBDLM at 25 kg N equivalent ha^{-1} with 3 sprays of PG at 3 per cent as compared to other treatments.

Keywords: Groundnut, EBDLM, jeevamrutha, cow urine, panchagavya, vermiwash

Groundnut is major oilseed crop of India grown over an area of about 4.19 m. ha. with 5.62 mt. production and productivity of 1341 kg ha^{-1}. In Karnataka, it is grown in an area of about 8.5 lakh ha and contributes 7.4 lakh t. production with a productivity of 921 kg ha^{-1} (Anon., 2013). Being a leguminous crop it has an inherent capacity to fix atmospheric nitrogen and also can explore the soil nutrients. Organic sources which are good for improvement of soil properties, besides supplying nutrients for longer period of time without leaving ill effects on soil. Further, there is a possibility of substituting fertilizers by organic nutrient sources. The physicochemical and biological properties of the soil determine the production potential. Keeping this in view, large quantity of organic manure is recommended for groundnut. But the use of organic manures has been continuously declining in Indian agriculture due to several reasons. Decrease in cattle population in recent years and utilization of agricultural wastes into valuable by-products have made the availability of organic manure in agriculture questionable both in time and quantity. Non-availability of sufficient quantity of farmyard manure drawn the attention of researchers and cultivators to utilize the on-farm wastes, green biomass of *Glyricidia maculata, Pongamia pinnata etc.* and ubiquitous weeds *viz.,* parthenium, euphotorium, lantana, calatropis *etc.* for biodigested liquid manure production which can substitute the farmyard manure and compost. Most of the research on groundnut was mainly concentrated on the use of FYM, compost, green manure, oil cakes *etc.* There is need to generate efficient organic manurial sources using on-farm available organic substrates in addition to integrated use of vermicompost, panchagavya, jeevamruta, beejambruta, vermiwash, mycorrhizae culture, neem cake / neem seed extractants in organic farming. Further, there are evidences of enriched biodigested liquid manure use in enhancing the yields of finger millet, groundnut, pigeonpea and soybean (Reddy *et al.,* 2011 and Somasundaram, 2003). Further, Liquid cattle manures could supplement the nitrogen requirements of crops. There is a need to enhance nitrogen, phosphorus and potassium content of biodigested liquid manure by enriching with neem, pongamia, jatropa cake *etc.* and these enriched sources need to be evaluated for their effect on productivity of groundnut. Further, there is also need to evaluate the beneficial effects of cow urine, panchagavya,vermiwash in conjunction with enriched biodigested liquid manure. Hence, the investigation was carried out to study the efficacy of bio-digested liquid manures on the yield potential and quality of groundnut.

Material and Methods

The field experiment was carried out during *kharif* 2015 and *kharif* 2016 in farmers' field of Chokkahalli village of Chintamanitaluk, Chikka-ballapura district, Karnataka to study the effect of bio-digested liquid manures on growth, productivity and quality of groundnut (*Arachis hypogaea* L.). The soil is red sandy loam in texture with a bulk density of 1.43 g cc^{-1} and water holding capacity 39.31 per cent. The soil p^H was neutral (7.59) and the electrical conductivity was normal (0.12 dSm^{-1}). The organic carbon content was low (0.29%). The soil was medium in available nitrogen (298.5 kg ha^{-1}), phosphorus (27.3 kg ha^{-1}), potassium (195.8 kg ha^{-1}) and available sulphur (21.56 kg ha^{-1}). During both the years of experimentation, more rainfall was received during the first year (917.6 mm) of cropping season with drought during second year (417.7 mm) except for beginning two months of crop period, as compared to normal rainfall (587.8 mm). Crop was raised under rainfed condition with protective irrigation at 5 cm depth during the dry spell of the cropping period. There were ten treatments comprising of three types of organic liquid manures *viz.,* jeevamrutha, enriched biodigested liquid manures (EBDLM) and cow urine (CU) along with foliar spray of 3 per cent panchagavya (PG) and 3 per cent vermiwash (VW) and recommended fertilizers for groundnut as detailed T_1: Jeevamrutha @ 25 kg N equivalent ha^{-1}, T_2: Jeevamrutha @ 25 kg N equivalent ha^{-1} + VW spray @ 3 per cent, T_3: Jeevamrutha @ 25 kg N equivalent ha^{-1} + PG spray @ 3 per cent, T_4: EBDLM @ 25 kg N equivalent ha^{-1}, T_5: EBDLM @ 25 kg N equivalent ha^{-1} + VW spray @ 3 per cent, T_6:EBDLM @ 25 kg N equivalent ha^{-1} + PG spray @ 3 per cent, T_7: CU@ 25 kg N equivalent ha^{-1}, T_8: CU@ 25 kg N equivalent ha^{-1} + VW spray @ 3 per cent, T_9: CU@ 25 kg N equivalent ha^{-1} + PG spray @ 3 per cent, T_{10}: Rec. FYM 10 t + 25:50:25 kg $N:P_2O_5:K_2O$ ha^{-1}. The treatments were laid out in randomized complete block design with three replications. The gross plot was 3.6 m x 3.2 m. The bio-digested liquid manure was prepared in a 200 litre cement tank by adding 15 kg cow dung, 20 litre cow urine, 30 kg of on-farm green biomass and 100 litre water by frequent stirring. The liquid manure was incubated for 45 days, then it was enriched with 10 per cent Pongamia cake. While, jeevamrutha was prepared by mixing 10 kg local cow dung with 10 litres cow urine, 2 kg local jaggery, 2 kg bengalgram flour and handful of garden soil was added and the volume was made upto 200 litres. The plastic drum was kept in shade covering with wet gunny bag and the mixture was stirred clockwise thrice a day and incubated for 9 days and the resultant jeevamrutha was used. Jeevamruth contained 1.48, 0.28 and 0.32 per cent N, P and K, respectively. While, enriched biodigested liquid manure has 1.29, 0.39, 0.57 per cent N, P and K, respectively. The required quantity of liquid manures on nitrogen equivalent was applied to the soil. Liquid manures were applied in two equal splits at 15 and 45 days after sowing groundnut.

Panchagavya was prepared by using five products of desi cow *viz.*, cow urine, dung, milk, curd and ghee. Vermiwash was prepared by dipping adult earth worms in luke warm water. Three per cent panchagavya and vermiwash solutions were prepared by mixing 30 ml each panchagavya and vermiwash in 1000 ml of water separately. Three sprays of 3 per cent panchagavya and vermiwash was applied at 25, 50 and 75 days after sowing to groundnut as per treatments. Treatment 1 to 9 were supplied with recommended FYM and vermicompost at 50 each based on N equivalent and treatment T_{10} received FYM+vermicompost at 10 t ha^{-1} two weeks before sowing and recommended dose of fertilizer 25:50:25 $N:P_2O_5:K_2O$ kg ha^{-1} for groundnut was incorporated into the soil at the time of sowing. The nutrients were applied in the form of urea, single super phosphate and muriate of potash.

The groundnut cultivar KCG 6 was sown during *kharif* of 2015 and 2016. The spacing adopted was 30 x 10 cm for groundnut. Thrips and aphids were controlled by spraying 4 per cent neem seed kernel extract twice during crop growth period of groundnut.The yield of groundnut was recorded at harvest. Further, protein and oil yield of groundnut were computed.

Results and Discussion

In general, the productivity of groundnut was more in the second year (2016) than during first year (2015) but response to different treatments was similar in both the years of experimentation hence, pooled data is discussed here. Application of enriched biodigested liquid organic manure at 25 kg N equivalent ha^{-1} + 3 sprays of panchagavya (PG) at 3 per cent produced significantly higher pod yield, kernel yield, number of pods $plant^{-1}$, 100 kernal weight and shelling per cent (2231.5 kg ha^{-1},1608.2 kg ha^{-1}, 35.9 g $plant^{-1}$, 43.12 g, 72.0 per cent, respectively), LAI, total dry matter production $plant^{-1}$, SPAD and nodules $plant^{-1}$ (2.73, 9.43 g $plant^{-1}$, 28.1 and 138.0, respectively) followed by EBDLM at 25 kg N equivalent ha^{-1} + 3 sprays of VW at 3 per cent (2157.0 kg ha^{-1}, 1552.5 kg ha^{-1}, 34.7 g $plant^{-1}$, 42.3 g and 71.8 per cent, 2.66, 9.22 g $plant^{-1}$, 24.0 and 131.1, respectively) and jeevamrutha at 25 kg N equivalent ha^{-1} + 3 sprays of PG at 3 per cent (2134.5 kg ha^{-1}, 1545.0 kg ha^{-1}, 33.8 g $plant^{-1}$, 40.6 g and 71.5 per cent, 2.61, 8.93 g $plant^{-1}$, 20.42 and 128.32, respectively) than all other treatments. Significantly lower pod yield, kernel yield, number of pods $plant^{-1}$, 100 kernal weight and shelling per cent (1807.0 kg ha^{-1}, 1182.6 kg ha^{-1}, 21.9 g $plant^{-1}$, 31.8 g and 65.4 per cent, respectively) was observed with recommended practice (Table II & III).

The increase in yield could be attributed to increased growth parameters. Yield being a complex character, is influenced by many morphological characteristics and biochemical processes that occur during the crop growth and development. These complicated events are in turn, based on environment under which the crop is grown. The agronomic practices can modify the crop environment to certain extent and thereby help the crop to exploit the available resources efficiently to achieve higher production. Thus maximum yields are obtained when optimum conditions are provided to crop. The balanced management of nutrients obviously results into greater variation in growth pattern leading to different levels of yield. This is ascribed with higher growth and yield components which might be due to supply of all nutrients through enriched biodigested liquid manure.

Such a conductive effect of organic manure could be attributed to the supply of nutrients through mineralization and improvement of physico-chemical properties of soil (Naveen Kumar, 2009). Higher yield parameters can be attributed to the ability of enriched biodigested liquid manure to satisfy the nutrient demand of crop more efficiently than inorganic manures.The increase in yield of groundnut in EBDLM and jeevamrutha along with three sprays of panchagavya and vermiwash at 3 per cent applied treatments may be also due to enrichment of biodigested liquid manure with *pongamia* cake and jeevamrutha with pulse flour which contributed secondary and micronutrients along with major nutrients besides improving the soil condition, which enhanced the root proliferation and source to sink relationship. Similar resuts were obtained by Sudheendra Saunshi *et al.* (2014). Foliar application of panchagavya and vermiwash readily supplied nutrients and growth hormones *viz.,* IAA and GA present in panchagavya which might have stimulated the production of growth regulators in cell system. Similar results of higher gross and net returns were obtained with the application of panchagavya by Yadav and Lourduraj (2006) in rice and Somasundaram (2003) in greengram. The significant effect of panchagavya was mainly attributed to its nutrient content, higher biological activity and presence of plant growth promoting substances, which was confirmed by Hazarika *et al.* (2006). The results also corroborate those of Pradeep Gopakkali and Sharanappa (2014) in chilli, Latha and Sharanappa (2014) in groundnut-onion sequence, Mahalingam and Sheela (2003) in garden pea, Ravi Kumar (2009) in groundnut.

Quality parameters *viz.,* protein and oil yield of groundnut were significantly higher (430.5 and 799.6 kg ha^{-1}, respectively) with the application of EBDLM at 25 kg N equivalent ha^{-1} + 3 sprays of PG at 3 per cent as compared to other treatments (Table III). This is in conformity with the findings of Kamdi *et al.* (2014) and Naveen Kumar (2009).

It can be concluded from the study that the application of enriched liquid organic manure or jeevamrtha 15 and 45 days after sowing for groundnut

TABLE I

Growth parameters ingroundnut as influenced by different liquid organic manures

Treatments	*LAI @ 60 DAS*			*SPAD @ 60 DAS*			*TDMA (G PLANT^{-1} @ HARVEST*			*No. of nodules plant^{-1} @ 60 DAS*		
	2015	2016	*Pooled*	2015	2016	*Pooled*	2015	2016	*Pooled*	2015	2016	*Pooled*
T_1	2.31	2.24	2.28	18.80	18.90	18.85	8.10	8.60	8.35	114.0	112.5	113.3
T_2	2.39	2.66	2.53	19.77	19.90	19.83	8.40	9.10	8.75	121.3	119.4	120.4
T_3	2.57	2.66	2.61	20.00	20.83	20.42	8.67	9.20	8.93	125.0	131.6	128.3
T_4	2.42	2.53	2.48	22.30	22.10	22.20	8.67	9.23	8.95	115.3	127.2	121.2
T_5	2.59	2.72	2.66	23.90	24.10	24.00	8.97	9.47	9.22	127.4	134.8	131.1
T_6	2.66	2.79	2.73	27.63	28.70	28.17	9.17	9.70	9.43	136.1	139.8	138.0
T_7	2.00	2.12	2.06	16.73	16.60	16.67	7.10	7.53	7.32	104.6	110.6	107.6
T_8	2.12	2.28	2.20	18.43	18.83	18.63	7.33	7.63	7.48	109.5	114.3	111.9
T_9	2.22	2.31	2.27	20.23	20.00	20.12	7.40	7.57	7.48	118.3	113.2	115.7
T_{10}	2.12	2.15	2.13	19.27	19.63	19.45	7.30	7.20	7.25	97.8	101.8	99.8
S.Em±	0.07	0.08	0.06	0.78	1.60	0.87	0.35	0.33	0.18	5.17	3.88	3.54
C. D. at 5 %	0.22	0.23	0.16	2.33	4.75	2.59	1.03	0.99	0.52	15.36	11.53	10.53

T1: Jeevamrutha @ 25 kg N equivalent ha-^{1}

T2: Jeevamrutha @25 kg N equivalent ha-^{1}+ Vermi wash(VW) spray @ 3 %

T3: Jeevamrutha @ 25 kg N equivalent ha-^{1}+ Panchagavya (PG) spray @ 3 %

T4: Enriched Bio-digester Liquid Manure (EBDLM) @ 25 kg N equivalent ha-^{1}

T5: EBDLM @ 25 kg N equivalent ha-^{1}+ VW spray @ 3 %

DAS: Days after sowing

T6: EBDLM @ 25 kg N equivalent ha-^{1}+ PG spray @ 3 %

T7: Cow Urine (CU) @ 25 kg N equivalent ha-^{1}

T8: CU@ 25 kg N equivalent ha-^{1}+ VW spray @ 3 %

T9: CU@ 25 kg N equivalent ha-^{1}+ PG spray @ 3 %

T10: Rec. POP. 25:50:25 kg NPK ha-^{1}

NS: Non significant

TABLE II

Yield and quality parameters in groundnut as influenced by different liquid organic manures

Treatments	*Number of pods plant^{-1}*			*100 Kernal weight (g)*			*Shelling %*			*Pod yield (kg/ha^{-1})*		
	2015	2016	*Pooled*	2015	2016	*Pooled*	2015	2016	*Pooled*	2015	2016	*Pooled*
T_1	30.4	29.8	30.1	37.50	37.30	37.40	70.8	69.3	70.1	2010.0	2025.0	2017.5
T_2	31.2	33.2	32.2	38.43	38.77	38.60	71.7	69.5	70.6	2087.3	2084.0	2085.6
T_3	32.3	35.4	33.8	40.50	40.77	40.63	71.1	71.5	71.3	2163.0	2106.0	2134.5
T_4	35.8	32.8	34.3	39.60	40.90	40.25	70.4	71.1	70.7	2092.0	2051.3	2071.6
T_5	36.1	33.4	34.7	42.20	42.57	42.38	71.7	71.9	71.8	2198.0	2116.0	2157.0
T_6	37.1	34.8	35.9	42.83	43.40	43.12	72.2	72.0	72.1	2243.0	2220.0	2231.5
T_7	29.3	28.4	28.8	33.40	33.80	33.60	65.6	66.5	66.0	1890.0	1863.0	1876.5
T_8	31.4	30.4	30.9	35.80	36.87	36.33	67.6	67.5	67.5	1906.0	1986.0	1946.0
T_9	32.5	32.8	32.6	36.43	37.57	37.00	68.6	68.8	68.7	2025.0	2089.0	2057.0
T_{10}	21.3	22.5	21.9	31.37	32.33	31.85	65.3	65.5	65.4	1816.0	1798.0	1807.0
S.Em±	1.76	1.65	1.21	1.28	1.35	0.91	2.06	2.05	1.51	104.23	105.24	64.86
C. D. at 5 %	5.23	4.90	3.60	3.80	4.01	2.71	6.12	6.09	4.50	309.70	312.69	192.70

T1: Jeevamrutha @ 25 kg N equivalent ha-^{1}

T2: Jeevamrutha @25 kg N equivalent ha-^{1}+ Vermi wash(VW) spray @ 3 %

T3: Jeevamrutha @ 25 kg N equivalent ha-^{1}+ Panchagavya (PG) spray @ 3 %

T4: Enriched Bio-digester Liquid Manure (EBDLM) @ 25 kg N equivalent ha-^{1}

T5: EBDLM @ 25 kg N equivalent ha-^{1}+ VW spray @ 3 %

DAS: Days after sowing

T6: EBDLM @ 25 kg N equivalent ha-^{1}+ PG spray @ 3 %

T7: Cow Urine (CU) @ 25 kg N equivalent ha-^{1}

T8: CU@ 25 kg N equivalent ha-^{1}+ VW spray @ 3 %

T9: CU@ 25 kg N equivalent ha-^{1}+ PG spray @ 3 %

T10: Rec. POP. 25:50:25 kg NPK ha-^{1}

NS: Non significant

TABLE III

Kernal yield, Oil yield and Protein yield in groundnut as influenced by different liquid organic manures

Treatments	Kernal yield (kg ha^{-1})			Oil yield (kg ha^{-1})			Protein yield (kg ha^{-1})		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
T_1	1422.4	1402.4	1412.4	666.43	635.33	650.88	331.10	328.78	329.94
T_2	1486.0	1424.0	1455.0	704.17	666.50	685.34	355.26	329.99	342.62
T_3	1553.0	1537.0	1545.0	753.83	750.54	752.18	380.38	384.86	382.62
T_4	1473.4	1495.4	1484.4	717.61	709.64	713.63	368.82	369.44	369.13
T_5	1580.2	1524.8	1552.5	774.62	729.44	752.03	408.69	392.45	400.57
T_6	1615.6	1600.8	1608.2	797.14	802.15	799.64	446.95	414.15	430.55
T_7	1242.3	1244.2	1243.2	558.13	543.31	550.72	280.05	264.76	272.41
T_8	1282.5	1337.9	1310.2	587.21	613.90	600.55	290.14	298.83	294.48
T_9	1391.6	1441.4	1416.5	647.95	663.26	655.60	326.58	344.03	335.31
T_{10}	1184.0	1181.2	1182.6	537.18	544.88	541.03	245.55	253.25	249.40
S. Em±	79.68	94.56	55.95	53.47	50.63	31.87	27.28	26.88	18.14
C. D. at 5 %	236.76	280.94	166.23	158.87	150.44	94.70	81.05	79.85	53.91

T1 : Jeevamrutha @ 25 kg N equivalent ha^{-1}

T2 : Jeevamrutha @25 kg N equivalent ha^{-1}+ Vermi wash(VW) spray @ 3 %

T3 : Jeevamrutha @ 25 kg N equivalent ha^{-1}+ Panchagavya (PG) spray @ 3 %

T4 : Enriched Bio-digester Liquid Manure (EBDLM) @ 25 kg N equivalent ha^{-1}

T5 : EBDLM @ 25 kg N equivalent ha^{-1}+ VW spray @ 3 %

DAS: Days after sowing

T6: EBDLM @ 25 kg N equivalent ha^{-1}+ PG spray @ 3 %

T7: Cow Urine (CU) @ 25 kg N equivalent ha^{-1}

T8: CU@ 25 kg N equivalent ha^{-1}+ VW spray @ 3 %

T9: CU@ 25 kg N equivalent ha^{-1}+ PG spray @ 3 %

T10: Rec. POP. 25:50:25 kg NPK ha^{-1}

NS: Non significant

equivalent to 100 per cent recommended dose of nitrogen with foliar spray of panchagavya or vermiwash at 3 per cent on 25, 50 and 75 DAS is the best option for higher productivity of groundnut, besides improving protein and oil yield.

REFERENCES

ANNONYMOUS, 2013, Directorate of Economics and Statistics, Govt. of Karnataka.

HAZARIKA, U. K., MUNDA, G. C., BUJORBORUAH, K. M., DAS, A., PATEL, D. P., PRASAD, K., RAJESHKUMAR, DANWAR, A. S., TOMAR, J. M. S., BORDOLOI, J., SHARMA, M. AND GIRIN, G., 2006, Components of nutrient management. *Nutrient Management Organic Farming*, p. 15 - 53.

KAMDI, T. S., PRITI SONAKAMBLE AND SAPNA JOSHI, 2014, Effect of organic manure and biofetilizers on seed quality of Groundnut (*Arachis hypogaea* L.). *The Bioscan*, **9** (3) : 1011 - 1013.

LATHA, H. S. AND SHARANAPPA, 2014, Production potential, nutrient -use efficiency and economics of groundnut (*Arachis hypogaea*) - Onion (*Allium cepa*) cropping system under organic nutrient management. *Indian J. Agron.,* **59** (1) : 59 - 64.

MAHALINGAM, P. U. AND SHELLA, S., 2003, Production of plant growth regulators by *Pseudomonas aeruginosa.* In: Abstract of the UGC sponsored state level seminar on indigenization of *Indian farming : Problems and prospects* held at Gandhigram Rural Institute, Deemed University, Tamil Nadu on 7 - 8th March, p. 84.

NAVEEN KUMAR, A. T., 2009, Effect of FYM and bio-digested liquid manure on growth and yield of groundnut under rainfed condition. *M.Sc. (Agri.) Thesis* (Unpub.), Univ. Agri. Sci., Bengaluru.

PRADEEP GOPAKKALI AND SHARANAPPA, 2014, Effect of organic production techniques on the growth, yield, quality and economics of chilli (*Capsicum annuum*) and soil quality in dry zone of Karnataka. *Indian. J. Agron.,* **59** (1) : 151 - 156.

RAVI KUMAR, H. S., 2009, Comparative performance of integrated organic nutrient supply systems on growth and yield of groundnut (*Arachis hypogaea* L.). *M.Sc.(Agri.) Thesis,* (Unpub.), Univ. Agril. Sci., Bengaluru.

REDDY, V. C., JAYARAM REDDY, M ., SHIVANANDM, V. N., YOGANANDA, S. B., GOVINDARAJU, C. AND JAGADEESH, B. R., 2011, Developing package of practices for production of finger millet through compost and bio-digester liquid manure. Annual Progress Report, Research Institute on Organic Farming, University of Agricultural Sciences, Bengaluru Karnataka, India. p. 13 - 21, 23 - 26, 30 - 34 and 47 - 48.

SOMASUNDARAM, E., 2003, Evaluation of organic sources of nutrients and panchagavya spray on the growth and productivity of maize-sunflower-greengram system. *Ph.D. degree Thesis* (Unpub.), Tamil Nadu Agri. Univ., Coimbatore.

SUDHEENDRA SAUNSHI, REDDY, V. C., MALLIKARJUN AND RAJESH RAWAL, 2014, Influence of enriched bio-digester liquid manure on growth and yield of finger millet.*The Bioscan.*, **9** (2) : 613 - 616.

YADAV, B. K. AND LOURDURAJ, C. A., 2006, Effect of organic manures and panchagavyaspray on yield attributes, yield and economics of rice (*Oryza sativa* L.). *Crop Research,* **32** (1) : 1 - 5.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 392-396, 2017

Effect of Method of Establishment, Planting Geometry and Nutrient Source on Growth and Yield of Finger Millet (*Eleusine coracana* L.)

NARAYAN HEBBAL AND B. K. RAMACHANDRAPPA
Department of Agronomy, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: narayan4902@gmail.com

ABSTRACT

Field experiment was conducted during *Kharif*-2015 at AICRP on dryland agriculture, GKVK, UAS, Bengaluru to assess the effect of planting geometry, method of establishment and nutrient sources on growth and yield of finger millet. Significantly higher growth parameters *viz*., number of tillers hill^{-1} (11.28), leaf area (1961.59 cm^2), total dry matter production hill^{-1} (41.17 g hill^{-1}), number of productive tillers hill^{-1} (10.84), grain (3240 kg ha^{-1}) and straw (5592 kg ha^{-1}) yield were recorded in transplanting method. The wider spacing (45 x 30cm and 30 x 30 cm) has recorded higher number of tillers (14.31 and 10.81, respectively), leaf area (2280.16 and 1906. 64 cm^2, respectively), total dry matter production (41.43 and 39.16 g hill^{-1}, respectively) and number of productive tillers hill^{-1} (14.19 and 9.81, respectively). Whereas, grain and straw yield was non-significant with respect to planting geometry. Significantly higher growth parameters *viz.,* plant height (77.5cm), number of tillers hill^{-1} (11.33), leaf area (2005.09 cm^2), SPAD meter observation (43.30), total dry matter production (40.37 g hill^{-1}), number of productive tiller hill^{-1}(10.75) grain (3051 kg ha^{-1}) and straw yield (5381 kg ha^{-1}) were recorded with the application of recommended dose of FYM 7.5 t ha^{-1}+ RDF (50:40:37.5 kg N, P_2O_5 and K_2O ha^{-1}).

Keywords: Methods of establishment, planting geometry, nutrient source, growth, yield parameters

FINGER millet (*Eleusine coracana* L.) is a staple food for working class and also an ideal food for people suffering from diabetes, cardiac and blood pressure issues since it contains higher dietary fiber. It is an annual plant belonging to family Poaceae widely grown as millet in the arid areas of Africa and Asia. It is one of the important cereal which occupies the highest area under cultivation among the small millets and a predominant food crop of Southern Karnataka, mainly grown under rainfed conditions. In India it is grown in an area of 1.19 m ha with a production of 1.98 m t with an average productivity of 1661 kg ha^{-1}. Karnataka is the largest producer of finger millet grown in an area of 1.05 m ha with a production of 1.57 m t with an average productivity of 1889 kg ha^{-1} (Anon., 2015).

For realizing higher yield of finger millet there is a need for the adoption of new high yielding, fertilizer responsive varieties with proper rain water conservation and nutrient management practices. The productivity is low due to late transplanting, faulty methods of cultivation and little or no use of fertilizers. The secret of boosting its yields mainly lies with suitable planting method with proper nutrient management practices. Hence this field study was undertaken.

MATERIAL AND METHODS

The experiment was conducted during *Kharif*-2015 at AICRP on dryland agriculture, GKVK, UAS, Bengaluru. The center is situated in the Eastern Dry zone of Karnataka at 12° 58′ North latitude and 77° 35′ East longitude with an altitude of 930 m above the mean sea level. The soils of GKVK Farm belong to Vijayapura series and are classified as *Oxichaplustalf.* Soils are reddish brown laterite derived from gneiss under subtropical semiarid climate. The soil of experimental site was red sandy clay loam in texture.

The study was undertaken in factorial RCBD with three factors which are replicated thrice. The first factor was Method of establishment (M_1: Direct sowing, M_2: Transplanting) second factor was planting geometry (S_1: Recommended spacing (30 cm×10 cm),

S_2: 30 cm × 30 cm and S_3: 45 cm × 30 cm) and the third factor was nutrient source (N_1: Recommended dose of FYM 7.5 t ha^{-1} + RDF (50:40:37.5 kg N, P_2O_5 and K_2O ha^{-1}) and N_2: FYM on N equivalent basis + FYM 7.5 t ha^{-1}).

The observations on growth parameters like plant height, number of tillers per m^2, number of leaves hill^{-1}, leaf area hill^{-1}and dry matter production were recorded at 30, 60, 90 DAS and at harvest. Grain and straw yield was calculated based on the yield obtained from each net plot and converted to kg ha^{-1}. The data was statistically analyzed by following the method of Gomez and Gomez (1984).

Results and Discussion

Plant growth is dependent on the rate of accumulation of dry matter and the dry matter accumulation may reflect on the economic yield. The fact is that vegetative part of the plants serve as source, whereas, grains are the sink. The need for the increased crop productivity is an outcome of a series of intermediate interaction of various biological events involving biochemical, physiological and morphological change which takes place during its development in accordance with the supply of light, water, temperature and nutrients.

Growth parameters of finger millet

Methods of establishment, planting geometry and nutrient source have significantly influenced the growth parameters of finger millet (Table I). With respect to method of establishment, transplanting has significantly influenced the number of tillers hill^{-1} (11.28), leaf area (1961.59 cm^2) and total dry matter production hill^{-1} (41.17 g hill^{-1}) at 90 DAS. Whereas, direct sowing has recorded significantly lower growth parameters (number of tillers hill^{-1} (10.26), leaf area (1928.35cm^2) and total dry matter production hill^{-1} (37.95 g). Non-significant results were obtained with respect to plant height and SPAD meter reading. Higher growth parameters in transplanting method of establishment had an opportunity to get better moisture, nutrient supply and optimum growth conditions during nursery.

The higher plant height was recorded in the recommended spacing (80.0 cm during 90 DAS). Whereas, significantly lower plant height was recorded with the 45 x 30 cm and 30 x 30 cm spacing (72.3 and 76.4 cm, respectively). Higher plant density brings morphological changes such as increase in plant height, which denotes the competition between plants for light, moisture and nutrients, favouring light interception and increases the dry matter production per unit area. Wider spacing (45 x 30cm and 30 x 30 cm) has recorded higher number of tillers (14.31 and 10.81, respectively), leaf area (2280.16 and 1906. 64 cm^2, respectively) and total dry matter production (41.43 and 39.16 g hill^{-1}, respectively). Wider spacing of finger millet also recorded higher growth parameters hill^{-1} due to availability of more space and nutrients to particular hill, which has resulted in lesser competition for growth resources, ultimately resulted in the higher growth parameters per hill. This was in conformity with Kalaraju (2007). The planting geometry did not influence much on chlorophyll content at 90 DAS.

Different nutrient sources have profoundly influenced the growth parameters of finger millet at different crop growth stages. Significantly higher growth parameters *viz.* plant height (77.5cm), number of tillers hill^{-1} (11.33), leaf area (2005.09 cm^2), SPAD meter observation (43.30) and total dry matter production (40.37 g hill^{-1}) were recorded due to the application of recommended dose of FYM 7.5 t ha^{-1}+ RDF (50:40:37.5 kg N, P_2O_5 and K_2O ha^{-1}). Higher growth parameters were attributed to integrated nutrient management that helped to supply the nutrients based on the crop demand. Whereas, significantly lower plant height (75.0 cm), number of tillers hill^{-1}, (10.21), leaf area (1884.85 cm^2), SPAD meter reading (39.49) and total dry matter production (38.75 g hill^{-1}) were noticed mainly due to lower availability of nutrients in FYM on N equivalent basis + FYM 7.5 t ha^{-1} was mainly due to lesser mineralization of organics which resulted in the lesser growth parameters of finger millet. These findings are in line with Vijayamahantesh (2012) and Pavan Kumar (2014).

None of the interaction effects were found to be significant with respect to growth parameters of finger millet.

Yield parameters and yield of finger millet

Methods of establishment, planting geometry and nutrient source have significantly influenced the yield

TABLE I

Growth parameters of finger millet as influenced by planting geometry, method of establishment and nutrient source at 90 DAS

Treatments	Plant hieght (cm)	No. of tillers hill^{-1}	Leaf area hill^{-1} (cm^2)	SPAD meter observation	Total dry matter production (g hill^{-1})
Method of establishment (M)					
M_1: Direct sowing	76.1	10.26	1928.35	41.47	37.95
M_2: Transplanting	76.4	11.28	1961.59	41.33	41.17
S. Em. (±)	0.8	0.22	6.71	0.94	0.41
C. D. @ 5 %	NS	0.65	19.68	NS	1.20
Planting geometry (S)					
S_1: Recommended spacing 30 cm × 10 cm	80.0	7.20	1648.12	40.78	38.09
S_2: 30 cm × 30 cm	76.4	10.81	1906.64	41.93	39.16
S_3: 45 cm × 30 cm	72.3	14.31	2280.16	41.48	41.43
S. Em. (±)	1.0	0.27	8.22	1.15	0.50
C. D. @ 5 %	3.0	0.79	24.11	NS	1.47
Nutrient source (N)					
N_1: Recommended dose of FYM 7.5 t + RDF (50:40:37.5 kg N, P_2O_5 and K_2O ha^{-1})	77.5	11.33	2005.09	43.30	40.37h a^{-1}
N_2: FYM on N equivalent basis + FYM 7.5 t ha^{-1}	75.0	10.21	1884.85	39.49	38.75
S. Em. (±)	0.8	0.22	6.71	0.94	0.41
C. D. @ 5 %	2.5	0.65	19.68	2.74	1.20
Method of establishment x Planting geometry (M x S)					
S. Em. (±)	1.4	0.38	11.62	1.62	0.71
C. D. @ 5 %	NS	NS	NS	NS	NS
Method of establishment x Nutrient source (M x N)					
S. Em. (±)	1.2	0.31	9.49	1.32	0.58
C. D. @ 5 %	NS	NS	NS	NS	NS
Planting geometry x Nutrient source (S x N)					
S. Em. (±)	1.4	0.38	11.62	1.62	0.71
C. D. @ 5 %	NS	NS	NS	NS	NS
Method of establishment x Planting geometry x Nutrient source (M x S x N)					
S. Em. (±)	2.1	0.54	16.44	2.29	1.00
C. D. @ 5 %	NS	NS	NS	NS	NS

NS-Non-significant, DAS: Days after sowing

parameters of finger millet (Table II). With respect to method of establishment, the transplanting method has significantly influenced the number productive tillers hill^{-1} (10.84) compared to direct sowing (9.51). Among different planting geometry, 45 x 30 cm spacing recorded significantly higher number of productive tillers (14.19) compared to 30 x 30 cm (9.81) and 30 x 10 cm (6.53). With respect to nutrient sources, application of recommended dose of fertilizer (50:40:37.5 kg N, P_2O_5 and K_2O ha^{-1})+FYM 7.5 t ha^{-1} recorded significantly higher number of productive tillers hill^{-1} (10.75) compared to application of FYM on N equivalent basis + FYM 7.5 t ha^{-1} (9.60).

Effect of methods of establishment and planting geometry on finger number ear^{-1} and ear length were found to be non-significant. Whereas, application of recommended dose of fertilizer (50:40:37.5 kg N, P_2O_5

TABLE II

Yield and yield parameters of finger millet as influenced by planting geometry, method of establishment and nutrient source

Treatments	No. of Productive tillers hill^{-1}	Finger No. / ear	Ear length (cm)	Test weight (g)	Grain yield (kgha^{-1})	Straw yield (Kg ha^{-1})
Method of establishment (M)						
M_1: Direct sowing	9.51	7.39	5.89	3.53	3034	5369
M_2: Transplanting	10.84	7.24	5.93	3.57	3240	5592
S. Em. (±)	0.22	0.16	0.07	0.07	45.47	65.12
C. D. @ 5 %	0.63	NS	NS	NS	133.35	191.00
Planting geometry (S)						
S_1: Recommended spacing 30 cm × 10 cm	6.53	7.12	5.80	3.51	3250	5543
S_2: 30 cm × 30 cm	9.81	7.45	5.83	3.55	3111	5462
S_3: 45 cm × 30 cm	14.19	7.39	6.09	3.58	3051	5436
S. Em. (±)	0.26	0.19	0.09	0.09	55.69	79.76
C. D. @ 5 %	0.77	NS	NS	NS	NS	NS
Nutrient source (N)						
N_1: Recommended dose of FYM 7.5 t ha^{-1} + RDF (50:40:37.5 kg N, P_2O_5 and K_2O ha^{-1})	10.75	7.57	6.01	3.54	3223	5581
N_2: FYM on N equivalent basis + FYM 7.5 t ha^{-1}	9.60	7.07	5.80	3.56	3051	5381
S. Em. (±)	0.22	0.16	0.07	0.07	45.47	65.12
C. D. @ 5 %	0.63	0.46	0.21	NS	133.35	191.00
Method of establishment x Planting geometry (M x S)						
S. Em. (±)	0.37	0.27	0.12	0.13	78.75	112.80
C. D. @ 5 %	NS	NS	NS	NS	NS	NS
Method of establishment x Nutrient source (M x N)						
S. Em. (±)	0.31	0.22	0.10	0.10	64.30	92.10
C. D. @ 5 %	NS	NS	NS	NS	NS	NS
Planting geometry x Nutrient source (S x N)						
S. Em. (±)	0.37	0.27	0.12	0.13	78.75	112.80
C. D. @ 5 %	NS	NS	NS	NS	NS	NS
Method of establishment x Planting geometry x Nutrient source (M x S x N)						
S. Em. (±)	0.53	0.39	0.17	0.18	111.37	159.52
C. D. @ 5 %	NS	NS	NS	NS	NS	NS

NS : Non-significant, DAS: Days after sowing

and K_2O ha^{-1}) + FYM 7.5 t ha^{-1} recorded higher finger number ear^{-1}(7.57) and ear length (6.01 cm) compared to application of FYM on N equivalent basis + FYM 7.5 t ha^{-1} (7.07 and 5.80 cm, finger number ear^{-1} and ear length, respectively). Test weight of finger millet did not differ significantly due to methods of establishment, planting geometry and nutrient sources.

Among different methods of establishment, significantly higher grain and straw yield (3240 and 5592 kg ha^{-1}, respectively) was recorded with transplanting when compared to direct sowing (3034 and 5369 kg ha^{-1}, respectively). The lower growth attributes in direct sowing were due to poor root length which failed to take up optimum quantity of nutrients and water which ultimately resulted in less productive tillers, grain and straw yield. This is also in line with Ahiwale *et al*. (2011).

No significant difference in grain and straw yield was observed with the planting geometry but higher grain and straw yield was recorded with recommended spacing of 30x10 cm (3250 and 5543 kg ha^{-1}, respectively) which was on par with 30 x 30 cm (3111 and 5462 kg ha^{-1}, respectively) and 45 x 30 cm spacing (3051 and 5436 kg ha^{-1}, respectively), Higher dry matter production per unit area which ultimately resulted in the higher grain and straw yield. The higher grain and straw yield was obtained in recommended spacing (30 x 10 cm) of finger millet was mainly due to higher population per unit area compared to 45 x 30 cm and 30 x 30 cm spacing. This is in conformity with the findings of Bitew and Asargew, (2014).

Among nutrient sources added, significantly higher grain and straw yield (3223and 5587 kg ha^{-1}, respectively) was recorded with application of recommended dose of FYM 7.5 t ha^{-1} + RDF (50:40:37.5 kg N, P_2O_5 and K_2O ha^{-1}) compared to application of FYM on N equivalent basis + FYM 7.5 t ha^{-1}(3051 and 5381 kg ha^{-1}, respectively). Similar results were reported by Veeresh Hatti. (2016). None of the interaction effects were found to be significant with respect to yield parameters and yield of finger millet.

From the study, it can be concluded that higher growth parameters, grain and straw yield of finger millet was recorded in transplanting method with recommended spacing (30 x 10 cm) along with the application of recommended dose of FYM 7.5 t ha^{-1} + RDF (50:40:37.5 kg N, P_2O_5 and K_2O ha^{-1}).

References

AHIWALE, P. H., CHAVAN, L. S. AND JAGTAP, D. N., 2011, Effect of establishment methods and nutrient management on yield attributes and yield of finger millet (*Eleusine coracana* G.,). *Adv. Res. J. Crop Improv.*, **2** (2) : 247 - 250.

ANONYMOUS, 2015, Area, production and productivity of millets. Directorate of economics and statistics.

BITEW, Y. AND ASARGEW, F., 2014, Determination of seed rate and inter row spacing for finger millet production (*Eleusine Coracona* Gaertn.) in north western Ethiopia. *Int. J. Res. Rev.,* **1** (4) :1 - 7.

GOMEZ, K. A. AND GOMEZ, A. A., 1984, *Stastical procedure for agricultural research*. John Wiley and sons, New Delhi, p. 680.

KALARAJU, K., 2007, Response of finger millet genotypes to methods of planting under organic farming. *M.Sc.* (*Agri.*) *Thesis* (Unpub.), Univ. Agric. Sci., Bengaluru.

PAVANKUMAR, G., 2014, Effect of rotation, use of rotation, use of organic and inorganic sources of nutrients on growth and yield of finger millet (*Eleusine coracana* L. Gaertn.). *M.Sc. (Agri.) Thesis* (Unpub.), Univ. Agric. Sci., Bengaluru.

VERRESH, HATTI, 2016, Effect of conservation tillage and nutrient management practices on finger millet in *Alfisols* under rainfed conditions. *Ph.D. Theses* (Unpub.), Univ. Agric. Sci., Bengaluru.

VIJAYAMAHANTESH, 2012, Effect of tillage and integrated nutrient management in pigeon pea (*Cajanus cajana* L.) and finger millet (*Eleusine coracana* L.) cropping system in relation to weed dynamics. *Ph.D. Theses* (Unpub.), Univ. Agric. Sci., Bengaluru.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 397-401, 2017

Effect of Subsurface Drip Fertigation Intervals and Fertilizer Levels on Yield and Economics of Sugarcane

G. K. Ningaraju and B. C. Shankaralingappa
Department of Agronomy, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: rajuagron@gmail.com

Abstract

A field experiment was conducted at ZARS, V.C. Farm, Mandya during 2015-16 to know the effect of subsurface drip fertigation intervals and fertilizer levels on sugarcane. Results revealed that fertigation once in 2 days recorded significantly higher cane yield (281.4 t ha^{-1}), millable canes m^{-1} row length (39.4), cane length (222.7 cm), internodes $cane^{-1}$ (21), cane girth (10.1 cm) and single cane weight (2.57 kg) than fertigation once in 6 days, but was on par with fertigation once in 4 days in respect of cane yield, millable canes m^{-1} length and single cane weight. Among the fertilizer levels of drip fertigation, 150 per cent RDF recorded significantly higher cane yield (283.1 t ha^{-1}), millable canes m^{-1} row length (41.3), cane length (234.9 cm), internodes $cane^{-1}$ (22.3), cane girth (10.07 cm), single cane weight (2.94 kg), than other fertilizer levels but was on par with 125 per cent RDF in case of cane yield. Higher cane yield (308.3 t ha^{-1}) and higher net returns (₹ 5,16,149 ha^{-1}) with B : C ratio (3.18) were recorded with fertigation interval once in 2 days with 150 per cent RDF through WSF that increased the cane yield by 95 per cent over surface irrigation with 100 per cent RDF and subsurface fertigation with 75 per cent of RDF once in two days interval recorded higher net returns (₹ 4,01,822 ha^{-1}) and increase in yield of 59 per cent over conventional method with saving of 25 per cent of fertilizers.

Keywords: Subsurface, drip fertigation, WSF, fertigation intervals, fertilizer levels and yield

Sugarcane is an important commercial sugar crop which requires more water and nutrients for its growth and development. In India, it is cultivated in an area of 5.3 mha with a production of 366.0 mt and productivity of 69 t ha^{-1}. Karnataka ranks third in area (0.50 m ha), fourth in production (47.0 mt) and third in productivity of 94 t ha^{-1} (Anon., 2015). For the normal growth and yield of sugarcane crop, optimum soil moisture condition with availability of nutrients in the root zone throughout its growing period is very much essential. One of the methods that is adopted to increase the water and nutrient use efficiency besides increasing productivity is drip fertigation.

Sugarcane being a long duration crop requires considerable quantity of water to the extent of 2000–2500 mm in the subtropics (Solomon, 2012). Its peak water requirement coincides with the crucial water deficit period. Providing optimum soil moisture condition throughout its growing period, however, is of paramount importance to realize higher yields. Drip fertigation, one of the potential technologies offers the great scope to increase cane productivity up to 200-220 t/ha (Senthil Kumar, 2009), by saving 40-50 per cent irrigation water and enhances nutrient efficiency by 40 per cent. Fertigation offers the possibility to optimize the water and nutrient distribution over time and space (Nanda, 2010).

A fertigation scheduling plan is often compounded by the changing demands of fertilizer requirements of growing plants. Nevertheless, fertigation should be carried out, not to adversely alter the solute dynamics in the root zone, but should provide optimum concentration of nutrients in the rhizosphere. Hence, accurate prediction of when and how much fertilizer to be applied is critical for fertigation management. The amount of fertilizer to be applied depends on the plant requirement. The frequency of application of fertilizers depends on the soil type and the length of the growing season. According to Ravikumar *et al.* (2011), the frequency of fertigation is usually as critical as achieving the right rate of fertilizer application at a given crop stage.The present study was therefore, conducted to determine the yield response of sugarcane to various fertigation intervals and different fertilizer levels under subsurface drip fertigation.

Material and Methods

The experiment was conducted at Zonal Agricultural Research Station, V.C. Farm, Mandya, during 2015-16. The Soil of the experimental site was red sandy loam with low organic carbon (0.4%), medium available N (344.9 kg ha^{-1}), available P_2O_5 (36.2 kg ha^{-1}) and available K_2O (162.3 kg ha^{-1}). The experiment was laid out in randomized complete block design with factorial concept and replicated thrice.The treatments consisted of two factors *viz.,* three fertigation intervals (I_2: Fertigation once in 2 days, I_4: Fertigation once in 4 days and I_6: Fertigation once in 6 days) and four fertilizer levels (75, 100, 125 and 150 per cent of RDF) along with conventional method of sugarcane cultivation (soil application of recommended dose of fertilizer 250-100-125 kg N, P_2O_5 and K_2O ha^{-1} with surface irrigation). The land was prepared by ploughing with tractor drawn disc plough followed by disc harrowing and passing cultivator twice to bring the soil to fine tilth. Layout was prepared with gross plot size of 15.6 m × 8.0 m. Drip irrigation system (pump, filter units, main line and sub line) was installed. The laterals were placed at 1.95 m apart. The drip line was passed in between 30 cm apart paired row at 20 cm below the soil surface. Inline emitters were placed 40 cm apart with discharge rate of 4 lph. Recommended FYM (25 t ha^{-1}) was applied one month before planting. 50 per cent P was applied as basal dose and remaining P was applied at 105 days after planting. N and K were applied through subsurface drip fertigation as per the fertigation in the intervals of once in 2 days, 4 days and 6 days in136, 68 and 45 equal splits, respectively upto 9 months. Drip irrigation was scheduled uniformly for every two days to all the treatments. Soil application of recommended dose of fertilizer (250: 100: 125 kg N,P_2O_5 and K_2O ha^{-1}) with surface irrigation was considered as conventional method of cultivation of sugarcane.

Viable and healthy two bud setts of variety Co- 86032 were planted in a zig-zag manner in paired row method of planting with spacing of 30 / 165 cm and intra row spacing of 30 cm. Atrazine 50 per cent WP at 1.0 kg aiha^{-1} was sprayed 2 days after planting and two hand weeding were done at 45 and 90 days after planting to control weeds. Optimum plant population was maintained by filling the gaps at 30 DAP. Earthing up was carried out twice by tractor drawn implement. In each plot, five plants were selected randomly and tagged for recording growth and yield observations as per standard procedures and B : C ratio was calculated by using net returns and cost of cultivation. The data was statistically analyzed by following the method of Gomez and Gomez (1984).

Results and Discussion

Yield and yield attributes of sugarcane were significantly influenced by fertigation intervals and levels of fertilizer and were not significantly influenced by interactions between fertigation intervals and levels of fertilizer (Table I).

Fertigation once in 2 days, irrespective of levels of fertilizer, resulted in significantly 19.8 per cent higher cane yield (281.4 t ha^{-1}) than fertigation once in 6 days (235.0 t ha^{-1}) and was on par with fertigation once in 4 days(267.5 t ha^{-1}). Significantly maximum cane yield with fertigation once in 2 days (I_2) over fertigation once in 6 days (I_6), higher cane length (222.7 cm compared to 209.5 in I_6), more number of internodes cane^{-1} (21.0 compared to 18.7 in I_6) resulting in significantly higher single cane weight (2.57 kg compared to 2.12 kg in I_6).

Irrespective of fertigation intervals, application of 150 per cent of RDF (F_4) through drip fertigation produced significantly higher cane yield (283.1 t ha^{-1}) than application of 100 (F_2) and 75 (F_1) per cent RDF through drip fertigation (251.7 and 229.7 t ha^{-1}, respectively) and was on par with 125 per cent of RDF through drip fertigation (271.4 t ha^{-1}). Increased sugarcane yield with increase in fertilizer level through subsurface drip fertigation was also reported by Gururaj Kombali *et al.* (2015). Significantly higher cane yield with 150 per cent RDF over 100 and 75 per cent RDF was attributed to significantly more number of millable canes m^{-1} row length (41.3 compared to 36.56 in F_2 and 35.54 in F_1), higher cane length (234.9 cm compared to 205.4 cm in F_2 and 201.5 cm in F_1), more number of internodes cane $^{-1}$ (22.3 compared to 18.9 in F_2 and 18.0 in F_1) and maximum cane girth (10.1 cm compared to 8.9 cm in F_2 and 8.5 cm in F_1). Increased number of millable canes with increase in dose of N, P and K fertilizers from 75 to

TABLE I

Yield and yield parameters of sugarcane as influenced by fertigation intervals and fertilizer levels in subsurface drip fertigation

Treatments	Millable canes m^{-1} row length	Cane length (cm)	Internodes $cane^{-1}$	Cane girth (cm)	Single cane weight (kg)	Cane yield ($t\ ha^{-1}$)
			Fertigation intervals (I)			
I_2	39.40	222.7	21.0	10.11	2.57	281.4
I_4	37.96	212.3	19.4	8.76	2.40	267.5
I_6	36.23	209.5	18.7	8.60	2.12	235
S.Em±	0.58	3.27	0.25	0.01	0.08	5.17
CD (p=0.05)	1.70	9.61	0.72	0.29	0.24	15.15
			Fertigation (F)			
F_1	35.54	201.5	18.0	8.47	1.77	229.7
F_2	36.56	205.4	18.9	8.85	2.20	251.7
F_3	38.04	218.7	19.6	9.23	2.53	271.4
F_4	41.30	234.9	22.3	10.07	2.94	283.1
S.Em±	0.67	3.13	0.28	0.11	0.09	5.96
CD (p=0.05)	1.96	9.17	0.83	0.33	0.28	17.49
			Interactions (I x F)			
I_2F_1	37.27	208.5	19.5	9.38	1.95	251.2
I_2F_2	38.07	212.6	20.1	9.98	2.33	272.7
I_2F_3	39.27	225.4	20.7	10.33	2.79	293.6
I_2F_4	43.00	247.7	23.9	10.67	3.19	308.3
I_4F_1	35.47	199.6	17.6	8.06	1.80	242.5
I_4F_2	36.80	201.4	18.5	8.38	2.27	261.7
I_4F_3	38.23	217.8	19.3	8.76	2.59	278.2
I_4F_4	41.33	230.6	22.3	9.82	2.96	287.7
I_6F_1	33.90	196.4	16.9	7.97	1.56	202.3
I_6F_2	34.80	202.3	18.1	8.13	2.02	227.8
I_6F_3	36.63	213.1	18.9	8.60	2.21	249.4
I_6F_4	39.57	226.3	20.9	9.70	2.67	260.4
S.Em±	0.38	5.42	0.49	0.20	0.16	10.33
CD (p=0.05)	NS	NS	NS	NS	NS	NS
Conventional method	22.83	186.6	14.33	8.16	1.54	158.0

Note:

Fertigation Intervals

I_2: Fertigation once in 2 days

I_4: Fertigation once in 4days

I_6: Fertigation once in 6days

Fertilizer levels

F_1: 75 % RDF

F_2: 100 % RDF

F_3: 125 % RDF

F_4: 150 % RDF

Conventional method: Soil application of 100 % RDF with surface irrigation.

(RDF-250:100:125 N P_2O_5 K_2O kg ha^{-1})

TABLE II

Economics of sugarcane cultivation as influenced by fertigation intervals and fertilizer levels in subsurface drip fertigation

Treatments	Cost of cultivation (₹ -1)	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B : C ratio
I_2F_1	150818	552640	401822	2.66
I_2F_2	154582	599940	445358	2.88
I_2F_3	158346	645920	487574	3.08
I_2F_4	162111	678260	516149	3.18
I_4F_1	147418	533500	386082	2.51
I_4F_2	151182	575740	424558	2.71
I_4F_3	154946	612040	457094	2.85
I_4F_4	158711	632940	474229	2.89
I_6F_1	144018	445060	301042	2.09
I_6F_2	147782	501160	353378	2.39
I_6F_3	151546	548680	397134	2.62
I_6F_4	155311	572880	417569	2.69
Conventional method	113982	347600	236618	2.07

Note :

Fertigation Intervals

I_2: Fertigation once in 2 days

I_4: Fertigation once in 4days

I_6: Fertigation once in 6days

Fertilizer levels

F_1: 75 % RDF

F_2: 100 % RDF

F_3: 125 % RDF

F_4: 150 % RDF

Conventional method: Soil application of 100 % RDF with surface irrigation.

(RDF-250:100:125 $NP_2O_5K_2O$ kg ha^{-1})

(Market price of sugarcane ¹ 2200 t^{-1})

150 per cent RDF through water soluble form under subsurface drip fertigation was also reported by Christy *et al*. (2016).

Interactions between fertigation intervals and fertilizer levels on cane yield were not significant. However higher cane yield (308.30 t ha^{-1}) was recorded with fertigation once in 2 days with 150 per cent RDF. Increased yield and yield parameters of sugarcane under subsurface drip fertigation was attributed to required availability of water and nutrients due to better wetting pattern, water distribution in soil and relative water and nutrient use by the crop throughout the crop growth stage (Deshmukh *et al.,* 2001).

The conventional method of cane cultivation (soil application of recommended dose of fertilizer- 250-100-125 kg N-P_2O_5-K_2O ha^{-1} with surface irrigation) recorded the lowest cane yield of 158 t ha^{-1}. This might be due to considerable wastage of plant nutrients to alternate drying and wetting with loss of nutrients through deep percolation below root zone and volatilization of nitrogen resulting in imbalance in soil water metabolism and nutrient environment (Ridge and Hewson, 2002).

Thus, subsurface drip fertigation once in 2 days with application of 150 per cent RDF through water soluble fertilizers recorded 95 per cent higher cane yield than surface irrigation with 100 per cent RDF in sugarcane. Subsurface drip fertigation once in 2 days with 75 per cent RDF through water soluble fertilizers produced 59 per cent higher cane yield over conventional method, there by 25 per cent of fertilizers could be saved by subsurface drip fertigation once in 2 days.

The cost of production of sugarcane was high in subsurface drip fertigation (₹ 1,44,018 to 1,62,111 ha^{-1}) as compared to that in conventional method of cultivation (₹ 1,13,982 ha^{-1}) (Table II). High cost of production in subsurface drip fertigation was mainly due to high cost of drip fertigation installation and high cost of water soluble fertilizers. But higher net returns (₹ 5,16,149 ha^{-1}) with higher B:C ratio (3.18) was realised with subsurface drip fertigation once in 2 days with application of 150 per cent RDF through water soluble fertilizers as compared to that in drip fertigation once in 4 and 6 days with application of 75, 100 and 125 per cent RDF and conventional method of cane cultivation (₹ 2,36,618 ha^{-1} with B:C ratio of 2.07). Higher net returns with fertigation once in 2 days with application of 150 per cent RDF was attributed to 95 per cent increase in cane yield over conventional method of sugarcane cultivation.

All drip fertigation treatments recorded higher net returns with higher B : C ratio as compared to conventional method of cultivation. Subsurface drip fertigation once in 2 days with 75 per cent RDF through water soluble fertilizers (I_2F_1) gave additional net returns of ₹ 1,65,204 ha^{-1} over conventional method of cultivation. Higher additional net returns in I_2F_1 over conventional method was due to increased cane yield by 59 per cent.

Finally it can be concluded that subsurface drip fertigation once in 2 days with 150 per cent RDF through water soluble fertilizers produced significantly 95 per cent higher cane yield with higher net returns and B: C ratio than conventional method of sugarcane cultivation.

References

Anonymous, 2015, Directorate of Economics and Statistics.*http:/www. Indiastat.com.*

Christy, N. M. P., Jeyasheelan, P. and Anitha, R., 2016, Best suited fertigation schedule and its effect on growth, yield, quality and uptake of nutrients of sugarcane (*Saccharum officinarum* L.) under Sustainable Sugarcane Initiative method. *Res. Crops*, **17** (3) : 616 - 621.

Deshmukh, A. S., Shinde, P. P., Katake, S. S., Phonde, D. B. and Imas, P., 2001, Effect of various levels of potash application through drip irrigation on yield and quality of sugarcane. *Potash Res. Inst. of India*, p. 1 - 7.

Gomez, K. A. and Gomez, A. A., 1984, Statistical procedures for for agricultural research (Ed). A Wiley Inter Science Publication, New York (USA).

Gururaj Kombali, Sheshadri, T., Nagaraju, Thimme Gowda, M. N., Basavaraja, P. K. and Mallikarjuna, G. B., 2015, Performance of sugarcane under varied levels of irrigation and nutrients through subsurface drip fertigation. *Mysore J. Agric. Sci.*, **50** (2) : 290 - 293.

Nanda, R. S., 2010, Fertigation to enhance farm productivity. *Indian J. Fertilizers*, **6** (2) : 13 - 6.

Ravikumar, V., Vijayakumar, G., Simunek, J., Chellamuthu, S., Santhi, R. and Appavu, K., 2011, Evaluation of fertigation scheduling for sugarcane using a vadose zoneflow and transport model, *Agric. Water Manag.*, **98** (1) : 1431 - 1440.

Ridge, D. R. and Hewson, S. A., 2002, Drip irrigation management strategies. Proceedings of the Australian Society of Sugarcane Technologies, **17** : 8 - 15.

Senthil Kumar, R., 2009, Feasibility of drip irrigation in sugarcane. M.Sc. project work submitted to Tamil Nadu Agric. Univ., Coimbatore.

Solomon, S., 2012, Cost effective and input efficient technologies for productivity enhancement in sugarcane. In: 25th meeting of sugarcane research and development workers of A. P. held at Visakhapatnam on 20 - 21st July, 2012, p. 1 - 10.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 402-407, 2017

Influence of Precision Management Practices on Growth and Yield of Drip Irrigated Aerobic Rice

D. S. Prabhudeva and Nagaraju
Department of Agronomy, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: prabhudev15@gmail.com

Abstract

Field experiment was conducted at ZARS, GKVK, UAS, Bengaluru to assess the precision management practices on growth and yield of aerobic rice during summer 2016. The results revealed that, among interactions between nutrient management, planting geometry and water management, application of 25 per cent N&K from sowing to 30 DAS +25 per cent N&K from 31 to 50 DAS +25 per cent N&K from 51 to 80 DAS +25 per cent N&K from 81 to 105 DAS with planting geometry of 25×15 cm and drip irrigation scheduling at 125 per cent PE up to tillering+150 per cent PE from tillering to PI+200 per cent PE from PI to physiological maturity produced significant grain (8.68 t ha^{-1}) and straw (10.80 t ha^{-1}) yield than other interactions and recommended practices in aerobic rice.

Keywords: Precision management practices, aerobic rice, planting geometry, drip irrigation

Rice (*Oryza sativa* L.) is among the most widely used cereals across the globe, grown under diverse range of climatic conditions to feed the mankind. About 75 per cent of the world's rice is produced from 79 m. ha. of irrigated lowland fields that together receive an estimated 24-30 per cent of the world's developed freshwater resources (Bouman *et al.,* 2007). The high productivity of irrigated lowland rice, however, is threatened by increasing water scarcity. In the next 25 years, 15-20 m. ha. of lowland rice in Asia are projected to suffer from water scarcity. A new technology to respond to more severe water shortages is the aerobic rice system, in which specially developed, input – response rice varieties with ''aerobic adaptation'' are grown in well-drained, non-puddled, and unsaturated soils without ponded water just like wheat or maize. Water requirement in aerobic rice systems (with aerobic rice cultivars) were 30-50 per cent less than in flooded systems and the yields were almost 15-20 per cent higher than puddled rice (Nagaraju *et al.,* 2014).

Macronutrients like N, P and K are the most important yield limiting nutrients affecting growth and quality in rice. Nitrogen use efficiency (NUE) of rice is usually low due to volatilization, runoff, denitrification and leaching losses. Moreover, direct seeded rice soils are often exposed to dry and wet conditions and difference in N dynamics and losses pathways often results in different fertilizer recoveries in aerobic soils. Even high and non-synchronous applied nutrients and irrigation water may limit grain yield due to limited grain filling rate by decrease in post-anthesis assimilates translocation (Zhang *et al.,* 2009). Split application is one of strategies for efficient use of N fertilizers throughout the growing season by synchronizing with plant demand and improved N uptake for maximum straw and grain yield. The more precise way of supplying nutrients in split is through fertigation, which is the judicious application of fertilizers through irrigation water, which will maximize the nutrient uptake, while using minimum amount of water and fertilizer. Plant geometry in rice has a direct role on the grain yield, since it is an important yield parameter maintaining inadequate or excess plant population often leads to reduction in yield. So, finding out the optimum split doses of nutrients, plant population and irrigation scheduling is of major importance. Keeping the above facts in mind, the present study was conducted to standardize the precision management practices and to know their effects on growth and yield of aerobic rice

Material and Methods

A field experiment was conducted at Zonal Agricultural Research Station, University of Agricultural Sciences, Bengaluru during summer 2016. The site is located at 13^0 05' 2" N latitude and 77^0 34'

02" E longitude with an altitude of 930 m above mean sea level. The soil of the experimental site was sandy loam. The initial soil pH was 5.93 and electrical conductivity was 0.34 dSm^{-1}. Available nitrogen, phosphorus and potassium were 319.3, 28.4 and 293.0 kg ha^{-1}, respectively. The experiment was laid out in Randomized Complete Block Design with factorial concept (FRCBD) and replicated thrice. Two nutrient management practices (N_1: 50% N&K from sowing to 30 DAS + 25% N&K from 31 to 50 DAS + 25% N&K from 51 to 80 DAS and N_2:25% N&K from sowing to 30 DAS + 25% N&K from 31 to 50 DAS + 25% N&K from 51 to 80 DAS + 25% N&K from 81 to 105 DAS), three planting geometry (P_1: 25×25 cm, P_2: 25×20 cm andP_3: 25×15 cm) and two water management practices (I_1: Drip irrigation at 125% PE up to tillering+150% PE from tillering to PI+200% PE from PI to physiological maturity and I_2: Drip irrigation at 100% PE up to tillering+125% PE from tillering to PI+150% PE from PI to physiological maturity) with one control (Recommended plant population and fertilizer dose with drip irrigation)and one absolute control (no RDF) were included in this study.

The land was brought to fine tilth before sowing by ploughing twice with tractor drawn disc plough and passing cultivator and two harrowing. Drip fertigation system included pump, filter units, fertigation tank, ventury, main line and sub line. Irrigation was provided through laterals separated at 50 cm apart in alternative rows. Inline emitters were at 40 cm apart with discharge rate of 3 lph. Seeds of MAS 946-1 rice variety were dibbled at 2 per hill by following spacing of 25cm × 25cm, 25cm × 20cm and 25cm × 15cm as per the treatment with seed rate of 5 kg ha^{-1}. FYM at 8 tonnes ha^{-1} was applied two weeks before sowing. The required fertilizer nutrients were calculated and was applied as per treatments whereas phosphorous was applied in two equal splits (50 per cent as basal and remaining 50 per cent at 30 DAS) uniform to all the treatments. The recommended dose of fertilizer was 100:50:50 kg N, P_2O_5 and K_2O ha^{-1}. Pre-sowing irrigation was uniformly given to all treatments. According to treatments drip irrigation was scheduled every day based on pan evaporation (Epan). As per treatment requirement fertigation was provided and the fertigation was scheduled at once in four days. Nitrogen and potassium were supplied through urea (46% N) and sulphate of potash (50% K_2O). However for control, muriate of potash used as potassium source and SSP as phosphorus source (for all the treatments). Londax power (Bensulfuron methyl 0.6% + Pretilachlor 6% GR) at 10 kg ha^{-1} was applied at 2 DAS as pre-emergence herbicide. Plant population was maintained according to the treatment by thinning excess seedlings at 21 DAS leaving one seedling per hill. Healthy crop stand was ensured by adopting need based plant protection and recommended package of practices. Five plants were selected at random and tagged. These plants were used for recording plant height, tillers, leaf area and leaf area index. Leaf area was measured using leaf area meter and LAI was calculated as ratio of leaf area per plant to area occupied by the plant. Yield attributes like number of productive tillers $hill^{-1}$, panicle length, panicle weight, grains $panicle^{-1}$, 1000 grain weight, grain yield, straw yield were recorded.The data was statistically analysed following standard procedures.

Results and Discussion

Growth parameters of aerobic rice

Growth parameters of rice were significantly influenced by precision management practices (Table I). Significantly higher plant height (93.4 cm), numbers of tillers (28.86 $hill^{-1}$), total dry matter accumulation (127.51 g $hill^{-1}$) at harvest and leaf area (3324.99 cm^2 $hill^{-1}$) and LAI (6.87) at 90 DAS were recorded in the treatment receiving 25 per cent N&K from sowing to 30 DAS +25 per cent N&K from 31 to 50 DAS +25 per cent N&K from 51 to 80 DAS +25 per cent N&K from 81 to 105 DAS (N_2) as compared to treatment receiving 50 per cent N&K from sowing to 30 DAS +25 per cent N&K from 31 to 50 DAS +25 per cent N&K from 51 to 80 DAS (N_1). This increase in growth parameters was attributed to timely supply of nutrients as per crop needs which increases photosynthetic area of crop and thereby higher assimilation of photosynthates. Similar findings were also reported by Vanitha and Mohandass (2014) in aerobic rice.

Planting geometry of 25×15 cm *i.e.* 26 hills m^{-2} recorded significantly higher plant height (91.0 cm) at harvest and LAI (7.49) at 90 DAS. Higher plant height

TABLE I

Growth parameters of aerobic rice as influenced by precision management practices under drip irrigation

Treatments	Plant height (cm)	No. of tillers hill^{-1}	Leaf area (cm^2 hill^{-1})	LAI	Total dry matter accumulation (g hill^{-1})
Nutrient management (N)					
N_1	84.1	23.64	2723.99	5.61	87.68
N_2	93.4	28.86	3324.99	6.87	127.51
S. Em±	0.75	0.34	38.85	0.08	1.27
C. D.@5%	2.17	0.98	112.94	0.23	3.69
Planting geometry (P)					
P_1	85.8	28.38	3269.94	5.23	121.20
P_2	89.5	25.98	2993.45	5.99	107.47
P_3	91.0	24.39	2810.08	7.49	94.12
S. Em±	0.91	0.41	47.58	0.10	1.55
C. D.@5%	2.66	1.20	138.33	0.29	4.52
Water management (I)					
I_1	90.2	26.81	3088.17	6.38	111.18
I_2	87.4	25.70	2960.81	6.10	104.01
S. Em±	0.75	0.34	38.85	0.08	1.27
C. D.@5%	2.17	0.98	112.94	0.23	3.69
Nutrient management x Planting geometry x Water management (N x P x I)					
$N_1P_1I_1$	82.4	26.13	3010.73	4.82	103.36
$N_1P_1I_2$	81.3	25.80	2972.33	4.76	97.47
$N_1P_2I_1$	85.9	23.30	2684.31	5.37	92.04
$N_1P_2I_2$	83.7	22.90	2638.23	5.28	83.58
$N_1P_3I_1$	86.4	22.87	2634.39	7.03	77.77
$N_1P_3I_2$	84.8	20.87	2403.97	6.41	71.84
$N_2P_1I_1$	91.2	31.57	3636.68	5.82	145.98
$N_2P_1I_2$	88.2	30.03	3460.03	5.54	137.99
$N_2P_2I_1$	95.6	29.57	3406.27	6.81	130.23
$N_2P_2I_2$	92.9	28.17	3244.98	6.49	124.01
$N_2P_3I_1$	99.4	27.40	3156.66	8.42	117.71
$N_2P_3I_2$	93.2	26.43	3045.29	8.12	109.14
Control	75.3	18.21	2097.91	4.20	66.76
Absolute control	60.7	15.55	1792.23	3.58	44.83
S. Em±	1.83	0.83	95.17	0.20	3.11
C. D.@5%	3.76	2.40	276.6	0.57	9.03

Note: CD-Critical difference, NS-Non-significant

N_1: 50% N&K from sowing to 30 DAS +25% N&K from 31 to 50 DAS +25% N&K from 51 to 80 DAS

N_2:25% N&K from sowing to 30 DAS +25% N&K from 31 to 50 DAS +25% N&K from 51 to 80 DAS +25% N&K from 81 to 105 DAS

P_1: 16 hills m^{-2} (25×25 cm),P_2: 20 hills m^{-2} (25×20 cm), P_3: 26 hills m^{-2} (25×15 cm)

I_1: Drip irrigation at 125% PE up to tillering+150% PE from tillering to PI+200% PE from PI to physiological maturity

I_2: Drip irrigation at 100% PE up to tillering+125% PE from tillering to PI+150% PE from PI to physiological maturity

Control: Recommended plant population with soil application of fertilizer dose and drip irrigation

Absolute Control: (No RDF and drip irrigation) under higher plant density might be due to competition between individual plants for space and nutrients there by instead of horizontal spread, plant has shown more vertical growth under high population level. Similar results were also observed by Shashidhar (2011). Whereas, 25×25 cm *i.e.* 16 hills m^{-2} recorded significantly more numbers of tillers (28.38 $hill^{-1}$), total dry matter accumulation (121.20 g $hill^{-1}$) at harvest and leaf area (3269.94 cm^2 $hill^{-1}$) at 90 DAS.Wider spacing had linearly increasing effect on the performance of individual plants. The plants grown with wider spacing have more area of land around them to draw nutrients and had more solar radiation to absorb for better photosynthetic process and hence performed better as individual plants (Shashidhar, 2011).

Among water management practices, drip irrigation scheduling at 125 per cent PE up to tillering+150 per cent PE from tillering to PI+200 per cent PE from PI to physiological maturity (I_1) recorded significantly higher growth parameters *viz.,* higher plant height (90.2 cm), numbers of tillers (26.81 $hill^{-1}$), total dry matter accumulation (111.18 g $hill^{-1}$) at harvest and leaf area (3088.17 cm^2 $hill^{-1}$) and LAI (6.38) at 90 DAS as compared to drip irrigation scheduling at 100 per cent PE up to tillering+125 per cent PE from tillering to PI+150 per cent PE from PI to physiological maturity (I_2). This might be due to availability of adequate moisture at different growth stages and continuous optimum soil moisture status in soil layer throughout the growth stages resulted in higher growth of the plant. Similar results were also reported by Balamani *et al.* (2012).

The interaction effect of nutrient management, planting geometry and water management with control and absolute control found to be significant. Application of 25 per cent N&K from sowing to 30 DAS +25 per cent N&K from 31 to 50 DAS +25 per cent N&K from 51 to 80 DAS +25 per cent N&K from 81 to 105 DAS with planting geometry of 25×25 cm and drip irrigation scheduling at 125 per cent PE up to tillering+150 per cent PE from tillering to PI+200 per cent PE from PI to physiological maturity recorded more growth parameters than other interactions, control and absolute control. In control, soil application of nutrients only in two splits resulted in inadequate availability to the growing plants leading to reduced growth parameters.

Yield and yield parameters of aerobic rice

Yield attributes like number of productive tillers $hill^{-1}$, panicle length, panicle weight, test weight, total number of grains $panicle^{-1}$, grain yield and straw yield were favourably influenced by different precision management practices (Table II). Among nutrient management practices, N_2 *i.e.* 25 per cent N&K from sowing to 30 DAS +25 per cent N&K from 31 to 50 DAS +25 per cent N&K from 51 to 80 DAS +25 per cent N&K from 81 to 105 DAS recorded significantly higher number of productive tillers (23.05 $hill^{-1}$), panicle length (23.80 cm), panicle weight (4.02 g), thousand grain weight (25.92 g), total number of grains (198.71 $panicle^{-1}$), grain yield (7.57 t ha^{-1}) and straw yield (9.43 t ha^{-1}) as compared to N_1 *i.e.* 50 per cent N&K from sowing to 30 DAS +25 per cent N&K from 31 to 50 DAS +25 per cent N&K from 51 to 80 DAS. Availability of nutrients to crop at all critical growth stages and better translocation of assimilates to panicles during anthesis resulted in high yield parameters and grain yield (Patel *et al.,* 2010).

Among 3 different planting geometries, significantly higher number of productive tillers (23.05 $hill^{-1}$), panicle length (23.79 cm), panicle weight (4.02 g), thousand grain weight (25.92 g), and total number of grains (198.71 $panicle^{-1}$) were recorded in planting geometry of 25×25 cm but the higher grain yield of 7.17 t ha^{-1} and straw yield of 8.96 t ha^{-1} was recorded in case of planting geometry of 25×15 cm. Planting geometry of 25 cm x 15 cm accommodated more number of plants per unit area than 25 cm x 25 cm and provided optimum space for light interception, nutrient absorption and weed suppression. Hence the higher yield was observed in case of planting geometry of 25 cm x 15 cm. These results are in accordance with the findings of Sultana *et al.* (2012).

Significantly higher number of productive tillers (21.57 $hill^{-1}$), panicle length (22.15 cm), panicle weight (3.74 g), thousand grain weight (24.12 g), total number of grains (172.30 $panicle^{-1}$), grain yield (6.56 t ha^{-1}) and straw yield (8.22 t ha^{-1}) were recorded when drip irrigation scheduling at 125 per cent PE up to tillering+150 per cent PE from tillering to PI+200 per

TABLE II

Yield parameters and yield of aerobic rice as influenced by precision management practices under drip irrigation

Treatments	No. of productive tillers hill^{-1}	Panicle length (cm)	Panicle weight (cm)	Thousand grain weight (g)	Total No. of grains panicle^{-1}	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
			Nutrient management (N)				
N_1	19.49	19.67	3.36	21.43	134.88	5.14	6.48
N_2	23.05	23.79	4.02	25.92	198.71	7.57	9.43
S.Em±	0.25	0.16	0.03	0.19	1.97	0.08	0.09
C.D. (P=0.05)	0.74	0.48	0.09	0.57	5.74	0.22	0.27
			Planting geometry (P)				
P_1	22.85	23.16	3.91	25.23	188.17	5.54	6.96
P_2	21.15	21.78	3.68	23.73	166.78	6.35	7.95
P_3	19.82	20.26	3.48	22.07	145.45	7.17	8.96
S.Em±	0.31	0.20	0.04	0.24	2.42	0.09	0.11
C.D. (P=0.05)	0.91	0.58	0.11	0.69	7.03	0.27	0.33
			Water management (I)				
P_1	22.85	23.16	3.91	25.23	188.17	5.54	6.96
P_2	21.15	21.78	3.68	23.73	166.78	6.35	7.95
P_3	19.82	20.26	3.48	22.07	145.45	7.17	8.96
S.Em±	0.31	0.20	0.04	0.24	2.42	0.09	0.11
C.D. (P=0.05)	0.91	0.58	0.11	0.69	7.03	0.27	0.33
		Nutrient management x Planting geometry x Water management (N x P x I)					
$N_1P_1I_1$	20.74	21.48	3.63	23.40	159.25	4.57	5.75
$N_1P_1I_2$	20.68	21.13	3.57	23.02	150.24	4.20	5.31
$N_1P_2I_1$	19.45	20.33	3.43	22.15	141.23	5.38	6.81
$N_1P_2I_2$	19.23	19.11	3.23	20.82	128.28	4.89	6.18
$N_1P_3I_1$	18.72	18.90	3.19	20.58	120.05	6.07	7.64
$N_1P_3I_2$	18.13	17.10	3.10	18.63	110.25	5.72	7.21
$N_2P_1I_1$	25.39	25.22	4.26	27.48	227.77	6.92	8.71
$N_2P_1I_2$	24.57	24.82	4.19	27.04	215.43	6.47	8.07
$N_2P_2I_1$	23.54	24.06	4.06	26.21	203.96	7.77	9.63
$N_2P_2I_2$	22.38	23.63	3.99	25.74	193.64	7.38	9.17
$N_2P_3I_1$	21.59	22.89	3.87	24.93	181.56	8.68	10.80
$N_2P_3I_2$	20.83	22.15	3.74	24.13	169.93	8.21	10.21
Control	16.10	16.34	3.04	18.28	102.90	3.92	4.94
Absolute control	10.28	12.82	2.25	17.30	69.04	2.63	3.32
S. Em±	0.62	0.40	0.08	0.48	4.84	0.18	0.23
C. D.@5%	1.81	1.16	0.22	1.38	14.05	0.53	0.66

Note: CD-Critical difference, NS-Non-significant

N_1: 50% N&K from sowing to 30 DAS +25% N&K from 31 to 50 DAS +25% N&K from 51 to 80 DAS

N_2:25% N&K from sowing to 30 DAS +25% N&K from 31 to 50 DAS +25% N&K from 51 to 80 DAS +25% N&K from 81 to 105 DAS

P_1: 16 hills m^{-2} (25×25 cm), P_2: 20 hills m^{-2} (25×20 cm), P_3: 26 hills m^{-2} (25×15 cm)

I_1: Drip irrigation at 125% PE up to tillering+150% PE from tillering to PI+200% PE from PI to physiological maturity

I_2: Drip irrigation at 100% PE up to tillering+125% PE from tillering to PI+150% PE from PI to physiological maturity

Control: Recommended plant population with soil application of fertilizer dose and drip irrigation

Absolute Control: (No RDF and drip irrigation) cent PE from PI to physiological maturity (I_1) compared to those with 100 per cent PE up to tillering+125 per cent PE from tillering to PI+150 per cent PE from PI to physiological maturity (I_2). Higher yield and yield component in I_1 might be due to adequate moisture regime and more frequent wettings at later stages of crop growth which might have facilitated to survive more number of productive tillers and to improve other yield attributes resulting in higher grain and straw yield (Shekara *et al.,* 2010).

The interaction effect of nutrient management, planting geometry and water management with control and absolute control found to be significant. Application of 25 per cent N&K from sowing to 30 DAS +25 per cent N&K from 31 to 50 DAS +25 per cent N&K from 51 to 80 DAS +25 per cent N&K from 81 to 105 DAS with planting geometry of 25×15 cm and drip irrigation scheduling at 125 per cent PE up to tillering+150 per cent PE from tillering to PI+200 per cent PE from PI to physiological maturity recorded higher grain (8.68 t ha^{-1}) and straw (10.80 t ha^{-1}) yield than other interactions, control and absolute control. This might be due to adequate supply of required plant nutrients and water at later stages of crop growth. These results are in accordance with the findings of Sundrapandiyan (2012).

From the study, it can be concluded that application of N&K in 4 equal splits upto 105 DAS with plant density of 26 hills m^{-2} and drip irrigation at 125 per cent PE up to tillering+150 per cent PE from tillering to PI+200 per cent PE from PI to physiological maturity are the best precision management practices in rice for realising higher grain yield (8.68 t ha^{-1}).

References

Balamani, K., Ramulu, M., Reddy, D. M. and Umadevi, M., 2012, Effect of irrigation methods and irrigation schedules on aerobic rice *(Oryza sativa* L.*). J. Res. ANGRAU.,* **40** (4) : 84 - 86.

Bouman, B. A. M., Humphreys, E., Tuong, T. P. and Barker, R., 2007, Rice and water. *Adv. Agron.,* **92** : 187 - 234.

Nagaraju, Anusha, S., Gururaj Kombali, Rekha, B., Sheshadri, T. and Shankar, M. A., 2014, Drip irrigation and fertigation in direct seeded aerobic rice in Karnataka, India- research status. In: *Proc. 4th international rice congress* 27th Oct. - 1st Nov., Bangkok, Thailand, p. 1042 - 1043.

Patel, D. P., Das, A., Munda, G. C., Ghosh, P. K., Borodoloi, J. S. and Kumar, M., 2010. Evaluation of yield and physiological attributes of high-yielding rice cultivars under aerobic and flood-irrigated management practices in mid-hills ecosystem. *Agric. Water Manage.,* **97** : 1269 - 1276.

Shashidhar, B. N., 2011, Influence of plant density and method of establishment on the performance of hybrid rice under aerobic methods of cultivation. *M.Sc. (Agri.) Thesis* (Unpub.), Univ. Agric. Sci., Bengaluru.

Shekara, B. G., Sharanappa and Krishnamurthy, N., 2010, Effect of irrigation schedules on growth and yield of aerobic rice (*Oryza sativa* L.) under varied levels of farm yard manure in Cauvery command area. *Indian J. Agron*., **55** : 35 - 39.

Sultana, M. R., Rahman, M. M. and Rahman, M. H., 2012, Effect of row and hill spacing on the yield performance of boro rice (cv. BRRI dhan45) under aerobic system of cultivation. *J. Bangladesh Agril. Univ.,* **10** (1) : 39 - 42.

Sundrapandiyan, R., 2012, Study on the effect of drip biogation on the productivity of aerobic rice, *M. Sc. (Agri.) Thesis*, Tamil Nadu Agril. Univ., Coimbatore.

Vanitha, K. and Mohandass, S., 2014, Effect of humic acid on plant growth characters and grain yield of drip fertigated aerobic rice (*Oryza sativa* L.). *The Bioscan,* **9** (1) : 45 - 50.

Zhang, L. S., Lin, B. A. M., Bouman, C., Xue, F., Wei, H., Tao, X., Yang, H., Wang, D., Zhao and Dittert, K., 2009, Response of aerobic rice growth and grain yield to N fertilizer at two contrasting sites near Beijing, China. *Field Crops Res.,* **114** : 45 - 53.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 408-413, 2017

Genetic Coefficient Calibration for Pigeonpea Cultivars in DSSAT Simulation Model Under Varied Dates of Sowing

SHARANAPPA KURI AND H. S. SHIVARAMU
Department of Agronomy, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: sharank26@gmail.com

ABSTRACT

Decision Support System for Agro-technology Transfer (DSSAT) CROPGRO model is worldwide accepted for yield prediction. CROPGRO - Pigeonpea is added in newer version 4.6.1 of DSSAT. An attempt to calibrate the genetic coefficients for two cultivars (TTB-7 and BRG-2). The experiment was conducted at UAS, GKVK, Bengaluru during 2015-16 and 2016-17. The results revealed that the model under estimated the yield for all combination of two cultivars and dates of sowing for both the year. The maximum difference of observed and simulated yield was found for TTB-7 compared to BRG-2; similarly, 2016-17 compared to 2015-16 and for second date sown crop compared to others. Statistical measures like relative mean error (ME), rootmean square error (RMSE), coefficient of residual mass (CRM) and modeling efficiency (EF) were used to evaluate the model. Model performance for genetic coefficients generated from combination of dates of sowing for both cultivars were inferior or on par with models run with coefficients generated individually. Evaluation show that model with coefficients generated from second date sown crop during 2015-16 is better than other models for both cultivars. So as a future line of work these coefficients are to be fine tuned and calibrated.

Keywords: DSSAT, CROPGRO-Pigeonpea, observed yield simulated

PIGEONPEA (*Cajanus cajan* (L.) Millsp) commonly known as red gram or arhar is the second most important pulse crop in India after chickpea. It is mainly cultivated and consumed in developing countries of the world. India is the largest producer and consumer of pigeonpea in the world. It accounts for about 11.8 per cent of the total pulse area and 17 per cent of total pulse production of the country. It is the rich source of protein and supplies a major share of the protein requirement of the vegetarian population of the country. It contains about 22 per cent protein which is almost three times than that of cereals. The pigeonpea grown in India in an area of 3.71 million hectares with production of 2.78 million tonnes with, the average yield 7.50 q ha^{-1} (Anon., 2015). In Karnataka, it is cultivated in an area of 0.73 million hectares with an annual production of 0.48 million tonnes. The average productivity of this crop in Karnataka is 6.58 q ha^{-1} (Anon., 2015). The major pigeonpea producing states are Maharashtra, Madhya Pradesh, Karnataka, Gujarat and Jharkhand (Anon., 2015).

In Karnataka, about 80 per cent of the crop is grown under rain-fed condition and due to vagaries of monsoon the year-to-year yield fluctuations are more. The productivity of pigeonpea is curtailed due to biotic and abiotic stresses. Weather is one of the important abiotic stress factor, which affects all stages of pigeonpea growth and finally the yield. The crop yield simulation models show considerable potential to evaluate crop cultivars, cropping pattern, sowing time and genetic potential pattern for yield. The Decision Support System for Agro-technology Transfer (DSSAT) has been found to be most widely used decision support system which includes models for cereals, legumes, oilseed and vegetable crops (Hoogenboom, 2000). Though different workers have evaluated the CROPGRO model for other crops *viz*. Suriharan *et al*. (2008) and Patel *et al*. (2013) validated the CROPGRO model for groundnut. Bhatia *et al*. (2008) for soybean and Srivastava *et al*. (2016) for chickpea. There is limited work on CROPGRO-Pigeonpea modeling. In this paper an attempt has been made to calibrate the DSSAT model for pigeonpea.

Material and Methods

The input data required for running the crop simulation model (CROPGRO-Pigeonpea) of DSSAT (version 4.6.1) includes crop data, daily weather data, soil data and crop specific genetic coefficients.

Crop management data : To evaluate the model, field experiments were conducted at UAS, GKVK, Bengaluru (Lat. 13° 05'N and Long.77° 34'E and altitude of 924 meters above MSL) with three dates of sowing (Table I) and two cultivar (V1: TTB-7 and V2: BRG-2) during *Kharif* seasons of 2015-16 and 2016-17. Soil and crop management practices are same for all treatments as per UAS, GKVK, Bengaluru package of practices. Details of genetic expressions of selected cultivar were based on results from research work of Satheesh Naik *et al*., 2012 and Yadav *et al*. (2016).

Table I

Dates of sowing for two year experiment

Date of sowing	Year	
	2015 - 16	2016 - 17
D_1	28 th May	30 th May
D_2	20 th June	16 th June
D_3	28 th July	29 th July

The daily weather data from 2015 to 2017 were collected from Agrometeorology observatory situated nearby (within 100 meter) the experimental plots. The layer wise soil physical composition (sand, silt and clay percentage), textural class, physical constrains (bulk density), soil chemical properties (soil pH, cation exchange capacity, organic carbon content and total N content) and soil *albedo* were recorded from the experimentation site.

The genetic coefficients for both cultivars are derived from field experimentation of two year. The genetic coefficients of pigeonpea were estimated by repeated iterations until a close match between simulated and observed phenology and yield was obtained inrespective treatments.

The statistical approach of model evaluation, involved the use of the following model evaluators as proposed by Loague and Green (1991): the relative mean error (ME) percentage, root mean square error (RMSE), coefficient of residual mass (CRM) and modeling efficiency (EF).

Relative mean error (ME) percentageis calculated as:

$$\mathrm{ME} = 100\frac{\left(\frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)\right)}{\bar{O}}$$

Coefficient of residual mass (CRM) : The CRM is a measure of the tendency of the modelto overestimate or underestimate the measurements. Positive values for CRM indicatethat the model underestimates the measurements and negative values for CRM indicatea tendency to overestimate.The CRM is defined by

$$\mathrm{CRM} = \left(\sum_{i=1}^{n}(O_i) - \sum_{i=1}^{n}(P_i)\right) \Big/ \sum_{i=1}^{n}(O_i)$$

Root mean square error (RMSE): The RMSE values show how much thesimulations overestimate or underestimate the measurements.RMSE tests the accuracy of the model and set of RMSE values were calculated. A smaller RMSE indicated less deviation of the simulated from the observed values.

$$\mathrm{RMSE} = \left(\frac{1}{n}\sum_{i=1}^{n}(P_i - O_i)^2\right)^{\frac{1}{2}}$$

Modeling efficiency (EF): The EF value compares the simulated values to the average value of the measurements.A negative EF value indicates that the average value of the measurements gives a betterestimate than the simulated values.

$$\mathrm{EF} = \left(\sum_{i=1}^{n}(O_i - \bar{O})^2 - \sum_{i=1}^{n}(P_i - O_i)\right) \Big/ \sum_{i=1}^{n}(O_i - \bar{O})^2$$

Where, P_i = yield predicted by the model; n = number of samples

O_i = yield observed, $\bar{O}$ = mean of all O_i values.

Results and Discussion

The seed yield of two cultivars TTB-7 and BRG-2, three dates of sowing (D_1, D_2 and D_3) with two years (2015-16 and 2016-17) model under estimated compared to the observed yield (Table II).

TABLE II

Observed and simulated yield (kg ha^{-1}) under different dates of sowing and cultivars of pigeonpea.

Treatments		2015 - 16		2016 - 17	
Cultivars	Date of sowing	Observed	Simulated	Observed	Simulated
TTB-7	D_1	1462.8	587	1030.2	128
	D_2	994.0	559	932.9	78
	D_3	866.7	248	443.2	21
BRG-2	D_1	1316.6	601	1024.4	133
	D_2	963.6	441	874.5	55
	D_3	708.6	343	395.9	31

This is due to the genetic coefficients are not yet stabilized. Because, process of stabilization requires minimum of four to five years experimental data under normal weather situation. Similar results are found for rice by Sreenivas and Reddy (2013). Yadav *et al.* (2012); Singh *et al.* (2014) also observed that the yield and yield attributes of groundnut as simulated by PNUTGRO model showed lesser efficiency when number of experimental years were minimum. Having said this, both the years under the research period being drought hit added to the lower efficiency of the model. Srivastava *et al*., 2016 observed that the crop models were calibrated for unlimited water conditions. However, such results need to be used cautiously as the model has its inherent error in simulation.

The maximum difference was found for TTB-7 cultivar compared to BRG-2. This is substantiated by the results as expressed by Yadav *et al.*, 2016 that modeling in determinate and longer duration cultivars are tough than the shorter duration cultivars.

Genetic coefficients generated from 2016-17 recorded lower simulated and observed yield compared to 2015-16. 2016-17 weather condition experienced more water stress during reproductive stage of crop. Among the dates of sowing, D_1 (May) month sowing pigeonpea recorded higher yield compared to D_2 (June) and D_3 (July) month of both the years. Delayed planting of long duration pigeonpea, cultivar reduces the pod filling period, biomass and seed yield. The date of sowing causes the change in crop growing environment specially the precipitation, thermal requirement and solar radiation received by the crop

TABLE III

The relative mean error (ME) percentage, rootmean square error (RMSE), coefficient of residual mass (CRM) and modeling efficiency (EF) of DSSAT CROPGRO-Pigeonpea model

	ME (%)	RMSE	CRM	EF
2015-16	-335.8	376264	0.56	1.01
2016-17	-543.1	553733	0.91	1.01
TTB-7	-309.0	295876	0.51	1.01
BRG-2	-549.3	711441	0.92	1.01
D_1	-280.1	721917	0.70	1.02
D_2	-279.6	466114	0.70	1.34
D_3	-293.5	206964	0.73	1.01
2015-16*TTB-7	-174.2	446347	0.58	1.01
2015-16*BRG-2	-161.0	306181	0.54	1.01
2016-17*TTB-7	-271.7	574357	0.91	1.01
2016-17*BRG-2	-271.4	533109	0.90	1.01
D_1*BRG-2	-137.3	653339	0.69	1.04
D_2*BRG-2	-146.0	472189	0.73	1.34
D_3*BRG-2	-132.3	133408	0.66	1.01
D_1*TTB-7	-142.6	790495	0.71	1.02
D_2*TTB-7	-133.9	460040	0.67	1.69
D_3*TTB-7	-158.9	280521	0.79	1.01
2015-16*D_1	-114.5	639555	0.57	1.15
2016-17*D_1	-174.6	804279	0.87	107.63
2015-16*D_2	-97.8	231011	0.49	3.03
2016-17*D_2	-185.3	701217	0.93	1.98
2015-16*D_3	-125.0	258227	0.62	1.08
2016-17*D_3	-187.6	155702	0.94	1.70

canopy (Majumdar, 2011). These results indicated that modification should be incorporated in the model for acceptable yield simulation results.

Statistical evaluation of experimental yield using ME, RMSE, CRM and EF are presented (Table III). Simulation of TTB-7 grain yield was in good agreement with the observed values with comparatively low ME (-309.0), RMSE (295876) and CRM (0.51) than the BRG-2ME (-549.3), RMSE (711441) and CRM (0.92). But both are very far from observed seed yield, so that further calibrations are must. As a step towards calibration we have tested the coefficients for different combinations of dates of sowing over the years. The model performance for yield simulation for both the cultivars and different date of sowing under both years were not within the acceptable limit (±20%).

Lesser values of ME, RMSE and CRM for 2015-16 (-335.8, 376264 and 0.56, respectively) compared to 2016-17 (-543.1, 553733 and 0.91, respectively) indicated that the coefficients for 2015-16 are nearer to actual coefficients. However, need to be calibrated further.

TABLE IV

Genetic coefficients of pigeonpea cultivars TTB-7 and BRG-2.

Genetic Parameter	Description	TTB - 7	BRG - 2
CSDL	Critical short day length below which reproductive development progresses with no day length effect (for short day plants) (hour)	12.00	12.00
PPSEN	Slope of the relative response of development to photoperiod with time (positive for short day plants) (1/hour)	0.35	0.35
EM-FL	Time between plant emergence and flower appearance (R1) (photothermal days)	70.4	68.5
FL-SH	Time between first flower and first pod (R3) (photothermal days)	10.4	10.1
FL-SD	Time between first flower and first seed (R5) (photothermal days)	23.7	20.2
SD-PM	Time between first seed (R5) and physiological maturity (R7) (photothermal days)	60.04	55.84
FL-LF	Time between first flower (R1) and end of leaf expansion (photothermal days)	58.37	50.63
LFMAX	Maximum leaf photosynthesis rate at 30°C, 350 vpm Co2, and high light (mg Co_2/m^2 s)	1.10	1.10
SLAVR	Specific leaf area of cultivar under standard growth conditions (cm^2/g)	320.0	320.0
SIZLF	Maximum size of full leaf (three leaflets) (cm^2)	172.0	172.4
XFRT	Maximum fraction of daily growth that is partitioned to seed + shell	0.85	0.80
WTPSD	Maximum weight per seed (g)	0.11	0.14
SFDUR	Seed filling duration for pod cohort at standard growth conditions (photothermal days)	50.0	45.0
SDPDV	Average seed per pod under standard growing conditions (#[seed]/pod)	3.3	3.3
PODUR	Time required for cultivar to reach final pod load under optimal conditions (photothermal days).	25.0	22.0
THRESH	The maximum ration of seed (seed/seed + shell) at maturity	75.0	70.0
SDPRO	Fraction protein in seed (g[protein]/g[seed])	0.225	0.225
SDLIP	Fraction oil in seeds (g(oil)/g(seed))	0.015	0.015

Among the dates of sowing, D_2 (June) the simulated grain yield was in good agreement with the observed values with comparatively low in ME (-279.6), RMSE (466114) and CRM (0.70) than the D_1 (May) and D_3 (July) sowing.

As an attempt, coefficients for interaction of dates of sowing of both cultivars over different years were generated and evaluated. Initially combination of year and cultivars were considered. Lower ME (-161.0), RMSE (306181) and CRM (0.54) values for 2015-16 for both cultivars showed that 2015-16 is superior to 2016-17. Similar results were seen when years were considered individually so this combination is of no use for calibration. Model performance for combination of dates of sowing for both cultivars were inferior or on par with models run with coefficients generated individually.

Higher model efficiency of 107.63 for first date sown crop during 2016-17 is attributed to the reason that the ratio (TTB-7:0.125 and BRG-2: 0.129) of actual and simulated yield is almost same. Sreenivas and Reddy (2013) also quoted that the inherent error of the model could be systematic which cannot be corrected using genetic coefficients. Further, he added saying that sometimes the ratio obtained can be permanent correction for other models.

Interestingly combination of year and dates of sowing for both cultivars had lower ME (-97.8), RMSE (231011) and CRM (0.49) for 2015-16 second date sown crop. So, we conclude that coefficients generated from this combination are more applicable and needs further attention. Final set of genetic coefficients obtained from the said combination is present (Table-IV).

DSSAT model has proved to be robust and valuable tool for predicting yield. CROPGRO-Pigeonpea was started in 2015. As an attempt, experimental results of two years are used for generation of genetic co-efficient. Further these generated coefficients are evaluated statistically. The yield was underestimated by the DSSAT model. Since the present research data base is very less, the process of calibration is incomplete and it has to befine-tuned. The validated DSSAT model has wide range of applications from improving and evaluating the current growth and management practices forprediction of crop growth,phenology, potential and actual yield, performance of pigeonpea under climate change.

References

Anonymous, 2015, Agricultural Statistics at a glance. Visit at: *www.agricoop.nic.in* & *http://eands.dacnet.nic.in*

Bhatia, V. S., Singh, P., Wani, S. P., Chauhan, G. S., Rao Kesava, A. V. R., Mishra, A. K. and Srinivas, K., 2008, Analysis of potential yields and yield gaps of *rainfed* soybean in India using CROPGRO-Soybean model. *Agric. Forest Met.,* **148** : 1252 - 1265.

Hoogenboom, G., 2000, Contribution of agro-meteorology to the simulation of crop production and its application. *Agric. Forest Met.,* **103** : 137 - 157.

Loague, K. M. and Green, R. E., 1991, Statistical and graphical methods for evaluating solute transport model. *J. Contaminated Hyd.,* **7** : 51 - 73.

Majumudar, D. K., 2011, *Pulse crop production: Principles and technologies*. Print House India publisher, p. 62.

Mote, B. M., 2013, Simulation modeling of rice (*Oryza sativa* L.) cultivars using DSSAT model (version 4.5) for South Gujarat heavy rainfall zone. *M. Sc. Thesis* (Unpub.), Navsari Agric. Univ., Navasari, Gujarat.

Patel, H. R., Lunagaria, M. M., Karade, B. L., Pandey, Vyas, Yadav, S. B., Shah, A. V., Rao, V. U. M. and Naresh Kumar, S., 2013, Impact of projected climate change on groundnut in Gujrat. *J. Agrometeorol.* (Special issue), p. 81 - 84.

Satheesh Naik, S. J., Byre Gowda, M., Venkatesha, S. C., Ramappa, H. K., Pramila, C. K., Mary Reena, G. A. and Ramesh, S., 2012, Molecular diversity among pigeonpea genotypes differing in response to pigeonpea sterility mosaic disease. *J. Food Legumes,* **25** (3) : 194 - 199.

Singh, P., Nedumaran, S., Ntare,B. R., Boote, K. J., Singh, N. P., Srinivas, K. and Bantilan, M. C. S., 2014, Potential benefits of drought and heat tolerancein groundnut for adaptation to climate change in

Indiaand West Africa. *An International Journal Devoted to Scientific, Engineering, Socio-Economic and Policy Responses to Environmental Change*, **18**(2) : 1-24.

Sreenivas, G. and Reddy, D. R., 2013, Evaluation of CERES-Rice model under variable weather conditions and nitrogen levels. *Proc. Nation. Symp. Climate Change and Indian Agriculture:Slicing Down the Uncertainties*. Association of Agro-meteorologists-AP Chapter & CRIDA 22-23 Jan 2013, p. 206 (S6-35).

Srivastava, A. K., Sandip Silawat and Agrawal, K. K., 2016, Simulating the impact of climate change on chickpea yield under *rainfed* and irrigated conditions in Madhya Pradesh. *J. Agrometeorol*., **18** (1) : 100 - 105.

Suriharan, B., Patanothai, A., Pannagpetch, K., Jogloy, S. and Hoogenboom, G., 2008, Determination of cultivar coefficients of peanut lines for breeding applications of the CROPGRO-Peanut model. *Crop Sci.,* **47** : 606 - 620.

Yadav, M. K., Singh, R. S., Singh, K. K., Mall, R. K., Chandrabhan Patel, Yadav, S. K. and Singh, M. K., 2016, Assessment of climate change impact on pulse, oilseed and vegetable crops at Varanasi, India. *J. Agrometeorol.,* **18** (1) : 13 - 21.

Yadav, S. B., Patel, H. R., Patel, G. G., Lunagariya, M. M., Karnde, B. I. and Pandey, V., 2012, Calibration andvalidation of groundnut for middle Gujarat agroclimaticzone. *J. Agrometeorol*. (Special issue), **14** : 292 - 297.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 414-419, 2017

Response of Nutrient Management Practices under Rice Establishment Methods

C. S. Shrinivas and N. Krishnamurthy
Department of Agronomy, College of Agriculture, UAS, GKVK, Bengaluru-560 065
Email: shriagron4037@gmail.com

Abstract

Field experiment was conducted at Zonal Agricultural Research Station, V.C. Farm, Mandya, University of Agricultural Sciences, Bengaluru during the *Kharif* season of 2015 to study the response of nutrient management practices under rice establishment methods. The experiment was laid out in split plot design with three replications consisting of twenty treatment combinations. Four establishment methods of rice such as Manual transplanted, Mechanized transplanted, Dibbling of seeds followed by SRI principles, and Wet direct seeded rice by broadcasting were follwed in main plots and five nutrient management practices such as 100 per cent RDF,150 per cent RDF, 75 per cent inorganic + 25 per cent Organic, LCC based N application and UASB POP recommended dose of manure and fertilizers, in sub plot. Among the different establishment methods, Dibbling of seeds followed by SRI principles significantly influenced the growth, yield attributes and yield and was on par with Mechanized transplanted. The plant height (92 cm), number of tillers / hill (25), leaf area / cm^2 / plant (1618), total dry matter (71 g), Root length (24.5 cm) at 90 DAS / T, Root weight (11.73 cm) at 90 DAS / T, Days to maturity (119), number of panicle/m^2 (451), length of panicle (20 cm), weight of 10 panicle (24.5 g), grain yield (5330 kg / ha) and straw yield (6356 kg / ha), were recorded under dibbling of seeds with SRI principlesand lowest growth, yield attributes and yield were recorded under wet direct seeded rice by broad casting during *kharif* season.

Keywords: Machine planting, rice establishment methods, nutrient management, LCC SRI method

Rice (*Oryza sativa*) is the staple food for more than half of the population of the world. The productivity and sustainability of rice-based systems are threatened by the inefficient use of inputs (fertilizer, water, and labour), increasing scarcity of resources, especially water and labour; climate variability, emerging energy crisis and rising fuel prices, rising cost of cultivation and emerging socio-economic changes such as urbanization, migration of labour, preference for non-agricultural work, and concerns about farm-related pollution. Method of establishment influences the performance of rice through its effect on growth and development. Although, transplanting has been reported to be the best establishment method, some alternatives like dry and wet direct seeding are being explored to reduce the cost of cultivation on account of high labour and water requirement. Integrated use of organic manures and chemical fertilizers has advantages over use of only organic manures or chemical fertilizers. Since sourcing of organic manure is difficult and the crop response to them during initial stages is not as spectacular, compared to the chemical fertilizers, an integrated approach of plant nutrition involving the judicious mix of organic, chemical and microbial sources could be helpful to sustain optimum yield and to restore the residual soil fertility.

Material and Methods

The investigation was carried out in the Zonal Agricultural Research Station, Vishveshwarya Canal Farm, Mandya, University of Agricultural Sciences, Bengaluru during the *Kharif* season of 2015. The experimental farm is located at an altitude of 704 m above mean sea level with the geographical location at 12º 34' North latitude and 76º 49' East longitudes comes under Southern dry zone of Karnataka (Zone-VI). The climate of the experimental field is classified as semi arid tropical with high humidity, moderate temperature and medium rainfall. The soil of the experimental plot was sandy loam in texture and well drained with acidic reaction (pH 5.1). Organic carbon content of the soil was found to be medium while available nitrogen was found to be low, phosphorous and potassium were found to be medium. The experiment was laid out in split plot design with three replications consisted of twenty treatment combinations. Four establishment methods of rice such as manual transplanted (M_1), mechanized transplanted (M_2), dibbling of seeds with SRI principles (M_3), and wet direct seeded rice by broadcasting (M_4) were grown in main plots and five nutrient management treatments of rice such as100 per cent RDF (F_1), 150 per cent RDF (F_2),75 per cent inorganic + 25 per cent Organic (F_3), LCC based N application (F_4) and UASB POP recommended dose of manure and fertilizers (F_5), in sub plot. Treatment F_5 UAS package of practices (10 t FYM/ha + 100: 50: 50: kg NPK / ha + 20 kg ZnSo4). The variety IR-30864 was taken as test crop during *kharif*, in manual transplanted 18-20 days old seedlings are transplanted. With respect to mechanized transplanted, fourteen days old seedlings of mat nursery were transplanted with a spacing of 25 x 25 cm, dibbling of seeds with SRI principles, seeds were soaked in water for 24 hours and incubated in dark for 12 hours to induce sprouting which are placed 2-3 seeds per corners of square, marked ropes were used for square planting and for wet direct seeded rice by broadcasting, the seeds are broadcasted at 25 kg / ha seed rate to maintain optimum plant population. Intercultural operations such as gap filling, irrigation and plant protection were carried out as required. The crop was harvested at four different dates depending on the maturity of the varieties manually and grain yield was recorded at 16 per cent moisture level. Data was collected from five hills per plot and then averaged. Observations on growth and yield were recorded during harvesting. Data recorded for different growth and yield parameters was compiled and tabulated in proper form for statistical analysis. Statistical analysis was performed following the method of Gomez and Gomez (1984).

Results and Discussion

Effect of establishment methods and nutrients on growth parameters of rice

Dibbling of seeds followed by SRI principles significantly influenced the plant height, number of tillers, Leaf area and total dry matter production (Table I), root length, root weight and days to maturity (Table II). Dibbling of seeds followed by SRI principles recorded significantly higher growth characters. The maximum plant height (92 cm), number of tillers / hill (25), leaf area (1618), total dry matter production (71 g), root length (24.5 cm), root weight (11.7 g) and days to maturity (119) were recorded under Dibbling of seeds followed by SRI principles which was on par with Mechanized transplanted method on growth parameters like plant height (91 cm), number of tillers / hill (22), leaf area (1577) total dry matter production (68 g), root length (23.2 cm), root weight (10.8 g) and days to maturity (120) in *kharif* season. There was a progressive increase in plant height, number of tillers, leaf area and TDMP under Dibbling of seeds followed by SRI principles system of planting when compared to manual transplanted, and mechanized transplanted methods. Wet direct seeded rice by broadcasting produced lesser plant height (79 cm), number of tillers / hill (16), leaf area (1138) and total dry matter production (52 g), root length (20.6 cm), root weight (8.9 g) and days to maturity (116). Dibbling of seeds followed by SRI principles which might have established quickly in the field due to wider spacing, less competition, without transplanting and started growing at a faster might be attributed to higher plant height. The number of tillers per plant was significantly higher in Dibbling of seeds followed by SRI principles. Dibbling of seeds in square method with wider spacing might have resulted in profused tillering under Dibbling of seeds followed by SRI principles, which might have facilitated plants for better utilization of the resources. This advantage of Dibbling of seeds followed by SRI principles in enhancing tiller numbers, leaf area and total dry matter production root length, root weight may be attributed to young seedlings used for transplanting at shallow depth and wider spacing, which provided good aeration for better establishment of crop. Higher root dry weight and root length in dibbling of seeds followed by SRI principles also led to proliferation of root system by contributing to higher biomass.

Days to maturity was affected by crop establishment methods (Table II). The growth duration of manual transplanting was 7 days more than Dibbling of seeds followed by SRI principles, whereas, it was 3 days more than wet direct seeded rice by broadcasting. Kumar *et al*. (2015) also reported that manual transplanting was 7 days more and matured later by 7

TABLE I

Growth of rice as influenced by response of nutrient management practices under rice establishment methods during Kharif 2015

Treatments	Plant height (cm) at harvest	Number of tillers hill^{-1} at harvest	Lear area (cm2 plant-1) at 90 DAS/T	Total dry matter (g/hill) at harvest
Establishment techniques (M)				
M_1	89	19	1281	60
M_2	91	22	1577	68
M_3	92	25	1618	71
M_4	79	16	1138	52
S.Em±	1	1	16.0	1
C.D. at 5%	2	3	55.4	4
Nutrient management practices (S)				
F_1	87	19	1342	54
F_2	90	23	1487	71
F_3	87	19	1372	60
F_4	89	21	1438	67
F_5	87	19	1378	62
S.Em±	1	1	32	2
C.D. at 5%	2	2	91	5
Interactions				
S.Em±	1.0	2.0	63	3
C.D. at 5%	NS	NS	NS	NS

Methods of crop establishment

M_1: Manual transplanted rice

M_2: Mechanized transplanted rice

M_3: Dibbling of seeds followed by SRI principles

M_4: Wet direct seeded rice by broadcasting (DSR)

DAS/T: Days after sowing / transplanting

Subplot: Nutrient management practices

F_1: 100 % RDF; F_2: 150 % RDF

F_3: 75 % inorganic + 25 % Organic (N equivalent basis)

F_4: LCC based N application

F_5: UASB package of practices (FYM 10 t/ha + 100: 50: 50: kg NPK / ha + 20 kg $ZnSo_4$)

NS: Non significant

days compared to Dibbling of seeds followed by SRI principles which was due to older seedlings and transplanting shock as reported earlier by Rakesh Choudary *et al*. (2016).

Among different nutrient management practices, significantly maximum plant height (90 cm), number of tillers / hill (23), leaf area (1487) and total dry matter production (71 g), root length (24.2 cm), Root weight (11.3 g) and days to maturity (123) were recorded with the application of 150 per cent RDF which was on par with LCC based N application [plant height (89 cm), number of tillers / hill (21), leaf area (1438), total dry matter production (67 g), root length (23.7cm) and root weight (11.0 g)] in *kharif* season. There was a progressive increase in plant height, number of tillers, leaf area and TDMP under 150 per cent RDF and LCC based N application system of planting when compared to UASB Package of practices, 100 per cent RDF and 75 per cent inorganic + 25 per cent

TABLE II

Growth of rice as influenced by response of nutrient management practices under rice establishment methods during Kharif 2015

Treatment	Root length (cm) at 90 DAS/T	Root weight (g.) at 90 DAS/T	Days to maturity
Establishment techniques (M)			
M_1	21.7	9.7	126
M_2	23.2	10.8	120
M_3	24.5	11.7	119
M_4	20.2	8.9	116
S.Em±	0.8	0.5	2
C.D. at 5%	2.8	1.8	5
Nutrient management practices (S)			
F_1	20.7	9.4	118
F_2	24.2	11.3	123
F_3	21.7	9.6	118
F_4	23.7	11.0	120
F_5	21.8	10.2	121
S.Em±	0.6	0.2	1
C.D. at 5%	1.9	0.7	3
Interactions			
S.Em±	1.3	0.5	2.00
C.D. at 5%	NS	NS	NS

Methods of crop establishment

M_1: Manual transplanted rice

M_2: Mechanized transplanted rice

M_3: Dibbling of seeds followed by SRI principles

M_4: Wet direct seeded rice by broad casting (DSR)

DAS/T: Days after sowing/transplanting

Subplot: Nutrient management practices

F_1: 100 % RDF; F_2: 150 % RDF

F_3: 75 % inorganic + 25 % Organic (N equivalent basis)

F_4: LCC based N application

F_5: UASB package of practices (FYM 10 t/ha + 100: 50: 50: kg NPK/ha + 20 kg $ZnSo_4$)

NS: Non significant

Organic. 100 per cent RDF produced lesser plant height (87 cm), number of tillers / hill (19), leaf area (1342) and total dry matter production (54 g), Root length (20.7 cm), Root weight (9.4 g) and Days to maturity (118). Application of nutrients as per crop requirement at various growth stages eventually leads to better utilization of nitrogen for growth and development (Aabid *et al*., 2016). The number of tillers per plant was significantly higher in 150 per cent RDF could attribute to more assured nutrients supply to the plants at active tillering stage. Further, tiller number and leaf size are the two important factors which influence leaf area and these, in turn, are greatly affected by soil nutrient availability. This advantage of application of 150 per cent RDF enhancing tiller numbers, leaf area and total dry matter production, root length, root weight and days to maturity may be attributed to better synchronization in supply and demand of nitrogen at all the critical growth stages. Besides, high leaf area coupled with high chlorophyll content at flowering has been reported to affect the amount of photosynthates available to the panicle (Avijit *et al*., 2011). UASB package of practices (FYM 10 t / ha + 100: 50: 50: kg NPK / ha + 20 kg $ZnSo_4$) and 75 per cent inorganic + 25 per cent Organic produced lesser plant height (87 and 87 cm),

TABLE III

Yields attributes and yield of rice as influenced by response of nutrient management practices under rice establishment methods during Kharif 2015

Treatment	Number of panicles / m^2	Panicle length (cm)	10 Panicle weight (g)	Grain yield (kg / ha)	Straw yield (kg / ha)
Establishment techniques (M)					
M_1	390	18	23.0	4910	5842
M_2	429	20	24.1	5043	6119
M_3	451	20	24.5	5317	6263
M_4	351	18	20.3	4789	5704
S.Em±	8	0	0.7	88	92
C.D. at 5%	26	1	2.5	303	320
Nutrient management practices (S)					
F_1	382	18	21.3	4698	5615
F_2	434	20	24.8	5350	6354
F_3	401	18	22.2	4758	5793
F_4	412	20	24.1	5238	6312
F_5	399	18	22.3	5029	5835
S.Em±	8	0	0.8	105	147
C.D. at 5%	23	1	2.3	302	423
Interactions					
S.Em±	16	1	1.6	209	294
C.D. at 5%	NS	NS	NS	NS	NS

Methods of crop establishment

M_1: Manual transplanted rice

M_2: Mechanized transplanted rice

M_3: Dibbling of seeds followed by SRI principles

M_4: Wet direct seeded rice by broad casting (DSR)

DAS/T: Days after sowing/transplanting

Subplot: Nutrient management practices (05)

F_1: 100 % RDF, F_2: 150 % RDF

F_3: 75 % inorganic + 25 % Organic (N equivalent basis)

F_4: LCC based N application

F_5: UASB package of practices (FYM 10 t/ha + 100: 50: 50: kg NPK/ha + 20 kg $ZnSo_4$)

NS: Non significant

number of tillers / hill (19 and 19), leaf area (1378 and 1372) and total dry matter production (62 and 60 g), root length (21.8 and 21.7 cm), root weight (10.2 and 9.6 g) and days to maturity (121 and 118).

Effect of establishment methods and nutrients on yield attributes and yield of rice

Among the different establishment methods Dibbling of seeds followed by SRI principles significantly influenced the yield attributes and yield like number of panicles / m^2, panicle length, Panicle weight, grain yield and straw yield and recorded significantly higher seed yield (5317 kg / ha) and straw yield (6263 kg / ha) (Table III) which was attributed to higher values of yield components *viz.,* number of panicles / m^2 (451), 10 panicle weight (24.5 g), panicle length (20 cm), which was on par with Mechanized transplanted method [seed yield (5043 kg / ha) and straw yield (6119 kg / ha), number of panicles / m^2 (429), 10 panicle weight (25 g), panicle length (20 cm)]. Optimum plant population and geometry under SRI system of planting led to availability of more resources to the plants that resulted in increased plant height and more number of tillers. This advantage of SRI method in enhancing tiller numbers, leaf area and dry matter production has been reported earlier byJayadeva and Prabhakar Setty (2011) and Senthil Kumar (2016). Wet direct seeded rice by broadcasting produced lesser seed yield (4789 kg / ha) and straw yield (5704 kg / ha), number of panicles / m^2 (351), 10 panicle weight (20.3 g), panicle length (18 cm), which was mainly due to closer spacing of rice seedlings in broadcasting has shown intra-plant competition for same resources resulted in poor growth and yield components.

Among different nutrient management practices, significantly higher seed yield (5350 kg / ha) and straw yield (6354 kg / ha) was recorded in 150 per cent RDFwhich was attributed to higher values of yield components *viz.,* number of panicles / m^2 (434), 10 panicle weight (24 g), panicle length (20 cm), which was on par with LCC based N application on yield and yield attributes [seed yield (5238 kg / ha) and straw yield (6312 kg / ha), number of panicles / m^2 (412), 10 Panicle weight (24.1 g), Panicle length (20 cm)]. There was a progressive increase in yield and yield attributes under 150 per cent RDF and LCC based N application system of planting when compared to UASB Package of practices, 100 per cent RDF and 75 per cent inorganic + 25 per cent Organic. This shows that the supply of nutrients in 150 per cent RDF and LCC based N application matched more effectively with the crop nutrient demand. Improving the synchronization between crop nutrients demand and the available nutrients supply is an important key to improve NUE. Nitrogen losses from soil-plant system are large thereby leading to low fertilizer NUE when nutrients application is not synchronized with crop demand. The results confirm the findings of Gupta *et al*. (2011) and (Avijit *et al*., 2011) and UASB package of practices (FYM 10 t / ha + 100: 50: 50: kg NPK / ha + 20 kg $ZnSo_4$) and 75 per cent inorganic + 25 per cent Organic produced lesser yield and yield attributes seed yield (5029 and 4758 kg / ha) and straw yield (5835 and 5793 kg / ha), number of panicles / m^2 (399 and 401), 10 panicle weight (22.3 and 22.2 g), panicle length (18 and 18 cm). This amply clarifies that the existing recommendation approach of lower rate of nutrients applications at specified growth stages is not adequate to synchronize nutrient supply with actual crop nitrogen demand due to poor NUE and variations in crop N demand and also loss of N results in lower yield and yield attributes.

Thus, the study revealed that after taking into account the overall results of all the observed parameters among different establishment methods of rice, Dibbling of seeds followed by SRI principles and mechanized transplanted are the best adjudged treatments and nutrient management treatments for rice do not match with the crop demand. Hence, 150 per cent RDF recorded significantly higher grain yield but remained on par with LCC based N application. Hence, 150 per cent RDF or LCC based N application is one of the best tool for nutrient management in order to increase grain yield and N-use efficiency of rice for the Southern dry zone of Karnataka.

References

Aabid H. Lone., Najar, G. R., Javid, A., Sofi., Mumtaz A. Ganie and Mir, S. A., 2016, Calibrating leaf colour chart for optimal fertilizer nitrogen management in basmati rice under temperate conditions of Kashmir. *Appl. Biol. Res.,* **18** (3) : 293 - 298.

Avijit, S., Srivastava, V. K., Singh, M. K., Singh, R. K. and Suneel, K., 2011, Leaf colour chart *vis- a vis* nitrogen management indifferent rice genotypes. *American J. Plant Sci.*, **2** : 223 - 236.

Gomez, K. A. and Gomez, A. A., 1984, Statistical procedures for for agricultural research (Ed). A Wiley Inter Science Publication, New York (USA).

Gupta, R. K., Varinderpal Singh., Yadvinder Singh., Bijay Singh., Thind, H. S., Kumar, A. and Vashisat, M., 2011, Need-based fertilizer nitrogen management using leaf colour chart in hybrid rice (*Oryza sativa*). *Indian J. Agric. Sci*., **81** (12) : 1153 - 1157.

Jat, A. L., Srivastava, V. K. and Rajesh Kumar Singh., 2015, Effect of crop-establishment methods and integrated nitrogen management on productivity of hybrid rice (*Oryza sativa*) – wheat (*Triticumaestivum*) cropping system. *Indian J. Agron*., **60** (3) : 341 - 346.

Jayadeva, H. M. and Prabhakar Setty, T. K., 2011, Effect of different sources of nutrients on methane emission of rice under different crop establishment techniques. *J. Agric. Res. Technol*., **36** (2) : 196 - 200.

Kumar, A., Kumar, S., Dahiya, K., Kumar, S. and Kumar, M., 2015, Productivity and economics of direct seeded rice (*Oryza sativa* L.). *J. Applied and Natural Sci.*, **7** (1) : 410 - 416.

Rakesh Choudhary, Guru Prem, Amit Kumar, Upasana Singh, H. S. Jat and Arvind Kumar Yadav, 2016, Comparative study on productivity and profit ability of rice (*Oryza sativa* L.) under different crop establishment methods in Amabala, Haryana. *Prog. Agric*., **16** (2) : 183 - 189.

Senthil Kumar, N., 2016, Evaluate the establishment techniques on growth and yield of rice, *Agric. Sci. Digest*., **36** (2) : 110 - 113.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 420-424, 2017

Growth and Yield of Maize as Influenced by Drip Fertigation

M. K. Shruthi and T. Sheshadri
Department of Agronomy, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail: shruthimangala21@gmail.com

Abstract

A field experiment was conducted at Zonal Agricultural Research Station, V.C. Farm, Mandya, University of Agricultural Sciences, Bengaluru during *Kharif,* 2015 to study the effect of drip fertigation on growth and yield of drip irrigated maize (*Zea mays* L.). The results revealed that application of 125 per cent of recommended nitrogen and potassium through drip fertigation with four or eight days interval with fertigation duration of 25 per cent from sowing to 30 DAS + 50 per cent at 31 to 50 DAS + 25 per cent at 51 to 80 DAS resulted in higher kernel yield (8869 kg ha^{-1}) and stover yield (10715 kg ha^{-1}) of maize. Whereas, drip fertigation of 75 per cent of recommended nitrogen and potassium with the same fertigation duration was found on par with 100 per cent recommended NPK application under surface irrigation method.

Keywords: Drip irrigation, fertigation schedule, leaf area, maize yield, harvest index

Maize (*Zea mays* L), globally an important cereal crop next to wheat and rice also known as Queen of Cereals because of its highest genetic yield potential among cereals. It is the most versatile emerging crop having wider adaptability under varied agro-climatic conditions. Maize is being consumed as food, fodder and also has industrial uses. In India, about 25 per cent of the maize produced is used for human consumption, 49 per cent in poultry and 12 per cent as cattle feed and 12 per cent in food processing industries mainly as starch and one per cent each in brewery and seed (Jat *et al.,* 2009). In India, it is cultivated in an area of 9.4 million hectare with production of 22.27 million tonnes. However, the productivity is 2.5 t ha^{-1} which is much lower than the global average. Karnataka being major maize producing state alone contributes 16.5 per cent of the total maize production with an area of 1.3 million hectare with production of 4.0 million tonnes and productivity of 2.88 t ha^{-1} (Anon., 2016). Although, the state productivity is greater than the national average, but it is still lower than global average. Its special features like higher dry matter production, ability to suppress weeds and high adaptability to both rain fed and irrigated situations have favoured expansion of its area.

Globally agriculture uses approximately 70 per cent of total water withdrawals. However, the majority of large-scale irrigation systems are performing well below their potential. The overall efficiency of the flood irrigation system ranges between 25 to 40 per cent. Adoption of micro irrigation may help in saving significant amount of water and increase the quality and quantity of the produce emphasizing the need for water conservation and improvement in water-use efficiency to achieve 'more crop per drop'. Many scientists have listed number of potential advantages for micro irrigation such as increased beneficial use of water, enhanced plant growth and yield, reduced salinity hazard, enhanced efficiency of fertilizer and other chemicals, limited weed growth, decreased energy requirements and improved cultural practices. Studies revealed that the fertigation through drip irrigation in maize improves the nutrient availability to the crop through nutrient distribution within the crop root zone which improves better crop uptake and reduces the loss of nutrients (Anitta, 2013). Therefore, to standardize the fertigation technique to the drip irrigated maize to achieve higher yield with reduced water and nutrient loss present study was undertaken.

Material and Methods

A field experiment was conducted during *Kharif* - 2015 at Zonal Agricultural Research Station, V.C.

Farm, Mandya, Southern Dry Zone (Zone-6) of Karnataka. The experimental site is located between 12º 51' N Latitude and 77º 35' E Longitude at an altitude of 930 m above Mean Sea Level (MSL). The soil is sandy loam in texture with low organic carbon content and soil pH of 6.9 and EC of 0.32 dSm^{-1}. Initial nitrogen, phosphorus and potassium status of the soil were 248.4, 26.50 and 189.3 kg ha^{-1}, respectively. The field experiment was laid out in a Randomized Complete Block Design with three replications using factorial concept involving different fertigation intervals of once in 4 days (I_1) and 8 days (I_2) with fertigation duration as D_1: 25 per cent RDF (from sowing to 30 DAS) + 50 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) and D_2: 50 per cent RDF (from sowing to 30 DAS) + 25 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) with varied levels of fertilizers *i.e*., 75 per cent (F_1), 100 per cent (F_2) and 125 per cent (F_3) of recommended NPK. Phosphorus was applied as basal dose through soil applications. Growth and yield observations of the crop were recorded at 30, 60 and 90 days after sowing and at harvest and subjected to statistical analysis. The drip line was passed in between paired row. This system included pump, filter units, fertigation tank, ventury, main line and sub line with control valves for each plots to regulate the fertigation frequency and duration. Calculated quantity of phosphorus was applied to all the treatments through single super phosphate by soil application basally, whereas, nitrogen and potassium were supplied through drip fertigation starting from 6^{th} day after sowing as per the treatments using water soluble urea and muriate of potash, respectively. Drip irrigation was given once in two days and fertigation was as per the treatments.

Results and Discussion

The growth parameters of maize were significantly influenced by varied fertilizer levels and fertigation duration. Among different fertigation durations studied the treatment with split application in 25 per cent RDF (from sowing to 30 DAS) + 50 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) recorded higher plant height of 184.8 cm with 12.69 leaves $plant^{-1}$and leaf area of 6976 cm^2 $plant^{-1}$, respectively when compared to 50 per cent RDF (from sowing to 30 DAS) + 25 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) which recorded plant height of 177.6 cm with 12.05 leaves $plant^{-1}$ and leaf area of 6312 cm^2 $plant^{-1}$ in the study. Further, different fertilizer levels have also shown significant difference where the plant height, number of leaves and leaf area were found significantly higher with 125 per cent of recommended NPK application (187.4 cm, 12.89, 7276 cm^2 $plant^{-1}$, respectively) followed by 100 per cent recommended NPK (182.9 cm,12.15, 6380 cm^2 $plant^{-1}$, respectively). The lower plant height (173.3 cm), number of leaves (12.07) and leaf area (6275 cm^2 $plant^{-1}$) were recorded with 75 per cent recommended NPK application. However, fertigation interval did not show significant difference on growth parameters (Table I).

Among the interactions, higher plant height (195.28 cm), number of leaves (13.53) and leaf area (7495 cm^2 $plant^{-1}$) were found with the treatment comprising 125 per cent NPK application as fertigation in split doses as 25 per cent RDF (from sowing to 30 DAS) + 50 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) followed by 125 per cent NPK application as 50 per cent RDF (from sowing to 30 DAS) + 25 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) recorded irrespective of fertigation frequency (Table I). Whereas lower growth attributes were recorded with the surface irrigation method (control- soil application of nutrients as 50 per cent recommended N and 100 per cent PK basal and one top dress with 50 per cent N at 40 DAS) which was on par with 75 per cent recommended NPK application under drip fertigation (Table I). The fertigation interval did not influence the growth parameters of crop significantly. Fertigation once in four days interval established comparatively good response under drip irrigation cultivation of maize with other factors under investigation. Since initial growth could be supported by soil nutrient status split application through drip fertigation could ensure the nutrient availability to the crop growth and development during later stages. The higher nutrient availability during grand growth period further attributed to higher photosynthates production. The results are in conformity with the finding of Amrutha *et al*. (2016) and Kumar *et al*. (2014).

TABLE I

Growth parameters of maize as influenced by fertigation interval, duration and fertilizer levels

Intervals	Plant height (cm)	No. of Leaves	Leaf area (cm^2 $plant^{-1}$)
I_1	181.8	12.41	6748
I_2	180.6	12.33	6540
SEm±	1.53	0.14	123
CD (p=0.05)	NS	NS	NS
Durations			
D_1	184.8	12.69	6976
D_2	177.6	12.05	6312
SEm±	1.53	0.14	123
CD (p=0.05)	4.46	0.40	358
Fertilizer Levels			
F_1	173.3	12.07	6275
F_2	182.9	12.15	6380
F_3	187.4	12.89	7276
SEm±	1.87	0.17	150
CD (p=0.05)	5.47	0.49	439
Interaction (IXDXF)			
$I_1D_1F_1$	172.7	12.33	6999
$I_1D_1F_2$	182.9	12.07	6209
$I_1D_1F_3$	195.3	13.53	7495
$I_1D_2F_1$	171.2	12.07	6076
$I_1D_2F_2$	188.3	11.93	6343
$I_1D_2F_3$	180.3	12.53	7364
$I_2D_1F_1$	181.0	12.13	6695
$I_2D_1F_2$	182.9	12.47	6603
$I_2D_1F_3$	194.6	13.60	7853
$I_2D_2F_1$	168.1	12.07	5332
$I_2D_2F_2$	177.6	11.80	6365
$I_2D_2F_3$	179.9	11.90	6393
CONTROL	166.1	11.60	5991
SEm±	3.75	0.34	301
CD (p=0.05)	10.87	0.98	878.92

Note: I_1: Fertigation once in 4 days,
I_2: Fertigation once in 8 days
D_1: 25 % RDF (from sowing to 30 DAS) + 50 % RDF (31 to 50 DAS) + 25 % RDF (51 to 80 DAS)
D_2: 50 % RDF (from sowing to 30 DAS) + 25 % RDF (31 to 50 DAS) + 25 % RDF (51 to 80 DAS)
F_1: 75 % of recommended dose of NPK
F_2: 100 % of recommended dose of NPK
F_3: 125 % of recommended dose of NPK
Control: Surface irrigation with soil application of recommended NPK (150:75:40 kg ha-

Simlarly the yield parameters were also higher with 125 per cent NPK application as fertigation given in split doses as 25 per cent RDF (from sowing to 30 DAS) + 50 per cent RDF (31 to 50 DAS) + 25 per cent RDF (51 to 80 DAS) recorded higher kernel yield (8869 kg ha^{-1}) and stover yield (10715 kg ha^{-1}), number of kernel rows (16.47), kernel weight per cob (141.82 g) and higher 100 kernel weight (34.83 g) compared to the control (6811, 8145 kg ha^{-1}, 14.17, 126.21 g and 30.43 g, respectively) and followed the same trend as observed in case of growth parameters (Table II). As the split application of nutrients through drip fertigation would ensure the higher nutrient availability throughout crop growth period and meets the crop needs for better photosynthates production and accumulation. Further, significant increase in growth and yield attributes contributed for higher kernel and stover yield of maize. This might be due to higher availability of nutrients to the crop according its requirement resulted in better translocation of photosynthates and reduced loss of nutrients under drip fertigation with split application according to the crop need. The results are in confirmation with Sampathkumar and Pandian (2010), Richa Khanna (2013), Reddy and Krishnamurthy (2017).

Among correlation studies, the kernel yield exhibited significant positive correlation with growth parameters like plant height (r = 0.87), number of leaves (r = 0.73) and leaf area $plant^{-1}$ (r = 0.87) and also the yield parameters such as number of kernel rows cob (r = 0.84), kernel weight cob^{-1} (r = 0.96) and 100 seed weight (r = 0.87) showed that kernel yield was determined by these parameters was observed for both growth and yield parameters with the maize yield (Table III). The results are in conformity with findings of Anusha (2015) in rice.

The results suggested that drip fertigation with an interval of four or eight days and split application ensuring maximum nutrient application at grand growth period might enhanced the availability of nutrient to the crop with improved growth and yield further resulted in achieving the maximum yield of maize under drip irrigated condition.

TABLE II

Yield and yield parameters of maize as influenced by fertigation interval, duration and fertilizer levels

Intervals	Number of kernel rows cob^{-1}	Kernel weight cob^{-1} (g)	100 Kernel weight (g)	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index
I_1	15.06	144.81	32.66	7926	9817	0.45
I_2	14.69	142.00	32.12	7881	9506	0.45
SEm±	0.13	1.23	0.21	84	145	-
CD (p=0.05)	NS	NS	NS	NS	NS	-
DURATIONS						
D_1	15.22	147.21	32.73	8104	9923	0.45
D_2	14.52	139.60	32.04	7704	9400	0.45
SEm±	0.13	1.23	0.21	84	145	-
CD (p=0.05)	0.37	3.58	0.60	245	424	-
FERTILIZE LEVELS						
F_1	14.27	130.80	31.75	7295	8668	0.46
F_2	14.78	142.89	31.93	7827	9760	0.45
F_3	15.57	156.53	33.49	8589	10557	0.45
SEm±	0.16	1.50	0.25	102	177	-
CD (p=0.05)	0.46	4.38	0.73	301	520	-
Interaction (IXDXF)						
$I_1D_1F_1$	14.40	134.57	32.23	7676	9971	0.43
$I_1D_1F_2$	14.60	141.82	31.53	7875	10184	0.44
$I_1D_1F_3$	16.47	159.63	34.83	8869	10715	0.45
$I_1D_2F_1$	13.53	117.94	32.00	6930	7849	0.47
$I_1D_2F_2$	14.47	140.31	32.23	7795	9878	0.44
$I_1D_2F_3$	14.67	157.71	33.13	8413	10305	0.45
$I_2D_1F_1$	14.67	141.03	31.83	7672	8694	0.47
$I_2D_1F_2$	15.07	147.76	31.93	7761	9579	0.45
$I_2D_1F_3$	16.13	158.48	34.03	8771	10398	0.46
$I_2D_2F_1$	14.47	129.67	30.93	6904	8157	0.46
$I_2D_2F_2$	15.00	141.67	32.00	7878	9399	0.46
$I_2D_2F_3$	15.00	150.29	31.97	8301	10810	0.43
CONTROL	14.17	126.21	30.43	6811	8145	0.46
SEm±	0.31	3.00	0.50	199	340	-
CD (p=0.05)	0.90	8.76	1.45	582	992	-

Note: I_1: Fertigation once in 4 days,
I_2: Fertigation once in 8 days
D_1: 25 % RDF (from sowing to 30 DAS) + 50 % RDF (31 to 50 DAS) + 25 % RDF (51 to 80 DAS)
D_2: 50 % RDF (from sowing to 30 DAS) + 25 % RDF (31 to 50 DAS) + 25 % RDF (51 to 80 DAS)
F_1: 75 % of recommended dose of NPK,
F_2: 100 % of recommended dose of NPK
F_3: 125 % of recommended dose of NPK

Control: Surface irrigation with soil application of recommended NPK (150:75:40 kg ha^{-1})

TABLE III

Correlation and regression equation for growth and yield components with yield as influenced by fertigation interval, duration and fertilizer levels

Parameters	Correlation coefficient (R)	Regression equation Y {Kernel yield (kg ha-1)}	R^2
	Between yield vs growth parameters		
Growth components			
Plant height at harvest	0.87 **	Y= 63.032X - 3530.5	0.75
Number of leaves at harvest	0.73 **	Y= 791.94X -1929.1	0.53
Leaf area at harvest	0.84 **	Y= 0.8126X +2461.7	0.71
Between yield and yield components			
Between yield and yield components			
Number of kernel rows cob^{-1}	0.84 **	Y= 485.48X - 7830.3	0.74
Kernel weight cob^{-1} (g)	0.96 **	Y= 49.227X +825.34	0.90
100 kernel weight (g)	0.86 **	Y= 721.87X -2877.9	0.70

Note : The independent variable X refers to the parameters listed in serial number
Y is dependent variable kernel yield in kg ha^{-1}
**Correlation is significant at P = 0.01

REFERENCES

AMRUTHA, T. G., JAYADEVA, H. M., SHILPA, H. D. AND SUNIL, C. M., 2016, Nutrient uptake and nutrient use efficiency of aerobic rice as influenced by levels and time of application of nitrogen. *Res. Envi. Life Sci.*, **9** (6) : 660 - 662.

ANITTA, F. S., 2013, Influence of drip fertigation and interseasonping on yield, agronomic efficiency and partial factor productivity of maize. *Madras Agric. J.*, **100** (1-3) : 102 - 106.

ANONYMOUS, 2016, Area, production and productivity of major cereals in India. *http//www.indiastat.com*.

ANUSHA, 2015, Studies on drip fertigation in aerobic rice (*Oryza sativa* L.). *Ph. D. Thesis* (Unpub.), Univ. Agril. Sci., Bengaluru.

JAT, M. L., DAS, S., YADAV, V. K. SHEKAR, J. C. AND SINGH, D. K., 2009, Quality protein maize for food and nutritional security in India. *Tech. Bull.* No.4, Directorate of maize, Pusa New Delhi .

KUMAR, M., RAJPUT, T. B. S. AND PATEL, N., 2014, Cost-effective baby corn (*Zea mays*) cultivation under drip fertigation. *Indian J. Agric. Sci.,* **84** (5) : 637 - 42.

REDDY, V. AND KRISHNAMURTHY, K., 2017, Studies on growth and yield of maize as influenced by drip fertigation. *Mysore. J. Agric. Sci.*, **51** (1) : 95 - 88.

RICHA KHANNA, 2013, Effect of precision nutrient and water management with different sources and levels of fertilizers on maize production. *M.Sc. (Agri.) Thesis* (Unpub.), Univ. of Agril. Sci., Bengaluru.

SAMPATHKUMAR, T. AND PANDIAN, B. J., 2010, Effect of fertigation frequencies and levels on growth and yield of maize. *Madras Agric. J.,* **97** (7-9): 245-248.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 425-429, 2017

Effect of Crop Geometry in Maize Based Intercropping System

S. S. Shree Harsha Kumar and B. C. Shankaralingappa
Department of Agronomy, College of Agriculture, UAS, GKVK, Bengaluru-560 065
E-mail : harshakumar931@gmail.com

Abstract

A field experiment was carried out during *kharif* season of 2014 at Zonal Agricultural Research Station, GKVK, Bengaluru to study the effect of crop geometry in maize based intercropping system. The results revealed that significantly higher kernel yield of maize (5802 kg ha^{-1}) was obtained in maize (paired row system-30 / 90 cm) + frenchbean + horsegram (as second intercrop after frenchbean) than maize (60 x 30 cm) + guar / frenchbean additive intercropping and it was on par with the sole maize with 30 / 90 cm paired row system. LER, maize equivalent yield, net returns and B:C ratio were also higher in maize (paired row system-30 / 90cm) + frenchbean + horsegram additive intercroppong (1.56, ₹ 13931 kg ha^{-1}, ₹ 112592 ha^{-1} and 2.95, respectively) and maize (paired row system-30 / 90cm) + frenchbean intercropping (1.47, 13738 kg ha^{-1}, 113561 ha^{-1} and 3.09, respectively) than in maize (60 x 30 cm) + guar/frenchbean additive intercropping. Maize (paired row system-30 / 90 cm) + frenchbean additive intercropping was superior to sole crop of maize (either in 60x30 cm or paired row system-30 / 90 cm) as indicated by higher net returns (113561 ha^{-1}) with B:C ratio (3.09).

Keywords: Maize, crop geometry, intercropping, paired row system

Maize (*Zea mays* L.) is one of the important cereals next to wheat and rice in the world. In India, it is consumed as food, fodder and also has industrial uses. About 35 per cent of the maize produced in India is used for human consumption, 25 per cent each in poultry and cattle feed and 15 per cent in food processing industries. In India it is cultivated over an area of 9.19 m ha with a production of 24.17 m.t and productivity of 2632 kg ha^{-1} (Anon., 2015). In Karnataka, it occupies an area of 13.31 lakh ha with a production of 40.85 lakh t and productivity of 3018 kg ha^{-1} which is greater than the national average.

The extent of cultivable land is gradually decreasing, mainly because of rapid urbanization and industrialization due to the global population explosion resulting in ever increasing pressure on cultivated land for food and commercial crops. Food supply is one of the most important problems the world is enduring nowadays; intercropping is used in many parts of the world for the production of food and feed crops (Carruthers *et al.,* 2000). The main objective of intercropping is to augment total productivity per unit area and time, besides judicious and equitable utilization of land resources and farming inputs without reducing base crop yield (Marer *et al.,* 2007 and Zhang *et al.,* 2007).

Maize provides an opportunity for inclusion of intercrops because of its wider row spacing and plasticity of the crop to row spacing. Maize and legume intercropping was found to be more productive and remunerative compared to sole cropping (Kumar *et al.,* 2008 and Kamanga *et al.,* 2010). Guar is a hardy legume containing gelling agent (guar gum) in seeds. Demand is rising rapidly due to industrial use of guar gum. The guar is being introduced into new areas because of higher commercial value and greater demand. It is an imperative to introduce guar crop in new areas, one way of introducing this crop is intercropping with cereals like maize.

The research information available on paired row agro-techniques of maize based intercropping system is meager. Hence, the present investigation was carried out to study the effect of crop geometry in maize based intercropping system.

Material and Methods

A field experiment was carried out during *kharif,* 2014 in Zonal Agricultural Research Station, GKVK, Benagluru, Karnataka which is situated in the Eastern Dry Zone (Zone–5) at 12° 58’ N latitude, 77° 35’ E longitude and an altitude of 930 m above mean sea level. The soil of experimental site was red sandy clay loam, neutral in soil reaction (pH 6.78), low in organic carbon content (0.32 %), medium in available nitrogen (286.15 kg ha^{-1}), low in available P_2O_5 (21.69 kg ha^{-1}) and medium in available K_2O (243.48 kg ha^{-1}). The experiment was laid out in a randomized complete block design with three replications. The treatments comprised of T_1: Sole maize (60 x 30 cm); T_2: Sole maize (Paired row system - 30 / 90 cm); T_3: Sole guar; T_4: Sole frenchbean; T_5: Sole horsegram; T_6: Maize (60 x 30 cm) + guar additive intercropping; T_7: Maize (60 x 30 cm) + frenchbean additive interropping; T_8: Maize (Paired row system - 30 / 90 cm) + guar additive intercropping; T_9: Maize Paired row system - 30 / 90 cm) + frenchbean additive interropping; T_{10}: Maize Paired row system - 30 / 90 cm) + frenchbean + horsegram additive interropping. Horsegram was sown as second intercrop after the harvest of french bean in maize (paired row system of 30 / 90 cm) + french bean intercropping. Farm yard manure was applied uniformly to all the plots at the rate of 7.5 t ha^{-1} two weeks before sowing. The recommended dose of fertilizer for maize (100 kg N, 50 kg P_2O_5 and 25 kg K_2O ha^{-1}), guar (25 kg N, 75 kg P_2O_5 and 60 kg K_2O ha^{-1}) and french bean (62.5 kg N, 100 kg P_2O_5 and 75 kg K_2O ha^{-1}) was applied in the form of urea, single super phosphate and muriate of potash. In case of maize, 50 per cent N was applied as basal and remaining dose of nitrogen (50 kg ha^{-1}) was applied in two equal splits as top dressing at 30 and 45 DAS. In intercropping treatments, recommended dose of fertilizer for maize plus fertilizer for intercrops based on their population was applied. The other management operations were done as per recommended package of practices for both main and intercrops. Growth and yield parameters were recorded as per standard procedures. B:C ratio was calculated by dividing the gross returns from the cost of cultivation and maize equivalent yield (MEY) was calculated on the basis of prevailing market prices of both maize and intercrops.

Results and Discussion

The kernel yield of maize in sole cropping was not significantly influenced by crop geometry (60 x 30 cm and paired row system of 30 / 90 cm). There was also no significant differences in yield parameters such as cob length, rows cob^{-1}, kernel weight plant^{-1} and 100-kernel weight (Table I) and growth parameters like plant height, leaf area and dry matter plant^{-1} (Table II) between 60 x 30 cm spacing and paired row system (30 / 90 cm) of sole maize crop. These results are in conformity with the findings of Ashoka (2011). For intercropping systems, paired row system of 30/90 cm was better for maize crop. In intercropping

Table I

Yield and yield components of maize as influenced by crop geometry in additive intercropping system

Treatments	Cob length (cm)	Rows cob^{-1}	Kernel weight plant^{-1} (g)	100 Kernel weight (g)	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1	18.2	15.2	104.0	31.6	5682	6954
T_2	18.4	17.7	115.8	33.7	5794	7307
T_6	17.3	14.5	99.6	31.2	5605	6937
T_7	17.5	14.8	100.6	31.0	5642	7018
T_8	17.6	16.9	122.2	30.7	5738	7406
T_9	17.5	17.3	117.8	33.1	5796	7288
T_{10}	17.6	16.6	123.9	31.7	5802	7219
S.Em±	0.9	1.0	9.2	2.0	43.1	193.9
C.D. (P=0.05)	NS	NS	NS	NS	132.7	NS

T_1: Sole maize (60 X 30 cm)
T_2: Sole maize (Paired row system - 30/90 cm)
T_3: Sole guar
T_4: Sole frenchbean
T_5: Sole horsegram
T_6: Maize (60 X 30 cm) + guar
T_7: Maize (60 X 30 cm) + frenchbean
T_8: Maize (Paired row system - 30/90 cm) + guar
T_9: Maize Paired row system - 30/90 cm) + frenchbean
T_{10}: Maize (Paired row system - 30/90 cm) + frenchbean + horsegram

TABLE II

Growth components of maize as influenced by crop geometry in additive intercropping system

Treatments	Plant height (cm)	Leaf area plant^{-1} (cm)	Dry matter plant^{-1} (g)
T_1	168.7	5929	242.2
T_2	174.5	6369	261.3
T_6	153.4	5834	246.4
T_7	161.3	5998	254.2
T_8	169.7	6225	267.5
T_9	173.9	6330	266.6
T_{10}	171.2	6305	270.9
S.Em±	2.68	144.6	10.4
C.D. (P=0.05)	8.26	445.7	NS

T_1: Sole maize (60 X 30 cm)
T_2: Sole maize (Paired row system - 30/90 cm)
T_3: Sole guar
T_4: Sole frenchbean
T_5: Sole horsegram;
T_6: Maize (60 X 30 cm) + guar
T_7: Maize (60 X 30 cm) + frenchbean
T_8: Maize (Paired row system - 30/90 cm) + guar
T_9: Maize (Paired row system - 30/90 cm) + frenchbean
T_{10}: Maize (Paired row system - 30/90 cm) + frenchbean + horsegram

systems, significantly higher kernel yield of maize (5802 kg ha^{-1}) was obtained in maize (paired row system of 30 / 90 cm) + frenchbean + horsegram additive intercropping than with maize (60 x 30 cm) + guar / frenchbean intercropping and it was on par with the sole maize in 30 / 90 cm paired row system. Higher kernel yield of maize in paired row maize + frenchbean / guar intercropping was due to marginally higher kernel weight plant^{-1} which was further due to significantly higher plant height and leaf area and marginally higher dry matter plant^{-1} (Table III). Similar results were also reported by Gollar and Patil (1997) and Asoka (2011). Stover yield of maize did not differ significantly due to crop geometry and intercropping with frenchbean or guar.

All intercropping treatments recorded more maize equivalent yield (MEY) and LER than sole maize crop (Table IV). Significantly higher MEY (13931 kg ha^{-1}) and higher LER (1.56) were observed in maize (paired row system of 30 / 90 cm) + frenchbean + horsegram additive intercropping and it was closely followed by maize (paired row system of 30/90 cm) + frenchbean intercropping (13738 kg ha^{-1} and 1.47 respectively). Similar results were also reported by Mandal *et al.*

TABLE III

Growth and yield parameters of intercrops as influenced by intercropping in maize at different crop geometry

Treatments	Plant height (cm)	Branches plant^{-1}	Dry matter plant^{-1} (g)	Pods plant^{-1}	Pod lenght(cm)	Pod / seed yield plant^{-1}	Pod / seed yield ha^{-1}	Haulm yield (kg ha^{-1})
T_3	42.76	3.37	9.28	21.42	3.62	2.92	414	1863
T_4	38.84	9.19	34.12	48.65	16.17	69.57	13628	2793
T_5	45.94	5.82	14.8	18.92	4.35	4.19	679	2914
T_6	31.49	1.44	3.99	9.11	3.05	1.45	100	584
T_7	27.72	4.79	19.21	32.62	12.93	37.21	3508	1932
T_8	37.36	2.19	5.33	15.63	3.29	1.82	125	729
T_9	35.14	7.85	28.05	39.33	15.42	60.43	6354	1786
T_{10}	34.66	8.02	29.28	41.94	14.19	62.92	6376	1891
	22.15 *	3.27 *	4.03 *	7.58 *	3.21 *	1.02 *	63 *	319 *

T_1: Sole maize (60 X 30 cm)
T_2: Sole maize (Paired row system - 30/90 cm)
T_3: Sole guar
T_4: Sole frenchbean
T_5: Sole horsegram
T_6: Maize (60 X 30 cm) + guar
T_7: Maize (60 X 30 cm) + frenchbean
T_8: Maize (Paired row system - 30/90 cm) + guar
T_9: Maize (Paired row system - 30/90 cm) + frenchbean
T_{10}: Maize (Paired row system - 30/90 cm) + frenchbean + horsegram
* Growth and yield parameters of horsegram

TABLE IV

Maize equivalent yield (MEY) and LER as influenced by crop geometry in additive intercropping system

Treatments	Yield (kg ha^{-1})		MEY (kg ha^{-1})	LER
	Maize	Intercrop		
T_1	5682	-	5682	1.00
T_2	5794	-	5794	1.00
T_3	-	414	1328	1.00
T_4	-	13628 *	17035	1.00
T_5	-	679	1698	1.00
T_6	5605	102	5932	1.23
T_7	5642	3508 *	10028	1.25
T_8	5738	125	6139	1.29
T_9	5796	6354	13738	1.47
T_{10}	5802	6376 *+ 64	13931	1.56
S.Em±	43.1	-	264.94	-
C.D. (P=0.05)	132.7	-	794.32	-

T_1: Sole maize (60 X 30 cm)
T_2: Sole maize (Paired row system - 30/90 cm)
T_3: Sole guar
T_4: Sole frenchbean
T_5: Sole horsegram
T_6: Maize (60 X 30 cm) + guar
T_7: Maize (60 X 30 cm) + frenchbean
T_8: Maize (Paired row system - 30/90 cm) + guar
T_9: Maize Paired row system - 30/90 cm) + frenchbean
T_{10}: Maize (Paired row system - 30/90 cm) + frenchbean + horsegram; LER: Land equivalent ratio
*Green bean yield of frenchbean

TABLE V

Cost of cultivation, gross returns, net returns and B:C ratio as influenced by crop geometry in maize based intercropping system

Treatments	Gross returns (₹ ha^{-1})	cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
T_1	70018	34827	35191	2.01
T_2	72085	34827	37258	2.07
T_3	16402	14054	2348	1.17
T_4	205118	47405	157713	4.33
T_5	21105	14485	6620	1.46
T_6	73758	38829	34929	1.90
T_7	123275	54292	68983	2.27
T_8	76442	38829	37613	1.97
T_9	167853	54292	113561	3.09
T_{10}	170251	57659	112592	2.95

T_1: Sole maize (60 X 30 cm)
T_2: Sole maize (Paired row system - 30/90 cm)
T_3: Sole guar
T_4: Sole frenchbean
T_5: Sole horsegram;
T_6: Maize (60 X 30 cm) + guar
T_7: Maize (60 X 30 cm) + frenchbean
T_8: Maize (Paired row system - 30/90 cm) + guar
T_9: Maize (Paired row system - 30/90 cm) + frenchbean
T_{10}: Maize (Paired row system - 30/90 cm) + frenchbean + horsegram
Market price: Maize-₹ 12 kg^{-1}; guar-38.5 kg^{-1}; frenchbean-15 kg^{-1}; horsegram-30 kg^{-1}

(2014). Higher maize equivalent yield in maize (paired row system of 30 / 90 cm) + frenchbean intercropping system was attributed to higher green bean yield of frenchbean in paired row system of intercropping than in normal planting of maize + frenchbean and its higher market price. Performance of frenchbean was better in maize (paired row system-30 / 90 cm) + frenchbean additive intercropping system compare to that in maize (60 x 30 cm) + frenchbean additive intercrop. This was due to higher growth and yield parameters of frenchbean in paired row system (Table III). These results are in conformity with the findings of Ashoka (2011) and Ganajaxi (2008). Lesser growth and yield parameters of maize were observed in maize (60 x 30 cm) + frenchbean/guar intercropping as compared to paired row system. This might be attributed to availability of more space for maize at 30 / 90 cm paired row in intercropping than at 60 x 30 cm spacing, which might have helped maize plant in exploitation of natural resources more efficiently resulting in higher dry matter accumulation (Aravindkumar *et al.,* 2004).

Among intercropping systems, maize (paired row system-30 / 90 cm) + frenchbean additive intercropping and maize (paired row system-30 / 90 cm) + frenchbean + horsegram additive intercropping had given more net returns (₹ 1,13,561 ha^{-1} and 112592 ha^{-1}, respectively) and B:C ratio (3.09 and 2.95) (Table V) than maize (60 x 30 cm) + frenchbean / guar intercropping and maize (paired row system-30 / 90 cm) + guar intercropping system and sole maize crop. This was due to higher frenchbean green pod yield and its higher market price. These results are in conformity with the findings of Ganajaxi (2008).

It can be concluded that paired row system of 30 / 90 cm is an ideal crop geometry for additive intercropping in maize. Maize (paired row system of 30 / 90cm) + frenchbean intercropping is highly productive and economical intercropping system as indicated by higher LER, net returns and B:C ratio under dryland condition.

References

Anonymous, 2015, Selected State / season-wise area, production and productivity of maize in India. *www.indiastat.com*

Aravindkumar, Singh, S. N. and Gajendra, G., 2004, Influence of planting ratio and fertilizer application on dry matter production, LAI and nutrient content and uptake by maize and groundnut intercropping. *Ann. Agric. Res. New Series,* **25** (2) : 283 - 288.

Ashoka, P., 2011, Agronomic investigations on maize (*Zea mays* L.) based cropping system. *Ph.D. Thesis,* Univ. Agric. Sci., Bengaluru.

Carruthers, K., Prithiviraj, B. F. Q., Cloutier, D., Martin, R. C. and Smith, D. L., 2000, Intercropping maize with soybean, lupin and forages: yield component responses. *Eur. J. Agro.,* **12** : 103 - 115.

Ganajaxi, 2008, Production potential of different cropping systems with frenchbean (*Phaseolus vulgaris* L.) in Northern Transition Zone of Karnataka. *Ph.D. Thesis,* Univ. Agric. Sci., Dharwad.

Gollar, R. G. and Patil, V. C., 1997, Studies on maize based cropping system under simultaneous and staggered planting of intercrops. *Karnataka J. Agri. Sci.,* **10** : 648 - 652.

Kamanga, B. C., Waddington, G. S. R., Robertson, M. J. and Giller, K. E., 2010, Risk analysis of maize-legume crop combinations with small holder farmers varying in resource endowment in central Malawi. *J. Exp. Agric.*, **46** : 1 - 21.

Kumar, R. B. P., Ravi, S. and Balyan, J. S., 2008, Effect of maize (*Zea mays*) + blackgram intercropping and integrated nitrogen management on productivity and economics of maize. *Int. J. Plant Sci.,* **3** (1) : 53 - 57.

Mandal, M. K., Banerjee, M., Banerjee, H., Alipatra, A. and Malik, G. C., 2014, Productivity of maize (*Zea mays*) based intercropping system during kharif season under red and lateritic tract of West Bengal. *The Bioscan.,* **9** (1) : 31 - 35.

Marer, S. B., Lingaraju, B. S. and Shashidhara, G. B., 2007, Productivity and economics of maize and pigeonpea intercropping under rainfed condition in northern transitional zone of Karnataka. *Karnataka J. Agric. Sci.*, **20** (1) : 1 - 3.

Zhang, L., Werf, W., Zhang, S., Li, B. and Spiertz, J. H. J., 2007, Growth, yield and quality of wheat and cotton in relay strip intercropping systems. *Field Crops Res.,* **103** : 178 - 188.

(*Received :* May, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 430-435, 2017

Comparative Efficiency of Soil and Foliar Application of Boron on Growth and Yield of Finger Millet (*Eleusine coracana*)

M. A. SHANKAR, M. N. THIMMEGOWDA, N. C. BHAVITHA AND B. N. MANJUNATHA
Directorate of Research, UAS, GKVK, Bengaluru-560065
E-mail : mnthimmegowda@gmail.com

ABSTRACT

Field experiments were conducted at AICRP for Dryland Agriculture, University of Agricultural Sciences, GKVK, Bengaluru for three seasons to study the efficiency of boron as foliar spray and soil application on performance of finger millet. In the present investigation, the average yield of finger millet over three years revealed that foliar application of boron @ 0.5 kg ha^{-1} recorded significantly higher grain yield (3498 kg ha^{-1}) and straw yield (4640 kg ha^{-1}) as compared to control (3083 kg ha^{-1}, 4118 kg ha^{-1}, respectively) and it was on par with soil application of boron @ 0.5 kg ha^{-1} (3466 and 4529 kg ha^{-1}). The per cent increase in yield was 13.4 per cent with foliar application of boron @ 0.5 kg ha^{-1} as compared to control. The higher benefit cost ratio (1.46) as well as higher uptake of micronutrients (142, 2680 and 87 g ha^{-1} of Zn, Fe and B, respectively) was observed with the soil application of boron @ 1 kg ha^{-1}.

Keywords: Efficiency boron, finger millet and foliar application

FINGER millet (*Eleusine coracana* L. Gaertn.) is the third most important millet crop in India, next to sorghum (*Sorghum bicolor* L.) and pearl millet (*Pennisetum glaucum* L.). It is grown on 1.27 million hectares (M ha) with an annual production of 1.89 million tons. It is an important crop of drought-prone regions because of its outstanding ability to withstand adverse weather conditions and grow in marginal and poor soils. The most striking feature, which made finger millet an important dry land crop, is its resilience and ability to withstand adverse weather conditions when grown in soils having poor water holding capacity. Integrated nutrient management is the maintenance of soil fertility and supply of plant nutrients at an optimum level for sustenance of desired crop production as well as minimizes nutrient losses to the environment (Singh and Balasubraman, 1986). Soil productivity declines through leaching, erosion and crop harvest. These losses are even exacerbated by tropical rainfall and anthropogenic forces. Unless the soil nutrients are replenished through use of organic wastes, crop residues, fallow and reconstruction of soil organic matter, soil fertility loss would continue unabated (Donova and Crassey, 1998). Intensification of use of mineral fertilizer has been reported to cause soil acidity and environmental health hazard. This situation renders use of inorganic fertilizer in sustainable soil productivity counterproductive.

Boron plays an important role in the physiological process of plants, such as cell elongation, cell maturation, meristematic tissue development and protein synthesis (Mengel and Kirkby, 1982). The need for B application in finger millet is to increase the growth, development and yield of crop. The application of boron also promotes the absorption of nitrogen from soil and increases the plant height and dry weight (Jing *et al*., 1994). The information on boron nutrition on finger millet in Karnataka is meagre. Therefore, the present investigation was aimed to study the effect of graded doses of boron on the growth and yield of finger millet, which is an important staple food crop of Eastern Dry Zone of Karnataka. Although various studies have been carried out in isolation, a comprehensive repeated experiment in different regions of Karnataka are necessary to assess the accurate response.

MATERIAL AND METHODS

A field experiment was conducted at AICRP for Dryland Agricultural Project, University of Agricultural Sciences, GKVK, Bengaluru for 3 years during *kharif* seasons to study the efficiency of boron both as foliar spray and soil application on growth and yield of finger millet. The Centre is located at 77^0 39’ 22.1” East longitude, 13^0 05’13.0” N latitude and 929 MSL altitude. The experimental area receives an average annual rainfall of 929.9 mm. Pre monsoon thunder showers are received right from February and terminated during May-June. The monsoon sets in two peaks, one during the month of May (100.8 mm) and other peek at September (211.9 mm). April (33.8^{0}C) is the hot month, while January (13.9^{0}C) is the coldest month of the year. It was 37 rainy days during second year while 19 rainy days in first year. The rainfall was very poor during cropping period. During the early 60 days, there was very scanty rainfall and the total rainfall during crop growth period was 293 mm. This was mainly responsible for lower productivity during first year. During second year, the rainfall distribution was optimum. The experiments were laid out in RCBD with three replications in a red sandy loam soil with pH 6.25, low in available nitrogen (250 kg ha^{-1}), low in available phosphorus (9 kg ha^{-1}) and medium in available potassium (160 kg ha^{-1}) with deficient in zinc (0.33 ppm) and boron (0.16 ppm). The treatments comprised of 2 methods of boron application (soil and foliar) at 3 levels (0.5, 1.0 and 2.0 kg ha^{-1}) along with a control (only RDF). The micronutrient boron in the form of borax (H_2BO_3) was applied basally at the time of sowing in soil application and sprayed on foliage at tillering stage. In addition to recommended dose of fertilizers (50:40:25 kg ha^{-1}) and FYM. At maturity, grain yield, straw yield, 1000 seed weight, ear head length and number of fingers / ear head were recorded by adopting the standard procedure. The soil samples were collected after the harvest of crops and analyzed for pH, EC, OC, available N, P, K and micronutrients. The soil pH was determined in 1:2.5 soil: water suspension by potentiometric method using glass electrode (Jackson, 1973). Electrical conductivity (1:2.5 soil-water extract) was determined using conductivity bridge and expressed as dSm^{-1} (Jackson, 1973). The soil organic carbon of a soil finely ground and sieved through 0.2 mm was determined by Walkely and Black wet-oxidation method as described by Jackson (1973), Available nitrogen was determined by macro distillation following alkaline permanganate method as suggested by Subbaiah and Asija (1956), Available phosphorus was determined by using a spectrophotometer (Jackson, 1973), available potassium was determined by flame photometer as described by Page *et al*., (1982) and available micronutrients in soils was determined with DTPA extractant as described by Lindsay and Norwell (1978) and estimated using Atomic Absorption Spectrometer (AAS).

Results and Discussion

Significantly higher grain (2242 kg ha^{-1}) and straw yield (3544 kg ha^{-1}) were recorded with foliar application of NPK+ boron @0.5 kg ha^{-1} as compared to control. It is followed by soil application of NPK+ boron @0.5 kg ha^{-1} (Table-1). The significant effect that B had on seed yield indicates that B plays an important role in seed formation. Foliar application of boron can have a direct effect on seed yield. Since boron is immobile, it will require during flowering and seed development stage from direct uptake through roots (Brown and Shelp, 1997).

During second year of the experimentation, significantly higher grain yield (4242 kg ha^{-1}) and straw yield (5433 kg ha^{-1}) were recorded in foliar spray of boron @ 0.5 kg ha^{-1} as compared to control [grain yield (3775 kg ha^{-1}) and straw yield (4829 kg ha^{-1}]. Similarly, higher grain and straw yield were recorded in the treatment receiving soil application of boron @0.5 kg ha^{-1} (4172 and 5258 kg ha^{-1}). However, it was found on par with soil application of boron @ 0.5 kg ha^{-1} and foliar spray of boron @ 1 kg ha^{-1}. The results clearly indicated that the application of boron @ 0.5 kg ha^{-1} either as through soil and foliar of same level did not vary significantly. Also higher doses of boron application either through soil or foliar decreases the yield attributes and yields of finger millet. The 1000 seed weight and number of fingers recorded with the same level of boron either through foliar or soil was on par with each other and they differ over other treatments.

During third year of experimentation, the effect of boron application on grain yield, straw yield, ear head length and number of finger millet per head were found to be significant except for 1000 seed weight. Significantly higher grain yield (4184 kg ha^{-1}), straw yield (5244 kg ha^{-1}) and benefit cost ratio (1.46) was recorded in the treatment receiving soil application of boron @ 1 kg ha^{-1} as compared to control (3683 and 4711 kg ha^{-1}) and it was on par with foliar application boron @ 1 kg ha^{-1} (4122 and 5183 kg ha^{-1}) or boron @ 2 kg ha^{-1} (3970 and 4835 kg ha^{-1}) and soil application of boron @ 0.5 kg ha^{-1} (4054 and 4975 kg ha^{-1}). The 1000 seed weight and number of fingers recorded with

TABLE I

Influence of Boron application on grain and straw yield (Kg Ha^{-1}) and B:C ratio of finger millet over three years

Treatments	Grain yield				Straw yield				B:C Ratio		
	Ist Year	IInd Year	IIIrd Year	Pooled	Ist Year	IInd Year	IIIrd Year	Pooled	Ist Year	IInd Year	IIIrd Year
Control (No boron application)	1793	3775	3682	3083	2816	4829	4711	4118	-0.04	0.95	1.21
Boron @0.5 kg ha^{-1} (soil application)	2171	4172	4054	3466	3356	5258	4975	4529	0.15	1.13	1.40
Boron @1.00 kg ha^{-1} (soil application)	2041	4032	4184	3419	3243	4998	5224	4495	0.08	1.03	1.46
Boron @ 2.00 kg ha^{-1} (soil application)	1916	3905	3864	3228	3083	4835	4743	4220	0.00	0.93	1.23
Boron @0.5 kg ha^{-1} (Foliar spray)	2242	4242	4012	3498	3544	5433	4943	4640	0.19	1.17	1.38
Boron @1.00 kg ha^{-1} (Foliar spray)	2018	4085	4122	3429	3289	5181	5183	4551	0.10	1.07	1.43
Boron @ 2.00 kg ha^{-1} (Foliar spray)	1966	3970	3916	3284	3136	4905	4813	4285	0.02	0.96	1.26
S. Em.±	55.2	51.5	68.2	40.2	72.9	31.2	96.2	76.3	-	-	-
C.D at 5%	170.1	158.8	210.2	123.7	224.7	96.2	296.5	235.1	NS	NS	NS

the same level of boron application @ 1 kg ha^{-1} either through foliar or soil was on par with each other and they differ over other treatments.

The effect of boron application on average grain and straw yield, 1000 seed weight, ear head length and number of fingers per head was found significant over three years. Second year was a good year in relation to weather. First year was a drought year and recorded lower yield and yield attributes in all the treatments. Over the years, higher grain yield (4242 kg ha^{-1}) was recorded during second year (Table-I) with the foliar application of boron @ 0.5 kg ha^{-1} and lower with NPK only (1793 kg ha^{-1}). This may be due to variation in the rainfall received during crop growth period. Better moisture availability associated with good rainfall hastened the root growth, nutrient absorption and biomass production (Basaveshwari *et al.*, 2008). Because of the congenial environment, the productivity was maximum during second and third year of the experimentation. These results are in conformity with Govinda Bhandari, 2013.

Significantly higher pooled (over 3 years) grain yield (3498 kg ha^{-1}), straw yield (4640 kg ha^{-1}), 1000 gain weight (2.78 g), ear head length (7.53 cm) and number of fingers per head (6.63) was noticed in foliar application of boron @ 0.5 kg ha^{-1}as compared to control (3083 and 4118 kg ha^{-1}, 2.29 g, 6.29 cm and 5.21, respectively) and it was on par with soil application of boron @ 0.5 kg ha^{-1} (3466 and 4529 kg ha^{-1}, 2.72g, 7.55 cm and 6.60) and foliar spray of boron @ 1 kg ha^{-1} (3429 and 4551 kg ha^{-1}, 2.75g, 7.6 cm and 6.60) (Table- I and II). Significantly lower grain yield (3083 kg ha^{-1}) with control *i.e.,* without boron application might be associated with poor pollination due to lower pollens exertion. While, boron treated plots noticed higher yield due to boron, might have enhanced pollen tube germination, pollination and improvement of grain setting. Boron application has a

TABLE II

Influence of boron application on 1000 seed weight, ear length and number of fingers per ear in finger millet

Treatments	1000 seed weight (g)				Ear length (cm)				No. of fingers / ear head			
	Ist year	IInd year	IIIrd year	Pooled	Ist year	IInd year	IIIrd year	Pooled	Ist year	IInd year	IIIrd year	Pooled
Control (No Boron application)	2.11	2.35	2.42	2.29	6.26	6.56	6.05	6.29	4.96	5.01	5.65	5.21
Boron @0.5kg/ha (soil application)	2.71	2.78	2.68	2.72	7.67	7.82	7.15	7.55	6.50	6.67	6.62	6.60
Boron @1.00kg/ha (soil application)	2.5	2.66	3.02	2.73	7.49	7.56	7.65	7.57	6.17	5.89	7.52	6.53
Boron @ 2.00kg/ha (soil application)	2.34	2.43	2.51	2.43	7.13	6.89	6.21	6.74	5.41	5.41	5.89	5.57
Boron @0.5kg/ha (Foliar spray)	2.79	2.92	2.63	2.78	7.72	8.02	6.85	7.53	6.58	6.85	6.45	6.63
Boron @1.00kg/ha (Foliar spray)	2.66	2.73	2.87	2.75	7.63	7.76	7.42	7.60	6.34	6.20	7.25	6.60
Boron @ 2.00kg/ha (Foliar spray)	2.41	2.52	2.58	2.50	7.33	7.34	6.62	7.10	5.93	5.70	6.12	5.92
S. Em.±	0.06	0.23	0.14	0.07	0.27	0.14	0.49	0.14	0.08	0.38	0.47	0.20
C.D at 5%	0.19	NS	NS	0.22	0.83	0.45	1.48	0.43	0.25	1.18	1.47	0.63

key role in plant metabolism and root growth through its influence on utilization of nitrogen and synthesis of carbohydrates, proteins besides efficient use of water. The higher B:C ratio (1.46) was noticed with the soil application of boron @ 1 kg ha^{-1}, which may be ascribed to higher grain and straw yield besides the lower cost of application.

The per cent increase in yield was to the tune of 13.4 per cent with foliar application of boron @ 0.5 kg ha^{-1} as compared to control. These results clearly indicated that application of boron @ 0.5 kg ha^{-1} either through soil or through foliar application at the same level did not vary significantly. The 1000 seed weight and number of fingers per head recorded with the same level of boron @ 0.5 kg ha^{-1} either through foliar or soil application was on par with each other. The higher yield may be due to overall growth parameters, higher plant biomass, which accumulated during early stage due to favoured and higher translocation of photosynthates to the sink (Bergmann, 1992).

The soil fertility status after the harvest of finger millet is presented in (Table-III). The pH, electrical conductivity (EC), organic carbon, macronutrients (P_2O_5 and K_2O) and micronutrient (Zn, Cu, Mn and Fe) contents were found to be non-significant. Further, boron content in soil varied significantly among the treatments, while other nutrient status remained non-significant. Soil and foliar application boron @ 1 kg ha^{-1} recorded significantly higher available boron content (0.27 ppm) compared to control (0.22 ppm). While the same treatment registered higher content of Zn, Cu, Mn & Fe of 1.76, 0.70, 19.50 and 23 ppm, respectively.

Higher uptake of nitrogen (73 kg ha^{-1}), phosphorus (14.5 kg ha^{-1}) and potassium (65 kg ha^{-1}) was observed in soil and foliar application of boron @ 1 kg ha^{-1} compared to control. Zinc (158 mg ha^{-1}) copper (44 mg ha^{-1}), manganese (154 mg ha^{-1}), iron (3904 mg ha^{-1}) and boron (96 mg ha^{-1}) showed higher values with the soil application of boron @ 1kg ha^{-1} (Table- IV).

TABLE III

Soil fertility status of the experimental plots after the harvest of finger millet

Treatments	pH	EC (dSm^{-1})	OC (%)	P_2O_5	K_2O	Zn	Cu	Mn	Fe	B
				kg ha^{-1}		-ppm-				
Control (No Boron application	5.8	0.06	0.52	76	189	1.64	0.6	18	21	0.22
Boron @0.5 kg ha^{-1} (soil application)	6.0	0.07	0.58	77	195	1.74	0.7	19	22	0.26
Boron @1.00 kg ha^{-1} (soil application)	6.1	0.07	0.62	78	200	1.76	0.7	19.50	23	0.27
Boron @ 2.00 kg ha^{-1} (soil application)	5.8	0.06	0.53	75	190	1.65	0.6	18	21	0.23
Boron @0.5 kg ha^{-1} (Foliar spray)	6.0	0.06	0.56	76	193	1.70	0.6	19	22	0.25
NPK+ boron @1.00 kg ha^{-1} (Foliar spray)	6.1	0.07	0.6	78	196	1.76	0.7	19.5	23	0.27
Boron @ 2.00 kg ha^{-1} (Foliar spray)	5.9	0.06	0.54	76	190	1.68	0.6	18.50	21	0.25
S. Em. ±	0.14	0.004	0.038	0.70	3.74	0.048	0.034	0.53	0.68	0.006
C.D at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.019

TABLE IV

Uptake of nutrients after the harvest of finger millet as influenced by boron application

Treatments	N	P_2O_5	K_2O	Zn	Cu	Mn	Fe	B
	kg ha-1		mg kg-1					
Control (No Boron application	69	12	60	143	38	148	3830	93
Boron @0.5 kg ha^{-1} (soil application)	72	14	64	156	42	152	890	95
Boron @1.00 kg ha^{-1} (soil application)	73	14.5	65	158	44	154	3904	96
Boron @ 2.00 kg ha^{-1} (soil application)	69	12	61	155	39	149	3850	94
Boron @0.5 kg ha^{-1} (Foliar spray)	71	14	63	155	41	151	3880	95
Boron @1.00 kg ha^{-1} (Foliar spray)	73	14.5	65	157	43	153	3900	96
Boron @ 2.00 kg ha^{-1} (Foliar spray)	70	13	62	154	40	150	3870	94
S. Em.±	1.38	0.88	1.71	5.10	2.11	2.08	24.88	0.41
C.D at 5%	NS	NS	NS	NS	NS	NS	NS	1.21

It can be concluded from present experiment that soil or foliar application of boron @ 0.5 kg ha^{-1} results in increased grain yield and yield components of finger millet. Thus foliar sprays of boron are suggested to be applied for better crop nutrition and increased crop growth, which will ensure higher yields.

REFERENCES

BASAVARAJESWARI, C. P., HOSAMNI, R. M., AJJAPPALAVARA, P. S., NAIK, B. H., SMITHA, R. P. AND UKKUND, 2008, Effect of foliar application of micronutrients on growth, yield components of Tomato (*Lycopersicon esculentum* Mill). *Karnataka J. Agric. Sci.,* **21**(3): 428-430.

BERGMANN, W., 1992, *Nutritional disorders of plants, developments, visual and analytical diagnosis*. Gustay Fisher Verlag Jena. Stuttgart, New York. Pub: VCH publishers.

BROWN, P. H. AND SHELP, B. J., 1997, Boron mobility in plants. *Plant and Soil*., **193** : 85–101.

DABAS, A. S. AND JINDAL, P. C., 1985, Effects of boron and magnesium sprays on fruit bud formation, berry set, berry drop and quality of thompson seedless grape (*Vitis vinifera* L.). *Indian J Agric. Res.,* **19** (1): 40-44.

DONOVA, G. AND CASSEY, C., 1998, Soil fertility management in sub-Sahara Africa. *African J. Agron.*, **94**:128-135.

JACKSON, M. L., 1973, *Soil Chemical Analysis*, Oxford IBH publishing Co. Bombay.

JING, R. F, ZHANG, Q. G., HAN, L. F., ZHANG, F. S. AND WEI, X. Q., 1994, Effect of boric fertilizers on peanut absorption of boron and nitrogen, *Plant and Soil*., **26**: 83-86.

LINDSAY, W. L. AND NORVELL, W. A., 1978, Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc. American J.,* **42** : 421-428.

MENGEL, K. AND KIRKBY, E. A., 1982, Principles of plant nutrition, 3rd Ed. *Int. Potash Inst. Berlin Switzerland*, p.125-127.

PAGE, A. L., MILLER, R. H. AND KENAY, D. R., 1982, Methods of soil analysis. Part-2, *Soil Sci. Soc. America,* Inc., Publs. Madison, Wisconsin, USA.

SINGH, B. B. AND BALASUBRAMAN, V., 1986, Maintenance of soil fertility in the hills with incorporation of legumes in cropping sequence. *Indian J Agric. Sci.*, **40**:40-48.

SUBBAIAH, B. V. AND ASIJA, G., 1956, A rapid procedure for the estimation of available nitrogen in soils. *Curr. Sci.,* **25** : 259-260.

(*Received :* January 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 436-439, 2017

Evaluation of Fish Production in Fish-cum-Poultry Integrated Aquaculture System

Y. Basavaraju, N. Manjappa, Ravindragouda Patil, K. S. Manjunatha Gowda,
C. Swetha and Priyanaka M. Gowda
Fisheries Research and Information Center (Inland), Karanataka Veterinary, Animal and Fisheries Sciences University, Hesaraghatta, Bengaluru - 560 089
E-mail : ravi.patil30@gmail.com

Abstract

A study was conducted to evaluate the growth performance of fish under integrated fish-cum-poultry system with three species polyculture in comparison with the non-integrated control in two 200 m^2 earthern ponds for one year. At the end of the culture period, the treatment pond recorded significantly different overall weight gain of 612.17±11.24 g for catla, 627.36±17.57 g for grass carp and 709.89±10.62 g for amur carp when compared to those of control . Overall survival percentage was higher (84%) in the treatment when compared to that of control (80.67%). Higher fish production of 25.78 kg / pond of catla, 25.83 kg / pond of grass carp and 30.53 kg / pond of amur carp was recorded in the treatment pond, while, the control pond pond recorded a lower fish production of 19.68 kg / pond of catla, 20.40 kg / pond of grass carp and 22.24 kg / pond of amur carp. A higher net fish production of 4,107.00 kg / ha for three species from integrated system was obtained when compared to the control (3,116.00 kg / ha). Also, an increase in fish production of 31.80 per cent was obtained in the integrated culture system when compared to the control.

Keywords : Evaluation, fish production, aquaculture

Integrated fish-cum-livestock systems aim at recycling the waste generated in the farm and its transformation into useful products in the form of various animal products like fish meat, milk, eggs and animal meat. These integrated systems play an important role in the eradication of protein malnutrition of the rural community in particular and human population in general (Gangawar *et al.*, 2013). Integrated fish farming system provide an additional income to the farmers, ensure food security, provide employment and empower rural community (Zira *et al.*, 2015). Fish-cum-poultry integration reduces the cost of production as bird droppings are excellent source of manure and the application of expensive supplementary feed and chemical fertilizers can be avoided. Thus, in fish –cum-poultry integration system, animal protein in the form of fish can be produced at very low production cost through waste recycling (Bhatnagar and Devi, 2013). Poultry dropping is preferred among all the regularly used manure because of its solubility and high level of phosphorus content (Safi *et al.*, 2016). The poultry dropping is one of the best organic manures due to its adequate amount of major nutrients (N, P and K) and trace elements (Vohra *et al.*, 2012). The present study was conducted using fish cum poultry integration using birds and fish in the polyculture. The bird droppings directly dropped in to the fish pond from poultry shed located over the pond. The objective of the present study was to evaluate the potential of integrated fish-cum-poultry culture system in enhancing fish production in polyculture combination of catla, grass carp and Amur carp.

Material and Methods

The study was conducted at Fisheries Research and Information Centre (Inland), Karnataka Veterinary, Animal and Fisheries Sciences University, Hesaraghatta, Bengaluru in two 200 m^3 earthern ponds for a period of 12 months. One of the earthern ponds was used as a treatment pond, which was used for the fish-cum-poultry integrated system while the other earthern pond was used as a non-integrated polyculture system as control.

Animal Husbandry component of the Integrated system

Housing: The poultry shed was constructed using iron frames, iron meshed walls and flooring. The top of the shed was covered with cement sheets with a slope. The size of the poultry shed was 5 x 3 x 3 feet. The iron mesh which formed the floor of poultry house were big enough to allow the poultry droppings to fall directly into the fish pond.

Feeding: 12 young chicks of Giriraja (Broiler-cum-layer) were stocked into the poultry shed. Care was taken to provide proper facilities for giving feed, water and also incandescent lamp facility to keep the birds warm. The birds were fed *ad libitum* daily with a specially formulated feed (Table I). The birds were harvested in batches upon reaching the minimum live weight of 3 to 3.5 kg.

TABLE I

Composition of specially formulated poultry feed

Ingredients	Percentage
Crushed wheat	50
Rice polish	14
GOC	15
Fish meal	19
Crushed Maize	1.5
Table salt	0.5
Vitamin and Mineral pre-mix	0.25
Total	100

Fisheries component of the Integrated culture system

Stocking: Polyculture system was followed and the fingerlings of catla *(Catla catla)*, grass carp (*Ctenopharyngodon idella*) and amur carp (*Cyprinus carpio*) weighing between 2.13 and 2.41g were stocked into both treatment and control earthern ponds at the rate of 7,500 no.s/ha. in equal proportion.

Feeding: The fish of the treatment pond were fed on the natural food (plankton) produced because of the poultry droppings falling directly into the pond. Some percentage of poultry droppings were directly accepted by the fish. The grass carp fingerlings were fed daily with green grass grown on the pond dykes @ 5 per cent of body weight. The fish fingerlings of the control pond were fed with farm made fish feed made of ground nut oil cake (GOC) and rice bran (RB) in the ratio of 1:1 (w / w) @ 10 per cent biomass for the first 2 months, @ 5 per cent biomass for the next two months and from the 5th month onwards @ 2 per cent biomass till the harvest. Manuring was not done in the control pond.

Water quality and sampling: Liming was done for both the treatment and control pond @ 400 kg / ha. The water quality parameters like pH, temperature, dissolved Oxygen, total hardness, total alkalinity and total ammonia were measured on monthly basis using the water quality kit TRANSCHEM (AGRITECH LTD., Vadodara, Gujarat, India) and were maintained within the optimal ranges (Table II). The growth and survival of fish was recorded by monthly sampling.

Statistical analysis: One way analysis variance (ANOVA) was used for finding the significant difference between the growth performance of fish in the treatment and control pond.

RESULTS AND DISCUSSION

Fish growth and survival: Significant difference in the average weight gain of fish, both within the treatment and between the treatment and the control was observed in the present study ($p<0.05$). A significantly higher mean final weight of Amur (709.89±10.62 g) was recorded when compared to other species in the treatment as well as all the three species in the control. The average final weight of all the three species was significantly higher when compared to those of control (Table III). Singh *et al.*

TABLE II

Water quality parameters observed in the ponds during the study period

Ponds	pH	Temperature (°C)	DO_2 (mg/l)	Hardness (mg/L $CaCO_3$)	Alkalinity (mg/L $CaCO_3$)	Ammonia (mg/L)
Treatment (Fish –cum-Poultry culture)	8.0	27	7.0	160	250	0.2
Control	7.8	26	7.2	150	200	0.2

TABLE III

Details of growth, survival and production of fish both in integrated treatment pond and non-integrated control

Particulars	Poultry cum fish culture			Control		
	Catla	Grass carp	Amur carp	Catla	Grass carp	Amur carp
Weight gain (g) (Mean±SE)	612.17±11.24[c*]	627.36±17.57[b]	709.89±10.62[a]	477±14.89[f]	507±13.47[e]	554±10.47[d]
Species-wise survival (%)	84.00	82.00	86.00	82.00	80.00	80.00
Overall survival (%)		84.00			80.67	
Species-wise fish production (Kg / 200 m^3 pond)	25.78	25.83	30.53	19.68	20.40	22.24
Species-wise fish production (Kg / ha)	1289.00	1291.50	1526.50	984.00	1020.00	1112.00
Total fish production (Kg / 200 m^3 pond)		82.14			62.32	
Total fish production (Kg / ha)		4,107.00			3,116.00	
Increase in Fish Production (%)			31.80			

* Values with the same superscripts are not significantly different

(2013) observed that the average final weight of grass carp (490.4 g) and common carp were (247.8g) cultured in the chicken-cum-fish integrated system were higher than their average final weights, 449.8g and 224.7 g, respectively in the control. In the present study, the overall survival percentage was higher (84%) in the treatment when compared to that of control (80.67%) (Table III). Singh *et al.* (2013) also reported that the survival rates of grass carp (62%) and common carp (73%) in the chicken-cum-fish culture system were higher when compared to the control which recorded lower survival rates of 58.7 and 66.3 per cent for grass carp and common carp, respectively.

Fish Production: In the present study, a high species-wise fish production of 1289.0 kg / ha of Catla, 1291.5 kg / ha of grass carp and 1526.5 kg / ha of amur carp for the integrated fish-cum-poultry system while a lower production of 984.0 kg / ha for catla,1020.0 kg / ha for grass carp and 1112.0 kg / ha for amur carp were observed for the non-integrated control for the three species polyculture system (Table III). Safi *et. al.* (2016) also reported a higher species wise fish production of 1,498.35 kg / ha for catla, 1,392.82 kg / ha for rohu and 962.02 kg / ha for mrigal when compared to lower 534.78 kg / h for catla, 391.13 kg / ha for rohu and 301.78 kg / ha for mrigal in the control. In the present study, a higher net fish production of 4,107.00 kg / ha for three species integrated system was obtained when compared to the control (3,116.00 kg / ha). Also, an increase in fish production of 31.80 per cent was obtained in the integrated culture system when compared to control in the present study. Singh *et al.* (2013) reported a higher net fish production of 6,870 kg / ha when compared to a mere 5,808 kg / ha in the control. Safi *et al.* (2016) reported a higher net fish production of 3,853.20 kg / ha for the polyculture with three species, catla, rohu and mrigal when compared to a mere 1,227.69 kg / ha in the control. In the present study, a higher net fish production of 82.14 kg / 200 m^3 was observed for the poultry-cum-fish integration and lower net fish production of 62.32 kg / 200 m^3 was observed for the control. The reasons for higher fish production from ponds fed with chicken manure as direct droppings might be due to the nutrients present in chicken excreta were fed directly by the fish to some extent and the remaining, induced the production of phytoplankton and zooplankton through detritus food chain (Oribhabor and Ansa, 2006). The fish fed on this naturally produced plankton *ad libitum* and hence, the increase in fish production when compared to that in the non-integrated fish culture system. Also, poultry manure is one of the best organic manure due to its adequate amount of major nutrients (N, P and K) and trace elements (Vohra *et al*., 2012) contributing to higher natural productivity of the ponds.

From the results of the present study, it is clear that integrated fish-cum-poultry farming achieves higher species-wise production in the polyculture combination of catla, grass carp and amur carp as well as net fish production, provides additional income to the rural community and ensures food security. It also greatly reduces the cost of production as it eliminates the need for the application of expensive supplementary feed and chemical fertilizers.

References

Bhatnagar, A. and Devi, P., 2013, Water quality guidelines for the management of pond fish culture. *Int. J. Environ. Sci.*, **3**:1980-2000.

Gangwar, L. S., Saran, S. and Kumar, S., 2013, Integrated poultry-fish farming systems for sustainable rural livelihood security in Kumaon Hills of Uttarakhand. *Agri. Econ. Res. Rev.,* **26** : 181 - 188.

Oribhabor, B. J. and Ansa, E. J., 2006, Organic waste reclamation, recycling and re-use in integrated fish farming in the Niger Delta. *J. Appl. Sci. Environ. Manag.,* **10** : 47 - 53.

Safi, V., Singh, A. D., Gogoi, B., Kumar, R., Saikia, R. and Das, D. N., 2016, Effect of poultry dropping on water quality and fish growth parameters of Indian major carp in the foothill ponds of Arunachal Pradesh, India. *Int. J. Multidisciplin. Res. Develop*.**,** **3** : 311 - 316**.**

Singh, U. P., Pandey, N. N. and Bisht, H. C. S., 2013, Growth performance of exotic carps in poultry waste recycled ponds. *Int. J Adv. Res.,* **1** : 239 - 248.

Vohra, A. R., Narejo, N. T., Naeem, M., Wadhar, G. M. and Dayo, A., 2012, Effect of dry poultry wastes on the phsico- chemical and fish growth parameters of exotic carps, *Cyprinus carpio* at carp hatchery (District Badin), Sindh, Pakistan. *Sindh. Uni. Res. Jour.*, **44** : 239 - 244.

Zira, J. D., Jaafaru, A., Badejo, B. I., Ghumdia, A. A. and Ali, M. E., 2015, Integrated fish farming and poverty alleviation / hunger eradication in Nigeria. *IOSR J. Agri. Vet. Sci.,* **8** : 15 - 20.

(*Received :* January, 2017 *Accepted :* June, 2017**)**

Mysore J. Agric. Sci., 51 (2) : 440-445, 2017

Child Labourer's Working Conditions and Terms of Employment in Mahabubnagar District of Andhra Pradesh

M. Prasuna and M. Sudarshan Reddy
Agricultural Information Centre, Administrative Building, ANGRAU, Rajendranagar, Hyderabad
E-mail : nanne@gmail.com

Abstract

A Descriptive Research Design was used for conducting the study. Among the working conditions, most of the girls and boys had inadequate toilet facilities, moderate amount of drinking water and unhygienic environment. Majority of them were always exposed to dirt, smoke and extreme weather conditions while working like sun, rain and cold. Regarding the terms of employment, the tenure of employment of majority of both girls and boys was temporary, worked for 8-9 hours during day time and most of them worked for 4-6 hours additionally during night time. The mode of payment was mostly annual. Advance payment of wages and daily provision of money for toddy, showing cinema in the theatre once in one to two months were among the major incentives provided by the employers to the child labourers. A little more than 50 per cent of child labourers had periodicity of employment for 5-8 months per year. Hence, the anti poverty programmes and the interventions of non government organisations could play a pivotal role in the elimination of child labour.

Keywords : Child labourer, working condition, employment

It is not a present day feature only that children are taking part in economic activities. To a greater or lesser extent, children in every type of human society have always taken part in economic activities. In earlier times, children used to work within their family circle. Little by little, through almost unconscious observation, association and imitation children learnt the work of adults and family occupations. During the process of socialization of the children, training formed a part and children grew physically and intellectually without facing hazardous difficult tasks and ill treatment and was simultaneously prepared for adult life. The work place in these societies was an extension of home and work relationships which were informal. But with the progress of industrialization and urbanization, the traditional crafts and family based economy was destroyed; people were displaced from the land due to mechanization of agriculture. The breeding of poverty among masses started to multiply in this situation with the increasing motive of profit maximization and exploitation. The strong urge of the employers for more profit resulted in neglect of working place with poor ventilation and unhygienic conditions, long hours of work, low wages, ill treatment, which proved detrimental to the growth and development of child labour. In this backdrop, the present study was carried out to find out the child labourer's working conditions and terms of employment.

Methodology

The study was conducted purposively in selected Mahabubnagar district of Andhra Pradesh. Descriptive research design was used to conduct the study. Out of the 64 mandals, five mandals were selected from the district through simple random sampling method. From the five selected mandals, three villages from each mandal, were selected randomly. In each village, ten child labourers comprising of five girl child labourers and five boy child labourers were selected randomly. Thus, making a total sample of 150 child labourers. A pre-tested interview schedule was used for collecting the required data through personal interview method.

Working conditions refer to the various facilities provided at the work place of child labourers and the kind of physical environment in which they are working. The working conditions comprised of six items. The responses were measured on a three point continuum of adequacy as; 'adequate', 'moderately adequate' and 'inadequate' with a scoring of three, two and one respectively. The frequencies on each of these items were obtained and percentages were calculated. Terms of employment of child labourers refer to the various terms and conditions or rules and regulations of employment. Terms of employment of child labourers include: i) tenure of employment, ii) working hours, iii) mode of payment, iv) incentives provided by the employer and v) periodicity of employment.

RESULTS AND DISCUSSION

Working conditions of child labourers

The Table I depicts that a great majority (91.33%) of the total child labourers had inadequate toilet facilities which comprised of 89.33 per cent of girls and 93.33 per cent of boys. A considerable majority (52.00%) of girls expressed inadequacy of drinking water at their work place and majority (68.00%) of boys felt that it is moderately adequate. Inadequacy of hygienic environment was reported by 73.33 per cent of girls and 58.66 per cent of boys together forming a sizeable majority (66.00%) of the total child labourers. A little less than half of the girls (48.00%) felt that working equipment provided at the work place was moderately adequate and majority (62.66%) of boys felt that it is adequate. Majority (70.00%) of the child labourers were always exposed to dirt, smoke etc out of whom girls were 77.33 per cent and boys form 62.66 per cent. Similar results were noticed by Bhargava (2003). Almost an equal majority (70.66%) of the total child labourers were also exposed to sun, rain and cold which comprised of 72.00 per cent and 69.33 per cent of girls and boys, respectively. The reason for this could be that most of the girls were involved as 'agricultural labourers' and boys in works like cattle rearing, agricultural labour and house construction. As many of them were working in the open fields outside the dwelling areas, where there was no accessibility for toilet facilities. Most of the child labourers expressed that the drinking water at the work place was inadequate to moderately adequate. This was because some of the child labourers were working at the employers/landlords homes who

TABLE I

Distribution of child labourers based on their working conditions

(N = 150)

Working conditions	Adequate			Moderately adequate			Inadequate		
	Girls (n=75)	Boys (n=75)	Total	Girls (n=75)	Boys (n=75)	Total	Girls (n=75)	Boys (n=75)	Total
Toilet facilities	-	-	-	3 (4.00)	5 (6.66)	8 (5.33)	67 (89.33)	70 (93.33)	137 (91.33)
Drinking water	8 (10.66)	18 (24.00)	26 (17.33)	28 (37.33)	51 (68.00)	79 (52.66)	39 (52.00)	6 (8.00)	45 (30.00)
Hygienic environment	4 (5.33)	2 (2.66)	6 (4.00)	16 (21.33)	29 (38.66)	45 (30.00)	55 (73.33)	44 (58.66)	99 (66.00)
Working equipment	28 (37.33)	47 (62.66	75 (50.00)	36 (48.00)	18 (24.00)	54 (36.00)	11 (14.66)	10 (13.33)	21 (14.00)
	Always			Sometimes			Rarely		
	Girls (n=75)	Boys (n=75)	Total	Girls (n=75)	Boys (n=75)	Total	Girls (n=75)	Boys (n=75)	Total
Exposure to dirt smoke etc.	58 (77.33)	47 (62.66)	105 (70.00)	17 (22.66)	28 (37.33)	45 (30.00)	-	-	-
Exposure to sun, rain and cold	54 (72.00)	52 (69.33)	106 (70.66)	19 (25.33)	23 (30.66)	42 (28.00)	2 (2.66)	-	2 (1.33)

Figures in parenthesis indicate percentages had access of drinking water as and when needed and others were not provided water at the work place. Most of the child labourers had inadequate hygienic environment as they were involved in works which are often performed in dirt and unhygienic environment such as agricultural fields, poultry farms, domestic work, house construction work, repairs etc. and were always exposed to sun, rain and cold.

Perusal of the Table II indicates that a majority (54.00%) of the total child labourers with 56.00 per cent of girls and 52.00 per cent of boys were temporary workers, whereas 44.00 per cent and 48.00 per cent of girls and boys, respectively both together figuring to 46.00 per cent were permanent workers. This is because most of them were engaged in agricultural work and as the district is drought prone, rainfall is not certain, therefore, agricultural production is also not uniform in all the seasons and years. Hence, most of the child labourers were taken on a temporary basis by the employers or landlords. The rest of the child labourers were permanent labourers due to the reason that most of the employers had cattle and a few had poultry farms, so the child labourers were permanently hired for the whole year.

Working hours

The working hours of the child labourers were categorised into 'hours of work during day time' and additional night hours of work.

TABLE II

Distribution of child labourers based on their tenure of employment

(N = 150)

Category	Girls (n = 75)		Boys (n = 75)		Total	
	No.	per cent	No.	per cent	No.	per cent
Temporary	42	56.00	39	52.00	81	54.00
Permanent	33	44.00	36	48.00	69	46.00

The data furnished in the Table III reveals that during day time, a sizeable majority (71.33%) of the total child labourers worked for 8-9 hours during day time, among which a large majority (82.66%) were girls and 60.00 per cent were boys. As far as additional night hours of work was concerned, a considerable number (36.66%) of the total child labourers among whom 56.00 per cent of girls and 17.33 per cent of boys worked for 4-6 additional night hours of work. These results are in confirmation with those of Reddy (2007). Hence, most of the child labourers worked beyond the stipulated hours of work because of fear of termination of their job. As it is understood that children work for supplementing their inadequate family incomes, they may not want to go against the instructions of their employers. The additional night hours of work was performed at the time of harvest of the agricultural produce, for cleaning,

TABLE III

Distribution of child labourers based on their working hours

(N = 150)

Category of working hours	Girls (n=75)		Boys (n=75)		Total	
	No.	Per cent	No.	Per cent	No.	Per cent
Day-hours of work						
Below 7 hours	5	6.66	-	-	5	3.33
7-8 hours	8	10.66	19	25.33	27	18.00
8-9 hours	62	82.66	45	60.00	107	71.33
Above 9 hours			11	14.66	11	7.33
Additional night hours of work						
2-4 hours	5	6.66	38	50.66	43	28.66
4-6 hours	42	56.00	13	17.33	55	36.66
6-8 hours	12	16.00	4	5.33	16	10.66

processing, storage and other operations. It was also found that most of the child labourers were working on a temporary basis, they had to work beyond the stipulated hours of work because of reasons like fear of job termination and anxiety about the continuation of the job. Children were therefore, forced to work due to these compulsive circumstances.

Mode of Payment

From the Table IV it was clear that majority (59.33%) of the total child labourers comprising of 64.00 per cent of girls and 54.67 per cent of boys were paid money annually followed by 29.33 per cent of the child labourers who were paid weekly of which a quarter number were girls (25.33%) and one third were boys (33.33%). Only 8.00 and 9.33 per cent of girls and boys, respectively together forming 8.67 per cent of the total child labourers were deriving their payment monthly.These results were in accordance with the findings of Siddiqui (2003). The child labourers were employed by their employers on an annual basis. In all the cases they were paid a fixed amount of cash for the prescribed contract period of one year. They were paid in cash and the repayment is in terms of exchange of labour. This was followed by weekly payment (29.33%) where some of the child labourers were involved in works like poultry farms, house construction works etc. Monthly payment was made by the employers of motor cycle repair shops, iron smiths, watchman, domestic servants and also by some of the poultry farm employers. Hence, mode of payment of wages varies depending upon the contract between the employers and labourers. The mode of payment also varied primarily according to the nature of employment.

TABLE IV

Distribution of child labourers according to their mode of payment

(N = 150)

Category	Girls (n = 75) No.	per cent	Boys (n = 75) No.	per cent	Total No.	per cent
Daily	2	2.67	2	2.67	4	2.67
Weekly	19	25.33	25	33.33	44	29.33
Monthly	6	8.00	7	9.33	13	8.67
Annually	48	64.00	41	54.67	89	59.33

Incentives provided by the employer

From the Table V it was evident that a good majority (69.33%) of the total child labourers received advance payment of salary out of whom 64.00 per cent were girls and 74.66 per cent formed boys. A considerable majority (54.66%) of the child labourers among which a large majority (88.00%) of girls and only 21.33 per cent of boys had a provision of money for toddy which was given daily to the children. The child labourers were shown cinema in the theatre in 44.00 per cent cases which comprised of 69.33 per cent and 18.66 per cent of girls and boys, respectively. A good number of both girls (41.33%) and boys (37.33%) together making 39.33 per cent of the total child labourers had provision of annual increment in advance. Slightly more than one fifth of the total child labourers (20.66%) were shown cinema through VCP at the employer's residence which comprised of 30.66 per cent of girls and 10.66 per cent of boys. A less per cent of total child labourers (17.33%) who were only boys (34.66%) were provided accommodation, food and clothes. An equal per cent of the total child labourers were provided cooking equipment, fire wood and cooking materials (12.00%) who constitute only boys (24.00%). Providing accomodation and food at work was observed in another 12.00 per cent out of which 10.66 per cent and 13.33 per cent were girls and boys respectively. It was found that the major incentive for child labourers was 'advance payment of wages' by the employers / landlords. This was their frequent practice with the child labourers, for the reason that they would be available to work through out the year and there would be no uncertainty of getting labour whenever they needed. Provision of money for toddy, was a frequent practice as this money (Rs. 2/-) would motivate them to attend the work regularly. Most of the child labourers who were involved in agricultural work were taken to cinema in a theatre or were shown VCP once in a month or two months and most of them were given annual increment in advance as this would tempt the parents and the children to continue in the work with the same employer/landlord.

TABLE V

Distribution of child labourers based on the incentives provided by the employer

(N= 150)

Category of working hours	Girls (n=75)		Boys (n=75)		Total	
	No.	Per cent	No.	Per cent	No.	Per cent
Below 7 hours	5	6.66	-	-	5	3.33
Advance payment of Wages	48	64.00	56	74.66	104	69.33
Provision of annual increment in the advance given	31	41.33	28	37.33	59	39.33
Showing cinema in theatre	52	69.33	14	18.66	66	44.00
Showing cinema through VCP	23	30.66	8	10.66	31	20.66
Daily provision of money for toddy	66	88.00	16	21.33	82	54.66
Providing cooking equipment, firewood and cooking materials	-	-	18	24.00	18	12.00
Providing accommodation & food at work	8	10.66	10	13.33	18	12.00
Providing food and clothes	5	6.66	9	12.00	14	9.33
Providing accmmodation food & clothes	-	-	26	34.60	26	17.33
Providing Accommodation	-	-	1	1.33	1	0.66

Periodicity of employment

From the Table VI it can be seen that a little above than half of the total child labourers (53.33%) with a large majority (81.33%) of girls and a quarter number of boys (25.33%) had work for a period of '5-8 months' per year. The possible reason for this could be that most of the child labourers were working as agricultural labourers and during the lean agricultural period i.e., during summer they do not find any employment. These findings are in conformity with the findings of (Reddy and Ramesh, 2002), followed by 40.66 per cent of child labourers having very less number of girls (6.66%) and a good majority (74.66%) of boys worked for a period of '9-12 months' per year, whereas only 6.00 per cent of the total child labourers which constituted only girls (12..00%) worked for 1-4 months per year. This was followed by 40.66 per cent who were employed for a period of nine months to the whole year as they were involved in works such as poultry farms, domestic servants, cattle rearing, iron smiths and motor cycle repair in which they need to be engaged mostly for the whole year. Hence, it was clear that the periodicity of employment was affected by the type of work in which they were involved.

TABLE VI

Distribution of child labourers based on their periodicity of employment

(N= 150)

Category	Girls (n = 75)		Boys (n = 75)		Total	
	No.	per cent	No.	per cent	No.	per cent
1-4 months / year	9	12.00	-	-	9	6.00
5-8 months / year	61	81.33	19	25.33	80	53.33
9-12months / year	5	6.66	56	74.66	61	40.66

Anti poverty programmes will be helpful in uplifting the living standards of poor families who are compelled to send their children to work as a helping hand in the family income. Families 'at-risk' should receive top priority in the allotment of funds under such anti-poverty programmes. The present anti-poverty programmes should have families of child labour as special target groups with allotment of funds and special skills-development programmes of short duration should be introduced among the families 'at-risk'. The Non Government Organizations for independent people's organizations have very important role to play in achieving the goal of abolition of child labour. The overall programme of rehabilitation of child labour needs people's participation and co-operation from all sectors *i.e.,* from their families to the societies working for them.

REFERENCES

BHARGAVA, G., 2003, Child labour, Kalpaz Publications, Delhi, Vol-II, p. 358 - 391.

REDDY, C. D., 2007, Child labour - A study, Serials Publications, New Delhi, p. 82 - 103.

REDDY, S. B. AND RAMESH, K., 2002, Girl child labour, a world of endless exploitation, Dominant Publishers and Distributors, New Delhi, p. 114 - 158.

SIDDIQUI, S. M. I., 2003, Child labour, how to investigate?, Deep & Deep Publications Pvt. Ltd., New Delhi, p. 64 - 72.

(*Received :* January, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 446-453, 2017

A Study on Breeding and Calf Management Practices in Bidar District of Karnataka - An Exploratory Study

R. Vranda, K. Satyanarayan, V. Jagadeeswary and J. Shilpa Shree
Department of Veterinary and Animal Husbandry Extension Education, Veterinary College, Hebbal, Bengaluru-560 024
E-mail : ksnkmk1960@gmail.com

Abstract

The study on breeding and calf management practices of buffaloes was purposively conducted in Bidar district of Karnataka adopting exploratory research design. A total of 180 buffalo farmers were selected randomly for the study. The study revealed that most of the farmers experienced problems in heat detection at right time in buffaloes (51.12 %). Majority of farmers preferred artificial insemination (51.22 %), bred their buffaloes 3 or more than 3 times for successful conception (71.67 %) and encountered repeat breeding in the buffaloes (56.12 %). Among the farmers who had encountered repeat breeding problem in the herd, about 37.23 per cent of farmers found that animals did not responded positively towards the treatment of repeat breeding and most of them did not maintain proper breeding record (96.67 %). Most of the farmers provided adequate floor space to the calves (70.55 %) but did not provide bedding material to protect from extreme weather (71.67 %) and also did not provide manger for feeding their calves (94.45 %). Majority of the farmers experienced calf mortality problem (54.44 %) caused due to diarrhea (35.55 %). Repeat breeding problem in the buffaloes (70.00 %) and poor conception rate through artificial insemination (58.88 %) were the major breeding constraints faced by farmers.

Keywords : Breeding, calf management, artificial insemination, conception, mortality

Animal Husbandry is helpful in generating gainful employment in the rural sector, particularly among the landless labourers, small and marginal farmers by supplementing their family incomes, hence animal husbandry is carried out by all farmers regardless of their economic status. Buffalo has inherent ability to produce milk with high milk fat content ranging from 6 to 8.5 per cent. Because of its higher milk fat contents, buffalo milk is preferred over cow milk and it fetches better price in the market (Khan *et al.,* 2010). The Murrah, Bhadawari, Jaffarabadi, Surti, Mehsana, Nagpuri and Nili Ravi are the important breeds of buffalo. Although the economic contribution of livestock seems to be quite substantial in the agricultural economy as well as in the national economy, the farmers who raise buffaloe are ignorant of scientific management practices. Genetic potentiality of the livestock and its production depends mostly on the managerial practices (Gupta *et al.*, 2008). Productivity and health starts when the cow is born as calf. The effect of nurture is many a times greater and pre-weaning period is a phase of development where the productivity of the calf can be modified to enhance the animal's genetic potential. Hence, proper management helps the calf to get a good start for a productive life. In this backdrop, the present study is undertaken to explore the breeding and calf management practices of buffaloe followed by farmers.

Methodology

The study on calf management practices was conducted in the state of Karnataka which is having high density of livestock population. Bidar district was purposively selected for the study since it has got predominantly buffalo based dairy production system. Two taluks viz., Bidar and Humnabad were randomly selected for the study. Ninety buffalo farmers were selected randomly from each of the two taluks under study, thus a total of 180 buffalo farmers were selected. Data was collected through informal and friendly visits to the farmers' homes and farms in the early hours of the day.

Results and Discussion

Breeding management practices for buffaloes

The distribution of buffalo farmers based on breeding management practices is depicted in Table I. The results in table revealed that, majority of the buffaloes belongs to small (68.33 %), medium (73.33 %), large (70.00 %) and pooled sample farmers (70.56 %) attained the maturity age between three to four years. The results of the present study are similar to the findings of Tiwari *et al*. (2007). About 36.37, 41.67, 30.00 and 36.11 per cent of the small, medium, large and pooled sample farmers respectively detected heat in buffaloes based on the symptom of mucous discharge and bellowing. Similar findings were reported by Sabapara *et al*. (2010). The data revealed that significant per cent of the small (41.67 %), medium (50.00 %), large (56.67 %) and pooled sample farmers (46.12 %) bred their buffaloes between 12 - 24 hours after heat detection in buffaloes. It confirms the awareness among farmers regarding the stages of breeding for successful conception and also due to better extension work by the artificial insemination workers regarding breeding stages in the buffaloes. Sabapara *et al*. (2010) in their study identified similar findings, where majority of the farmers bred their animals between 12 - 18 hours after heat detection.

A glance at Table I also found that, majority of the small (55.00 %), medium (58.33 %), large (53.33 %) and pooled sample farmers (51.12 %) had problem in detection of heat in buffaloes. As there are no external symptoms exhibited during heat, it becomes difficult for the farmers to detect heat symptoms in buffaloes. The results are in agreement with the findings of Vijay *et al.* (2008). Artificial insemination was preferred by majority of the small (55.00 %), medium (60.00 %) and pooled sample farmers (51.22 %), whereas, natural method was preferred by large farmers (61.67 %). The reason for the above findings might be due to non availability of graded buffalo bull for natural service, high cost offered by the buffalo bull owners and also due to the availability of artificial insemination service facility. The results are in consonance with the findings of Sabapara *et al.* (2010) and differ with the findings of Rathore *et al.* (2010), who reported that, majority of the farmers preferred natural service for breeding in their animals.

Seventy, 80, 65 and 71.67 per cent of the small, medium, large and pooled sample farmers, respectively, bred their buffaloes for 3 or more than 3 times for successful conception. The time of breeding, quality of semen and physiological stage of buffaloes plays a major role in early conception. Gupta *et al.* (2008), reported similar findings in their study, where majority of the buffaloes conceived by three services only.

Majority of small (51.67 %), medium (53.33 %), large (63.33 %) and pooled sample famers (56.12 %) had problem of repeat breeding in their herd. Among those who had repeat breeding problem in their herd, 41.67, 46.67, 63.33 and 50.56 per cent of the small, medium, large and pooled sample farmers respectively, offered treatment for repeat breeder buffaloes from the Veterinarians. Among them, substantial number of buffaloes belonging to small (30.00 %), medium (33.33 %), large (48.33 %) and pooled sample farmers (37.23 %) did not respond to the treatment offered from Veterinarians.

With respect to age at first calving, majority of the buffaloes belong to small (55.00 %), medium (66.67 %), large (58.33 %) and pooled sample farmers (60.00 %) calved between 3 - 4 years of age. The perusal of Table I also found that, 55.00, 46.66 and 44.45 per cent of the small, medium and pooled sample farmers, respectively, carried breeding after 5 months of parturition in buffaloes, whereas, 43.33 per cent of the large farmers carried breeding within 3-5 months after parturition. The post partum breeding interval can be considered as a good indicator of reproduction efficiency in animal. It might be due to the fact that, majority of the farmers thought that breeding at early stage in buffaloes decrease the milk production and further may be lack of knowledge among the farmers to rebreed their buffaloes after 3 months of parturition.

It is evident from the results that, 50 per cent each of the small and medium farmers and 43.88 per cent of the pooled sample farmers had calving interval for more than 18 months, whereas, in case of large farmers (46.67 %) had calving interval between 12-18 months. The long inter-calving period puts the dairy farmer into economic loss and increases the cost of maintenance; this might be due to lack of knowledge among the farmers regarding rebreeding leading to

TABLE I

Distribution of buffalo farmers based on breeding management practices

Breeding management practices	Farmers: Small (n=60) No.	%	Medium (n=60) No.	%	Large (n=60) No.	%	Pooled sample (N=180) No.	%
1	2	3	4	5	6	7	8	9
Maturity age of buffaloes								
a. Below three years	3	5.00	5	8.33	8	13.33	16	8.88
b. Three to four years	41	68.33	44	73.33	42	70.00	127	70.56
c. Four to five years	16	26.67	11	18.34	10	16.67	37	20.56
Heat detection method								
a. Bellowing	2	3.33	5	8.33	3	5.00	10	5.55
b. Mucous discharge	6	10.00	6	10.00	9	15.00	21	11.67
c. Attempt to mount on other animal	1	1.67	2	3.33	3	5.00	6	3.33
d. Mucousdischarge + Attempt to mount on other animal	6	10.00	5	8.33	9	15.00	20	11.11
e. Mucous discharge + Bellowing	22	36.67	25	41.67	18	30.00	65	36.11
f. Mucous discharge + Bellowing + Attempt to mount on other animal	16	26.67	11	18.34	12	20.00	39	21.67
g. Others: Sticking of the mucous below the tail	7	11.66	6	10.00	6	10.00	19	10.56
Stages of heat period for breeding								
a. Within 12 hours	16	26.66	21	35.00	27	45.00	64	35.55
b. Between 12 - 24 hours	25	41.67	30	50.00	28	56.67	83	46.12
c. More than 24 hours	19	31.67	9	15.00	5	8.33	33	18.33
Problem in detecting silent heat								
a. Yes	33	55.00	35	58.33	32	53.33	92	51.12
b. No	27	45.00	25	41.67	28	46.67	88	48.88
Preference for breeding method								
a. Artificial insemination	33	55.00	36	60.00	23	38.33	92	51.22
b. Natural method	27	45.00	24	40.00	37	61.67	88	48.88
Number of breeding for successful conception								
a. 1 or 2 times	18	30.00	12	20.00	21	35.00	51	28.33
b. 3 or more than 3 times	42	70.00	48	80.00	39	65.00	129	71.67
Repeat breeding problem, treatment and response of treatment								
A. Yes								
i. Treated from Veterinarians and responded positively	7	11.67	8	13.34	9	15.00	24	13.33

1	2	3	4	5	6	7	8	9
ii. Treated from Veterinarians and not responded positively	18	30.00	20	33.33	29	48.33	67	37.23
iii. Not treated	6	10.00	4	6.66	0	0.00	10	5.56
B. No	29	48.33	28	46.67	22	36.67	79	43.88
Age at first calving								
a. Below 3 years	1	1.67	9	15.00	6	10.00	16	8.88
b. Between 3 - 4 years	33	55.00	40	66.67	35	58.33	108	60.00
c. More than 4 years	26	43.33	11	18.33	19	31.67	56	31.12
Post partum breeding								
a. 2 - 3 months	6	10.00	16	26.67	15	25.00	37	20.55
b. 3 - 5 months	21	35.00	16	26.67	26	43.33	63	35.00
c. After 5 months	33	55.00	28	46.66	19	31.67	80	44.45
Inter-calving period								
a. Within 12 months	3	5.00	16	26.67	13	21.67	32	17.78
b. 12 - 18 months	27	45.00	14	23.33	28	46.67	69	38.34
c. More than 18 months	30	50.00	30	50.00	19	31.66	79	43.88
Maintenance of breeding record								
a. Yes	0	0.00	1	1.66	5	8.33	6	3.33
b. No	60	100.0	59	98.33	55	91.67	174	96.67

long calving interval period. Regarding maintenance of breeding record, cent per cent of small farmers and majority of the medium (98.33 %), large (91.67 %) and pooled sample farmers (96.67 %) did not maintain breeding record. This shows lack of awareness among the farmers regarding the importance of breeding record.

Calf management practices for buffaloes

The distribution of buffalo farmers based on calf management practices are depicted in Table II. The results revealed that, all the small farmers (100.00 %) and majority of the medium (90.00 %), large (81.67 %) and pooled sample farmers (90.56 %) tied their buffalo calves along with their mother. The results were in accordance with the findings of Tiwari *et al.* (2007). Significant number of the small (75.00 %), medium (70.00 %), large (78.33 %) and pooled sample farmers (74.44 %) were practicing to feed colostrum immediately after the birth of calves. This indicated that farmers were aware on timely colostrum feeding. The results of the present study are in contrary with the findings of Tiwari *et al.* (2007) and Sinha *et al.* (2010) who reported that, majority of farmers were feeding colostrum after the expulsion of placenta. Majority of the small (80.00 %), medium (55.00 %), large (76.67 %) and pooled sample farmers (70.55 %) provided adequate floor space to the calves. The findings of Tiwari *et al.* (2007) were contrary with the findings of present study, who reported that, calves were housed in a crowded way due to lack of space.

The data presented in Table II reveals that, majority of the small (73.33 %), medium (60.00 %), large (56.67 %) and pooled sample of farmers (63.33 %) left the navel cord as it is, for natural fall out, which indicates the lack of knowledge among farmers regarding the navel cord disinfectation. Tiwari *et al.* (2007), Rathore *et al.* (2010), Sabapara *et al.* (2010) and Sinha *et al.* (2010), observed similar findings. Majority of the small (63.33 %), medium (76.67 %), large (75.00 %) and pooled sample of farmers (71.67 %) did not provide any bedding material to the calves to protect from extreme heat

TABLE II

Distribution of buffalo farmers based on calf management practices

Breeding management practices	Farmers Small (n=60)		Medium (n=60)		Large (n=60)		Pooled sample (N=180)	
	No.	%	No.	%	No.	%	No.	%
1	2	3	4	5	6	7	8	9
Housing system								
a. Separate shed	0	0.00	1	1.67	2	3.33	3	1.67
b. Created space in the shed in shed	0	0.00	5	8.33	9	15.00	14	7.77
c. Tied calf with mother	60	100.0	54	90.00	49	81.67	163	90.56
First colostrum feeding								
a. Immediately after birth	45	75.00	42	70.00	47	78.33	134	74.44
b. After expulsion of placenta	7	11.67	9	15.00	5	8.33	21	11.67
c. Never feed	8	13.33	9	15.00	8	13.34	25	13.89
Floor space provided								
a. Adequate	48	80.00	33	55.00	46	76.67	127	70.55
b. Inadequate	12	20.00	27	45.00	14	23.33	53	29.45
Practice of navel cord separation								
a. Cutting and disinfecting the navel cord.	16	26.67	24	40.00	26	43.33	66	36.67
b. Left as it is, for natural fall ouT	44	73.33	36	60.00	34	56.67	114	63.33
Bedding materials provided to calves	6	10.00	2	3.33	5	8.33	13	7.22
a. Gunny bag	3	5.00	3	5.00	2	3.33	8	4.44
b. Straw	13	21.67	9	15.00	8	13.34	30	16.67
c. Gunny bag + Straw	38	63.33	46	76.67	45	75.00	129	71.67
d. Nil								
Milk suckling time by the calves								
a. Before milking	33	55.00	36	60.00	39	65.00	108	60.00
b. After milking	27	45.00	24	40.00	21	35.00	72	40.00
Practice of weaning								
a. Yes	0	0.00	0	0.00	0	0.00	0	0.00
b. No	60	100.0	60	100.0	60	100.0	180	100.0
Deworming practice								
a. Regularly	28	46.66	39	65.00	34	56.67	101	56.12
b. Occasionally	16	26.67	12	20.00	15	25.00	43	23.88
c. Never practice	16	26.67	9	15.00	11	18.33	36	20.00

1	2	3	4	5	6	7	8	9
Age of feeding fodder								
a. Less than 1 week	9	15.00	6	10.00	8	13.33	23	12.77
b. Between 1 – 2 week	51	85.00	54	90.00	52	86.67	157	87.23
Calf mortality problem and major causes								
a. Yes								
I. Diarrhoea	24	40.00	19	31.66	21	35.01	64	35.55
II. Endoparasitic infestation	5	8.34	4	6.67	3	5.00	12	6.67
III. Navel ill	5	8.33	0	0.00	3	5.00	8	4.44
IV. Pneumonia	2	3.33	3	5.00	2	3.33	7	3.89
V. Bloat	2	3.33	3	5.00	2	3.33	7	3.89
Calf mortality problem total	38	63.33	29	48.33	31	51.67	98	54.44
b.. No	22	36.67	31	51.67	29	48.33	28	15.56
11 Manger provided for calves								
a. Yes	0	0.00	5	8.33	5	8.33	10	5.55
b. No	60	100.0	55	91.67	55	91.67	170	94.45

and cold. The exposure of calves to extreme heat and cold leads to physical stress and the body of calves is not adapted to bear such stress and the calves may collapse. The results of the present study were in agreement with the findings of Tiwari *et al.* (2007) but not in agreement with the findings of Vijay *et al.* (2008), who reported that, majority of the farmers were providing bedding material to the calves.

Majority of the small (55.00 %) and large farmers (65.00 %) and an equal percentage (60.00 % each) of the medium and pooled sample farmers allowed their calves to suckle milk before milking, but not after milking. Most of the farmers are using calf for letting down of milk only but not feeding sufficient quantity of milk to the calves which indicated the improper feeding of milk in the calves. Vijay *et al.* (2008), observed similar findings in their study. The findings of Tiwari *et al.* (2007) were contrary with the present findings, who reported that, majority of the farmers allowed their calves to suckle milk both before and after milking.

It was observed from the results that, none of the farmers from all the categories, i.e., small, medium and large did not practice weaning in calves. The findings are in partial agreement with the findings of Sinha *et al.* (2010) and Aulakh and Rajbir (2012) who reported that, low percentage of farmers practiced weaning in the calves. Significant per cent of small farmers (46.66 %) and majority among the medium (65.00 %), large (56.67 %) and pooled sample farmers (56.12 %) were practicing regular deworming in the calves. This confirmed the awareness among the farmers regarding the importance of deworming in the calves. The findings of Tiwari *et al.* (2007), Gupta *et al.* (2008), Vijay *et al.* (2008) and Sabapara *et al.* (2010) were not in agreement with the findings of the present study, who reported that, majority of the farmers did not practice deworming in calves. Majority of the small (85.00 %), medium (90.00 %), large (86.67 %) and pooled sample of farmers (87.23 %) started to feed fodder to the calves at the age of 1 - 2 weeks. The results are contrary with the findings of Sinha *et al.* (2010), who reported that, in rural and semi-rural areas, farmers started feeding fodder from 3 months of age and in urban areas, within 2 months of age.

Majority of the small (63.33 %), large (51.67 %) and pooled sample farmers (54.44 %) had problem of calf mortality, whereas, majority (51.67 %) of the

TABLE III

Distribution of buffalo farmers based on the breeding constraints

Breeding management practices	Farmers: Small (n=60) No.	%	Medium (n=60) No.	%	Large (n=60) No.	%	Pooled sample (n=180) No.	%	Ranking
Insufficient information about of heat detection signs in animals	0	0.00	1	1.66	0	0.00	1	0.55	X
Insufficient information about timing of artificial insemination /Natural service	14	23.33	7	11.66	9	15.00	30	16.66	VII
Inability to detect heat symptoms in buffaloes due to silent heat	15	25.00	15	25.00	18	30.00	48	26.66	VI
Poor conception rate through artificial insemination	32	53.33	35	58.33	39	65.00	106	58.88	II
Non availability of artificial s insemination facilitie	6	10z.00	2	3.33	0	0.00	8	4.44	IX
Repeat breeding problem in buffaloes	39	65.00	41	68.33	46	76.66	126	70.00	I
Delayed maturity age in heifers	29	48.33	28	46.66	26	43.33	83	46.11	III
Lack of high quality pedigree bull for Natural service	25	41.66	20	33.33	10	16.66	55	30.55	IV
Low productivity of non -desc ript animals	19	31.66	15	25.00	20	33.33	54	30.00	V
Long inter-calving period	6	10.00	5	8.33	15	25.00	26	14.44	VIII

medium farmers, did not have the problem of calf mortality. The calf mortality among the small (40.00 %), medium (31.66 %), large (35.01 %) and pooled sample farmers (35.55 %) was due to diarrhea, indicating the lack of knowledge regarding proper deworming schedule in calves. The results are similar with the findings reported by Tiwari *et al.* (2007) and Shrivastava *et al*. (2013). None of the small farmers and an equal percentage (91.67 %) each of the medium and large farmers and 94.45 per cent of the pooled sample of farmers did not provide manger for feeding their calves. The findings were in partial agreement with the findings of Tiwari *et al.* (2007), who reported that, none of the farmers provided manger to the calves.

The data in Table III reveals that, repeat breeding problem in the buffaloes as the major constraint faced by majority of the pooled sample farmers (70.00 %) followed by poor conception rate through artificial insemination (58.88 %), delayed maturity age in heifers (46.11 %), lack of high quality pedigree bull for Natural service (30.55 %) and low productivity of non-descript animals (30.00 %). The other constraints are inability to detect heat symptoms in buffaloes due to silent heat (26.66 %), insufficient information about timing of artificial insemination / Natural service (16.66 %), long inter-calving period (14.44 %) and non availability of artificial insemination facilities (4.44 %). The findings are similar with the findings of Rathore *et al.* (2010).

The present study has revealed that there is a considerable gap existing between recommended scientific management practices and the adopted management practices. Young farmers have to take interest in dairy activity, for which suitable extension strategies should be developed. Training programmes on improved breeding and calf management practices will help the farmers to overcome the certain management problems like repeat breeding, long calving interval, navel infections, etc. Adoption of suitable and scientific management strategies in buffalo farming will substantially help in increase of production as well as income generation.

References

AULAKH, G. S. AND RAJBIR. S., 2012, Adoption of recommended management practices by buffalo owners. *Indian J. Dairy Sci.,* **65** (5) : 431 - 43.

GUPTA, D. C., SURESH, A. AND MANN, J. S., 2008, Management practices and productivity status of cattle and buffaloe in Rajasthan. *Ind. J. Anim. Sci.,* **78** (7) : 769 - 774

KHAN, A. M., BASET, M. K. AND FOUDER, S. K., 2010, Study on management and production system of small scale dairy farm in a selective rural areas of Bangladesh. *J. Sci. Foundation*., **8** (1 & 2) : 13 - 23.

RATHORE, R. S., RAJBIR SINGH, KACHWAHA, R. N. AND RAVINDER KUMAR., 2010, Existing management practices followed by the cattle keepers in churu district of Rajasthan. *Ind. J. Anim. Sci.,* **80** (8) : 798 - 805

SABAPARA, G. P., DESAI, P. M., RANA RANJEET SINGH AND KHARADI, V, B., 2010, Breeding and health care management status of dairy animals in the tribal area of south Gujarat. *Ind. J. Anim. Sci.,* **80** (11) : 1148 - 1151.

SHRINIVASTAVA, M., NANAVATI, S. AND YADAV, D. S., 2013, Management practices to minimise calf mortality in Buffaloes (*Bubalus Bubalis*). *Indian J. Field Vet*., **9** (1) : 22 - 24.

SINHA, R. K., TRIVENI DUTT, BHARAT BHUSHAN, MUKESH SINGH AND SANJAY KUMAR. 2010, Feeding and housing management practices of dairy animals in Uttar Pradesh. *Ind. J. Anim. Sci.,* **79** (8) : 829 - 833.

TIWARI, R., SHARMA, M. C. AND SINGH. B. P., 2007, Buffalo calf health care in commercial dairy farms: a field study in Uttar Pradesh (India). *Livestock Research for Rural Development.,* **19**(3).http://www.lrrd.org/lrrd19/3/tiwa19038.htm

VIJAY, A., UPAYANA AND RAM KUMAR, 2008, Existing dairy farming practices of six major dairy tribes of Nilgiris District of Tamil Nadu. *Indian J. Dairy Sci.,* **61** (1) : 80 - 87.

(*Received :* February, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 454-457, 2017

Research Note

Growth and Yield of Tomato as Influenced by Polyhouse Conditions

TOMATO is considered as a warm season vegetable crop. Conventional cultural practices and mere application of chemical fertilizers are not enough to fill-up the gaps between production and demand. Therefore, a sustainable and low cost technology for tomato cultivation is very important. Phenological development governs the plant growth and productivity (Awal and Ikeda, 2003a). Days to flowering, fruiting and maturity of the crop are the important phenological events which determine the productivity of a crop. Temperature plays a major role in phenological development and productivity of crop plants. High temperature influences crops to early growth and flowering (Awal and Ikeda, 2003b). The early and higher yield of different vegetable crops inside the polyhouse was mainly because of better microclimate such as higher temperature (4-9 ^{0}C than the open field) observed during winter months (Cheema *et al*., 2004). Therefore, the polyhouse environment may provide a new scope for commercial production of high value vegetable crops like tomato. It has been in use for vegetable production with far better yield in more than fifty countries all over the world (ICAR, 2005 and Aberkain *et al*., 2006). Therefore, the present experiment was conducted to explore the growth, development and yield of tomato grown under simple, environmentally friendly and low cost polyhouse which can be used by the small and marginal farmers in the area.

The investigation was carried out at the Horticultural Research Station, Mahanandi, Kurnool District, Andhra Pradesh during 2009. The experimental field soil is sandy red loam in texture, low in nitrogen, medium in phosphorus, fairly rich in potash and low in organic carbon content. The treatments consisted of five varieties V_1-Lakshmi, V_2-Shaktiman, V_3-Abhinava (V_1, V_2, V_3- determinate type), V_4-Hamsa samole, V_5-US-618 (V_4, V_5-Indeterminate type).

A Randomized Block Design (RBD) with five varieties, four replications and ten plants from each plot were selected randomly and tagged for recording observations. Soil inside the polyhouse was turned to a depth of 20 to 25 cm. One month prior to planting, weeds and stubbles were removed and the soil brought to a fine tilth by ploughing 3 to 4 times with cultivator. Fumigation was done with 20% formaldehyde to control soil borne pathogens. After application of formaldehyde, the soil was covered with black polythene for one week and then removed. Well decomposed farm yard manure (FYM) was applied at 20 t/ha at the time of last ploughing.

The recommended dose of fertilizers followed for the experiment consisted of 110 kg urea, 375 kg SSP and 100 kg MOP/ ha. The required dose of urea was calculated and applied in 3 split doses at 30th, 45th and 60 days after planting. The entire dose of SSP and MOP was applied before planting. The tomato was planted at a spacing of 60 cm x 45 cm. The size of the unit plot was 2 m x 1.5 m. All the required cultural practices were kept constant such as irrigation, weeding, pest and disease control *etc.* and given uniformly in all the experimental plots. All the four hoeings were practiced manually to check the growth of different weeds during the growth period of the crop. Ten plants were randomly selected from each plot in such a way that the marginal effect was avoided and data were recorded on plant height, stem diameter, number of primary branches, number of secondary branches, number of tertiary branches, spread of the plant along the row, spread of the plant across the row, number of days taken for first flowering, number of days for 50 per cent flowering, number of flowers per plant, weight of the fruit, length of the fruit, diameter of the fruit and yield.

Data recorded on biometric observations as influenced by polyhouse on five varieties are presented in Table 1. Significantly highest plant height (116. 50 cm) and stem diameter (6.60 cm) was recorded in Shaktiman (V_2) compared to remaining varieties. Highest plant height might be due to uptake of N, the chief constituent of chlorophyll, protein and amino acids is accelerated through its increased supply at appropriate time to the plants. Similar line of results was also obtained by Parvej *et al*. (2010) in tomato. Among hybrids, significantly higher branches (4.51, 13.51, 11.25) was produced by Shaktiman (V_2) compared to all the varieties.

The lower amount of incident PAR under polyhouse was due to the greater inference of the roof of polyhouse against the incoming solar beam. Although, polyhouse permits easy entrance of short-wave radiation. As a result, the air temperature inside the polyhouse gradually increased due to the greenhouse effect. Thus, the inner of the polyhouse becomes warm to warmer and temperature remained at optimum level (about 28 ^{0}C) for the growth and development of tomato plants during the cooler months (November to February). Such warmer air inside the polyhouse induced the soil warming. Therefore, soil temperature was also higher under polyhouse than open field (Montero and Anton, 2003). Morphological development like plant height, stem diameter and number of branches were positively favoured due to the warmer environment inside the polyhouse (Pandey *et al*., 2004) in spite of lower amount of PAR.

The plant height, stem diameter and number of branches were influenced by growing environment. This may be due to enhanced photosynthesis and respiration due to the favourable micro-climatic conditions in the polyhouse. This agrees with results of Ramesh and Arumugam (2010) on vegetables grown under polyhouse.

The information made available in Table I showed significantly higher spread of the plant along the row (101.50 cm) and across the row (92.24 cm) in Shaktiman (V_2) among the varieties. This phenomenon could be due to the fact that favourable environmental conditions *viz.* higher temperature, lower relative humidity and high light intensity inside polyhouse during the period of crop growth favoured better growth which resulted in higher spread of the plant.

Data from the Table II revealed that the hybrid Shaktiman (V_2) took minimum period for first flowering (35.83 days) and 50 per cent flowering (58.67 days). Polyhouse climate influenced the crops to open flower and mature of fruits earlier than open field (Cheema *et al*., 2004; Kang and Sidhu, 2005) due to the advancement of required heat unit or thermal time of the crops (Awal and Ikeda, 2003a) grown inside the polyhouse. This might also be due to accumulation of photosynthates which triggered early initiation of flowers.

Data presented in Table II indicated that significantly higher number of flowers (63.75) was also produced by Shaktiman (V_2). This could be due to the fact that the hybrid had higher number of branches which would result in production of higher number of flowers per plant compared to other hybrids.

It was seen from the Table II that the variety Shaktiman (V_2) produced significantly higher fruit weight (74.85 g), longer fruit (13.10 cm) and diameter of the fruit (18.21 cm). Similar trend of results were

TABLE I

Growth parameters of tomato varieties influenced by polyhouse conditions

Varieties	Plant height (cm)	Stem diameter (cm)	Number of primary branches	Number of secondary branches	Number of tertiary branches	Spread of the plant along the row (cm)	Spread of the plant across the row (cm)
V_1: Lakshmi	100.25	6.14	2.88	12.12	9.95	88.59	87.95
V_2: Shaktiman	116.50	6.60	4.51	13.51	11.25	101.50	92.24
V_3: Abhinava	94.50	5.98	2.49	8.79	9.81	70.52	74.15
V_4: Hamsa samole	74.25	5.05	2.23	6.95	7.88	63.81	65.32
V_5: US-618	97.50	5.88	2.32	10.44	10.20	70.54	73.09
S. Em ±	4.31	0.16	0.09	0.19	0.34	2.49	0.45
CD (P=0.05)	13.44	0.50	0.30	0.59	1.07	7.76	1.43
CV%	8.93	5.49	6.76	3.68	7.02	6.30	1.16

TABLE II

Flower, fruit characters of tomato varieties as influenced by polyhouse conditions

Varieties	Number of days for flowering	Number of days for 50% flowering	Number of flowers per plant	Weight of the fruit (g)	Length of one fruit (cm)	Diameter of the fruit (cm)	Yield (t/ha)
V_1: Lakshmi	42.33	63.08	37.67	65.59	10.233	17.48	31.10
V_2: Shaktiman	35.83	58.67	63.75	74.85	13.108	18.21	47.59
V_3: Abhinava	36.41	59.00	34.67	56.54	9.300	16.22	36.74
V_4: Hamsa samole	42.41	62.41	20.83	44.17	6.880	11.62	32.89
V_5: US-618	38.67	62.41	27.50	49.86	10.215	12.73	24.34
S. Em±	0.75	0.75	0.79	0.74	0.377	0.27	1.23
CD (P=0.05)	2.17	2.19	2.30	2.17	1.174	1.71	3.84
CV%	5.36	3.50	7.44	4.06	7.574	5.22	7.14

obtained by Yeptho *et al*. (2012) and Rajasekhar *et al*. (2013) in tomato.

Table II revealed that significantly higher yield (47.59 t/ha) was obtained from Shaktiman (V_2). Significantly higher fruit yield in the plants grown under polyhouse condition was associated with the production of higher number of fruits with greater length and diameter. Higher values of all the yield components and yield of tomato crop grown under polyhouse was due to the taller plants and more number of branches attributed by warmer temperature. Tomato had higher yield under polyhouse conditions due to light compensation for higher photosynthesis.

Since hi-tech glasshouse technology requires huge initial investments where production cost is very high. The small and marginal farmers cannot afford that technology due to high capital investment. Hence, low cost with locally available materials like bamboo and transparent polyethylene have been found quite effective for nursery raising and off-season production of tomato which fetched premium prices in the market. It is concluded that the better growth, development and yield of tomato were achieved under polyhouse due to the higher (optimum) temperature and lower relative humidity during the winter months (November to February) which positively influenced the morpho-phenological and physiological events of tomato plants. This simple and low cost polyhouse may be suitable for Kurnool District. Andhra Pradesh, where the temperature falls during winter. The growth and development of tomato plant becomes restricted during the cold winter months. Therefore, if tomato is planted under polyhouse, it will establish good stands that mature earlier. The optimum temperature accompanied by low relative humidity inside polyhouse hasten crop development and early maturity, so growers are benefited by being able to produce higher and off-season tomato which fetched premium prices in the market.

Horticultural Research Station, Vijayarai Dr. Y.S.R. Horticultural University, West Godavari Dist. Andhra Pradesh

M. RAJA NAIK
C. H. CHINNABBAI

E-mail : naik_raja2006@rediffmail.com

REFERENCES

ABERKAIN, K., GOSSELIN, A., VINEBERG, S. AND DORAIS, M, 2006, Effects of insulating foams between double polyethylene films on light transmission, growth and productivity of greenhouse tomato plants grown under supplemental lighting. *Acta Hort.*, **711**: 449-454.

AWAL, M. A. AND IKEDA, T, 2003a, Effect of elevated soil temperature on radiation-use efficiency in peanut stands. *Agric. Forest Meteoro.,* **118** (1-2) : 63-74.

AWAL, M. A. AND IKEDA, T., 2003b, Controlling canopy formation, flowering and yield in field grown stands of peanut (*Arachis hypogaea* L.) with ambient and regulated soil temperature. *Field Crops Res.*, **81** (2-3): 121-132.

CHEEMA, D. S., KAUR, P. AND KAUR, S., 2004, Off-season cultivation of tomato under net house conditions. *Acta Hort.*, **659**:177-181.

ICAR (Indian Council of Agricultural Research), 2005, Low cost polyethylene technology for off-season vegetable production. Dr. Mangala Rai, Secretary (DARE) and Director-General, ICAR, New Delhi, 110 001. India. **11** (2): April-June. 2005.

KANG, B. S. AND SIDHU, B. S., 2005, Studies on growing off-season tomato nursery under polyhouse. *Ann. Agri. Bio. Res.*, **10** (1): 53-56.

MONTERO, J. J. AND ANTON, A., 2003, Greenhouse characteristics and microclimatic conditions. *Acta Hort.*, **614**: 323-333.

PANDEY, V. K., DWIVEDI, S. K., PANDEY, A. AND SHARMA, H. G, 2004, Low cost polyhouse technology for vegetable cultivation in Chhattisgarh Region. *Plant Archives*, **4** (2): 295-301.

PARVEJ, M. R., KHAN, M. A. H. AND AWAL, M. A., 2010, Phenological development and production potentials of tomato under polyhouse climate. *J. Agric. Sci.* **5**(1):19-31.

RAJASEKHAR, M., ARUMUGAM, T. AND RAMESH KUMAR, S., 2013, Influence of weather and growing environment on vegetable growth and yield. *J. Hortic. Forestry*, **5** (10): 160-167.

RAMESH, K. S. AND ARUMUGAM, T., 2010, Performance of vegetables under naturally ventilated polyhouse conditions. *Mysore J. Agric. Sci.*, **44** (4): 770-776.

YEPTHO, V., KANAUJIA, S. P., SINGH, V. B. AND SHARMA, A., 2012, Effect of integrated nutrient management on growth, yield and quality of tomato under polyhouse conditions. *J. Soils Crops*, **22** (2): 246-252.

(*Received :* January, 2017 *Accepted :* June, 2017)

Mysore J. Agric. Sci., 51 (2) : 458-460, 2017

Mass Media Utilization by Farm Women

RURAL women share abundant responsibilities and perform a wide spectrum of activities like running the family, maintaining the household, attending to farm labour, performing several farm activities, looking after domestic animals and extending a helping hand in rural artisanship and handicrafts; but their contribution in economic terms has not been recognized. They are extensively involved in agriculture as female farm heads, co-owners, family farm workers and also employees (Zaidi and Munir, 2014). About 38 per cent of family workers in agriculture are women. But, although their contribution to local and community development is significant, their role still goes unnoticed and they are still not fully involved in decision-making, besides spending time on various duties and responsibilities in on-farm and off-farm activities. Though women have made their presence felt in all spheres of agriculture, they lag behind in technical competency and advanced information on farm technologies. In a study conducted on the knowledge level of farm women on farm technologies by Sankaran and Perumal, (1993), it was reported that 50.00 per cent of the farm women belonging to small farm category and possessed low level of knowledge on farm technologies.

Farm women should be fully aware of the latest agricultural technologies so as to achieve faster development in agriculture. The transfer of technology approach which mainly includes mass media is not paying much attention towards dissemination of adequate and timely agricultural information to the farm women. Access to communication media prepares women for improving their communication and mediation skills to strengthen their capacity to contact and mediate with the external world. In this backdrop, the present study was undertaken with the following specific objectives:

1. To know the extent of utilization of mass media by farm women
2. To find out the relationship and extent of contribution of personal, socio-economic, psychological and communication characteristics of farm women with their extent of utilization of mass media

The study was conducted in Mandya and Maddur taluks of Mandya district in Karnataka State during 2014-15. Five villages were randomly selected for the study from each of the two sampled taluks. From each village, six farm women were randomly selected for the study. Thus, the total sample constituted 60 farm women. Relevant data was collected from 60 farm women using a pre-tested interview schedule.

Mass media utilization of participation is referred to the exposure of the farm women to different mass communication media such as listening to radio, viewing television and reading newspapers and farm magazines. Procedure followed by Trivedi (1963) was used for computing the extent of utilization of mass media by farm women. The response for each media were obtained on three options namely, 'regularly', 'occasionally' and 'never' for which scores assigned were 2, 1 and 0, respectively. Minimum and maximum score a respondent could get was 0 and 12, respectively. Based on the total score obtained, the respondents were classified into three categories, viz., low, medium and high on the basis of mean and half standard deviation.

Category	Criteria	Score
Low	< (Mean – ½ SD)	Below 5.26
Medium	(Mean ± ½SD)	5.26 to 6.56
High	> (Mean + ½ SD)	Above 6.56

Information regarding personal, socio-economic, psychological and communication characteristics of farm women were collected using suitable scales. The collected data were analysed using frequency, percentage, mean, standard deviation, zero order correlation and multiple regression analysis.

The data in the Table I reveals that 45.00 per cent of farm women had medium level of overall utilization of mass media, followed by 31.66 per cent having low and 23.34 per cent having high level of overall utilization of mass media. It can inferred that more than three-fourth (76.66 %) of the farm women were having low to medium level of overall utilization of mass media. More or less similar findings was

TABLE I

Overall utilization of mass media by farm women

(n=60)

Category	Farm women	
	Number	Per cent
Low	19	31.66
Medium	27	45.00
High	14	23.34

observed by Swathilakshmi *et al.* (2015). Low literacy level, non-availability of newspapers and farm magazines in the villages, lack of free time to utilize mass media and non-coverage of local agricultural issues in mass media are the major reasons for majority (76.66 %) of farm women having low to medium level of overall utilization of mass media.

The Table II revealed with respect to the extent of utilization of mass media of farm women, it is observed that less than one-tenth of the farm women 'regularly' viewed television (6.67 %) and read newspaper (3.33 %). Whereas, less than one-fourth of farm women 'occasionally' read newspaper (23.33 %) and farm magazines (3.33 %), viewed television (15.00 %) and listened to radio (10.00%). A majority of the farm women have not read newspaper (73.34 %) and farm magazines (96.67 %), listened to radio (90.00 %) and viewed television (78.33 %) for obtaining information on improved agricultural technologies.

The results in Table III presents the data on the relationship and extent of contribution of personal, socio-economic, psychological and communication characteristics of farm women with their extent of utilization of mass media. It is seen from table III that age, socio-economic status and deferred gratification were not having significant relationship with the extent of utilization of mass media by farm women. Variables such as, achievement motivation, management orientation, innovativeness, extension agency contact and extension participation of farm women were having significant relationship at five per cent level with the extent of utilization of mass media by farm women, whereas education and attitude towards farming had highly significant relationship at one per cent level with the extent of utilization of mass media by farm women. It can be inferred that for every unit increase in the education, achievement motivation, management orientation, innovativeness, extension agency contact and extension participation there will be an increase in the utilization of mass media by farm women. Similar findings were reported by Ani and Baba (2009) Lakshminarayan *et al.* (2010) and Viswanatha *et al.* (2014).

All the ten socio-economic, psychological and communication characteristics had contributed to the tune of 60.20 per cent of variation in utilization of mass media by farm women. Variables such as education, attitude towards farming, extension agency contact and extension participation had contributed significantly towards utilization of mass media among farm women.

The findings of the study indicate that television was the most popular media used by the farm women probably due to its easy availability and portability that warrants the wide scale use of mass media. Community television sets can be installed in common places such as market shandies and community halls

TABLE II

Extent of mass media utilization by farm women

Mass media	Farm women					
	Regularly		Occasionally		Never	
	No.	%	No.	%	No.	%
Reading newspaper	02	3.33	14	23.33	44	73.34
Reading farm magazines	0	0.00	02	3.33	58	96.67
Listening to radio	0	0.00	05	10.00	54	90.00
Viewing television	04	6.67	09	15.00	47	78.33

TABLE III

Association of independent variables with the decision making pattern of farmers in sugarcane cultivation activities

(n=60)

Independent variables	Correlation value		t value	
Age	0.111	NS	0.999	NS
Education	0.333	**	2.500	*
Socio economic status	0.121	NS	1.68	NS
Achievement motivation	0.261	*	1.79	NS
Management orientation	0.121	NS	1.92	NS
Attitude towards farming	0.390	**	2.96	**
Innovativeness	0.268	*	0.196	NS
Deferred gratification	0.09	NS	0.111	NS
Extension agency contact	0.279	*	2.16	*
Extension participation	0.312	*	2.30	*

NS= Non-significant;* = Significant at 5 per cent level; ** = Significant at 1 per cent level; R2 value=0.692

for facilitating easy viewing by farm women. Farm Universities, Development Departments and other concerned agencies can promote the use of farm magazines effectively by making available these publications free of cost to the farm women; who are members of local media forums. Similarly the feedback behavior of farm women can be enhanced by giving interesting agricultural programmers for women through television such as backyard farming, new farm equipment reducing the drudgery of farm women and also by increasing the coverage of agricultural features in print media.

Farm women have been long accorded as invisible workers in agriculture and their contribution for agricultural development is tremendous. Hence, organizing and promoting effective use of media forums like radio, television and print media would play a vital role in enlightening farm women for agricultural development. Therefore, dissemination of improved production technologies through media (newspapers, farm magazines, radio, television etc.) in local languages will increase their knowledge and adoption of modern agricultural technologies.

Dept. of Agril. Extension K. NISHITHA
College of Agriculture M. T. LAKSHMINARAYAN
UAS, GKVK B. KRISHNAMURTHY
Bengaluru-560 065

REFERENCES

SANKARAN, S. AND RANI PERUMAL,1993, Tamil Nadu agriculture and farm women in agriculture – developmental issues. Proceedings of the National Seminar, December 28-30. National Academy of Agricultural Research Management, Hyderabad.

ANI, A. O. AND BABA, S. A., 2009, Utilization of selected electronic mass media as sources of Agricultural information by farmers in Northern Taraba State, Nigeria. Tropical Agricultural Research & Extension **12** (1) : 17 - 21.

LAKSHMINARYAN, M. T., PILLEGOWDA, S. M. AND NAGAMANI, M. K., 2010, Adoption behavior of paddy farmers. *Mysore J.Agric. Sci.,* **45** (3) : 661 - 665.

SWATHILAKSHMI, P. S., CHANDRAKANDAN, K. AND BALASUBRAMANI, N., 2015, Mass media utilization behaviour of farm women. *Agric. Sci. Digest,* **36** (1) : 51 - 55.

TRIVEDI, G., 1963, Measurement and analysis of socio-economic status of rural families. *Ph.D. Thesis,* (Unpub.), Indian Agri. Res. Inst., New Delhi.

VISWANATHA, H., MANJUNATHA, B. N., LAKSHMINARAYAN, M. T. AND ANANAD, T. N., 2014, Participation of rural youth in sericulture. *Mysore J. Agric. Sci.*, **48** (2) : 251 - 256

ZAIDI, N. H. AND MUNIR, A., 2014, Participation of women in sugarcane farming system – A case study of Bijnor district, Western Uttar Pradesh. *Economic Affairs,* **59** (3) : 449 - 457.

(*Received :* February, 2017 *Accepted :* June, 2017)

Abstracts of Ph. D. Theses submitted to the University of Agricultural Sciences, Bengaluru

AGRICULTURAL ECONOMICS

Assessment of Production, Market Competitiveness and Ex-Ante Consumer Preference of Ragi in Karnataka : An Economic Analysis

VEERABAHDRAPPA BELLUNDAGI

IN this study, the production, market competitiveness and ex-ante consumer preference for ragi in Karnataka was analyzed during 2015-16. The study was taken up in Tumakuru and Hassan districts with 160 farmers and Bengaluru urban and Hassan districts with 60 consumers. The relevant information was collected from farmers, consumers and records. The collected information was analyzed using growth and instability models, Total Factor Productivity (TFP), market cointegration and logistic regression. The results revealed that, the net returns realized in irrigated ragi was ₹ 6554 / ha and in rainfed ragi it was negative (₹ 2631 / ha). The analysis showed an increasing trend both in production and productivity in major ragi growing districts of Karnataka. Public research has significantly contributed to TFP growth in ragi. The results of cointegration analysis showed that, out of five markets, three were cointegrated and there existed both bidirectional and unidirectional causality among the selected ragi markets. The conjoint analysis revealed that, yield and colour were the most significant attributes in respect of producers. With respect to consumers preference, taste and aroma were found most important attributes. Further to know the willingness to pay (WTP) for new variety by producers was analyzed using logit model. The results showed that, yield and colour had significant influence on farmers WTP for new ragi variety. The findings of the study further reinforce the potentials of ragi cultivation in Karnataka. Besides, the implementation of "Anna Bhagya Yojana" in Karnataka has given further imputs for increased demand for ragi. Therefore, there is a need to increase the production by means of increasing productivity. The scientists need to develop yield enhancing technologies with drought tolerance varieties. Extension efforts should be strengthened to make farmers to adopt improved technology.

2016
Department of Agricultural Economics
UAS, GKVK, Bengaluru

K. B. UMESH
Major Advisor

An Economic Analysis of Influence of Allied Agricultural and Rural Non-Farm Activities on Agricultural Transformation in Karnataka

GAYATHRI MOHAN

THE study aimed at analysing the influence of emergence of allied activities (AA) and non-farm activities (NFA) among the farm households on the agriculture sector of the rural areas in the dry land and irrigated regions of Karnataka. Using multistage random sampling technique 75 sample farm households each from four districts of Karnataka, *viz.,* Kolar, Chitradurga, Hassan and Mandya, representing four agro-climatic zones with diversity in irrigation pattern were selected for the study. Correspondence analysis revealed that emergence of AA and NFA in Kolar and Chitradurga district representing the dry zones, were driven by agricultural push factors while the AA-NFA pull factors predominantly contributed in the water abundant Mandya and Hassan districts. Agricultural transformation in dryland regions occurred due to emergence of both AA and NFA and in irrigated regions this occurred majorly due to NFA. Multiple linear regression model showed that the flow of investment was significant between AA, NFA and agriculture in Hassan and Mandya districts. However, NFA – agriculture investment flow was significant in dryland regions. The income and employment elasticity of AA and NFA was studied using Logarithmic regression. The income elasticity of AA was significantly high in all the four districts. Contrarily the income elasticity from NFA was low in dryland regions and high in the irrigated regions. Employment elasticity of AA was significant for Chitradurga and Mandya districts while in the case of NFA, it was significant only for the former. The highest level income inequality in caste and gender was seen in Chitradurga district while in Mandya district class inequality was predominant. Overall, Chitradurga district showed a comparatively lower level of agricultural transformation towards commercialisation, necessitating the need for optimum crop plan as well as promotion of AA and NFA activities as an alternate income source.

2016
Department of Agricultural Economics
UAS, GKVK, Bengaluru -65

B. V. CHINNAPPA REDDY
Major Advisor

AGRICULTURAL ENTOMOLOGY

Role of Flower Visitors in Bitter Gourd (*Momordica charantia* L.) Pollination and Seed Production

K. B. THARINI

STUDIES on pollination ecology, pollinator diversity and the behaviour of pollinators in bitter gourd were carried out in the Department of Agricultural Entomology, UAS, GKVK, Bengaluru between 2014 and 2016. In all three seasons, flowering started 40 to 45 days after sowing and blooming period varied from 55 to 60 days. Anthesis commenced around 2.00 am and continued till 8.00 am with the opening of pistillate flowers followed by staminate flowers with a ratio of 18:1 (Staminate: Pistillate flowers). Staminate flowers offered rewards (nectar and pollen) for flower visitors, while the pistillate flowers were rewardless. Longevity of flowers was for one day. Pollen viability, stigma receptivity and nectar production was maximum from 10.00 h to 14.00 h and coincided with peak activity of pollinators (*Apis cerana* and *A. florea*). Among 27 species of flower visitors, *A. cerana* and *A. florea* were more abundant. *A. cerana* was efficient pollinator since it visited more number of flowers per trip (310 ± 31.07), spent less time per flower (109 ± 9.96 seconds) and covered greater distance per unit time (72.00 ± 6.57). Open pollination, hand pollination, green house with *A. cerana* colony and open pollination supplemented with *A. cerena* resulted in nearly 100 per cent fruit set. However, green house with *A. cerana* colony was significantly superior, showing maximum fruit weight (207.92 g) and seed numbers (38.32). Similarly, the fruit weight and seed numbers in male and female lines at ratio of 1:2 bitter gourd was significantly superior over remaining treatments in obtaining maximum fruit weight (269.38 g) and seed number (37.50 / fruit) with high germination per cent and more viable seeds. The estimated B:C ratio of open pollination + *A. cerana* pollination was found to be higher compared to other treatments which suggested that deployment of *A. cerana* hives in open pollination is best suited for obtaining high fruit yield and seed numbers with low cost of cultivation.

2016
Department of Agricultural Entomology
UAS, GKVK, Bengaluru

H. KHADER KHAN
Major Advisor

AGRICULTURAL EXTENSION

Behavioural Dimensions of Farmers Regarding IPM Practices in Tomato Cultivation : A Study in Kolar and Chickballapur Districts

C. NARAYANASWAMY

THE present study was conducted in Kolar and Chickballapur districts of Karnataka during the year 2015-16. The sample constitutes 180 farmers from six taluks Kolar and Chickballapur districts adopting ex-post facto research design. The scale was developed to measure the perception of farmers towards IPM practices in tomato cultivation. Different risk management strategies adopted by the farmers are recorded. The personal interview was adopted with structured schedule. The data collected was quantified, categorized and tabulated using mean, standard deviation, percentage, zero order correlation, chi-square test and multiple regression analysis. The results revealed that most (40.00%) of the farmers had good perception towards IPM practices. The results on overall knowledge level of farmers on IPM practices indicated that as high as 49.45 per cent of the farmers had medium level of knowledge. The data regarding the overall adoption of IPM practices indicated that most (41.67%) of the farmers had medium level of adoption. The results regarding the level of risk management strategies adopted by tomato growing farmers indicated that majority (55.00%) of the farmers had low level of risk management level. The variables such as achievement motivation, annual income, aspiration, attitude towards farming, cosmopoliteness, economic orientation, education, extension agency contact, extension participation, farm scientist contact, innovativeness, management orientation, mass media participation, risk orientation, scientific orientation, tomato farming experience and training programmes undergone had significant relationship with the perception, knowledge level and adoption of IPM practices by tomato growing farmers. The independent variables have contributed 79.90, 81.00 and 82.60 per cent to the variation in the perception, knowledge and adoption level of IPM practices in tomato cultivation, respectively. Non availability of IPM inputs was the major constraint faced by the farmers in adoption of the IPM practices and majority (58.33%) of the farmers suggested that IPM inputs should available at low cost.

2016
Deaprtment of Agricultural Extension
UAS, GKVK, Bengaluru

N. NARASIMHA
Major Advisor

AGRICULTURAL MICROBIOLOGY

Molecular and Biochemical Characterization of Endophytic Bacteria Associated with Aerobic Rice and their Role in Plant Growth

AMANDA SHYLLA

BACTERIAL endophytes occur inside a plant and act as plant growth promoting bacteria. The present study was carried out to isolate and characterize endophytic bacteria residing inside the aerobic rice varieties and evaluate their role as plant growth promoters. Twenty-four endophytic bacteria were isolated from the leaves, stems, and roots of four aerobic rice genotype. The diversity study was carried out by culture dependent and culture independent techniques. Through culture based method four genera were identified and were further clarified by culture independent method. The genera identified are *Pantoea, Pseudomonas, Serratia, Bacillus, Achromobacter, Brevundimonas*, and two other genera which wereyet to be characterized. Metagenomic work was carried to get clear picture of diversity of bacterial endophytes. Through 16S rRNA sequence using specific primers, it was confirmed that there are ten genera associated with the aerobic rice variety. Most of the isolated endophytes showed plant growth-promoting (PGP) ability like nitrogen fixing ability,phosphate solubilizing activity and production of gibberellic acid (GA), indole acetic acid (IAA), cytokinin, 1-aminocyclopropane-1-carboxylate (ACC) and siderophores. Four isolates showed antagonistic effect against *Rhizoctonia solani* and the best isolates was identified as *Pseudomonas* sp. Three isolates *Pseudomonas* sp, *Serratia* sp. and *Pantoea* sp. were selected for greenhouse study. These bacterial endophytes either individually or in combination with reduced amount of fertilizers improved plant growth and yield of the aerobic rice. These results strongly suggest that the endophytic bacteria characterized in this study could be successfully used to promote plant growth and inducing fungal resistance in plant.

2016
Deaprtment of Agricultural Microbiology
UAS, GKVK, Bengaluru

M. K. SHIVAPRAKASH
Major Advisor

AGRONOMY

Standardization of Liquid Manures for Organic Frenchbean (*Phaseolus vulgaris* L.) Production

BASAVARAJ KUMBAR

FIELD experiments were conducted during *kharif,* 2014 and 2015 at organic farming Research and Development block, UAS, Bengaluru for standardisation of liquid manures for organic frenchbean production under Factorial Randomised Complete Block Design with 12 treatments replicated thrice. The first experiment consisted three factors *viz*., FYM (100, 150 and 200 % N equivalents through FYM), Jeevamrutha (0 and 1000 litre ha^{-1}) and Panchagavya (0 and 3%) levels. Among the treatments, 200 per cent N equivalent through FYM recorded significantly higher frenchbean yield during 2014 and 2015 (135.2 and 168.5 q ha^{-1}) as compared to 100 per cent N equivalent (120.3 and 134.4 q ha^{-1}). Significantly higher pod yield was recorded with soil application of Jeevamrutha (141.7 and 168.3 qha^{-1}) as compared to without Jeevamrutha (117.0 and 139.5 qha^{-1}). Foliar spray of Panchagavya recorded significantly higher pod yield (138.7 and 164.7 qha^{-1}) as compared to without Panchagavya (120.0 and 143.1 qha^{-1}) application during both the years. Interaction of these treatments did not differ significantly. Second experiment consisted of two factors *viz.*,Jeevamrutha (0, 1000, 1500 and 2000 litre ha^{-1}) and Panchagavya (0, 3 and 6 %) levels. Among the jeevamrutha levels, application of 2000 litre ha^{-1} recorded significantly higher pod yield (134.3 and 156.9 q ha^{-1}) followed by 1500 litre ha^{-1} (115.0 and 136.5 qha^{-1}) and 1000 litre ha^{-1} (106.7 and 123.1 qha^{-1}) as compared to without jeevamruta application (99.8 and 112.8 qha^{-1}) during both the years. Similarly, application of higher level of panchagavya at 6 per cent recorded significantly higher frenchbean yield (124.4 and 142.8 qha^{-1}) as compared to 3 per cent panchagavya (116.1 and 134.1 qha^{-1}) and without panchagavya application (101.4 and 120.1 qha^{-1}) during both the years. There were no significant differences between the treatment interactions effects.

2016
Department of Agronomy
UAS, GKVK, Bengaluru

N. Devakumar
Major Advisor

Standardization of Fertigation Scheduling in Sugarcane through Subsurface Drip Irrigation

M. Padmanabhan

The field investigation on fertigation duration and fertigation levels on growth, yield and quality parameters of sugarcane juice and jaggery was carried out during *kharif* 2014 and 2015 at ZARS, V.C. Farm, Mandya. The experimental site soil was red sandy loam with neutral pH 6.92, low electrical conductivity 0.162 dSm^{-1} and organic carbon 0.46 per cent, medium available nitrogen (292.5 kg ha^{-1}), phosphorus (38.2 kg ha^{-1}) and potassium (178.3 kg ha^{-1}). The experiment consisting fifteen treatments combinations with five fertigation duration and three fertigation levels with one control, laid out in factorial RCBD and replicated thrice. Results revealed that fertigation upto 9.5 months recorded significantly higher plant (250 t ha^{-1}) and ratoon (224 t ha^{-1}) cane yield which was on par with fertigation upto 8.0 months plant (234 t ha^{-1}) and ratoon (212 t ha^{-1}) cane yield. Fertigation levels did not differ significantly however, interaction effect of fertigation upto 9.5 months with 125 per cent RDF recorded significantly higher plant (255 t ha^{-1}) and ratoon (227 t ha^{-1}) cane yield and was on par with fertigation upto 9.5 months with 100 per cent RDF plant (249 t ha^{-1}) and ratoon (225 t ha^{-1}) cane yield and fertigation upto 9.5 months with 75 per cent RDF plant (246 t ha^{-1}) and ratoon (221 t ha^{-1}) cane yield. Soil application of 100 per cent RDF with surface irrigation recorded significantly lower plant (147 t ha^{-1}) and (139 t ha^{-1}) ratoon cane yield. Thus results clearly indicated that 25 per cent saving in RDF besides recording 75 per cent higher cane yield with net return plant (₹ 435185 ha^{-1}) and ratoon (₹ 405965 ha^{-1}) cane could be obtained through sub surface drip irrigation.

2016
Department of Agronomy
UAS, GKVK, Bengaluru

Nagaraju
Major Advisor

Utilization of Sugar Mill Effluent for Cane Production in Cauvery Command Area

G. K. Madhu

Field experiments to investigate effects of treated sugar mill effluent (SME) irrigation with amendments on production of plant and ratoon sugarcane was conducted at Research and Development Farm, M/s. Sri Chamundeshwari Sugars Ltd., Mandya district during 2014-16. Both the experiments were laid out in randomized complete block design with eight treatments replicated thrice. First experiment comprised different cycles of SME and fresh water irrigation and second experiment was on usage of amendments along with SME irrigation. Treated sugar mill effluent had neutral pH (7.25) and its electrical conductivity was moderate (1.55 dSm^{-1}). The effluent had considerable quantity of N,P and K (3.40, 1.71 and 37.5 ppm, respectively) and it also contained calcium (51.0mg L^{-1}), sodium (37.8 mg L^{-1}) and magnesium (23.3mg L^{-1}). The concentration of dissolved and suspended solids was 96.3 and 1929 mg L^{-1}, respectively. The results indicated that cycle of 3 irrigations with fresh water + one irrigation with treated sugar mill effluent + RDF produced significantly superior cane yield (101.6 t ha^{-1}), number of millable canes (101.8 thousands ha^{-1}), higher growth parameters *viz,* plant height, leaf area (262.8 cm and 17012.0 cm^2 $clump^{-1}$, respectively), population of bacteria (42.1 x 10^5 CFU g^{-1}), fungi (23.9 x 10^3 CFU g^{-1}), actinomycetes (7.5 x 10^3 CFU g^{-1}), gross returns, net returns and B:C ratio (₹ 228600, 138554 ha^{-1} and 2.54, respectively). Further, irrigation with treated SME + RDF + green manuring (GM) *in-situ* + gypsum application for plant and ratoon crop of sugarcane variety Co-86032 recorded significantly higher cane yield (188.7 and 156.7 t ha^{-1}), number of millable canes (142.3 and 127.0 thousands ha^{-1}), higher growth parameters *viz,* plant height (346.3 and 294.3 cm), leaf area (16231.9 and 15555.0 cm^2 $clump^{-1}$), gross returns (₹ 424575 and 352575 ha^{-1}), net returns (₹ 355809 and 293729 ha^{-1}) and B:C ratio (5.17 and 5.0).

2016
Department of Agronomy
UAS, GKVK, Bengaluru

S. Bhaskar
Major Advisor

Optimization of Irrigation and Fertilizer Levels in Sugarcane Under Drip Fertigation

GURURAJ KOMBALI

FIELD experiment was conducted at ZARS, V.C. Farm, Mandya during 2014-15 and 2015-16 on red sandy loam soil with neutral reaction (6.92), low organic carbon (0.46 %), medium available nitrogen (292.5 kg ha^{-1}), phosphorus (38.2 kg ha^{-1}) and potassium (178.3 kg ha^{-1}) to optimize irrigation and fertilizer levels in sugarcane under drip fertigation. The experiment comprising of three levels of irrigation and four levels of fertilizer was laid out in split-plot design with three replications. Subsurface drip irrigation at 100 per cent E_{pan} recorded 47.9 to 58.1 per cent higher cane yield (219 and 214 t ha^{-1}) by saving 54.3 to 56.2 per cent irrigation water (129.8 and 119.5 cm) over furrow irrigation (148 and 129 t ha^{-1}) which used 238.4 and 240.3 cm water in plant and ratoon crop, respectively. However, subsurface drip irrigation at 75 per cent E_{pan} shown on par results with 100 per cent E_{pan}. This was attributed to higher growth and yield attributes of cane with higher NUE and water productivity. Application of 125 per cent RDF registered significantly higher cane yield (216 and 197 t ha^{-1} in plant and ratoon crop, respectively) over lower levels of fertilizers, but found to be on par with 100 per cent RDF. Sub surface drip fertigation at 100 per cent E_{pan} with 125 per cent RDF registered higher growth and yield attributes which lead to higher cane yield (248 and 228 t ha^{-1}), sugar yield (35.19 and 31.17 t ha^{-1}), gross returns (₹ 545289 and 501529 ha^{-1}), net returns (₹ 412257 and 384097 ha^{-1}) and B:C ratio (4.1 and 4.3) in plant and ratoon crop, respectively. These findings revealed that, 5 per cent of fertilizers could be saved by adopting drip fertigation in sugarcane besides considerable enhancement in cane yield with lesser water use and higher efficiency.

2016
Department of Agronomy
UAS, GKVK, Bengaluru

T. SHESHADRI
Major Advisor

GENETICS AND PLANT BREEDING

Identification of Genetic Determinants Controlling Fresh Pod Yield and its Component Traits in Dolichos Bean (*Lablab purpureus* L. Sweet) through Genome-Wide Association Mapping

P. V. VAIJAYANTHI

ASSOCIATION mapping (AM) which exploits linkage disequilibrium (LD) between alleles at marker loci and those controlling target traits in natural populations is one of the approaches to identify genetic determinants affecting target traits. AM is effective in self-pollinated crops such as dolichos bean as LD extends over longer genomic distance driven-by low rate of recombination and thereby requiring fewer markers for exploring marker-traits associations. A core set of dolichos bean germplasm consisting of 64 accessions were evaluated for nine quantitative traits (QTs) at University of Agricultural Sciences (UAS), Bengaluru during 2014 and 2015 rainy seasons and genotyped using 234 SSR markers. Ninety-five of the 234 SSR markers were polymorphic among the core set of accessions with alleles ranging from 1 to 3. The wide range of phenotypes as revealed by variances and polymorphic information content (PIC) suggested substantial diversity among the core set of accessions at loci controlling QTs and at 95 SSR marker loci. The structure analysis although revealed three sub-populations, low magnitude of the estimates of fixation indices suggested weak population structure, which in-turn indicated low possibility of false discovery rates in marker-QTs association. The marker allele's scores were regressed onto phenotypes at nine QTs following general linear model (GLM) and mixed linear model (MLM) which accounted for population structure (Q) and kinship (K) for exploring marker-QTs associations. As many as 62 and 60 SSR markers were found significantly associated with genomic regions controlling nine QTs based on GLM and MLM, respectively. A few of the significantly associated markers such as KTD 200 for days to 50 per cent flowering, KTD 273 for fresh pod yield $plant^{-1}$ and KTD 130 for fresh pods $plant^{-1}$ explained ≥ 10 per cent of the trait variations. These linked SSR markers are suggested for validation for their use as surrogates of different-to-select traits for breeding dolichos bean for improved productivity.

2016
Department of Genetics and Plant Breeding
UAS, GKVK, Bengaluru

S. RAMESH
Major Advisor

Evaluation of Marker Assisted Introgressed Multiple Gene / QTL Pyramided Genotypes for Abiotic and Biotic Stress in Rice (*Oryza sativa* L.)

G. UDAY

RICE (*Oryza sativa* L.) is the second highest producing cereal crop. Drought stress (abiotic stress) and blast and bacterial diseases (biotic stress) are considered as major limitations to rice production. In order to identify genotypes tolerant to disease and drought stress, sixty F_7 selected multi trait QTL / gene pyramided lines with blight, blast and drought related traits were evaluated under stress and non stress condition in *Dry season*, 2015; *Wet season 2014* and 2015. Comprehensive effort was made to identify sixty pyramided genotypes conferring genes / QTL for drought tolerance and disease resistance characters. Genes / QTL pyramid combinations were confirmed *via* marker assisted selection with trait specific SSR markers. Genotype 23-5-277 *(qRT2+qRT9+qWUE2+Pi-1+Xa4)* showed positive marker alleles for root length, root thickness, water use efficiency, leaf blast and bacterial blight. Similarly 23-5-287, 23-5-145, 23-5-319 and 23-5-321 genotypes had genes for leaf blast and bacterial blight. For grain yield plant^{-1}, 23-5-108 (*qRT9+qWUE2+ Xa5)* recorded high grain yield with 'bi' value approaching unity indicates the average stable performance across three moisture conditions (aerobic, moisture stress at vegetative stage and reproductive stage). Pyramid genotypes 23-5-277 (*qRT2+qRT9+qWUE2+Pi-1+Xa4*), 23-5-108 (*qRT9+qWUE2+Xa5*) and 23-5-67 *(qRT2+qRT7+qWUE2+Xa4)* were found superior for grain yield with early flowering and high drought resistance index. Reference based transcriptome sequencing for drought and annotation study showed 30992 genes for different path ways among them. 13.0 44.11 and 42.89 % of genes were annotated to be involved in biological, cellular and molecular function. These pyramided lines could be used as donor parental lines in the breeding programmes.

2016
Department of Genetics and Plant Breeding
UAS, GKVK, Bengaluru

SHAILAJA HITTALMANI
Major Advisor

PLANT PATHOLOGY

Etiology and Management of Wilt Complex in Black Pepper (*Piper nigrum* L.)

N. UMASHANKAR KUMAR

BLACK pepper (*Piper nigrum* L.) known as the King of spices and Black gold is prone to attack by burrowing nematode, *Radopholus similis* and fungal wilt pathogen, *Phytophthora capsici* causing wilt complex and considerable yield loss. Roving survey in five major black pepper growing malnad regions of Karnataka during 2013-14 revealed maximum wilt complex incidence in Chickmagalur district (31.28%) followed by Coorg (30.94%), Uttara Kannada (29.3%) Shivamogga (29.07%) district and least was recorded in Hassan district (25.77%). Maximum wilt complex was observed in Bilimalligesara cultivar (33.86%) and lowest was in Karimunda (17.41%) cultivar. *R. similis* was a predominant nematode with highest prominence values in all the taluks of malnad districts surveyed. Major plant parasitic nematode includes *Radopholus similis, Meloidogyne inocgnita, Pratylenchus coffeae, Helicotylenchus multicinctus* and *Rotylenchulus reniformis*. Major fungal pathogen includes *Phytophthora capsici*, *Fusarium* sp. and *Rhizoctonia solani*. Maximum number of lesions (63.20) and highest lesion index (3.80) on roots were recorded with *R. similis* alone followed by combined inoculation of *R. similis* and *P. capsici* (15 days before) with 53.60 and 3.40 number of lesions and lesion index, respectively. Soil pH 5.50 to 6.00 favoured both pathogens in soil. The cultivars, Girimunda, Malabar XL, Shakthi, Karimunda, and Panniyur-1 were highly susceptible to *R. similis* with lesion index of 5.00. Panchami, Shreekara, Pournami and Thevam showed susceptible reaction to *R. similis* with lesion index 4.20, 4.00 and 3.80, respectively. None of the cultivars showed immune or resistant or tolerant reaction to wilt complex. Integrated application of Bordeaux mixture spray (before and after monsoon) + 50g soil application of *Trichoderma harzianum* (15 days after spray) or Bordeaux mixture spray (before and after monsoon) + 50g soil application of *Purpureomyces lilacinum* (15 days after spray) was most effective in managing wilt complex and also with increased cost benefit ratio.

2016
Department of Plant Pathology
UAS, GKVK, Bengaluru

N. G. RAVICHANDRA
Major Advisor

SEED SCIENCE AND TECHNOLOGY

Studies on Bio-Priming of Paddy Seeds to Combat Blast Disease (*Magnaporthe oryzae* L.)

N. Amruta

A study was conducted in the laboratory, greenhouse and field to know the influence of bio-priming on paddy seeds against blast disease at GKVK, Bengaluru and V.C. Farm, Mandya. The total 60 bacterial strains were isolated from paddy rhizosphere and used for *in vitro* and *in vivo* evaluation against *M. oryzae* along with two reference strains *B. subtilis* and *P. fluorescens* and eleven bacterial strains showed maximum inhibition. Thirteen strains were characterized as bacteria belong to genera *Bacillus*, *Pseudomonas*, *Serratia*, *Alcaligenes* and *Proteus* using 16S rRNA sequencing. The bacterial isolates exhibited antagonist property showed the presence of antimicrobial peptide genes. *In vitro* evaluation revealed that the *B. amyloliquefaciens* UASBR9 and *Serratia marcescens* UASBR4 found most effective against the pathogen (84.14 and 76.83 per cent, respectively) compared to reference cultures RBs-1 (72.00 %) and RPf-1 (55.24 %). The least PDI and highest germination was recorded in HR-12 seeds bio-primed with UASBR9 (0.69 and 99.00 %) compared to untreated control (3.43 and 95.00 %) under *in vivo* condition. Seeds bio-primed with formulated product of UASBR9 and talc+$MgSO_4$ @10g / kg seed was recorded least PDI (6.63 %), highest seed yield / plot (0.68 kg) and maximum germination (99.50 %) compared to untreated control (20.25 %, 0.27 kg and 90.00 %, respectively). Seed bio-primed with UASBR9 showed induced systemic resistance in rice on challenge inoculation with *M. oryzae* and increased activities of peroxidase (0.563 min^{-1} $gram^{-1}$), PPO (0.825 min^{-1} $gram^{-1}$) and PAL (6.849 nmol t-CA) and defense-related enzymes response against pathogen compared to untreated control.

2016
Department of Seed Science and Technology
UAS, GKVK, Bengaluru

S. Narayanaswamy
Major Advisor

SERICULTURE

Studies of Micronutrients on Bioresponses in Mulberry (*Morus* Spp.) and Silkworm (*Bombyx mori* L.)

P. Sowmya

The experiment on studies of micronutrients on bioresponses in mulberry (*Morus* spp.) and silkworm (*Bombyx mori* L.) was conducted at the Department of Sericulture, UAS, GKVK, Bengaluru during 2014-2016. In this experiment eight treatments were evaluated by conducting the experiment in RCBD. Among the treatments, T_5 (100% recommended dose of N through 20% each of compost, *Glyricidia maculata*, castor cake, vermicompost and urea + 10 kg each of *Azospirillum brasilense* + *Aspergillus awamori* bio- fertilizer + remaining P, K through chemical fertilizer + FYM 20 t / ha + $ZnSO_4$ 7 H_2O @ 20 kg / ha / year) recorded higher leaf yield (65.07 ton / ha). The leaf quality also significantly improved in this treatment recording higher total soluble protein (12.07 %), crude protein (20.24 %) and total sugar (13.08 %). In the silkworm rearing T_8 (T2 + Borax @ 2 kg / ha / year) recorded higher V instar larval weight (38. 38 g / 10 larvae), cocoon weight (1.92 g / cocoon), pupal weight (1.57 g / pupae) and shell weight (0.31 g / shell). The T_5 treatment recorded higher shell ratio (16.33 %), ERR (98.44 %), higher fibroin (21.58 µg / ml) and sericin (12.33µg / ml) content of cocoon, grainage parameters *viz.,* moth emergence percentage (97.80 %), fecundity (486.67 / dfl) and hatching percentage (92.42 %). The soil properties like higher available N (287.00 kg / ha), P (44.40 kg / ha) and K (288.33 kg / ha) were recorded in T_5. The B: C ratio of mulberry production was higher in T_5 and T_8 (1: 3.21). Similarly the highest B: C ratio of cocoon production was recorded in T_3 (1:2.24).

2016
Department of Sericulture
UAS, GKVK, Bengaluru

T. K. Narayanaswamy
Major Advisor

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Status and Revalidation of Sulphur Requirement for Finger Millet - Groundnut Cropping Sequence in Eastern Dry Zone of Karnataka

K. R. ASHOKA

THE present study conducted during 2010-12 at UAS, GKVK, Bengaluru on Alfisol addresses (a) the requirement of sulphur for finger millet and groundnut cropping sequence (b) the available soil sulphur status in EDZ of Karnataka and (c) revalidation of soil test ratings for sulphur. From different parts of EDZ, 138 soil samples were collected and analyzed for available sulphur status. The response of finger millet and groundnut to graded levels of sulphur was studied by creating five sulphur fertility gradient strips *viz.*, S_0 (Very low), S_1 (Low), S_2 (Medium), S_3 (High) and S_4 (Very high) (<5.00, 6.00-15.00, 16.00-25.00, 26.00-35.00 and >35.00 mg kg^{-1}, respectively). Critical concentration of sulphur in finger millet and fertility ratings for available sulphur in soil were determined by conducting pot experiment using soils from six different locations belonging to four categories, applied with graded levels of sulphur and finger millet as test crop. The results revealed that, application of 100 per cent NPK + 40 kg S + FYM recorded higher finger millet (35.63 and 68.49 q ha^{-1} grain and straw, respectively) and groundnut (23.26 and 31.79 q ha^{-1} pod and haulm) yield. Apparent sulphur recovery (%) by finger millet and groundnut crops increased with increased sulphur fertility gradient. The total sulphur fraction recorded was higher in S_4 followed by S_3>S_2>S_1>S_0 gradient strips. Critical limit for available sulphur was 5 mg kg^{-1} and for finger millet plant 0.23 per cent. The newly proposed sulphur fertility ratings were <5.00, 5.10-14.00, 14.10-24.00 and >24.00 mg kg^{-1} for Very Low: Low : Medium : High, categories, respectively. Available sulphur content of soils in EDZ ranged from 3.32 to 37.15 mg kg^{-1}. Percentage of soil samples under different categories in the ascending order was high (5.65%) > very low (8.76%) > medium (22.16%) > low (63.29%).

2016
Department of Soil Science and Agricultural Chemistry
UAS, GKVK, Bengaluru

C. A. SRINIVASAMURTHY
Major Advisor

Direct and Residual Effect of Applied Zinc on Growth, Yield and Quality of Vegetables Grown in Sequence and Dynamics of Native and Applied Zinc in Alfisols

G. SRINIVASA RAO

AN investigation under taken to study the dynamics of applied and native zinc and their response to zinc fertilization in vegetable based cropping sequence on Alfisols of Chickballapur and Kolar districts of southern Karnataka through field, pot and laboratory experiments. Analysed soil samples from Chickballapur and Kolar districts showed Zn and Cu above the critical limit. Applied Zn at both 30 and 15 kg Zn ha^{-1} increased the levels of soil DTPA extractable Zn after harvest of cabbage, french bean, tomato and rhodes grass in pot studies. Applied zinc accumulated maximum as residual zinc and the least in water soluble fraction in all soils. Application of 30 and 15 kg Zn ha^{-1} recorded highest dry matter and DTPA extractable zinc in pot experiments. Crops absorbed maximum Zn in plots receiving 30 kg Zn ha^{-1}.

In field experiments annual application of 15 kg Zn ha^{-1} recorded higher individual crop yields and also highest crop equivalent yields and total Zn uptake in cabbage, french bean and tomato based cropping sequence. Over two years of experimentation annual application of 15 kg Zn ha^{-1} was promising in enhancing yield of cabbage, french bean and tomato irrespective of the sequences of crops in cabbage, french bean and tomato grown in sequence. Fractionation of soil Zn at the end of the crop rotations showed irrespective of the crop sequence in the rotation, zinc accumulated maximum in soil as residual zinc and least amount was recorded in water soluble fraction. The quantum of Zn accumulated depended upon the amount of Zn applied to crops in the rotations. It is inferred that annual application of 15 kg Zn ha^{-1} is the most efficient zinc management practice for better growth, yield and soil fertility for the continuous cabbage, french bean and tomato based cropping sequence.

2016
Department of Soil Science and Agricultural Chemistry
UAS, GKVK, Bengaluru

A. N. GANESHAMURTHY
Major Advisor

Abstracts of M.Sc. Theses submitted to the University of Agricultural Sciences, Bengaluru

AGRICULTURAL ECONOMICS

Economics of Integrated Farming System (IFS) in Tumkur District Central Dry Zone of Karnataka

P. V. KAVYASHREE

THIS study aimed at analyzing existing farming systems and their synergies for augmenting the farm income of farmers. This study was undertaken in Madugiri and Pavagada taluks of Tumkur district in Karnataka. The prominent farming systems identified in the study area included, Crop + Dairy (C+D), Crop + Dairy + small ruminates (C+D+S), Crop + Dairy + Poultry (C+D+P) and Crop+ Dairy+ small ruminates+ poultry (C+D+ +P). Since, the study area is drought prone, most of the farmers own livestock especially dairy and small ruminants. Thus the livestock forms an integral part of farming system for majority of the farmers. The economic analysis of farming systems indicated that the irrigated IFS farmers derived more income in all most all type of systems, in that C+D+S system is relatively profitable (1:2.6) of un irrigated IFS farmers compare to irrigated IFS farmers had (1:2.5). In all farming systems, farmers invariably included food crops and pulses to meet their family consumption. The synergy contribution by different enterprise mix revealed that as the integration increases the synergy contributed to the farming system also increased. Among the total net income of all the systems, proportion of synergistic income has more than 50 per cent of existing farming system both irrigated and unirrigated IFS farmers. Among Irrigated IFS farmers had 57.47 per cent in C+D system, 58.81 per cent in C+D+P system 59.09 per cent in C+D+S system and 60.25 per cent in C+D+S+P system. Unirrigated IFS farmers had had 56.74 per cent in C+D system, 57.31 per cent in C+D+P system 59.80 per cent proportion of synergistic income more in C+D+S system of unirrigated IFS and 60.10 per cent in C+D+S+P system.

2016
Department of Agricultural Economics
UAS, GKVK, Bengaluru

HONNAIAH
Major Advisor

AGRICULTURAL ENGINEERING

Drying Studies of Selected Mushroom Varieties

K. M. PUNEETHA

PHYSICAL properties like moisture content, size, shape, colour, texture and nutritional properties like protein content, fat, ash and crude fibre were determined for three-button, oyster and shiitake mushroom varieties. Sliced mushrooms after initial pre-treatment in 0.5 per cent KMS for 15 minutes, were dried by convective hot air, microwave, dehumidified air and solar drying methods. For production of dried mushroom slices, convective hot air tray drying at 55 ºC was found to be best. Microwave dried mushrooms were not of acceptable quality; Dehumidified air dried mushrooms were acceptable, but the drying time required was too high. Dried button, oyster and shiitake mushroom slices were stored in three flexible air-tight pouches *viz.,* LDPE, PP and laminated Al, at ambient conditions for 90 days. Among three packages, laminated Al pouches was found to be best for dried mushrooms storage. For stored mushroom slices, rehydration ratio of was in the range of 4.37 to 8.25, 5.23 to 8.27 and 5.92 to 8.45; yellowness index was in the range of 0.77 to 1.08, 0.86 to 1.08 and 0.91 to 1.11; and whiteness index was in the range of 33.03 to 34.13, 30.96 to 32.04 and 30.49 to 33.33, respectively, in LDPE, PP and Al pouches. After storage, the organoleptic scores of three varieties of dried mushroom slices for colour, flavor, texture, appearance and overall acceptability were respectively, 7.30, 7.20, 7.53, 7.46 and 7.40 for button mushrooms; 7.10, 7.10, 7.40, 7.13 and 7.06 for oyster mushrooms; and 7.36, 7.50, 7.23, 7.63 and 7.20 for shiitake mushrooms.

2016
Department of Agricultural Engineering
UAS, GKVK, Bengaluru

V. PALANIMUTHU
Major Advisor

Storage Studies on Field Bean (*Dolichos lablab* L.) using Diffusion Channel Technology

R. NISHA

STUDIES were conducted on the storage of field beans using diffusion channel technology, at different temperatures (3, 10 and 24 °C). Diffusion channels of various lengths (7, 9.5 and 12 cm) and diameters (3, 5 and 7 mm) were used to determine the diffusivity of O_2 and CO_2 into the storage chambers. Quality of field beans were assessed before and after storage. Respiration rate of field beans was at a peak of 85.71 mg CO_2 / kg^{-h} at 24 °C (ambient), 53.57 mg CO_2 / kg^{-h} was at 10 °C temperature and 29.14 mg CO_2 / kg^{-h} at 3 °C temperature. The quality of the field beans stored in diffusion channel chambers having a channel length of 12 cm and diameter 3 mm were found to be of good quality compared with the other storage chambers. It was also observed that the quality of the product was better for longer periods at lower temperatures. At 10 °C, the field beans maintained a good quality for 6 days and at 3 °C for 9 days. The concentrations of O_2 and CO_2 inside the chambers were measured during storage and it was found to be 0.2 and 35 per cent, at 24 °C (ambient) after 4 days of storage. Similarly, at 10 and 3 °C, the O_2 and CO_2 concentrations were found to be 2.45 and 13.9 per cent, 3.6 and 14.4 per cent after 6 and 9 days of storage, respectively.

2016
Department of Agricultural Engineering
UAS, GKVK, Bengaluru

M. RAMACHANDRA
Major Advisor

Mechanical Extraction of Oil from Watermelon (*Citrullus lanatus*) Seeds at Different Moisture Contents

D. S. POORNIMA

WATERMELON fruit contains large quantities of seeds and the seed oil has got many benefits. In order to make effective and efficient utilization of seeds, in the present investigation the physical properties of watermelon and their seeds were measured. The oil from watermelon seeds was extracted using mechanical screw press and the oil content was estimated using Soxtherm apparatus which works on the principal of solvent extraction and found 38 per cent oil in the seeds. To optimize the effect of temperature and moisture content on oil recovery, factorial completely randomized design of experiments was employed and the oil was extracted at five different temperatures *viz.,* 30, 40, 50, 60 and 70 ºC and moisture contents *viz.*, 4, 6, 8, 10 and 12 per cent. The best combination for maximum oil recovery was observed to be at 10 per cent moisture content and 50 ºC temperature. As the watermelon seed oil is the renewable energy source, the extracted oil was converted into biodiesel and subjected to study for its quality parameters at five different levels *viz.*, extracted crude oil, obtained biodiesel (B-100) and three different blends such as B-30 (30 % biodiesel:70 % diesel), B-20 (20 % biodiesel:80 % diesel) and B-10 (10 % biodiesel: 90 % diesel). The best performance for flash point, fire point, viscosity, free fatty acid value and calorific values were found to be 70 ºC, 80.50 ºC, 25.37 millipoise, 0.36 mg KOH / g and 43845.03 kJ / kg, respectively.

2016
Department of Agricultural Engineering
UAS, GKVK, Bengaluru

K. VENKATACHALAPATHY
Major Advisor

AGRICULTURAL ENTOMOLOGY

Studies on Pollination Biology of Ridge Gourd (*Luffa acutangula* L.)

K. N. RAME GOWDA

POLLINATORS play an important role in fruit set of ridge gourd. The present study concentrated on the floral biology of ridge gourd, flower visitors, foraging behaviour of efficient pollinators and their role in fruit set. Ridge gourd is monoecious with solitary female and clusters of male flowers. Anthesis occurred in late evening hours (17.00-19.00) and flowers remained for 13 to 14 hours. Stigma receptivity and pollen viability were maximum during early morning hours (6.00-8.00). Nectar production was only in staminate flowers. Four species of Hymenoptera (28.15%), seven species of Lepidoptera (50 %), two of Coleoptera (14.28%) and one Diptera (7.14%) visited ridge gourd flowers. However, the major flower visitors were *Apis cerana* and *Apis florea.* Of these, *A.cerana* was the most frequent and efficient pollinator. Both *A.cerana* and *A.florea* spent significantly more time on staminate flowers (42.83 ± 12.79 and 27.08 ± 6.99) compared to pistillate flowers (15.1 ± 4.76 and 11.21 ± 3.49). Among the two species *A.cerana* was better pollen remover and pollen depositer when compared to *A. florea.* In pollinator exclusion experiments, Neetha and Anitha ridge gourd plants that were left for open pollination and hand pollination set significantly higher per cent of fruit set (93.33% and 100%, respectively, in both the seasons) compared to caged plants that were prevented from flower visitors which did not set any fruits. More than ten bee visits per flower significantly influenced per cent fruit set, fruit weight, fruit length and number of sound seeds per fruit. The value of pollination service by honey bees amounts to ₹ 58,500/-

2016
Department of Agricultural Entomology
UAS, GKVK, Bengaluru

SHIVAMURTHY NAIK
Major Advisor

Studies on *Rhyzopertha dominica* (F.) and its Management in Small Millet Environment

SUPRABHA

BIOLOGY and feeding behaviour of *Rhyzopertha dominic*a was studied on husked and unhusked grains of little millet, foxtail millet, barnyard millet, proso millet and kodo millet during summer 2015-16 and management studies using different treatments. The eggs were white, oblong and waxy in appearance. Incubation period ranged from 5 to 8 days. The grubs fed mainly on the germ portion of the seed. Mean total developmental period ranged from 44.2 to 45.9 days in unhusked and 41.9 to 47.8 days in husked grains. Per cent survival of different stages of *Rhyzopertha* was highest in proso millet followed by foxtail and least in kodo millet. The per cent feeding damage was also more in proso millet (57 % in husked and 72 % in unhusked grain) and kodo was least preferred (27 % in unhusked). An analysis of biochemical parameters and mineral contents of different millets, clearly showed that the extent of protein, tannic acid, dietary fibers, nitrogen, potassium, iron and manganese had a role to play in deciding on the preference for different small mllets. In management spinosad 45 SC @2 ppm was found to be a good alternative toaluminium phosphide (@ 9 g / tonne) and was found very effective in controlling *Rhyzopertha dominica* infesting small millets.

2016
Department of Agricultural Entomology
UAS, GKVK, Bengaluru

S. SUBRAMANYA
Major Advisor

Biological Activity of Organic Solvent Extracts of *Vitex* spp. on Red Spider Mite, *Tetranychus macfarlanei* Baker and Pritchard Infesting Okra

K. N. Nandini

Laboratory investigations were carried out during 2015-16 on the biological activities of organic solvent extracts from leaves of *Vitex* spp. on *Tetranychus macfarlanei* infesting okra. Petroleum ether extract of *V. altissima* at 15 per cent concentration caused repellence of 15.56 per cent and mortality of 17.78 per cent; diethyl ether extract of *V. negundo* (white) extract at 12 per cent concentration repelled 37.78 per cent mites, while mortality of 66.67 per cent was by *V. negundo* (purple) extract at 15 per cent concentration. Ethyl acetate extract of *V. trifolia* extract at 12 per cent and *V. negundo* (purple / white) extract at 15 per cent recorded repellence of 28.89 per cent and mortality of 36.67 per cent, respectively. Methanol extract of *V.negundo* (purple) extracts at 20 per cent concentration repelled 73.33 per cent mites and caused highest mortality of 88.89 per cent. Among the methanol extracts, *V. altissima* extract was most toxic with the lowest LC_{50} value of 3.14 per cent and *V. trifolia* extract was least toxic with the highest LC_{50} value of 10.91 per cent. *V. trifolia* at 12 per cent and *V. negundo* (purple) at 15 per cent were more ovicidal, as 52-54 per cent of treated eggs of *T. macfarlanei* did not hatch. Less number of eggs was laid with *V. altissima* methanol extract treatment recording the highest Oviposition Deterrence Value of 70.53. Mortality of phytoseiid predator due to methanol leaf extract ranged from 7 per cent (*V. trifolia*) to 23 per cent (*V. negundo* purple). Predators which survived laid least number of eggs (2.80 eggs / female) in 15 per cent *V. negundo* (purple) extract treatment.

2016
Department of Agricultural Entomology
UAS, GKVK, Bengaluru

N. Srinivasa
Major Advisor

Studies on Insect Pests of Sugarcane with Special Reference to Insect Plant Interaction and Management of Early Shoot Borer, *Chilo infuscatellus* Snellen (Pyralidae : Lepidoptera)

H. G. Umashankar

The investigation on insect pests of sugarcane with special reference to insect plant interaction and management of early shoot borer, *Chilo infuscatellus* was conducted at College of Agriculture, V.C. Farm, Mandya during 2014-15. A total of 25 species of insects and one mite pests have been recorded. Among the various insect pests incidence of *C. infuscatellus* was observed from 30 to 150 DAP. Highest reduction in cane yield was recorded in clumps where both primary and secondary shoots were attacked by this pest. Correlation studies on the incidence of ESB with weather parameters revealed significant positive relationship with maximum and mean temperature. Whereas, significant negative relationship was observed with morning, evening and mean RH and rainfall. Field screening of different sugarcane genotypes to ESB, revealed 47 less susceptible genotypes and 9 moderately susceptible genotypes. None of the genotypes were found to be highly susceptible. Studies on the influence of morphological parameters of different genotypes on cumulative incidence of ESB revealed significant positive correlation with leaf inclination and significant negative correlation with leaf sheath thickness and shoot girth. Biochemical analysis of the genotypes indicated lower quantity of total sugars and reducing sugar and higher quantity of phenols, cellulose, lignin and silica were found imparting resistance to ESB of sugarcane. Among the different insecticides evaluated for their bioefficacy revealed lowest cumulative incidence of ESB and highest per cent reduction of ESB was recorded in Cholrantraniliprole 0.4G. Highest net profit and benefit cost ratio was obtained with Fipronil 0.3G, Cholrantraniliprole 0.4G and Cartap hydrochloride 4G.

2016
Department of Agricultural Entomology
V.C. Farm, Mandya

V. N. Patel
Major Advisor

Studies on Seasonal Incidence and Abundance of Sucking Pests of Okra (*Abelmoschuses culentus* (L.) Moench) and their Management

THAMMALI HEMADRI

THE investigations on seasonal incidence and abundance of sucking pests of okra and their management was under taken at College of Agriculture, V. C. Farm, Mandya during summer 2015. The peak incidence of sucking pests were recorded in first and second fortnights of March. Likewise, the activities of predators *viz.*, coccinellids, syrphids, green lacewings and big eyed bugs were also noticed in higher number in March. During *kharif* the peak incidence of sucking pests were recorded in second week of October and predators during September-October. During summer among abiotic factors, the maximum temperature recorded a significant negative correlation with leafhoppers and aphids, while, whitefly showed a significant positive correlation with maximum temperature. During *kharif* the maximum temperature recorded a significant negative correlation with population of leafhoppers, aphids and whiteflies whereas, the afternoon relative humidity recorded significant negative correlation with leafhoppers and aphids. The effect of plant spacing on the sucking pests of okra, and their impact on yields revealed that, the aphid, leafhopper and whitefly population and the natural enemies *viz.*, coccinellids, syrphids, green lacewings and big eyed bugs were high by decreasing planting space but fruit yield increases by increasing planting space. Among new insecticide molecules evaluated against leafhopper, aphid, whitefly revealed that imidacloprid 17.8 SL @ 0.5 ml / l and acetamiprid 20 SP @ 0.5 g / l were found effective. Fruit yield and net returns and C: B ratio were high in imidacloprid 17.8 SL @ 0.5 ml / l treatment.

2016
Department of Agricultural Entomology
V.C. Farm, Mandya

L. VIJAY KUMAR
Major Advisor

Nesting Sites, Nesting Biology and Trap Nesting of Leaf Cutter Bees (Hymenoptera : Megachilidae)

SACHIN HEGDE

THE female of solitary and cavity nesting megachilid bees built their nests in 19 out of 20 sites chosen for study in GKVK from August 2015 to March 2016, where of the total 615 *Ipomea carnea* J. nests occupied, 190 nests were of megachilids (30.89 %). Megachilids preferred the sites with best combination of favourable characters (H, I and P blocks) for nesting than the sites which had poor qualities (Q, C, M and O blocks). Majority of megachilids collected pollen from legumes. Leaf cutting bees used leaves from 5 plant families. The female mason bee, *Megachile lanata* (F.) constructed linear chains of tubular mud cells filled with pollen and nectar within the offered trap nests. An average female, took 2.72 ± 0.04 h to construct a single cell and the total process of nest construction (n=2 nests; mean 6 cells) took 34.30 ± 1.68 hours. Megachilids used mud (*M. lanata*), resins (*M. disjuncta and M. stirostoma*) and leaves (*M. anthracina, M.* sp. 1 *etc*.) for nest construction. Eggs of *M. lanata* hatched in 2.5 days. Larval stageof males and females was 25.5 ± 0.71 and 28 days, respectively. Pupal duration was 10.5 ± 0.71 and 12 days for males and females, respectively. Sex ratio was 1: 1.4 (male: female). Significant mortality (41.77%) was observed in the nests by natural enemies. Among six types of trap nests used (*Ipomeacarnea,* Bamboo, Sal wood, mud, cement and mixed types), diversity of megachilids was highest (H'=1.71) in *Ipomea* nests, even though nesting was highest in the mixed nests (30.77%). Megachilids faced significant competition by cavity nesting non-megachilids with their nesting and usurpation behaviours. Non-megachilids occupied the trap nests in much larger portions (55.88%) than that of megachilids (19.01%).

2016
Department of Agricultural Entomology
UAS, GKVK, Bengaluru

V. V. BELAVADI
Major Advisor

The Effect of Agro-chemicals on Soil Fauna in Grassland Ecosystem

BANASHREE MEDHI

INVESTIGATIONS were carried out at ZARS, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru from August 2015 to February 2016. The evaluated agro-chemicals included insecticides (flubendiamide 0.25 g / l), acaricide (fenazaquin 1.7 ml / l), fungicide (tricyclazole 1.25 g / l), insect growth regulator (buprofezin 1 ml / l) and fertilizer (50: 40: 25 kg NPK / ha) against litter and soil invertebrates. The toxic effect of agro-chemicals on litter faunal composition was more pronounced in tricyclazole > fertilizer > buprofezin > flubendiamide > fenazaquin > untreated control. Whereas, the order of toxicity to soil invertebrates was tricyclazole = fenazaquin = flubendiamide > buprofezin = fertilizer. Among the treated plots, two foliar applications of tricyclazole was significantly more toxic to collembolan population in litter and soil samples. The population of sminthurids in both litter and soil sample was least affected with the application of buprofezin but, buprofezin was toxic to onychiurids in both soil and litter. Two foliar applications of tricyclazole showed significantly higher toxicity to Cryptostigmata in litter and soil. Fenazaquin was significantly toxic to total Acari of soil sample and was on par with tricyclazole but buprofezin and fertilizer were relatively less toxic to total Acari population. The plots treated flubendiamide was significantly toxic to total macrofauna. The soil mesofauna, Cryptostigmata, other Acari and total Acari exerted a significant negative association with soil microbial biomass - C. Microbial biomass - C and abiotic factors influenced the soil mesofauna up to 10.4 and 79.6 per cent, respectively. Minimum temperature, total rainfall and *insitu* soil moisture of the soil showed significant positive correlation with soil mesofauna.

2016
Department of Agricultural Entomology
UAS, GKVK, Bengaluru

N. G. KUMAR
Major Advisor

Studies on Genetic and Biochemical Basis of Resistance to Brown Planthopper (*Nilaparvata lugens* Stal) in Select Landraces of Rice

P. GANGARAJU

THE investigations on the evaluation of rice genotypes against brown planthopper (*Nilaparvata lugens* Stal) under glass house and field conditions, mechanisms of resistance and determination of genetic and biochemical basis for resistance against BPH in local rice genotypes were undertaken at ZARS, V.C. Farm, Mandya during 2015-16. Among the 60 landraces screened Bantwal local, Kavadari, Karibatha, Danisel and Esadi showed resistance to BPH. These five landraces showed higher days to wilt, more unhatched eggs, less oviposition preference, less nymphal survival, lower honeydew excretion and functional plant loss index as compared to susceptible checks. The genetic basis of resistance in F_2 population of the six crosses *viz*., 'Jaya × Rajamudi', 'Jaya × Ratnachoodi', 'Jaya × JBT 36 / 14', 'TN 1 × Ratnachoodi', 'TN 1 × Rajamudi' and 'TN 1 × JBT 36 / 14' showed single dominance, inhibitory and complementary digenic interaction in resistance. The biochemical basis of resistance to BPH in already identified six resistant genotypes indicated, greater expression of defence enzymes *viz*., peroxidase, polyphenol oxidase, phenyl alanine ammonia lyase, total phenol, â-1, 3 glucanase and chitinase in response to BPH feeding. Among these, Ratnachoodi, Honasu, JBT 36/14, Rajamudi recorded higher level of defence enzymes, potassium levels with lower nitrogen levels as compared to susceptible genotypes. Based on preliminary screening, subsequent genetic and biochemical analysis of BPH resistance in the selected local rice genotypes indicated the combined effects of genetic and biochemical factors in enhancing the resistance and in the development of durable resistant rice genotypes against BPH.

2016
Department of Agricultural Entomology
V.C. Farm, Mandya

T. SHIVASHANKAR
Major Advisor

Studies on Seasonal Incidence of Insect Pests with Special Reference to Shoot Weevil (*Alcidodes affaber* Aurivillius) (Curculionidae : Coleoptera) in Bt Cotton

RIZVANASAB YERESHIMI

THE investigations on seasonal incidence of insect pests and occurrence of natural enemies in Bt cotton, incidence of shoot weevil (*Alcidodes affaber* Aurivillius) on different Bt cotton varieties and its management was conducted at Southern dry zone of Karnataka during 2015-16. The study revealed the occurrence of 28 insect species and 6 natural enemies on both fresh and ratoon Bt cotton. Among the insect pests shoot weevil was observed through out the year with peak population during August month both on fresh and ratoon Bt cotton. Its incidence was high at Begur due to the presence of ratoon cotton. The most susceptible Bt cotton variety to shoot weevil was SP 911 BG-II. The minimum incidence of shoot weevil was observed on cotton grown under black soil. The shoot weevil had multiple (Overlapping) generations on Bt cotton. The chemical control studies showed profenophos 50 EC @ 2 ml / l + DDVP 76 EC @ 1 ml / l as a combination of insecticides was most effective in reducing the shoot weevil. While, the efficacy of imidacloprid 17.8 SL @ 0.3 ml / l insecticides spray was effective on jassids, aphids and thrips. Efficacy of profenophos 50 EC @ 2 ml / 200 ml and DDVP EC @ 1 ml / 200 ml insecticide applied as stem smearing on shoots was effective on the mortality of grubs of *A. affaber.* The cost benefit ratio (C: B) of insecticide as a spray against cotton shoot weevil was maximum for profenophos 50 EC @ 2 ml / l + DDVP 76 EC @ 1 ml / l.

2016
Department of Agricultural Entomology
V.C. Farm, Mandya

T. SHIVASHANKAR
Major Advisor

Studies on Seasonal Incidence of Major Insect Pests of Brinjal with Special Reference to Bio-ecology and Management of Shoot and Fruit Borer, *Leucinodes orbonalis* Guenee (Pyralidae : Lepidoptera) in Cauvery Command Area

S. SHIVARAJU

THE investigations on seasonal incidence of major insect pests of brinjal with special reference to bio ecology and management of shoot and fruit borer, *Leucinodes orbonalis* (Pyralidae : Lepidoptera) conducted at College of Agriculture, V. C. Farm, Mandya. As many as 18 species of insect pests belongs to five orders and 16 families of class insecta have been recorded on brinjal. Of these, Hemipterans (06) recorded the highest number of species followed by Lepidoptera (05), Coleoptera (04), Diptera (01) and Orthoptera (01). Of which, *Leucinodes orbonalis* and *Henosepilachna vigintioctopuctata* caused serious damage. The peak incidence of *Leucinodes orbonalis* was observed during first week of October (40th MSW) and third week of March (12th MSW) during *Kharif* and rabi-summer, respectively. The Coccinellids and Spiders were recorded as potential natural enemies on insect pests of brinjal. Majority of the insect pests attacked during flowering and fruit development stage of the crop. Correlation studies on incidence of *L. orbonalis* and meteorological variables revealed that significant positive relationship was observed with maximum temperature (r=0.56* and r=0.55*) and minimum temperature (r=0.52*) during both the seasons. The average life cycle of male and female was recorded 25.20 and 29.67 days, respectively. Among the insecticides evaluated, highest per cent reduction was recorded in quinalphos 25 EC @ 2.00 ml / l followed by flubendiamide 39.5 SC @ 0.15 ml / l against *L. orbonalis* during both the seasons. Whereas, quinalphos 25 EC @ 2.00 ml / l registering higher C: B ratio of ₹ 4.95 and ₹ 3.30 during *kharif* and rabi-summer season, respectively.

2016
Department of Agricultural Entomology
V.C. Farm, Mandya

D. JEMLA NAIK
Major Advisor

Studies on Damage Potential and Biology of South American Tomato Leafminer, *Tuta absoluta* (M.) (Lepidoptera : Gelechiidae)

SHEIKSALMAN

BIOLOGY of *Tuta absoluta* was studied on tomato, potato, brinjal and black night shade under laboratory conditions. Damage potential of the pest on tomato was studied in Kolar, Chickballapura, Bengaluru rural, Bengalurau urban, Mandya and Ramanagar districts of Karnataka. The natural enemies of *T. absoluta* were also recorded. The incubation period of eggs was 6.50, 6.37, 5.45 and 5.42 days on black night shade, brinjal, potato and tomato, respectively. The total life cycle was longer (32.67 days) on black night shade as compared to brinjal (31.16 days), potato (27.04 days) and tomato (26.52 days). The magnitude of damage (64.4%) leafmine and (30.2%) fruit damage in the villages surveyed in Kolar district was severe as compared to Bengaluru Urban (55.62 %) leafmine and (20.97 %) fruit damage, Mandya (45.62 %) leafmine and (33.52 %) fruit damage, Ramanagar (15.50 %) leafmine and (5.62%) fruit damage, Chickballapur (14.24 %) leafmine and (7.94%) fruit damage and Bengaluru Rural (7.72 %) leafmine and (3.42%) fruit damage. A large population of the zoophytophagousmirid bug, *Nesidiocoris tenuis* (Hemiptera : Miridae) was observed on the tomato in all the places surveyed. A spider species, *Plexippu spaykulli* (Araneae : Salticidae) found commonly predating on adult moths of *T. absoluta* in the fields surveyed.

2016
Department of Agricultural Entomology
UAS, GKVK, Bengaluru

C. S. JAGADEESHBABU
Major Advisor

Studies on Pollination Biology of Pumpkin (*Cucurbita Pepo* L.) with Emphasis on Foraging Behavior of Pollinators in Relation to Seed Production

R. CHIDANANDA

PUMPKIN (*Cucurbita pepo* L.) crop being monoecious depends on pollinators for successful fruit set. The present investigation focused on floral biology of pumpkin in relation to activity of pollinators and their role in seed production. Flowering started 72.4 ± 1.07 and 63.27 ± 2.28 days after planting in the post-monsoon and summer seasons, respectively. Ratio of male and female flowers was 12.35:1 and 23.66:1 in the two seasons, respectively. Male flower opened 10-15 minutes earlier than female flowers. Peak anthesis of male and female flowers was observed between 03.00 h to 05.00 h. The longevity of both flowers was only one day. The anther dehiscence was observed in cleistogamous condition between 22.00 h to 00.00 h. Peak stigma receptivity was observed at 08.00 h in the two seasons, respectively. A diverse group of insects comprising 8 species belonging to Hymenoptera (7 species) and Diptera (1 species) visited pumpkin flowers. *Apis* bees, constituted nearly, 96.48 per cent of all insect visitors. The abundance and diversity of floral visitors increased from 06.00 h to 12.00 h and later decreased. *A. dorsata* appeared to be more efficient pollinator since it deposited 229.4 ± 188.62 pollen grains on stigma upon single visit compared to *A. cerana* (67.00 ± 44.87). There was a significant difference in seed number *i.e.*257.5 ± 52.1 / fruit and 271.9 ± 30.94 / fruit, respectively, with hand and open pollination. The total seed yield was 231.43 kg per acre under open pollination.

2016
Department of Agricultural Entomology
UAS, GKVK, Bengaluru

V. V. BELAVADI
Major Advisor

AGRICULTURAL EXTENSION

A Study on Consumer Perception and Awareness on Functional Foods in Bangalore Urban District

C. AKSHATHA

THE study was conducted during 2015-16 in Bengaluru Urban district of Karnataka to study the consumer perception and awareness on functional foods. Total sample of 120 consumers were selected from four taluks of Bengaluru Urban district. Majority of the consumers were young, graduates, female, private employees belonging to nuclear family having medium family size, medium income group, high media exposure, medium level of brand preference and high purchasing frequency. Overall perception level of consumers on functional foods was found to be high (39.2%) followed by medium (30.8 %) and low level perception (30.0 %). Above half of consumers were having high awareness (57.50%) followed by medium awareness (29.17 %) and low awareness (13.33 %). The motivating factors for consuming functional food were that it helps in maintenance of healthy gut function, it helps to keep healthy life style and it increases the wellness of consumers. Education and annual income of consumers was highly significantly associated with consumer perception. Age, occupation, type of family, size of family, media exposure, brand preference and frequency of purchase were significantly associated with consumer perception. Age, education, occupation, annual income, media exposure, brand preference and frequency of purchasing were significantly associated with the consumer awareness. Consumers expressed that fear of artificial additives, too expensive, fear of side effects as major constraints.

2016
Department of Agricultural Extension
UAS, GKVK, Bengaluru

K. C. LALITHA
Major Advisor

An Analysis of Krishidarshan Programme of Bengaluru Doordarshan

B. H. AYISHATHUL RAMZEENA

KRISHIDARSHAN programme telecast by DD Chandana is popular among the farming community of Karnataka. The study was conducted to know the content and viewers behaviour of Krishidarshan programme. Content analysis of Krishidarshan programme was done from the secondary data of one year (2015). Simultaneously, 120 farmers were selected from four taluks of Chickballapur district to know the viewers behaviour of Krishidarshan programme. Respondents were interviewed with the help of structured interview schedule. The results regarding the content analysis showed that majority of the programmes (30 %) were related to agriculture followed by horticulture (28.89 %) and animal husbandry (12.50 %) and most of the programmes telecast were timely. With regard to subject matter expertise, more number of programmes was given by University scientists followed by Development departments and National Research Institutes. The results regarding overall Krishidarshan programme viewing behaviour of the respondents revealed that 43.33 per cent of the respondents had medium Krishidarshan programme viewing behaviour followed by low (32.50 %) and high (24 %). The socio-economic variables such as annual income, education, land holding, extension participation, mass media participation, and attitude were significantly associated with the viewer's behaviour. Suggestions like change the time of telecast, increase the duration of the programme, enhance the number of live phone in programmes etc. were given by the farmers keeping the importance of Krishidarshan among farming community, it was suggested to telecast the programme in suitable timing, expand the duration, educate the farmers to view Krishidarshan to obtain need based, timely and credible information.

2016
Department of Agricultural Extension
UAS, GKVK, Bengaluru

K. P. RAGHUPRASAD
Major Advisor

AGRICULTURAL MICROBIOLOGY

Studies on Isolation, Characterization and Evaluation of Potassium Solubilizing Bacteria with other Beneficial Microorganisms on Growth and Yield of Maize (*Zea mays* L.)

Vijayakumar S. Benahal

Potassium (K) is an important nutrient for crop plants next to nitrogen and phosphorous. Potassium availability in the soil is more in the form of mineral K (98 %), which is not available for plant uptake. Potassium solubilizing bacteria (KSB) plays an important role in the conversion of unavailable mineral K into available soluble K. With these views potassium solubilizing bacteria were isolated from banana and maize rhizosphere soils of GKVK campus. Two KSB isolates were isolated from banana rhizosphere (KSBB-1 & KSBB-2) and one from maize (KSBM-3) rhizosphere and all the three isolates were characterized on the basis of morphological and biochemical characters. Among the three KSB isolates KSBB-2 showed higher zone of solubilization on Aleksandrov's medium (1.42cm) and potassium mineralization in Aleksandrov's broth (45.62µg / ml) followed by KSBB-1 (1.25 cm and 42.72 µg / ml, respectively). The selected KSB isolates were evaluated with other beneficial micro organisms on growth and yield of maize. All the treatments which received triple inoculation of KSB, *A. chroococcum* and *B. megaterium* were found to have increased growth and yield of maize. Microbial population, enzyme activity in rhizosphere and nutrient content of maize were also found to be increased in the treatments with triple inoculation compared with dual and single inoculation under glasshouse condition. Results showed that the KSB, *A. chroococcum* and *B. megaterium* were compatible with each other without any inhibition. Shelf life studies on KSB showed that it can be stored for upto 180 days in lignite formulation to maintain its population at 30 °C.

2016
Department of Agricultural Microbiology
UAS, GKVK, Bengaluru

L. Krishna Naik
Major Advisor

AGRICULTURAL STATISTICS

Modelling of Rainfall Distribution and Variability in Yadgir District

K. Pavan Kumar

The amount of rainfall and its pattern is one of the important factors that affect agricultural system. The analyses of rainfall data for long period provide information about pattern and its variability. For this purpose daily rainfall (mm) data pertaining to 16 rain gauge stations spread over three taluks of Yadgir district were collected from the AICRP on Agrometeorology, UAS, GKVK for the period of 34 years (1980-2013). The average annual rainfall in the district during the study period was found to be 648.36 mm with a coefficient of variation of 34.37 per cent. Eighty per cent of the annual rainfall was received from South-west monsoon of which September month received highest amount of rainfall in the district. Decreasing trend in rainfall was noticed in all rain gauge stations of the district which was revealed from Mann Kendall test at 5 per cent level of significance. Fitting of probability distributions *viz.*, normal, lognormal, Gamma (1P, 2P, 3P), General Extreme Value (GEV), Weibull (1P, 2P, 3P), Gumbel and Pareto were used for rainfall data of different periods of the district and goodness of fit was tested using Kolmogorov-Smirnov test. From the analysis Weibull (3P) and Weibull (2P) were found to be best fit distributions for annual and seasonal (SWM) rainfall data, respectively, while for weekly (23^{rd} to 39^{th} SMW) rainfall data, Gamma (3P), lognormal and GEV were found to be the best fit distributions.

2016
Department of Agricultural Statistics, Mathematics,
Computer Science, UAS, GKVK, Bengaluru

M. Gopinath Rao
Major Advisor

AGRONOMY

Studies on Intercropping in Maize (*Zea mays* L.) under Paired Row Drip Fertigation in Southern Dry Zone of Karnataka

H. S. SHIVARAJKUMAR

A field experiment entitled Studies on intercropping in maize (*Zea mays* L.) under paired row drip fertigation in southern dry zone of Karnataka was conducted at Agronomy field unit, College of Agriculture, V.C. Farm, Mandya, University of Agricultural Sciences, Bengaluru. The experiment comprised of 13 treatments consists of two paired rows of maize under drip *viz*., 30 / 60 cm (from 45 cm row) and 30 / 90 cm (from 60 cm row) spacing with three intercrops *viz*., green gram, black gram and soybean. These combinations were compared with respective paired row alone or 45 or 60 cm traditional row spacing of maize without intercrops or respective sole crop of pulses. The experiment was laid out in RCBD with three replications. The soil type was red sandy loam. The variety *viz*., NAH-1137, KKM 3, Rashmi and KB 79 were used in maize, green gram, black gram and soybean, respectively. The results revealed that, adoption of 30 / 90 cm paired row of maize under drip fertigation with two rows of green gram or black gram or soybean intercropping gave significantly higher maize kernel yield (7790 to 7975 kg / ha) than sole maize at 60cm×30 cm spacing with surface irrigation and fertilizer application. Further, growing intercrops in the former treatments recorded additional pulse crop yield (643,606 and 801kg / ha green gram, black gram and soybean, respectively), higher maize equivalent yield (9976 to 12585 kg / ha), land equivalent ratio (1.57 to 1.65), net returns (₹ 84,076 to 1,06,056 / ha) and B:C ratio (2.74 to 3.63) as compared to 30 / 90 cm paired row of maize alone or 30/60cm paired row of maize with intercropping.

2016
Department of Agronomy
V.C. Farm, Mandya

G. R. DEENESH
Major Advisor

Efficacy of Pre and Post Emergent Herbicides in Direct Seeded Rice Under Cauvery Command Area of Karnataka

C. R. NAGESH

A field experiment to study the efficacy of pre and post-emergent herbicides in direct seeded rice under Cauvery command area of Karnataka was conducted during *kharif* 2015 at ZARS, V.C. Farm, Mandya. The experiment comprised of thirteen treatments including two pre-emergence herbicides (Pendimethalin and pretilachlor + bensulfuron methyl) followed by three post-emergence herbicides (Penoxsulam, bispyribac sodium and azimsulfuron) and was laid out in Complete Randomized Block Design with three replications. The weed control treatments were compared with hand weeding and weedy check. Among the weed control treatments, pre-emergence application of pendimethalin @ 750 g *a.i.* ha^{-1} followed by post-emergence application of penoxsulam @ 22.2 g *a.i.* ha^{-1}, significantly, controlled the weeds and this was on par with standard check *i.e.* two hand weeding at 20 and 40 DAS and also recorded, significantly, lower weed count (3.6 m^{-2}), weed dry weight (1.13 g m^{-2}) and higher weed control efficiency (88.36 %) at 60 DAS and resulted in higher grain and straw yield (6328 Kg ha^{-1} and 7432 Kg ha^{-1}, respectively). Similarly, nutrient uptake by crop (N-113.27, P_2O_5-37.97 and K_2O-103.33 kg ha^{-1}), net return (₹ 34753 ha^{-1}), and B:C ratio (2.03) was significantly higher with the same treatment. The pre-emergence application of pendimethalin @ 750 g *a.i.* ha^{-1} followed by post-emergence application of either bispyribac sodium @ 25 g *a.i.* ha^{-1} or azimsulfuron @ 26.25 g *a.i.* ha^{-1} were found to be the next best weed control treatments.

2016
Department of Agronomy
V.C. Farm, Mandya

S. B. YOGANANDA
Major Advisor

Effect of Foliar Application of Water Soluble Fertilizers on Growth and Yield of Maize (*Zea mays* L.)

NIRERE

A field experiment was conducted during *Kharif* – 2015 at agronomy field unit, Zonal Agricultural Research Station, GKVK, Bengaluru on sandy loam soil. The hybrid Hema (NAH-1137) was sown at the spacing of 60 x 30 cm. The experiment consisted of seven treatments with three replications laid out in RCBD. The treatments included two levels of RDF (75 % and 100 %) applied to soil in combination with foliar spray of water soluble NPK (19: 19: 19) at 0.5 per cent concentration sprayed at knee height stage, tasselling stage and knee height + tasselling stage. The treatments were compared with recommended dose of fertilizer (150: 75: 40 kg NPK ha^{-1}). The investigation revealed that significantly higher kernel yield and stover yield (9361 and 15505 kg ha^{-1}, respectively) was recorded with soil application of 100 per cent RDF followed by 0.5 per cent foliar spray of water soluble fertilizers at knee height and tasselling stages. High yielding ability of the crop with this treatment was attributed to better yield components *viz*, cob weight (211.90 g), cob length (18.53 cm), number of kernel rows cob^{-1} (17.27), number of kernels per row (35.13) and kernel weight $plant^{-1}$ (171.23 g $plant^{-1}$) as a result of higher growth components (plant height; 247.23 cm, number of green leaves; 10.40, leaf area; 10989 cm^2, and total dry matter; 468 g $plant^{-1}$). Further, significantly higher NPK uptake and protein content (306.60, 100.57 and 216.24 kg NPK ha^{-1} and 11.5 per cent protein content, respectively), higher net returns (₹ 72500 ha^{-1}) and B: C ratio (2.8) were also recorded with 100 per cent RDF followed by 0.5 per cent foliar spray of water soluble fertilizers at knee height stage and tasselling stages compare to other treatments.

2016
Department of Agronomy
UAS, GKVK, Bengaluru

K. N. KALYANA MURTHY
Major Advisor

Performance of Clusterbean (*Cyamopsis tetragonoloba* L.) Varieties with Different Seed Rates on Green Fodder Yield and Quality

V. BHAVYA

THE field experiment was carried out during *Kharif* 2015 in sandy loam soil at ZARS, VC Farm, Mandya which comes under the southern dry zone of Karnataka (Zone-VII). The study was carried out to know the performance of clusterbean (*Cyamopsis tetragonoloba* L.) varieties with different seed rates on green fodder yield and quality. Experiment was laid out in factorial RCBD with 18 treatment combination *viz.,* six varieties (HG 870, HG 563, HG365, HG 220, Goma Manjari and BR 99) and 3 seed rates (30, 40 and 50 kg ha^{-1}), respectively. Variety HG 563 had recorded significantly higher plant height (78.02 cm), branches $plant^{-1}$ (5.63), trifoliate leaves (16.97 $plant^{-1}$), green fodder yield (214.52 q ha^{-1}) and dry matter yield (40.76 q ha^{-1}) compared to other varieties. Among seed rates, 50 kg ha^{-1}recorded significantly higher plant height (72.55 cm), green fodder yield (204.18 q ha^{-1}) and dry matter yield (38.79 q ha^{-1}). In quality parameters variety HG 563 had recorded significantly higher crude protein (19.80 %), total ash (8.32 %) and organic matter yield (35.54 q ha^{-1}) but, variety HG 365 resulted in significantly higher crude fibre (27.99 %) and ether extract (3.67 %). Seed rate of 50 kg ha^{-1} observed significantly higher crude protein (19.11 %), crude fibre (27.85 %), ether extract (2.75 %) and organic matter (92.60 %) over other seed rates. Variety HG 563 with seed rate of 50 kg ha^{-1} had given higher net returns (₹ 15316ha^{-1}) and benefit cost ratio (3.09).

2016
Department of Agronomy
UAS, GKVK, Bengaluru

B. S. LALITHA
Major Advisor

Evaluation of Methods of Seed Preparation on Growth and Yield of Sugarcane (*Saccharum officinarum* L.)

C. SATHISHA

A field experiment was conducted to study the evaluation of methods of seed preparation on growth and yield of sugarcane during 2015-16 at ZARS, V. C. Farm, Mandya. The experiment was laid out in RCBD design with nine methods of sugarcane seed preparation as treatments. The results revealed that planting of single eye budded setts raised in polybag and nursery beds recorded statistically on par growth and yield parameters compared to planting of three eye budded setts directly in main field with respect to germination per cent (75.33, 72.89 and 74.87 %), number of tillers (152660 ha^{-1}, 148750 $ha^{-1}$and 159920 ha^{-1}), number of millable canes (95080 ha^{-1}, 94930 ha^{-1} and 102400 ha^{-1}), single cane weight (1.58 kg, 1.55 kg and 1.60 kg) and cane yield (122.2 t ha^{-1}, 119.06 t ha^{-1} and 127.02 t ha^{-1}), respectively. Quality parameters *viz.,* brix, pol, purity and CCS per cent were not influenced by methods of seed preparation. Planting of single eye budded setts raised in bed was found to be economical with higher net returns (126011 Rs ha^{-1}) and B:C ratio (1.85) compared to planting of three eye budded setts (98408 Rs ha^{-1} and 1.51, respectively) directly in main field.

2016
Department of Agronomy
V.C. Farm, Mandya

K. V. KESHAVAIAH
Major Advisor

Evaluation of Rice (*Oryza sativa* L.) Varieties Under Direct Seeding Methods in Puddled Soil for Higher Profitability

PRAKASH AJAGOL

A field experiment was conducted at ZARS, V. C. Farm, Mandya during *Kharif*2015 to study the Evaluation of rice (*Oryza sativa* L.) varieties under direct seeding methods in puddled soil for higher profitability. The soil of the experimental site was sandy loam with moderate acidity (pH 6.90). The experiment consists of 18 treatment combinations comprised three main plot treatments (method of establishment) and six subplot treatments (varieties / hybrids) were laid out in split plot design with three replications. The results indicated that among two hybrids DRRH-3 recorded more number of tillers $hill^{-1}$ (20), higher panicle length (23.88 cm, panicle weight (3.48 g), grain yield (6453 kg ha^{-1}), straw yield (7558 kg ha^{-1}) and B:C ratio (2.55) compared to hybrid KRH - 4 (18.56, 22.88 cm, 3.22 g, 6381 kg ha^{-1}, 7429 kg ha^{-1} 2.53, respectively). Among varieties, IR-64 recorded significantly more number of tillers $hill^{-1}$ (17.44), higher panicle length (22.68 cm), panicle weight (2.96 g), test weight (24.49 g), grain yield (5291 kg ha^{-1}), straw yield (6632 kg ha^{-1}) and B:C ratio (2.22) compared to MTU-1001, MTU-1010 and Thanu. Among different establishment methods direct seeding of sprouted seeds recorded significantly higher plant height (116.11 cm), more number of tillers $hill^{-1}$ (18.22), panicle length (22.95 cm), panicle weight (3.08 g), grain yield (5518 kg ha^{-1}), straw yield (6721 kg ha^{-1}) and B:C ratio (2.44) and which was on par with direct seeding of dry seeds as compared to transplanting. Interaction between varieties and different establishment methods were non significant.

2016
Department of Agronomy
V.C. Farm, Mandya

C. RAMACHANDRA
Major Advisor

Effect of 2, 4-Diacetylphloroglucinol (DAPG) Produced by *Pseudomonas fluorescens* on Growth and Productivity of Groundnut (*Arachis hypogaea* L.)

B. ANIL KUMAR

A field experiment was conducted during *rabi-summer* 2015 at ARS, Chintamani,University of Agricultural Sciences, Bengaluru to study the Effect of 2, 4-diacetylphloroglucinol (DAPG) produced by *Pseudomonas fluorescens* alone and in combination with *Trichoderma harzianum* on growth, yield, nutrient use efficiency (NUE), incidence of soil borne diseases and economics of groundnut in red sandy loam soil. The soil of the experimental site is neutral in reaction (pH 7.10), medium in organic carbon content (0.56 %) and EC (0.13 dSm^{-1}). The experiment was laid out in RCBD with 12 treatments and replicated thrice. The investigation revealed that seeds treated with both DAPG4 produced by *P. fluorescens* and *Trichoderma harzianum* recorded significantly higher plant height (40.1 cm), LAI (4.09), total dry matter (26.73 g), pod yield (2673 kg ha^{-1}), haulm yield (3351 kg ha^{-1}) and oil yield (984 kg ha^{-1}) over all other treatments. Significantly higher nutrient use efficiency was recorded in combined application of DAPG4 produced by *P. fluorescens* and *Trichoderma harzianum* (106.5, 35.53, 71.06 kg kg^{-1} of N, P and K, respectively) and least incidence of both stem rot (6.90 %) and root rot (7.10 %) was observed in the same treatment. Similarly same treatment recorded higher net returns (67057 ₹ ha^{-1}) and B:C (2.46) compared to other treatments

2016
Department of Agronomy
UAS, GKVK, Bengaluru

V. SHANKARNARAYANA
Major Advisor

APICULTURE

Influence of Hive Design on Seasonal Performance of Stingless Honey Bee *Tetragonula iridipennis* (Smith)

K. PALLAVI

STUDY on influence of different hive designs on colony growth, food storage, foraging activity and temperature maintenance of stingless honey bee, *Tetragonula iridipennis* (Smith) was carried out during 2015-2016 at UAS, GKVK, Bengaluru. Four different hive designs were used for rearing stingless bees for four seasons *viz.,* wooden hive (30×10 ×10 cm³), bamboo hive (30 cm length and 10 cm diameter), plastic hive (30 cm length and 10 cm diameter) and Kerala hive (20 cm length and 12 cm diameter). Across four seasons, it was revealed that the increase in brood volume was highest in wooden hive (9.98 %), followed by plastic (5.75 %) and bamboo (0.9 %) hives while it was decreased in Kerala (3.7 %) hive. Maximum increase in food storage volume and colony weight was in bamboo (12.9 and 13.5 %), followed by wooden (9.98 and 9.98 %), plastic (2.31 and 3.13%) and Kerala (1.79 and 1.84 %) hives. The increase in outgoing foragers was highest in wooden hive (39.37 %), followed by plastic (19.4 %), bamboo (10.1 %) and Kerala (7.5 %) hives. There was an increase in nectar and pollen foragers in wooden hive (1.3 and 5.6 %) during all seasons, while it showed a decrease in plastic (8.7 and 4.3 %), Kerala (11.8 and 2.9 %) and bamboo (11.8 and 7.3 %) hives. There was general decrease in resin foragers were recorded in all hive types. During all seasons temperature inside and outside hives was almost same.

2016
Department of Apiculture
UAS, GKVK, Bengaluru

G. C. KUBERAPPA
Major Advisor

CROP PHYSIOLOGY

Isolation and Evaluation of Endophytic Fungi from Drought Tolerant Plants and their Ability to Confer Drought Tolerance

NITHIN J. SHETTY

ENDOPHYTES (fungal or bacterial) are microorganisms that complete their life cycle inside living plant tissue without causing any overt negative symptoms and are believed to confer habitat-adapted fitness benefits to host species. Endophytic fungi have gained importance in the area of agriculture because of their ability to confer resistance to different biotic and abiotic stress. In this study, we addressed two hypotheses, *viz.,* a) that endophytes from arid habitat plants would possess habitat adapted symbiotic tolerance to drought and b) that upon inoculation to crop plants, such endophytes would impart tolerance to drought sensitive plants. We addressed these hypotheses by evaluating endophytic fungi isolated from 17 plant species collected from the arid habitats of Rao Jodha Desert Park, Rajasthan for their ability to impart drought tolerance to a drought sensitive paddy genotype, IR-64. A total of 409 fungal isolates were obtained from 17 plant species adapted to arid habitats. They were morphologically classified into 52 Operational Taxonomic Units (OTU's). *Aspergillus niger* was the predominant fungi. Of these, 6 OTU's were able to significantly modulate the growth of paddy seedlings (IR-64 genotype) under PEG stress (-6 bars) compared to paddy seedlings that were not treated with endophytes. Gene expression studies of SAP-3 endophyte treated paddy seedlings did not indicate differential expression as compared to untreated seedling. More work needs to be done to unravel the mechanism of plant-endophyte interactions, responsible for modulation of plant growth under stress.

2016
Department of Crop Physiology
UAS, GKVK, Bengaluru

R. UMASHAANKAR
Major Advisor

Role of Organic Biostimulants in Growth, Nutrient use Efficiency and Productivity of Mungbean (*Vigna radiata* L.)

N. S. SWETHA

THE use of organic biostimulants in sustainable agriculture has been increasing in recent years. Biostimulants can be obtained from different organic materials like, humic substances, peptides, amino acids, phenols, alkaloids, seaweed extractsand other N-containing substances. Applications of these biostimulants to plants were shown to influence higher growth and productivity because of positive metabolic changes. In the present study an attempt was made to evaluate the effect of these biostimulants on growth, nutrient use efficiency and productivity in mungbean. Two biostimulants *viz.,* humic acid and protein hydrolysate (siapton) were used. Different bioassays were conducted byusing humic acid and siapton, to check the hormone like activity. The results revealed that, both humic acid and siapton have growth promoting effects similar to that of auxins, cytokinins and gibberllins. The effect of humic acid on growth stimulation was significantly more compared to siapton. A field experiment was conducted, to check the effect of different concentration and method of application of biostimulants on growth and productivity. The results revealed that soil+foliar application is the best method, resulting in higher productivity. Field experiment results showed that both humic acid and siapton enhance the growth and productivity of mungbean. Higher content of iron and zinc were noticed in roots, leaves and seeds of biostimulant treated plants as compare to untreated plants.

2016
Department of Crop Physiology
UAS, GKVK, Bengaluru

I. S. AFTAB HUSSAIN
Major Advisor

FOOD SCIENCE AND NUTRITION

Effect of House hold Processing on Total Antioxidant Activity and Total Polyphenolics of Selected Vegetables

SIDHARTH SUMAN

NON-COMMUNICABLE Diseases (NCDs) such as diabetes, CVD, cancers are a major global health problem. Free radicals are considered to be one of the important causative agent for these diseases. Vegetables are good source of antioxidants. Cooking may affect the antioxidant activity of vegetable. Hence, the study was undertaken to study the effects of open boiling, pressure cooking and microwave cooking for 2, 4 and 6 minutes on total antioxidant activity (TAA) and total polyphenolic content (TPP) of spinach, cabbage, tomato, bitter gourd, carrot and beetroot. Bioactive compound was extracted using 80 per cent acidified methanol. The TAA and TPC were determined using 2, 2-Diphenyl-1-picrylhydrazyl (DPPH) and Folin-Ciocalteu (FC) method, respectively. TPC ranged from 19.36 to 107.11 mg GAE / 100 g in raw vegetables and are listed in descending order: beetroot, bitter gourd, spinach, cabbage, tomato, carrot. TAA ranged from 31.63 to 187.46 mg TE / 100 gm in raw vegetables and are listed in descending order: beetroot, cabbage, bitter gourd, spinach, tomato, carrot. Different cooking methods significantly affected the TPC and TAA. Boiling decreased the TPC and TAA and was inversely proportional to boiling time in all vegetables, except carrot. Pressure cooking reduced the TPC and TAA content. Microwave cooking significantly increased the TPC and TAA in all vegetables and was directly proportional to the microwaving time.Vegetables with peel had higher TPC and TAA than that of without peel. High correlation was found between TPC and TAA in all vegetables except carrot. Selection of appropriate cooking method and cooking time will increase the antioxidant in diet which may help to reduce the oxidative stress.

2016
Department of Food Science and Nutrition
UAS, GKVK, Bengaluru

K. GEETHA
Major Advisor

GENETICS AND PLANT BREEDING

Assessment of Genetic Variability for Yield, Yield Attributes and Blast Disease in Two F_2 Populations involving Traditional Varieties of Rice (*Oryza sativa* L.)

MAMATA KHANDAPPAGOL

RICE is the most important cereal crop and being main source of energy and income for the majority of the world's population. The present investigation was undertaken during 2014-2015 at the ZARS, V.C. Farm, Mandya, Karnataka to study the genetic variability for grain yield, yield related components and molecular analysis to identify presence of blast resistance genes in segregating generations. The variation for twelve quantitative characters in F_2 population of crosses Rajamudi × BR-2655 and Rathnachoodi × BR-2655 indicated wide variability for all the characters studied except days to fifty per cent flowering and panicle length. GCV and PCV values for grain yield per plant in Cross I and productive tillers per plant, filled grains per panicle and grain yield per plant in Cross II showed higher and lower values for 1000 grain weight in both the crosses. Path analysis in F_2 indicated positive direct effect of harvesting index and straw yield per plant; low direct effect of panicle length on grain yield. The results showed correlation coefficients were positive and significant for harvest index, panicle weight and plant height indicating additive gene action. Therefore, the performance of the plants in F_2 generation is a reliable indicator of the performance of their progeny in subsequent generations. In the present investigation superior promising individual plants were identified in F_2 segregating generation. Molecular analysis revealed presence of blast resistant genes in eleven F_3 segregants that were showed resistance to blast; these results can be used for further evaluation to produce blast resistant varieties.

2016
Department of Genetics and Plant Breeding
V.C. Farm, Mandya

M. P. RAJANNA
Major Advisor

Genetic Variability Studies for Grain Yield and Powdery Mildew Resistance in Segregating Generations of Green Gram [*Vigna radiata* (L.) Wilczek]

H. S. ADARSHA

The presence of useful genetic variability in the breeding material coupled with resistance to major biotic and abiotic stresses is essential. With this background. genetic variability for yield and its attributing characters was assessed in F_4 and F_s progenies of five different crosses *viz.*, BL-865 x Chinamung, LM-192 x MDU-3465, BL-865 x SML-348, LM-192 x SML-348 at UAS, GKVK. Bengaluru during *kharif* and *rabi* 2016. Observations were recorded on seed yield and its attributes. The results indicated significant difference among the families for all the characters in F_4 and F_5 generations. Moderate to high PCV and GCV for the traits studied indicated higher magnitude of genetic variability among the families and narrow difference between them indicated lower environmental influence except for days to 50 per cent flowering and pod length. High heritability coupled with high GAM was recorded in both the generations indicating the prevalence of additive gene action and usefulness of selection to improve the traits. The positive association of plant height, primary branches plant^{-1}, clusters plant^{-1}, pod yield plant^{-1} with seed yield^{-1} and positive direct effects of pod yield plant^{-1}, pods plant^{-1} and indirect effect of plant height, primary branches plant^{-1}, clusters plant^{-1} on seed yield plant^{-1} was noticed. The best families were selected based on powdery mildew resistance coupled with high yield from F_5 generation.

2016
Department of Genetics and Plant Breeding
UAS, GKVK, Bengaluru

J. SHANTHALA
Major Advisor

Identification of Cowpea Germplasm for Iron, Zinc, Protein, Seed Yield and its Attributing Traits

C. A. MANOJ

IN the present investigation 169 cowpea germplasm accessions were evaluated to assess the genetic diversity and to identify nutritious rich accessions by underlying 13×13 simple lattice design. ANOVA indicated the significant difference for all the traits under consideration, justifying the selection of accessions for the study. Genetic variability estimates, heritability, GAM were high for plant height, clusters plant^{-1}, pods plant^{-1}, pod yield plant^{-1} and seed yield plant^{-1} indicating the predominance of additive gene action and these traits offer scope for direct selection. Trait association analysis revealed positive significant association of seed yield with pod yield plant^{-1}, pods plant^{-1}, clusters plant^{-1}, pods cluster^{-1}, seeds pod^{-1}, pod length and primary branches plant^{-1}. Negative association was found for iron, zinc and protein content with that of seed yield. Hence direct selection for these traits will not help in improving seed yield. By 'K-means' clustering method genotypes were grouped into 9 clusters, of which cluster VII was largest with 56 accessions followed by cluster III and V with 43 and 35 genotypes, respectively, indicating diversity among them. Five principal components with eigen values greater than one contributed 70.5 per cent of the total variability. Through estimation of nutrients, twelve accessions identified as iron, zinc and protein rich and 27 accessions as low iron, zinc and protein and these belong to the different clusters and are genetically divergent, hence they could be used as parents in future for breeding programmes aimed at obtaining transgressive segregants surpassing the parents with respect to nutrients in segregating generations.

2016
Department of Genetics and Plant Breeding
UAS, GKVK, Bengaluru

N. MARAPPA
Major Advisor

Genetics of Response to Powdery Mildew Infection and Grain Yield in F_4 and F_5 Recombinant Inbred Lines (RIL's) of Green Gram [*Vigna radiata* (L.) Wilczek]

ANKESH KUMAR

GREEN GRAM, (*Vigna radiata* (L.) Wilczek) is severely affected by powdery mildew caused by *Erysiphe polygoni* D. C., the most devastating foliar disease of green gram. In view of this, the present study was formulated involving F_4 and F_5 generations of RILs of two crosses *viz*., Chinamung x BL 849 and Chinamung x LM 1668 which had characteristic features contrasting to pod yield and powdery mildew resistance with 260 and 249 lines, respectively, were evaluated for resistance to powdery mildew and yield and yield related traits under field condition. Genetic variability estimates were high for plant height, primary branches plant^{-1}, clusters plant^{-1}, pods plant^{-1}, seeds per pod, pod yield plant^{-1} and seed yield plant^{-1} representing the reserve of sufficient amount of variability in both populations enabling exploitation of these traits for direct selection programmes. Strong positive correlation was manifested by the seed yield with yield contributing characters *viz*., pod yield plant^{-1} (0.98), clusters plant^{-1} (0.53) and pods plant^{-1} (0.38) in both the crosses, suggesting that selection based on these traits would improve the seed yield in green gram. Among all the RILs studied, 20 RILs were high yielding coupled with resistance to powdery mildew were selected. The top performing lines are C1-16A-13,C1-200-129 in cross Chinamung BL 849 and C2-35-26, C2-13-10 in cross Chinamung LM 1668 are high yielding and resistant to powdery mildew disease which can be further stabilized to release as a variety or use as a parent in other breeding programmes.

2016
Department of Genetics and Plant Breeding
UAS, GKVK, Bengaluru

J. SHANTHALA
Major Advisor

Genetic Variability for Mungbean Yellow Mosaic Virus (MYMV) Disease Resistance in Segregating Generations of Interspecific Crosses of Green Gram (*Vigna radiata* L.) and Ricebean (*Vigna umbellata*)

H. N. MOHAN

THE present investigation was undertaken to study the disease resistance in segregating generations of interspecific crosses of Mungbean and Ricebean. The experiment was conducted during summer 2015 and *Rabi* 2015-16 in Augmented design at MRS, Hebbal, Bengaluru. The segregating population from the following interspecific cross derivatives for screening MYMV using appropriate disease scoring scale and other genetic variability parameters. The six interspecific crosses used in the present study *viz.,* 1. BGS-9 x RBL-50, 2. BGS-9 x RBL-35, 3. Selection-4 x KBR-1, 4. Selection-4 x RBL-1, 5. Yellowmung x KBR-1 and 6. Chinamung x KBR-1. Chinamung and Yellowmung which are susceptible to MYMV were used as check varities to screen for MYMV along with the parents used in the interspecific crosses. The heritability was moderate for pod length, number of pods per cluster, number of seeds per pod and seed yield per plant. Path coefficient analysis in six interspecific crosses of mungbean x ricebean showed that number of branches per plant, number of pods per plant, number of clusters per plant, number of pods per plant had positive direct effect on seed yield. Further, all these traits exhibited significant and positive correlation with seed yield. The number of branches per plant recorded highest indirect positive influence on seed yield through number of pods per plant followed by pod length through number of seeds per pod. Inheritance study of MYMV disease resistance in F3 and F_4 generations of interspecific crosses showed that MYMV resistance is governed by a single dominant gene.

2016
Department of Genetics and Plant Breeding
UAS, GKVK, Bengaluru

NIRANJAN MURTHY
Major Advisor

Assessment of Genetic Variability for Powdery Mildew, Rust, Yield and Yield related Traits in Blackgram [*Vigna mungo* (L.) Hepper]

NIVEDITA SHETTIGAR

A field experiment was conducted to screen 72 blackgram genotypes in *Kharif* 2015 for powdery mildew and rust diseases, with two checks Rashmi (resistant) and TAU-1(susceptible) under natural conditions. Sixteen genotypes were found resistant to powdery mildew and five genotypes were found resistant to rust. The genotypes MU-44 and MU-06 were found resistant to both the diseases. The same set of genotypes was evaluated for yield and yield related traits in summer 2016. Analysis of variance revealed significant genotypic differences for all the traits except shelling percentage. These 72 genotypes exhibited higher level of variation for qualitative traits and quantitative traits like plant height, number of branches plant^{-1}, number of clusters plant^{-1}, number of pods plant^{-1}, seed yield and pod yield plot^{-1} showed high PCV and GCV estimates. Broad-sense heritability as well as expected GAM were higher for plant height, branches plant^{-1}, number of cluster plant^{-1}, number of pods plant^{-1}, pod yield, seed yield and 100 seed weight. Correlation analysis revealed that pod yield exhibited highest positive correlation with seed yield. Pod yield per plot had highest positive direct effect on seed yield. There were total nine clusters formed and among them six clusters were solitary. Maximum of 41 genotypes were found in cluster I. Pod yield per plot had contributed maximum towards diversity. The genotypes MU-44 and MU-06 with resistance to both the diseases and high yielding ability can be used in future breeding programme.

2016
Department of Genetics and Plant Breeding
V.C. Farm, Mandya

P. MAHADEVU
Major Advisor

Genetic Investigation in Mid-late Maturing Sugarcane (*Saccharum officinarum*) Clones Isolated for Cauvery Command Area

KASAYYA

THE present experiment was carried out to estimate genetic variability, correlation and path analysis, genetic diversity and selection indices in 35 sugarcane clones, using RCBD design with 2 replications during 2014-15 at Zonal Agricultural Research Station, V.C. Farm, Mandya. The analysis of variance indicated the presence of significant variability among the genotypes for all traits studied. CCS yield, CCS cane yield and millable canes number exhibited high Genotypic and Phenotypic coefficient of variation coupled with high GAM, whereas, high heritability coupled with high GAM was exhibited by tillers, millable cane number, internode length, single cane weight, CCS yield, CCS cane yield and cane yield indicating the role of additive genes for expression of these traits, hence selection for these traits could be effective. Cane yield and CCS (t / ha) had significant positive correlation with number of tillers, NMC, cane diameter and single cane weight. CCS (t / ha) also had significant positive correlation with CCS per cent, Brix per cent, CCS cane yield and cane yield. CCS yield and cane yield exhibited highest direct effects on cane and sugar yields, respectively. Seven clusters were formed on grouping of clones based on Mahalanobis D^2 distances. The results indicated that cluster IV, VI and VII involved highly diverse genotypes can be chosen for isolating desirable clone combinations. Cluster IV (CoVC 0961-07) and cluster VII (CoVC 0965-04) were found superior for cane yield, cane and quality characters. Selection indices for cane and CCS yield recognised that there was sizable improvement in the target characters.

2016
Department of Genetics and Plant Breeding
V.C. Farm, Mandya

T. E. NAGARAJA
Major Advisor

Identification of Advanced Breeding Lines Resistant to Neck, Finger Blast and Lodging in Finger millet [*Eleusine coracana* (L.) Gaertn.]

U. S. BHAGYASHREE

FINGER millet [*Eleusine coracana* (L.) Gaertn.] is one of the most important staple food crop in India. In recent years, scarcity of labour at the time of ragi harvest is resulting in yield loss and mechanical harvesting requires the utmost attention. To facilitate mechanical harvesting the plant type should be non lodging and sturdy. In addition blast caused by the fungus *Pyriculria grisea* (Cooke Sacc.) also reduces the yield to a large extent under extreme conditions. Hence, development of varieties resistant to lodging and blast disease is one of the major breeding objectives. In the present study 50, 50, 60 and 180 F_4 progenies derived from the crosses GPU 28 × HR 911, GPU 28 × Indaf 8, GPU 28 × MR 6 and GPU 28 × GPU 67, respectively, were evaluated during *kharif* 2015 at ZARS, Bengaluru. In all the crosses low GCV and PCV values for lodging indicative trait *i.e.,* recovery angle after bending was exhibited. Except GPU 28 × Indaf 8 all the crosses recorded high heritability for this trait. The results indicated that recovery angle was negatively correlated with plant height and number of tillers per plant. The estimates of GCV and PCV were found to be higher for both neck and finger blast in all the crosses. High heritability along with high genetic advance was observed in all the crosses for both neck and finger blast. The best lines resistant to lodging, neck and finger blast were identified in all the crosses.

2016
Department of Genetics and Plant Breeding
UAS, GKVK, Bengaluru

P. RAVISHANKAR
Major Advisor

Studies on Genetic Divergence among Active Germplasm of Green Gram [*Vigna radiata* (L.) Wilczek.]

ARIFA ATTAR

HUNDRED genotypes of green gram were evaluated to assess genetic divergence using agro morphological traits and to study character association among seed yield and yield contributing traits and also to assess the G×E interaction for different traits in summer, early *kharif* and *rabi* of 2015. Genotypes were screened to identify resistance sources for powdery mildew in *rabi*. Based on 'K means' clustering approach, 100 accessions were grouped into six clusters. Cluster VI was the largest with 28 genotypes and cluster IV had the smallest with eight genotypes and inter cluster distance indicated considerable diversity among accessions. Morphological characterization clearly indicated that, majority of the genotypes were towards dark purple stem and hypocotyledon; green with purple spot petiole and erect growth habit; deltate leaf shape; pendent, sparsely pubescent and light green pods; drum shape and light green seeds. At both genotypic and phenotypic level, highly significant and positive association was found between seed yield and yield components *viz*., clusters per plant, pods per cluster, plant height, primary branches and seed mass. Path coefficient analysis revealed that clusters per plant, pods per cluster and seed mass showed positive direct effect on seed yield. Out of 100 genotypes, 22 genotypes showed stable performance for seed yield across the seasons and 16 high yielding genotypes showed resistance to powdery mildew disease. Genotypes *viz*., TM-965, LGG-587, LGG-573 and GMBL-1 were found to be stable high yielding with resistance to powdery mildew disease.

2016
Department of Genetics and Plant Breeding
UAS, GKVK, Bengaluru

JAYARAME GOWDA
Major Advisor

Genotype × Environment Interaction for Grain Yield and other Quantitative Traits in Maize Hybrids (*Zea mays* L.)

N. SELVARAJESWARI

A study was conductedat seven locations of southern Karnataka during *kharif* 2015 to analyze the genotype × environment interaction of eleven hybrids developed at CIMMYT - Asia, Hyderabad, along with six commercial checks using additive main effects and multiplicative interaction (AMMI) model. The AMMI analysis of variance showed significant differences in genotype, environment and genotype × environment interaction. Environment was the major source of variation. The interaction was studied using principal component axes and the first two IPCAs were highly significant for all the traits studied. AMMI biplots and stability parameters *viz.,* AMMI stability value (ASV) and genotypic selection index (GSI) were used to study the interaction and selection of stable hybrids. AMMI stability value revealed NAH 2049 (1.95), followed by NAH 1137 (2.78) and CAHCM 1427 (2.97) as the stable hybrids and CAHCM 1430 (12.83) as the most responsive one among the seventeen hybrids studied. The hybrid CAHCM 1459, that recorded the least GSI (11) had higher stability and high mean grain yield per hectare (106.70 q / ha) and served as a potential hybrid to be released for cultivation in southern Karnataka. The parental inbreds of the 11 hybrids were genotyped using 13 SSR markers. Jaccard's similarity indices were calculated based on the DNA profile data. The *per se* performance of the hybrids, commercial heterosis over the hybrid NAH 1137, the AMMI stability value and the yield stability index were regressed on the SSR markers based similarity coefficients. All the parameters showed non-significant linear relationship with Jaccard's similarity coefficient.

2016
Department of Genetics and Plant Breeding
V.C. Farm, Mandya

H. C. LOHITHASWA
Major Advisor

HORTICULTURE

Effect of Spacing and Different Levels of Fertigation on Growth, Yield and Quality of Onion (*Allium cepa* L.) Hybrid Arka Lalima

D. JEEVITHA

A study was conducted in Precision Farming Development Centre (PFDC), Division of Horticulture, UAS, GKVK in 2015-16 to determine the effect of spacing and different levels of fertigation on growth, yield and quality of onion (*Allium cepa* L.) hybrid Arka Lalima under open condition with thirteen treatments in combination of six spacing two fertigation levels and one control. The treatment T_5- 20 cm × 15 cm + 80 per cent recommended dose of fertilizers through drip fertigation recorded maximum plant height (55.76 cm), number of leaves (6.77), leaf width (1.5 cm) and longer harvesting duration (123.33 days). The same treatment recorded the maximum bulb equatorial diameter (6.47 cm), bulb length (6.10 cm), weight of the bulb (121.17 g), bulb volume (122.63 cc) and high TSS (12.17ÚBrix). But the highest yield per plot (25.67 kg plot^{-1}), yield per hectare (64.17 tons ha^{-1}), number of bulbs per kg (32 bulbs kg-^{1}) shelf life (45.33 days) and pungency was noticed in T_1- 10 cm ×5 cm + 80 per cent recommended dose of fertilizers. The treatment T_5 has got highest cost benefit ratio (1:2.81). From this experiment it can be concluded that spacing of 20 cm ×15 cm + 80 per cent recommended dose of fertilizers (100:60:100 kg NPK ha^{-1}) of water soluble fertilizers through drip fertigation helps in improving growth, yield and quality of onion (*Allium cepa* L.) hybrid Arka Lalima.

2016
Department of Horticulture
UAS, GKVK, Bengaluru

R. KRISHNA MANOHAR
Major Advisor

PLANT BIOTECHNOLOGY

Evaluation and Molecular Marker Analysis in Backcross Progenies (BC2F1) of Tomato for Shelf Life

N. Lavanya

In India up to 40 per cent of the fruit losses occur due to excessive fruit softening. Hence, the present investigation was aimed the high shelf life character into commercially well accepted variety which has low shelf life by backcross breeding method. Two backcross populations (BC2F1) of cross Pusa Ruby/L121//Pusa Ruby and Vaibhav / RIL126 / Vaibhav were developed and grown in the field condition. All characters studied were significant among backcross progenies and between checks and progenies except number of fruits per cluster in both populations. The shelf life has positive significant correlation with number of fruits per cluster (0.22), rind thickness (0.45) and lycopene (0.35) in the population of the cross Pusa Ruby / L121 // Pusa Ruby. In the other population of the cross Vaibhav / RJL126 // Vaibhav shelf life as significant positive correlation with number of fruits per cluster (0.21) and lycopene content (0.21), whereas, rind thickness has no significant correlation (0.15). The SSR marker TGS 293 used to screen the 40 backcross progenies of the cross Pusa Ruby / LI21 // Pusa Ruby. Out of these, 21 progenies showed heterozygous bands and 19 progenies showed recurrent parental type of band which shows the approximate 1:1 ratio and the heterozygous progenies was association with high shelf life character. Hence this marker is linked to shelf life.

2016
Department of Plant Biotechnology
UAS, GKVK, Bengaluru

P. H. Ramanjini Gowda
Major Advisor

PLANT PATHOLOGY

Interaction of Root-knot Nematode (*Meloidogyne incognita*) and Fungal (*Fusarium oxysporum*) Wilt Complex in Gerbera under Protected Cultivation

Gururaj Hawaldar

Gerbera is the fifth most used cut flower in the world and has tremendous demand in both domestic and international markets. A combination of *Meloidogyne incognita* with *Fusarium oxysporum* results in wilt complex in gerbera. The present studies were undertaken to isolate, proving the pathogenicity and interaction of *M. incognita* with *F. oxysporum* on gerbera, to screen available cultivars of gerbera against both the pathogens individually as well as in combination and the management of wilt complex using bio-agents, neem cake and chemicals under glass house condition. Based on the morphological studies, fungus was identified as *F. oxysporum* and *M. incognita*. All growth and yield parameters recorded lowest and wilt incidence was maximum with inoculation of *F. oxysporum* 15 days after inoculation of *M. incognita.* Among the seven popular cultivars of gerbera screened against *M. incognita* and *F. oxysporum* wilt complex, Julia and Rionegro were found resistant, Nigela was moderately susceptible while, Havana, Teresa, Marinilla and Kyllian were susceptible. Drenching with Carbendazim 0.1 per cent along with soil application of Carbofuran 3G 16 g / m^2 recorded 90 per cent reduction in wilt incidence over untreated check. It was found effective in reducing the number of galls, egg mass, root-knot index, nematode population and improving the plant growth and yield parameters as compared to untreated check. However, neem cake and all bioagents showed significant reduction in wilt incidence, nematode parameters and increase in growth and yield parameters.

2016
Department of Plant Pathology
UAS, GKVK, Bengaluru

B. M. R. Reddy
Major Advisor

Evaluation of Black Gram, *Vigna Mungo* (L.) Hepper Genotypes for Resistance Against Powdery Mildew Caused by *Erysiphe polygoni* DC.

MALAPPA S. KOHALLI

POWDERY mildew disease caused by *Erysiphe polygoni* DC. is a major constraint in the black gram cultivation, causing both quantitative and qualitative losses (40-90%). Development of resistant cultivars plays an important role in management of powdery mildew. An attempt was made to identify resistant sources of black gram genotypes against powdery mildew. Of 188 genotypes screened under field (*rabi* and *kharif*) and glass house conditions, the lowest disease severity was observed in resistant genotypes *viz.,* LBG-17 (7.64 and 7.5 %), IC-281977(5.5 and 5.8 %) and RASHMI (5.0 and 5.2 %) under field conditions during *kharif* and glass house conditions, respectively. Two resistant genotypes *viz.,* LBG-17 and RASHMI showed disease severity of 5.80 per cent during *rabi*. The disease severity of moderately resistant genotypes *viz.*, LBG-626 (20.9, 18.1 and 20.5%), KU-5-527 (17.9, 16.8 & 18.8%) and IC-546468 (17.5, 19.1 and 19.0%) under field (*rabi* and *kharif*) and glass house conditions respectively. The amount of phenols, peroxidase, polyphenyl oxidase, chitinase and phenyl ammonia lyase content in infected leaves of resistant genotypes *viz.,* LBG-17, IC-281977 and RASHMI was 7.21,7.62,7.63 mg / g LFW; 6.34,4.71,5.37 mg / g LFW; 5.12,4.67,4.92 mg / g LFW; 152.0,166.0,176.0 m Mol / g LFW and 2.51,2.43,2.01 mg / g LFW, respectively, was more compared to the infected leaves of susceptible genotypes. Accumulation of total sugar less in infected leaves of resistant genotypes ranged from 155-162µg / g LFW compared to susceptible resistant genotypes (295-300 µg / g LFW). The resistant genotypes would be used for further breeding programmes to develop resistant black gram varieties against powdery mildew.

2016
Department of Plant Pathology
UAS, GKVK, Bengaluru

Y. M. SOMASEKHARA
Major Advisor

Studies on Brown Leaf Spot of Paddy Caused by *Drechslera oryzae* (B. de Haan) Subram. and Jain and Its Management

C. CHANNAKESHAVA

RICE (*Oryza sativa* L.) is the world's most important food crop. Globally, more than 3.5 billion people depend on rice for more than 20 per cent of their daily calories. Among the rice diseases brown leaf spot caused by *Drechslera oryzae*has been reported to occur in all rice growing regions of India and Karnataka. Disease severity was estimated in Cauvery command areas of Mandya district during *kharif* 2015 by employing roving survey method. Maximum average disease severity of 16.88 per cent was recorded in Mandya taluk followed by Malavalli taluk (14.65 %) and lowest average disease severity was recorded in Maddur taluk (7.91%) followed by Srirangapattana taluk with (8.02%). Among 50 genotypes screened against the pathogen, maximum disease severity was recorded in Rathnachoodi (21.20 %) followed by CTH-3 (18.80%). Genotypes *viz.,* Rasi, JLG-1798, BR-2655, Raksha, KMP-201and BI-33 showed immune reaction. Among the solid and liquid media evaluated, paddy leaf extract agar and broth was found best, which recorded maximum dry mycelial weight of 113.06 mg and radial growth of 84.83 mm. Maximum growth of the pathogen was observed on glucose, potassium nitrate, temperature of 30°C, pH 7.0 and continuous dark (24 hrs). Propiconazole 25% EC was significantly superior over other fungicides where it recorded 94.42 per cent average mycelial growth inhibition *in vitro.* Among the different plant extracts tested garlic clove extract showed 100 per cent mycelial growth inhibition at all the concentrations (5, 10 and 15%). Among the bioagents tested *in vitro,Trichodema viridae* exhibited maximum average growth inhibition of 48.49 per cent.

2016
Department of Plant Pathology
V.C. Farm, Mandya

N. S. PANKAJA
Major Advisor

Studies on the Late Blight Disease of Potato (*Solanum tuberosum* L.)

B. Kavya

Potato (*Solanum tuberosum* L.) is one of the most important commercial vegetable crop cultivated in the world. Among the diseases, late blight caused by *Phytophthora infestans* is exerting the major threat in potato cultivation. Random survey was conducted during *kharif* in major potato growing taluks of Hassan and Chikkamagalur districts revealed that the disease was severe in Hassan district (61.46%) compared to Chikkamagalur district (9.43%). Isolation was made on Rye Agar Medium shown that the fungal colonies were dull white, cottony thin with profused sporulation. The maximum radial growth 84.50 mm of *P. infestans* colony was recorded on Rye Agar Medium. The optimum temperature and pH for the growth and sporulation of the pathogen was 18 ºC (86.17 mm) and pH 6.5 (85.00 mm), respectively. Among the different fungicides evaluated under *in vitro* conditions, Fenamidone+Mancozeb found highly inhibitory against *P. infestans* (97.28%). The field evaluation also revealed that, the treatment Fenamidone+Mancozeb found to be highly effective in managing late blight of potato with least per cent disease severity of 16.67. Among the antagonists tested under *in–vitro Trichoderma harzianum* exhibited the maximum inhibition (72.00%) of *P. infestans.* The field trials were also revealed that Kufri Himalini found highly resistant with the least disease severity of 3.48 per cent and FL-1533 found to be highly susceptible towards late blight of potato.

2016
Department of Plant Pathology
V.C. Farm, Mandya

M. S. Nagaraj
Major Advisor

Studies on Phyllody Disease of Sesamum (*Sesamum indicum* L.) and Management

T. N. Mahadevaprasad

Phyllody caused by phloem limiting phytoplasma is a very serious disease in most sesamum growing areas of Southern Karnataka. Sesamum phyllody is gaining importance in recent years because it causes an yield loss of upto 100 per cent. During survey phyllody infected plants showed excessive stunting, severe reduction in leaf size, reduced internodal length, excessive axillary proliferation and floral malformation like abnormal green structures in place of normal flowers. The incidence of sesamumphyllody ranged from 13.6 to 31.21 per cent during survey in sesamum growing areas of Southern Karnataka. The disease incidence was lowest in Ramanagar district with incidence of 13.6 per cent. Hassan district recorded the highest incidence of 31.21 per cent. Three genotypes showed resistant reaction, 27 genotypes showed moderately resistant reaction and 13 genotypes showed susceptible reaction against the phyllody disease under field conditions. Management of sesamumphyllody through two dates of sowing and vector (leafhopper) control revealed that lowest disease incidence (22.90%) was observed in late sown crop compared to early sown crop (25.43%). Seed yield was maximum (266.24 kg / ha) in late sown crop compared to early sown crop (249.15 kg / ha). Of the different treatment combinations, late sowing with seed treatment with imidacloprid 70 WS @ 5 g / kg+spray of acetamiprid 20% SP @ 0.3 g / L and late sowing with seed treatment with imidacloprid 70 WS @ 5 g / kg+spray of imidacloprid17.8% SL @ 0.5 ml / L at 20 days interval significantly reduced the disease incidence (18.51 and 19.78%) and increased seed yield of 315.77 and 303.61 kg / ha, respectively.

2016
Department of Plant Pathology
UAS, GKVK, Bengaluru

K. Karuna
Major Advisor

Investigations on Seed Mycoflora of Mung Bean (*Vigna radiata* L.)

B. D. DEVAMANI

MUNG bean seeds are infected by various organisms affecting germination, leading to yield loss. Eighteen mung bean seed samples collected from thirteen districts of Karnataka were tested for mycoflora by employing standard blotter method which revealed the association of twelve fungi *viz*., *Aspergillus niger*, *Alternaria alternata*, *Aspergillus flavus*, *Aspergillus candidus*, *Penicillium notatum*, *Rhizopus stolonifer*, *Cladosporium* sp., *Fusarium oxysporum*, *Mucor* sp., *Curvularia lunata*, *Macrophomina phaseolina* and *Chaetomium globosum*. Seed samples collected from Kalaburagi, Raichur and Bagalkot districts recorded the highest mycoflora. Seeds of mung bean genotypes grown in *kharif* recorded highest association of seed mycoflora compared to *rabi*. Among different incubation methods employed, blotter method was found ideal in enumerating seed mycoflora. Location of mycoflora in mung bean seeds showed that *A. flavus* was confined to both seed coat and cotyledons, whereas, *Fusarium* to embryo. Survival of mycoflora on mung bean seeds revealed that field fungi decreased after eight months of storage whereas storage fungi increased. Hot water treatment at 40 °C for 30 minutes was found best in managing seed mycoflora followed by solar heat treatment and dry heat treatment. Seed treatment with captan at the rate 4 g kg^{-1} of seed significantly reduced seed mycoflora (78.68 %). Seed treatment with *Trichoderma harzianum*at the rate of 8 g kg^{-1} of seed reduced the seed mycoflora up to (69.63 %) followed by *Pseudomonas fluorescences*(66.49 %) and *T. viride* (64.39 %).

2016
Department of Plant Pathology
UAS, GKVK, Bengaluru

M. SAIFULLA
Major Advisor

Bio-management of Blast of Finger Millet (*Ragi*) Caused by *Pyricularia grisea* (Cke.) Sacc.

RAKESHA

FINGER millet is an important millet crop of Southern Karnataka, affected by blast disease that causes yield loss ranges from 50 to 60 per cent. A total of 35 bacterial and six fungal antagonistic organisms isolated from finger millet phyllosphere were identified as species of *Pseudomonas*, *Bacillus* and *Trichoderma* based on the cultural, morphological and biochemical tests. *In vitro* evaluation of phyllosphere microflora against *P. grisea* revealed that *Bacillus* isolates B13, B3, RBs1, B7 and *Pseudomonas* isolates P2,P17, P22, RPf1 and *T. harzianum* (Th3) recorded maximum inhibition of 66.79, 66.41, 66.29, 59.35, 62.24, 52.16, 50.16, 50.09 and 56.60 per cent, respectively. *Bacillus* isolate B13 found potential against *P. grisea* which was further identified as *Bacillus amyloliquefaciens* based on 16S rRNA sequence and these isolates were tested for their efficacy under pot culture. Foliar spray of *P. fluorescens* (RPf1) recorded minimum PDI of leaf (30.46), neck (1.59) and finger (3.12) blast besides maximum plant growth promotion in-terms of shoot (106.20 cm) and root length (42.83 cm) which was on par with *B. amyloliquefaciens* and *T. harzianum*. Further, field evaluation of these bioagents revealed that Seed treatment + Seedling dip + Foliar spray with *P. fluorescens* RPf1 recorded minimum PDI of leaf (19.49), neck (1.42) and fingerblast (1.26) with maximum growth promotion *i.e.,* shoot length (99.10 cm), fresh shoot weight (45.33 g), grain yield (1900 kg ha^{-1}) and straw yield (5375 kg ha^{-1}) followed by *B. amyloliquefaceins* confirming usage of bioagents in the management of finger millet blast.

2016
Department of Plant Pathology
UAS, GKVK, Bengaluru

T. NARENDRAPPA
Major Advisor

Studies on Late Blight Disease of Tomato Caused by *Phytophthora infestans* (Mont.) de Bary

A. POORNASHREE

TOMATO is one of the important commercial vegetable crops cultivated in the world. Among the diseases of tomato; late blight disease caused by *Phytophthora infestans* (Mont.) de Bary, is causing more loss. A systematic survey was carried out in potential tomato growing taluks of Mandya district, revealed that maximum disease incidence and severity was recorded in Malavalli taluk. Among the different nutrient media evaluated for the growth of *P. infestans*, Rye agar was found to be the best media for the growth and sporulation. Colony color and growth on Rye agar medium was dull white and the growth appeared as cottony thin, radiating with profuse mycelia. Maximum colony growth of the pathogen was recorded when it was incubated at temperature 18 p C and at pH 6.5. *In vitro* evaluation of different fungicides against *P. infestans* revealed, combi-product fungicides *viz*., Fenamidone + Mancozeb and Famoxadone + Cymoxanil inhibited maximum at all the concentrations *viz*., 100, 200 and 300 ppm. *In vitro* evaluation of antagonistic micro-organisms revealed, *Trichoderma harzianum* showed maximum inhibition (90.33%) and minimum inhibition (35.17%) recorded by *Bacillus subtilis*. Among the different fungicides spray schedule tested, the spray schedule consisting of first spray with Fenamidone + Mancozeb @ 0.3% followed by second fortnightly spray with Mancozeb @ 0.3% followed by third fortnightly spray with Fenamidone + Mancozeb @ 0.3% has resulted in minimum disease incidence and severity, as compared to control. Among the 50 tomato germplasm screened two germplasm lines MTL- 40 and MTL- 48 showed highly resistant reaction.

2016
Department of Plant Pathology
V.C. Farm, Mandya

VENKATESH
Major Advisor

Studies on *Sarocladium oryzae* (Sawada) W. Gams and Hawksworth Causing Sheath Rot of Rice

U. DARSHAN

SHEATH rot (*Sarocladium oryzae*) is emerging as one of the important disease in rice contributing significant yield loss. Survey conducted during 2015-16 revealed highest PDI of 36.12 was recorded in Mandya district followed by Mysuru 21.97. Among different media tested maximum colony diameter was observed on Oatmeal agar media (6.39 cm) and PDA media (6.16 cm). Maximum dry mycelial weight was recorded in PDB and Richard's broth. The temperature of 30 ^{0}C and the pH of 6.0 to 7.0 were found best for mycelial growth. Maltose as carbon source and Sodium nitrate as the nitrogen source showed maximum dry mycelia weight of *S. oryzae*. Ten *S. oryzae* isolates were identified and characterized by morphological, physiological and molecular approachs (sequencing ITS regions of the *S. oryzae*). A distinctive five groups were formed among the ten isolates based on the ITS sequences. Thirteen SSR markers were screened which showed the diversity of isolates collected from different locations. UAS(B) Saro7 (Holalu) showed highest diversity among the isolates which formed different group. Under *in vitro* flusilazole 12.55 + carbendazim 25 % at 1500 ppm was found effective in inhibiting the growth of *S. oryzae* (92.80 %) and tebuconazole 60 FS at 1500 ppm (92.22 %). Fungal bioagent*T. harzianum* was very effective against *S. oryzae*with 83.26 % inhibition followed by *B. subtilis* (75.35 %). In field conditions tebuconzole 60 WS at 2.5 ml / kg seeds was found significantly superior in reducing the disease with least PDI of 14.92 and 62.98 per cent control over untreated check.

2016
Department of Plant Pathology
V.C. Farm, Mandya

M. K. PRASANNA KUMAR
Major Advisor

SEED SCIENCE AND TECHNOLOGY

Studies on Influence of Provenance and Packaging Materials on Seed Quality and Storability of Sunflower (*Helianthus annuus* L.) Hybrids

C. K. Bhavya

A laboratory experiment was conducted to study the influence of provenance and packaging materials on seed quality and storability of sunflower (*Helianthus annuus* L.) hybrids at Department of Seed Science and Technology, UAS, GKVK, Bengaluru during *Kharif* 2015-16. The experiment consisted of three factors replicated 4 times. Factors included; two hybrids, ten locations and three packaging materials. KBSH-44 collected from Chitradurga recorded significantly higher initial quality parameters *viz.,* seed index (6.53 g), seed density (0.818 g / cc), seed germination (95.67 %), mean seedling length (26.43 cm), seedling vigour index-I (2336), field emergence (92.33 %), total dehydrogenase activity (3.950 A_{480}) and lower electrical conductivity of seed leachate (0.653 mS / ppt) compared to other locations. Seeds of KBSH-44 collected from Chitradurga and stored in polythene bag (700 gauge) recorded highest seed quality parameters like germination (85.33 %), mean seedling length (26.39 cm), mean seedling dry weight (29.53 mg), seedling vigour index-I and II (2126 and 2212, respectively), field emergence (83.67 %) and lower electrical conductivity of seed leachate (1.973 mS / ppt), seed infection (11.33 %) and seed infestation (3.33 %) at the end of 10 months of storage. During accelerated ageing test (0 to 6 days), seeds of KBSH-44 collected from Chitradurga recorded less reduction of seed quality attributes like germination (84.00 %), mean seedling length (24.09 cm), mean seedling dry weight (28.67 mg), seedling vigour index-I and II (2024 and 2566, respectively), field emergence (80.00 %) and electrical conductivity of seed leachate (1.654 mS / ppt) at the end of 6 days of ageing period.

2016
Department of Seed Science and Technology
UAS, GKVK, Bengaluru

P. Balakrishna
Major Advisor

Characterization of Genotypes Based on Morphological and Biochemical Characters in Green Gram [*Vigna radiata* (L.) Wilczek]

Shabana D. Nadaf

A field experiment was conducted in the field unit of the department of Seed Science and Technology of UAS, GKVK, Bengaluru during *Kharif* 2015 with twenty five green gram genotypes to characterize the genotypes based on morphological characteristics. The morphological characteristics included seedling, plant, pod and seed characters which resulted in grouping of genotypes into different groups which might be due to genetic factor of genotypes, soil and environmental conditions. For yield parameters, genotype Selection-4 has taken less days (33.33) and maximum seed yield was recorded in GG-13-10 (950 kg / ha). Further, a study was conducted in the Seed Science and Technology laboratory to characterize the genotypes based on seed biochemical characters and to know the effect of seed physical and biochemical characters on seed quality. Wide variations were observed for biochemical characterization of genotypes. The genotype BGS-9 was found with large seed (60.65 mm^3), maximum 100 seed weight (5.16 g), more seed density (1.58 g / cc),protein (25.85 %), alpha-amylase activity (250 µg / maltose), viable seeds (98.67 %), total dehydrogenase activity (3.02 $A_{480\ nm}$) and least electrical conductivity (21.8µSppm^{-1}) which resulted in maximum seed germination (93.00 %), root length (13.94 cm), mean seedling length (25.27 cm), mean seedling dry weight (17.25 mg), seedling vigour index-I (2371) and II (1604) which might be due to more matured embryo containing adequate nutrient reserves in large seeds which indicated positive correlation between seed physical, biochemical characters and seed quality.

2016
Departmentment of Seed Science and Technology
UAS, GKVK, Bengaluru

P. Balakrishna
Major Advisor

Influence of Foliar Application of Nano Nutrients on Plant Growth, Seed Yield and Quality of Paddy (*Oryza sativa* L.) Genotypes

S. J. ANUSHA

A field and laboratory experiments were conducted at Farmer's field near ZARS, V. C. farm, Mandya and Department of Seed Science and Technology, University of Agricultural Sciences, Bengaluru, respectively, during *Kharif* 2015. Influence of foliar application of nano nutrients on plant growth, seed yield and quality of paddy (*Oryza sativa* L.) genotypes were studied. The experiment consists of 16 treatment combinations with three replications. The results revealed that Genotype BR-2655 recorded highest plant height (129.01 cm), number of tillers (22.25), leaf area plant^{-1} (344.37 cm^2), number of panicles plant^{-1} (16.43), panicle length (22.79 cm), seed yield plant^{-1} (48.65 g), seed yield ha^{-1} (44.25 q ha^{-1}) and dry matter production plant^{-1} (35.31 g) compared to other genotypes. Among the treatments, treatment T_2 (FYM + 3 Sprays) recorded significantly higher number of tillers (22.90), leaf area plant^{-1}(339.71 cm^2), number of panicles plant^{-1} (16.71), panicle length (21.30 cm), seed yield plant^{-1} (49.38 g), seed yield ha^{-1} (44.60 q ha^{-1}) and dry matter production plant^{-1} (27.53 g) compared to control number of panicles plant^{-1} (15.05), panicle length (19.36 cm) and seed yield ha^{-1} (37.96 q ha^{-1}).The seed quality parameters *viz*., germination (96.00 %), mean seedling length (26.90 cm), seedling vigour index-I (2581), field emergence (90.67 %), test weight (26.02 g), total dehydrogenase activity (0.39 A_{480nm}), protein (9.60 %) and also B:C ratio (2.27) were significantly higher with the interaction between G_1T_2(BR-2655 + FYM + nano nutrient spray at maximum tillering, booting and end of flowering stage) compared to other treatments.

2016
Department of Seed Science and Technology
UAS, GKVK, Bengaluru

R. PARAMESH
Major Advisor

SOIL SCIENCE AND AGRICULTURAL CHEMISTRY

Studies on Growth and Yield of Maize (*Zea mays* L.) as Influenced by Drip Fertigation in Southern Dry Zone of Karnataka

J. S. VENKATA SHIVA REDDY

FIELD experiment was conducted during *kharif*, 2015 at ZARS V.C. Farm, Mandya to optimize water and nutrient requirement for maize under drip fertigation. The experiment comprised of eleven treatments with three replication in sandy loam soil with low available nitrogen, medium available phosphorus and potassium and laid out in RCBD. The treatment irrigation @ 100 per cent CPE + DF 125 per cent RDF recorded higher plant height (206.10 cm), number of leaves (13.19), cob length (16.12 cm), cob weight (160.16 g), rows per cob (17.56) and test weight (28.80 g) which resulted in higher kernel yield (77.63 q ha^{-1}) and straw yield (81.59 q ha^{-1}) and accounted for 50.23 per cent increase in kernel yield compared to irrigation @ 75 per cent CPE + DF 50 per cent RDF. Irrigation @100 per cent CPE + DF 125 per cent RDF registered higher available nutrient (231.12, 28.00 and 231.10 N, P and K kg ha^{-1}, respectively), (5.83, 2.16 and 12.33, Ca, Mg (cmol kg^{-1}) and S mg kg^{-1}, respectively) and (8.89, 11.02, 1.75, 0.72 and 0.81 Mn, Fe, Cu, Zn and B mg kg^{-1}, respectively) after harvest. Higher Water use efficiency (132.17 kg ha-cm^{-1}) was found in T_4: irrigation @75 per cent CPE + DF 125 % RDF, while B:C ratio of 1.95 was registered in treatment T_{10}: irrigation @100per cent CPE + DF 75 % RDF, whereas, higher gross return (₹ 104998 ha^{-1}), higher net returns (₹ 37089 ha^{-1}) was found in T_8: irrigation @100 per cent CPE + DF 125 per cent RDF over other treatment combinations.

2016
Departmentment of Soil Science and Agricultural Chemistry
V.C. Farm, Mandya

R. KRISHANA MURTHY
Major Advisor

Land Resources Assessment of Gollarahatti-2 Micro-watershed, Jagalur Taluk, Davanagere District using Remote Sensing and GIS Techniques

N. K. VIKAS

THE study was undertaken to characterize the land resources of Gollarahatti-2 micro-watershed in Central Dry Zone of Karnataka. Eleven typifying pedons of soil series identified based on detailed soil survey techniques with remote sensing and GIS. The soils were described for their site, morphological, physical, chemical characteristics and classified. Eighty composite surface samples were collected and analyzed for fertility status. The information gathered from toposheets, cadastral map and satellite imagery has been processed under GIS to generate soil map and other thematic maps on crops suitability and nutrient status. Twenty-two phases of soil series were mapped and their identifying characteristics has been listed. Soils were moderately deep, moderately shallow or shallow with sandy clay loam, very gravelly sandy clay or clay in texture, slightly acidic, mildly or moderately alkaline in soil reaction. Organic carbon and CEC were low to medium. The base saturation was medium to high. The entire micro-watershed was low in available nitrogen whereas available P and K were low to medium in range. The major portion of study had medium range of sulphur, deficient in Zn, Fe and B whereas Cu and Mn were sufficient. The soil sub-groups are Rhodic Kanhaplustalfs, Kanhaplic Rhodustalfs, Typic Rhodustalfs, Typic Haplustepts and Lithic Ustorthents. Depending on the potentials and soil related constraints, alternate land uses and their suitability have been evaluated. Areas having good land capability and irrigability were suitable for intensive agriculture with critical irrigation, while marginal lands were suitable for horse gram or biofuel plants.

2016
Departmentment of Soil Science and Agricultural Chemistry
UAS, GKVK, Bengaluru

K. S. ANIL KUMAR
Major Advisor

Response of Aerobic Rice to Different Sources and Levels of Sulphur Application in Southern Dry Zone of Karnataka

N. R. SUDHAKARA

A survey was conducted to investigate the availability of sulphur in rice growing areas of Mandya district. Out of one hundred and nineteen soil samples collected and analyzed, 77.31 per cent soils were sufficient in available sulphur and remaining 22.69 per cent were deficient. A field experiment was conducted during *kharif*, 2015 on sandy loam soil at V.C. Farm, Mandya to study the response of aerobic rice to different sources and levels of sulphur application. The experiment was laid out in Completely Randomized Block Design with twelve treatments and three replications including absolute control, control (RDF+FYM alone), RDF+ FYM + two levels of sulphur application (13 and 26 kg ha^{-1}) through five different sulphur sources *viz.,* gypsum, ammonium sulphate, elemental sulphur, complex 20:20:0:13 and SSP. Results revealed that application of RDF+FYM+26 kg sulphur ha^{-1} through ammonium sulphate (T_6) recorded significantly higher grain and straw yield of 2716.45 kg ha^{-1} and 4240.49 kg ha^{-1}, respectively. Higher grain and straw yield was mainly attributed to growth parameters like higher plant height (85.87 cm), number of tillers (20.47) and number of leaves per hill (83.20) at harvest, and yield parameters *i.e.,* number of panicles per hill (15.93), length of panicle (20.03cm), number of grains per panicle (117.0), 1000 grain test weight (23.65g) and lower per cent chaffyness (6.33). Significantly higher soil available nutrients (N,P,K, Ca,Mg and S) were observed with the same treatment. The plant nutrient content was also significantly higher with application of sulphur at 26 kg ha^{-1} through ammonium sulphate.

2016
Departmentment of Soil Science and Agricultural Chemistry
V.C. Farm, Mandya

N. SRINIVASA
Major Advisor

INSTRUCTIONS TO AUTHORSINSTRUCTIONS TO AUTHORS

The Mysore Journal of Agricultural Sciences is a quarterly journal published by the University of Agricultural Sciences, Bengaluru which contains original review article / research paper / research note in the field of Agricultural Sciences including Soil, Plant, Animal, Engineering, Home Science and allied subjects. It is suggested to potential authors to contact the editor with the intended review article. Authors should submit the duly signed declaration stating that review article / research paper / research note has neither been published nor sent for publication in any other Journal. **Articles with data of five years old experiment or trial will not be accepted.** Once a paper is accepted for publication, it should not be published elsewhere either in the same or abridged form or in any other language, without the permission of the Editor. **Invariably all the authors of the review article / research paper / research note should be the subscribers (Annual membership fee Rs. 400-00 / Life membership fee Rs. 3000-00) of the Journal and should pay processing fee of Rs. 100-00 per article. Subscription amount should pay through bank challen to the S/B Account No. 0425101030928, Canara Bank, GKVK, Bengaluru-560 065 and upload the same or Demand Draft drawn in favour of the Editor, Communication Centre, UAS, GKVK, Bengaluru-560 065.** The Editiorial Committee has right to accept or reject a paper and the committee does not shoulder any responsibility for the opinion(s) expressed in the paper by the author(s). **The article in duplicate should be routed through proper channel either hard copy or on-line submission through website e-krishiuasb.karnataka.gov.in (e-journal).** Papers presented in conferences, seminars, symposia, workshops *etc.* will not be accepted for publication.

All correspondence should be addressed to **The Editor, Communication Centre, University of Agricultural Sciences, GKVK, Bengaluru - 560 065, India.**

Email ID : editor@uasbangalore.edu.in

Manuscript and its arrangement

Manuscript, not less than 30, 12 and 6 pages inclusive of tables, diagrams and references for review article, research paper and research note, respectively should be typed in double line space on A4 size paper on one side of the page only, with at least 5 cm margin on the left and 2 cm margin on the right. The presentation of the subject should be simple, lucid and logical with appropriate headings. Care should be taken to check up the spellings, punctuations etc. All tables should be serially numbered, should not be too lengthy and should have a heading stating concisely the contents. Each table should be typed on separate sheet and not with the running matter.

The contents of **Review Article** should include **Title, Abstract, Keywords and Conclusion** with sub-headings as required in the article. The contents of **Research Paper** should be organised as **Title, Abstract, Keywords, Introduction, Material and Methods (Methodology in case of Social Science), Results and Discussion, Conclusion and References.** The contents for **Research Note** should be organised without mentioning the sub-headings as above but, with the **Title and References.**

Cover page : The cover page of the manuscript should carry the title of the review article, research paper and research note, Name(s) of the Author(s), their affiliation followed by **E-mail ID of the corresponding author** compulsorily. **The authorship and its order furnished at the time of registration of the manuscript is final.** Indicate the source of review paper / research paper / research note in the footnote of the first page. Further, a Certificate by the Head of the Department to the effect that the authors were associated with the research work (M.Sc. / Ph.D. research of the student) in the capacity of Chairman / Member of the Advisory Committee must accompany the research paper. In such cases, the first name should necessarily be of the student concerned.

Note : No manuscript should carry Author(s) Name(s) and addresses any where on the body of the manuscript other than the cover page.

Title : This should be informative but concise. While typing the title of the review article / research paper / research note only first letter of the title must be in capital. The title must be typed just before the commencement of abstract.

Abstract : The abstract must be brief and informative and should not be more than 250 words for Masters and for 300 words for Ph.D. degree.

Introduction : The introduction should be brief and state the objectives of the experiment. The review of literature should be pertinent to the problem.

Material and Methods : This should be precise and whenever the methods of other authors are followed, it woiuld suffice if reference to their paper is made instead of repeating the procedure. It should include experimental design, treatments and techniques employed.

Results and Discussion : This should govern the presentation and interpretation of experimental data only and each each of the experiments should be properly titled. Common names of plant species, micro-organisms, insects etc. should be supported with authentic, latest. Latin names should be underlined in the typescript. When such names are first mentioned, the full generic name and the species name with the authority should be mentioned and in subsequent reference, the generic name be abbreviated and the authority be deleted.

All headings must be typed in lower case from the left hand margin. The sub-headings must be typed in lower order capitals and must start from the left hand margin and underlined. The para under a sub-heading must start from a line below the sub-heading.

Tables : Every table should be on a separate sheet and be clear with proper reference in the text. The units of the data should be defined. Appropriate statistical tests should be applied to the data presented. Footnote should be seldom used. Lengthy tables should be avoided.

Illustrations : The illustrations and text-figures should be clear and capable of reproduction in print. If there are many photo prints they are to be grouped compactly. Whenever photo prints are included, the magnification should be indicated. Photostat copies of any illustrations are not accepted and in all cases, originals should be sent. Legends to figures and photos should be typed in the foot of the figure / photo.

Abbreviations should be used sparingly if advantageous to the reader. All new or unusual abbreviations should be defined when they are used for the first time in the paper. Ordinarily, the sentences should not begin with abbreviations or numbers.

References : References should be typed in double line space along with the body of the paper, but starting on a fresh page. These should be listed in the alphabetical and chronological order. In the text, the references should be cited as Hayman (1970) or (Hayman, 1970). Sen and Bhowal (1961) or (Sen and Bhowal, 1961). Tosh *et al.* (1978) or (Tosh *et al.*, 1978) when there are more than two authors. Recent references only should be included. **References older than ten years with reference to the scientific journals are not allowed in the paper.**

Citing references : The papers cited in the text should only be included in the references. While listing the References, the following examples should be followed.

While citing an article from :

Annual Report

ANONYMOUS, 2015, Annual Report (2015-16). Univ. Agric. Sci., Bengaluru, p. 86.

Book

AMIR HASAN, 1992, *Tribal development in India an appraisal.* Print House India, Lucknow.

Bulletin

GULED, M. B., LINGAPPA, S., ITNAL, C. J., SHIRAHATTI, M. S. AND YARNAL, R. S., 2004, Resource management in rainfed ecosystem - a research information kit. Tech. Bull. No. 34, Univ. Agric. Sci., Dharwad (India).

Edited Book

BALASUBRAMANIAM, S. AND CHARLES JEEVA, J., 2007, Extension Pluralism for Fisheries Development and Management. In : *New Dimensions and Approaches in Extension Pluralism for Rural Development.* [(Eds.) J. Vasanthakumar, H. Philip, R. K. Theodore and M. S. Nataraju]. Agrobios (India), Jodhpur, p. 71-80.

Newsletter

BAIG, M. M. V., BAIG, M. I. A. AND MULEY, S. M., 2002, Enhanced growth of groundnut by plant growth promoting *Rhizobacteria.* Int. Arachis Newsltr., **22 :** 60-63.

Paper Presented at Symposium / Seminar / Workshop

KULKARNI, K. A., KAMBREKAR, D. N., GUNDANNAVAR, K. P., DEVARAJ, K. AND UDIKERI, S. S., 2004, Biomintensive integrated pest management for Bt.cotton. Paper presented In: *Int. Symp. Strat. Sust. Cotton Prod. - A Global Vision,* Univ. Agric. Sci., Dharwad. November 23-25, p. 149.

Proceedings of Annual Meetings

DESHPANDE, S. S. AND BARGALE, P. C., 2004, Impact of nutrition education on utilization of soybean in selected rural areas of Bhopal district. *Proc. Nutrition Society of India.* XXXVI Annual meet, 5-6th November, Mysore.

Proceedings of Symposium / Seminar / Workshop (Published)

TANEJA, H. K., PRASAD, D., SAXENA, D. B. AND TOMAR, S. S., 2005, Nematotoxicity of some seed extracts against root knot and reniform nematodes. *Proc. Nation. Symp. Biopest,* IARI, New Delhi, p. 14-15.

Report

ANONYMOUS, 2002, Production of food grains. Surv. Indian Agric., The Hindu Year Book, Chennai, p. 46-47.

Scientific Journal

LAKSHMINARAYAN, M. T., BANUPRAKASH, K. G. AND SHANKARANARAYANA, V., 2011, Attitude of farmers towards sericulture. *Mysore J. Agric. Sci.,* **45** (2): 399-402.

Thesis

MAMATHALAKSHMI, N., 2013, An analysis of livelihood security among agricultural labourers in Karnataka. *Ph.D. Thesis* (Unpub.), Univ. Agric. Sci., Bengaluru.

Website

www.kar.nic.in
www.doughenhancers.com

Conventional symbols and abbreviations may be used in the manuscript in addition to the following:

Particulars	Symbol / Abbreviation
Centigrade	^{0}C
Centimetre/s	cm
Cubic Centimeter/s	cc
et al.	*et al.*
Gram/s	g
Hour/s	hr
Hectare/s	ha
Kilometre/s	km
Kilogram/s	kg
Litre/s	l
Minute/s	min
Millimetre/s	mm
Metre/s	m
Milligram/s	mg
Millilitre/s	ml
Micron/s	µ
Per cent	%
Quintal/s	q
Second/s	sec
Square	sq
Tonne/s	t

FORM IV (See Rule 8)

1.	Name of Publication	—	The Mysore Journal of Agricultural Sciences
2.	No. Registration	—	ISSN - 0047 - 8539
3.	Place of Publication	—	Bengaluru
4.	Periodicity of the Publication	—	Quarterly
5.	Printer's Name	—	Dr. B. N. Manjunatha
	Nationality	—	Indian
	Address	—	Editor Communication Centre University of Agricultural Sciences GKVK, Bengaluru - 560 065
6.	Publisher's Name	—	Dr. B. N. Manjunatha
	Nationality	—	Indian
	Address	—	Editor Communication Centre University of Agricultural Sciences GKVK, Bengaluru - 560 065
7.	Editor's Name	—	Dr. B. N. Manjunatha
	Nationality	—	Indian
	Address	—	Editor Communication Centre University of Agricultural Sciences GKVK, Bengaluru - 560 065
8.	Names and addresses of individuals who own the newspaper and partners or shareholders holding more than oneper cent of the total capital	—	University of Agricultural Sciences GKVK, Bengaluru - 560 065

I, Dr. B. N. Manjuntha hereby declare that the particulars given above are true to the best of my knowledge and belief.

(Sd.)
B. N. Manjunatha
Signature of Publisher

Naik Bhavan

An administrative fulcrum of the university