Andhra Pradesh J Agril. Sci : 1(1): 1-6, 2015

REVALIDATION OF SOIL TEST BASED FERTILIZER DOSE FOR CHILLI CROP AND THEIR INFLUENCE ON SOIL NUTRIENTS

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ABSTRACT

A field experiment was conducted during *kharif* 2011 at a farmer's field in Koliwad (Hubli *taluk*) village in Northern transitional Zone of Karnataka between 15° 21' N latitude and 75° 24' E longitudes and at an altitude of 629 m above mean sea level (MSL). In the soil test crop response (STCR) NPK dose (216:116:166, N: P_2O_5: K_2O kg ha^{-1}, respectively) gave higher chilli dry fruit yield. The RDF (100:50:50 kg N: P_2O_5: K_2O kg ha^{-1}) recorded dry fruit yield of 763 kg ha^{-1} and it increased to 1257 kg ha^{-1} under STCR dose indicating an increase of 39 per cent. The highest ascorbic acid content of 151.3 mg 100 g^{-1} was recorded in the STCR dose of NPK and it was on par with soil test based N and K dose modified by ± 50 per cent and P dose modified by ± 25 (149.5 mg 100 g^{-1}). Soil phosphatase activity (14.12 µg g^{-1} soil h^{-1}) was significantly higher in phosphate solubilizing bacteria (PSB) treated plot which also received N and K dose as per state soil testing laboratory recommendation + 75 per cent of RDP under medium level of P test values as compared to untreated plots.

KEY WORDS: Ascorbic cid content, Chilli, Organic carbon, Soil fertility, Soil phosphatase activity,

INTRODUCTION

Chilli (*Capsicum annum* L.) is an important spice as well as vegetable crop grown all over India. In India, chilli is cultivated in an area of 7.67 lakh hectares in India with a production of 12.34 lakh tones. Chilli is an indispensable spice essentially used in every Indian cuisine, due to its pungency, taste, colour and aroma. Chilli fruits are rich source of vitamin C, A and E and pungency is due to crystalline and volatile alkaloid called capsaicin present in the placenta of fruit. The major chilli producing states in India are Andhra Pradesh, Karnataka, Maharashtra, Odisha, Rajasthan and Tamil Nadu. These states constitute about 86 per cent of total area under chilli and 90 per cent of the total India's production. The important chilli growing districts in Karnataka are Haveri, Gadag, Dharwad, Koppal, Belgaum, Bellary and Raichur. Haveri and Dharwad districts make-up 72 and 60 per cent respectively of total area and production, respectively. In Karnataka, the area under chilli was 1,09,185 ha, with a production of 1,05,401 kg and productivity of 1016 kg ha^{-1} (Anonymous, 2009).

Among the various methods of fertilizer applications, the one based on 'yield targeting' is the unique in the sense that this method not only indicates soil test based fertilizer dose but also levels of yield that the farmer can hope to achieve if good agronomic practices are followed. For soil-plant system, this approach is also unique because it provides a scientific base for balanced fertilization not only among the fertilizer nutrient themselves but also soil available nutrients. The existing practice of farmers is application of general dose of fertilizers to chilli without consideration of soil fertility and crop response. Balanced nutrition is the most important in modern farming. This necessitates remodeling of our approach to the problem of economic and judicious use of fertilizers based on the soil test. Keeping these views in background, a field experiment was conducted to assess response of chilli to varied fertilizer does based on soil testing.

MATERIAL AND METHODS

A field experiment was conducted during *kharif* 2011 in the farmer's field at Koliwad (Gadag *taluk* and district) village in Northern transitional Zone (Zone - VIII). The experiment was laid-out on black clay soil. A composite soil sample was collected from the experimental site at a depth of 0 to 15 cm before sowing and was analyzed for various chemical and physical characteristics. Soil reaction was slightly alkaline (8.10), non saline ($EC_{1:2.5}$ 0.5 dSm^{-1}) low in organic carbon (4.12 g kg^{-1} of soil), low in available N (246 kg ha^{-1}), medium in available P_2O_5 (23.5 kg ha^{-1}) and high in available K_2O (392 kg ha^{-1}).

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Chilli (Dyavnur *dabbi*) was raised on flat bed one month before transplanting and transplanted to the main field on July 24, 2011. The field experiment was laid out in Randomized Complete Block Design (RCBD). There were six soil test based fertilizer doses as treatments and four replications. The treatment details are as follows.

1. Recommended N, P_2O_5 and K_2O dose (150:75:75, N, P_2O_5, K_2O, kg ha^{-1})
2. N, P_2O_5 and K_2O dose based on yield targeted STCR (soil test crop response) approach (216:116:166 N: P_2O_5: K_2O kg ha^{-1}) the equations were.

   F N = 50.23 T – 0.54 SN,

   F P_2O_5 = 27.09 T – 3.17 S P_2O_5 and

   F K_2O = 36.48 T – 0.30 S K_2O
   (www.icar.org.in)
3. Soil test based modified recommended N, P_2O_5 and K_2O dose as per state Soil testing laboratory recommendations (175:75:62.25, N, P_2O_5, K_2O kg ha^{-1})
4. Soil test based ± 25 per cent modified recommended N, P_2O_5 and K_2O dose (187.5:75:56.25, N: P_2O_5: K_2O kg ha^{-1})
5. Soil test based ± 50 per cent modified recommended N and K_2O and ± 25 per cent modified recommended P_2O_5 dose (225: 75: 37.5, N, P_2O_5, K_2O kg ha^{-1})
6. Soil test based modified recommended N and K_2O dose as per state soil testing laboratory recommendations and + 50 per cent RDP as soil test for P is high + recommended dose of PSB (175:56.25:62.5, N, P_2O_5, K_2O kg ha^{-1})

Dehydrogenase activity in the soil was determined by following procedure as described by Casida *et al*., (1964) and results were expressed as µg of Triphenyl formazan (TPF) formed g^{-1} soil day^{-1}. Phosphatase activity in soil was determined by following the procedure outlined by Evazi and Tabatabai (1979) and phosphatase activity in the soil was expressed as µg paranitrophenol formed g^{-1} soil hr^{-1}.

Freshly harvested green chillies were used for ascorbic acid estimation and it was determined volumetrically by reducing 2, 6-dichlrophenol indophenols dye to get a pink red colour. Ascorbic acid was calculated and expressed in mg 100 g^{-1} fruit (Sadasivam and Manickam 1992).

RESULTS AND DISCUSSIONS

Pod yield

Dry pod yield was lower (763 kg ha^{-1}) for RDF (recommended fertilizer dose) application as compared to all other soil test based fertilizer doses (Table 1). The STCR dose (216:116:166 N:P_2O_5:K_2O kg ha^{-1}) of NPK (1257 kg ha^{-1}) registered the highest pod yield than rest of the soil test based fertilizer doses *viz.,* RDF, soil test based N and K ± 50 per cent and P ± 25 per cent (+ 50 per cent N, -50 per cent K and -25 per cent P), Karnataka State Soil Test Laboratory (STL) based recommended NPK dose and N and K as per STL +75 per cent of RDP + RD of PSB . But, soil test based N and K ± 50 per cent and P ± 25 per cent and N and K as per STL + 75 per cent of RDP under medium level of P test values + RD of PSB stood second and third after STCR dose with respect to pod yield (942 and 862 kg ha^{-1}, respectively). The STL dose of NPK (855 kg ha^{-1}) and soil test based NPK ± 25 per cent (862 kg ha^{-1}) were on par with each other. Yield performance of chilli under soil test based NPK ± 25 per cent and soil test based N and K ± 50 per cent and P ± 25 per cent applications were significantly different. Yield increased from 763 to 1257 kg ha^{-1} in soil test based fertilizer application by registering an increase of 39 per cent. Nitrogen being most deficient in soils, the crop yield and growth might have been hindered predominantly by its deficiency. Higher doses of nitrogenous fertilizer (being deficient) and recommended dose of P (being medium) and reduced dose of K (being sufficient) might have made balanced availability of nutrients. Increased yield attributes *viz.* number of fruits per plant and fruit length had positive impact on yield under soil test based fertilizer dose application.

Ascorbic acid content

Dry fruit ascorbic acid content was significantly influenced by the application different doses of fertilizer. The highest ascorbic content was found in STCR dose of NPK (151.3 mg 100 g^{-1}). However, it was on par with the soil test based N and K ± 50 per cent and P ± 25 per cent (149.5 mg 100 g^{-1}). These treatments (Table 1) were followed by soil test based NPK ± 25 per cent, STL dose of NPK and N and K as per STL + 75 per cent of RDP under medium level of P test values + RD of PSB (146.5, 142.1 and 139.8 mg 100 g^{-1}). Significantly lower ascorbic acid content was observed RDF (130.5 mg 100 g^{-1}). Increased ascorbic acid content of fruits under higher doses of fertilizer application (STCR and ± 50 per cent soil test

based modified fertilizer dose) might be due to strong positive relationship between carbohydrate metabolism and formation of ascorbic acid (Majumdar *et al.*, 2000).

Soil Enzymes

Dehydrogenease activity

The Highest dehydrogenase enzyme activity was recorded in the treatments that received N and K as per STL + 75 per cent of RDP under medium level (Table 2) of P test values + RD of PSB (3.94 µg g^{-1} day^{-1}), followed by soil test based NPK ± 25 per cent (2.51 µg g^{-1} day^{-1}). The RDF recorded the lowest dehydrogenase activity (1.19 µg g^{-1} soil day^{-1}). The STL dose of NPK and STCR were found to be differing with each other (1.33 and 2.36 µg g^{-1} soil day^{-1} respectively).

Phosphatase activity

The higher phosphatase enzyme activity was recorded in N and K as per STL + 75per cent of RDP under medium level of P test values + RD of PSB (14.12 µg g^{-1} soil h^{-1}), followed by soil test based N and K ± 50 per cent and P ± 25 per cent (11.75 µg g^{-1} soil h^{-1}) and RDF recorded the lowest (Table 2) phosphatase activity (10.3 µg g^{-1} soil h^{-1}). However, the treatment that received STL dose of NPK (9.49 µg g^{-1} h^{-1}), STL dose of NPK ± 25 per cent (10.55 µg g^{-1} soil h^{-1}) and STCR dose of NPK (8.35 µg g^{-1} soil h^{-1}) were statistically comparable to each other. This was mainly due to the organic acids such as acetic, citric and oxalic produced by microorganism could increase mineral dissolution. Badar *et al.,* (2006) also recorded higher dehydrogenase enzyme activity under PSB applied plots. The results obtained in the present investigation were in concurrence with the findings of Apoorva *et al.* (2010).

Soil pH, EC and OC

There was no significant difference in soils pH due to application of different levels of fertilizesr. Similarly, there was no significant difference in soluble salt content (EC) in soils due to application of different levels of fertilizers. Furthermore, use of different levels of fertilizer based on soil testing did not change soil organic carbon (Table 3).

Available N, P_2O_5, K_2O and S

Available N was significantly higher under STCR dose of NPK (283.9 kg ha^{-1}), followed by soil test based N and K ± 50 per cent and P ± 25 (Table 4) per cent (260.5 kg ha^{-1}) and N and K as per STL + 75 per cent of RDP under medium level of P test values + RD of PSB (256.1 kg ha^{-1}). The lowest available N (246.7 kg ha^{-1}) was recorded in soil test based NPK ± 25 per cent and it remained on par with all other treatments (Table 4) except STCR dose of NPK and soil test based N and K ± 50 per cent and P ± 25 per cent.

Significantly higher available P_2O_5 (84.6 kg ha^{-1}) was recorded in STCR dose (Table 4) , followed by soil test based N and K ± 50 per cent and P ± 25 per cent (67.5 kg ha^{-1}) and N and K as per STL + 75 per cent of RDP under medium level of P test values + RD of PSB (63.5 kg ha^{-1}). However, all these treatments remained on par with each other. The lowest available phosphorus (52.3 kg ha^{-1}) was observed by soil test based NPK ± 25 per cent.

Application of STCR dose of K_2O showed significantly higher available potassium status of (372.4 kg ha^{-1}). But soil test based N and K ± 50 per cent and P ± 25 per cent and N and K as per STL + 75 per cent of RDP (Table 5) under medium level of P test values + RD of PSB (347.0 and 343.7 kg ha^{-1} respectively.) were on par with STCR dose of NPK. Lower available potassium (320.9 kg ha^{-1}) was recorded in soil test based NPK ± 25 per cent. Except treatments STCR dose of NPK and soil test based N and K ± 50 per cent and P ± 25 per cent remaining all treatments were on par with Soil test based NPK ± 25 per cent treatment. Further, available sulphur didn't differ significantly due to different levels of fertilizer application based on soil test results.

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Table 1. Effect of soil test based fertilizer doses on yield and quality of chilli

Treatments	Dry fruit yield (kg ha^{-1})	Ascorbic acid content in fruits (mg 100 g^{-1})
T_1 : RDF (recommended dose of fertilizer) (100:50:50, N, P_2O_5, K_2O, kg ha^{-1})	763	130.5
T_2 : STCR dose of NPK (216:116:166 N, P_2O_5. K_2O kg ha^{-1})	1257	151.3
T_3 : STL dose of NPK (125:50:37.5, N, P_2O_5, K_2O kg ha^{-1})	855	142.1
T_4 : Soil test based NPK ± 25 per cent (125:50:43.75 N, P_2O_5, K_2O kg ha^{-1})	862	146.5
T_5 : Soil test based N & K ± 50 per cent and P ± 25 per cent (150:50:25 N, P_2O_5, K_2O kg ha^{-1})	942	149.5
T_6 : N and K as per STL +75 per cent of RDP under medium level of P test values +RD of PSB (125:37.5:37.5, N, P_2O_5, K_2O kg ha^{-1})	862	139.8
S. Em ±	10.9	0.8
CD (0.05)	32.9	2.6

Table 2. Effect of soil test based fertilizer doses on soil enzymes at flowering stage of chilli crop

Treatments	Dehydrogenase activity (µg TPF g^{-1} of soil day^{1})	Phosphatase activity (µg paranitrophenol g^{-1} soil h^{-1})
T_1 : RDF (recommended dose of fertilizer) (100:50:50, N, P_2O_5, K_2O, kg ha^{-1})	1.19	8.35
T_2 : STCR dose of NPK (216:116:166 N, P_2O_5. K_2O kg ha^{-1})	1.33	9.49
T_3 : STL dose of NPK (125:50:37.5, N, P_2O_5, K_2O kg ha^{-1})	2.36	10.30
T_4 : Soil test based NPK ± 25 per cent (125:50:43.75 N, P_2O_5, K_2O kg ha^{-1})	2.51	10.55
T_5 : Soil test based N & K ± 50 per cent and P ± 25 per cent (150:50:25 N, P_2O_5, K_2O kg ha^{-1})	1.68	11.75
T_6 : N and K as per STL +75 per cent of RDP under medium level of P test values +RD of PSB (125:37.5:37.5, N, P_2O_5, K_2O kg ha^{-1})	3.94	14.12
S. Em ±	0.02	0.19
CD (0.05)	0.08	0.58

Table 3. Effect of soil test based fertilizer doses on chemical parameters after harvest of chilli crop

Treatments	Soil chemical properties		
	$pH_{(1:2.5)}$	$EC_{(1:2.5)}$ dSm^{-1}	OC (g kg^{1})
T_1 : RDF (recommended dose of fertilizer) (100:50:50, N, P_2O_5, K_2O, kg ha^{-1})	8.15	0.29	7.90
T_2 : STCR dose of NPK (216:116:166 N, P_2O_5. K_2O kg ha^{-1})	8.10	0.37	8.40
T_3 : STL dose of NPK (125:50:37.5, N, P_2O_5, K_2O kg ha^{-1})	8.27	0.35	8.32
T_4 : Soil test based NPK ± 25 per cent (125:50:43.75 N, P_2O_5, K_2O kg ha^{-1})	8.26	0.33	8.21
T_5 : Soil test based N & K ± 50 per cent and P ± 25 per cent (150:50:25 N, P_2O_5, K_2O kg ha^{-1})	8.28	0.33	8.27
T_6 : N and K as per STL +75 per cent of RDP under medium level of P test values +RD of PSB (125:37.5:37.5, N, P_2O_5, K_2O kg ha^{-1})	8.22	0.31	8.32
S. Em ±	0.078	0.026	0.06
CD (0.05)	NS	NS	NS

Table 4. Effect of soil test based fertilizer doses on available nitrogen, phosphorus, potassium and sulphur (kg ha^{-1}) after harvest of chilli crop

Treatments	Soil chemical properties			
	N	P_2O_5	K_2O	S
T_1 : RDF (recommended dose of fertilizer) (100:50:50, N, P_2O_5, K_2O, kg ha^{-1})	250.4	56.0	327.4	38.5
T_2 : STCR dose of NPK (216:116:166 N, P_2O_5. K_2O kg ha^{-1})	283.9	84.6	372.4	29.5
T_3 : STL dose of NPK (125:50:37.5, N, P_2O_5, K_2O kg ha^{-1})	252.3	58.5	336.1	35.7
T_4 : Soil test based NPK ± 25 per cent (125:50:43.75 N, P_2O_5, K_2O kg ha^{-1})	246.7	52.3	320.9	35.5
T_5 : Soil test based N & K ± 50 per cent and P ± 25 per cent (150:50:25 N, P_2O_5, K_2O kg ha^{-1})	260.5	67.5	347.1	33.2
T_6 : N and K as per STL +75 per cent of RDP under medium level of P test values +RD of PSB (125:37.5:37.5, N, P_2O_5, K_2O kg ha^{-1})	256.1	63.5	343.7	34.0
S. Em ±	3.67	0.9	2.7	2.9
CD (0.05)	11.0	2.7	8.1	NS

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(Received on 18-04-2015 and revised on 30-04-2015)

Andhra Pradesh J Agril. Sci : 1(1): 7-11, 2015

INFLUENCE OF VARYING MOISTURE LEVELS AND SPACING ON PRODUCTIVITY AND B:C RATIO OF HYBRID MAIZE UNDER SUBSURFACE DRIP IRRIGATION

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ABSTRACT

A field experiment was conducted during *rabi* season, 2013 to study the effect of different IW : CPE ratios and crop geometry on yield and economics of maize. The IW: CPE ratio of 1.0 produced significantly higher grain and stover yield which was at par with I_2 (IW: CPE ratio of 0.8). With regard to crop geometry, significantly higher grain yield was obtained at a spacing of 30/90 × 20 cm, whereas higher stover yield was obtained at a spacing of 60 × 15 cm. The highest B:C ratio was obtained at IW:CPE ratio of 1.0 with a spacing of 30/90 × 20 cm.

KEY WORDS: Crop geometry, Irrigation, *Rabi* maize

INTRODUCTION

Water is considered as the most critical resource for sustainable agricultural development, which is often costly and limiting input use efficiency, particularly in semi arid tropics and needs judicious use of water to reap the maximum benefit from other inputs. Since, agriculture is the major water user, efficient use of water in agriculture is needed for the conservation of this limited resource. Increase in water use-efficiency (WUE) for enhanced drought tolerance can be achieved by strategies like change in crops, which are capable of producing acceptable yields under deficit irrigation or rainfed situations (Zwart and Bastiaanssen, 2004 and Farre and Maria, 2006).

Maize is the third most important cereal crop after wheat and rice. It is the most efficient coarse cereal crop in utilizing radiant energy and has the highest capacity to generate carbohydrates per day as compared to other cereals. The cost of production per kg of grain is less compared to other cereals, which lead to drawing the attention of the farmers of Andhra Pradesh and India.

In India it is cultivated in an area of 8.71 million hectares with grain production of 21.57 million tones and productivity of 2476 kg ha^{-1} (www.indiastat.com). In Andhra Pradesh, it is cultivated in an area of 0.86 million hectares with grain production of 3.7 million tones and productivity of 4232 kg ha^{-1}. Maize yield is a function of climate, soil, variety and cultural practices. Correlating these functions to produce the highest possible yields with the greatest efficacy has been the aim of research workers ever since the maize production began. Since, there is a limited scope to increase the area under maize cultivation because of competition from other cereals and commercial crops, the only alternative is through increasing the productivity of maize by various management factors. Among the factors limiting the grain yield of maize in many areas is inadequate irrigation and low plant population.

Drip irrigation plays an important role in water scarcity areas by maintaining the optimum soil moisture in crop root zone with increased yield. Drip irrigation provides the efficient use of limited water with higher water use efficiency. Subsurface drip irrigation method facilitate optimum moisture content near to the crop root zone with negligible evaporation losses compared to surface drip irrigation. The utilization of soil moisture by crop varies with method and time of irrigation. IW : CPE is one of the method for scheduling irrigation water.

In addition to irrigation management, optimum plant population also play a crucial role in enhancement of crop productivity. It is an established fact that higher yield depends on optimum plant population and adequate nutrient application, particularly nitrogen. In addition to plant population, it is the proper crop geometry which is important from the point of intercepting sunlight for photosynthesis besides efficient use of nutrients and moisture from soil. Correlating these functions to produce

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the highest possible yields, there is a need to investigate the optimum crop geometry with suitable irrigation schedule through IW : CPE ratio under subsurface drip irrigation to hybrid maize in sandy loam soils. Therefore, the present study was undertaken to study the effect of different IW : CPE ratios and crop geometries on yield and economics of hybrid maize.

MATERIAL AND METHODS

A field experiment was conducted during *rabi*, 2013 at College Farm, S.V. Agricultural College, Tirupati, Acharya NG Ranga Agricultural University. The soil of the experimental site was sandy clay loam and it was slightly alkaline in reaction with a pH of 7.9, Electrical Conductivity of 0.24 dSm^{-1} low in organic carbon (0.29%) and available nitrogen (186 kg ha^{-1}), medium in available phosphorous (23.4 kg P_2O_5 ha^{-1}) and high in available potassium (174.3 kg K_2O ha^{-1}). In the subsurface drip layout, the laterals are placed 1 feet below the soil surface. Spacing between the laterals in 1.5 m. Spacing between the emitters is 40 cm. Main line and lateral diameters are 75 mm and 16 mm respectively. Dripper discharge rate is 4 lph. The experiment was laid out in a split plot design and replicated thrice. The treatments consisted of three IW : CPE ratios of 0.6, 0.8 and 1.0 and four crop geometries *viz.,* 60 × 15 cm, 30/90 × 15 cm, 60 × 20 cm and 30/90 × 20 cm. Maize hybrid DHM-117 which matures in 100-105 days was tested in this experiment. Recommended dose of fertilizers (150, 60 and 40 kg N, P_2O_5 and K_2O ha^{-1}) was applied. Nitrogen, phosphorous and potassium were applied in the form of urea, single super phosphate and muriate of potash. Nitrogen was applied in three splits *i.e.,* one fourth at the time of sowing, half at 35 DAS and one fourth at tasselling stage. The entire phosphorous and potassium were applied as basal at the time of sowing. Atrazine @ 1.5 kg *a.i.* ha^{-1} was applied as pre-emergence followed by one hand weeding at 30 DAS. Irrigation was given based on IW: CPE ratio and a total of 4, 5 and 6 irrigations had been given to IW: CPE ratio of 0.6, 0.8 and 1.0, respectively. Economics was calculated based on present market price of yield and inputs.

RESULTS AND DISCUSSION

Yield

The grain and stover yield of hybrid maize was significantly influenced by different irrigation levels and crop geometries (Table 1). The highest grain and stover yield were recorded with the highest level of irrigation tried *i.e.,* IW: CPE ratio of 1.0 (I_3), which was however comparable with IW: CPE ratio of 0.8 (I_2), and both of them were significantly higher than with IW: CPE ratio of 0.6 (I_1), which has resulted in the lowest yield. The highest grain yield at IW : CPE ratio of 1.0 might be accounted to their favorable influence on the crop growth lead to enhanced growth and yield attributes (Ertek and Kara, 2013). The increased stover yield might be due to better vegetative growth and higher dry matter production at frequent irrigations (Vijay Kumar Choudhary *et al.*, 2006).

As regards the crop geometry practices, the highest grain yield was recorded with a spacing of 30/90 × 20 cm, which was at par with 60 × 20 cm followed by paired row spacing of 30/90 × 15 cm and 60 × 15 cm with no significant difference between them, which produced the lowest grain yield (Table 2). As plant density increased, changes may occur in the allocation of assimilates to different plant parts as a result of which a greater proportion of plants may become barren and also there may be a critical period for light interception in relation to grain formation at higher populations (Ummedsingh *et al.*, 2012). Significantly higher stover yield was recorded with 60 × 15 cm, which was comparable with paired row spacing of 30/90 × 15 cm. The next best treatment was 60 × 20 cm which was at par with 30/90 × 20 cm which produced the lowest stover yield. This is due to increased number of plants per unit area and increased growth of plants *i.e.,* plant height, leaf area, dry matter production (Ummed Singh *et al.*, 2012).

The interaction effect of irrigation levels and crop geometry practices with respect to grain yield was significant. The highest yield being produced with IW : CPE ratio of 1.0 at a paired row spacing of 30/90 × 20 cm and the lowest grain yield was produced with IW : CPE ratio of 0.6 at crop geometry of 60 × 15 cm (Table 3). This is due to more number of cobs ha^{-1} under adequate moisture availability which had direct bearing on the production of highest yield (Salah E. El- Hendawy *et al.,* 2008). The interaction effect of irrigation levels and crop geometry practices with respect to stover yield was significant and the highest stover yield being produced with I_3G_1 (the highest level of irrigation in combination with a spacing of 60 × 15 cm) and I_1G_4 (the lowest level of irrigation in combination with a spacing of 30/90 × 20 cm) produced the lowest stover yield. It was due to increased leaf area index and leaf area duration at harvest (Vijay Kumar Choudhary *et al.*, 2006).

Table 1. Yield and economics of maize as influenced by different IW:CPE ratios and crop geometry under subsurface drip irrigation

Treatment	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index (%)	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C ratio
IW:CPE ratio (I)						
0.6	2615	4079	39.2	45921	16575	1.57
0.8	4658	6489	41.6	81021	51601	2.76
1.0	4919	6753	42.0	85459	55963	2.90
SEm±	87	140	0.6	1500	4915	0.08
C.D. (P=0.05)	343	551	2.3	5892	6950	0.33
Crop geometry (G)						
60 × 15 cm	3483	6079	36.0	61814	31709	2.07
30/90 × 15 cm	3553	6023	36.8	62875	33207	2.10
60 × 20 cm	4575	5501	45.2	78711	49594	2.70
30/90 × 20 cm	4644	5491	45.7	79801	51008	2.76
SEm±	26	18	1.1	410	1073	0.03
C.D. (P=0.05)	78	56	3.4	1219	1517	0.08
Interaction						
C.D. (P=0.05)	Significant	Significant	Non significant	Significant	Significant	Significant

Table 2. Grain yield (kg ha^{-1}) of maize as influenced by different IW: CPE ratios and crop geometry under subsurface drip irrigation

Treatments	IW:CPE ratio (I)			
Crop geometry (G)	**0.6**	**0.8**	**1.0**	**Mean**
60 × 15 cm	2264.2	3967.8	4218.3	3483.4
30/90 × 15 cm	2329.8	4032.1	4297.8	3553.2
60 × 20 cm	2897.6	5287.9	5541.5	4575.7
30/90 × 20 cm	2968.9	5345.2	5618.9	4644.3
Mean	2615.1	4658.3	4919.1	

	SEm±	CD (P=0.05)
I	87.41	343.2
G	26.33	78.2
I at G	95.93	361.1
G at I	45.62	135.5

Table 3. Stover yield (kg ha^{-1}) of maize as influenced by different IW: CPE ratios and crop geometry under subsurface drip irrigation

Treatments	IW:CPE ratio (I)			
Crop geometry (G)	**0.6**	**0.8**	**1.0**	**Mean**
60 × 15 cm	4518	6704	7015	6079
30/90 × 15 cm	4487	6676	6907	6023
60 × 20 cm	3685	6302	6515	5501
30/90 × 20 cm	3625	6275	6574	5491
Mean	4079	6489	6753	

	SEm±	CD (P=0.05)
I	140.4	551.3
G	18.9	56.2
I at G	143.3	557.0
G at I	32.8	97.2

Economics

The highest gross and net returns with hihger benefit -cost ratio were realized with IW: CPE ratio of 1.0, which was however comparable with IW: CPE ratio of 0.8 but significantly higher than with IW: CPE ratio of 0.6. Crop geometry practice of 30/90 × 20 cm produced the highest gross and net returns and B:C ratio, which was at par with 60 × 20 cm. Plant spacing of 60 × 15 cm has resulted in the lowest gross and net returns and B:C ratio under subsurface drip irrigation in sandy clay loam soils.

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(Received on 15-04-2015 and revised on 24-04-2015)

Andhra Pradesh J Agril. Sci : 1(1): 12-15, 2015

SELECTION INDICES FOR THEORETICAL YIELD OF ALCOHOL IN SUGARCANE

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ABSTRACT

Selection indices were formulated using seventy seven genotypes of sugarcane in second clonal stage considering theoretical yield of alcohol and seven of its component characters which showed high correlation with it. Among eight characters that were used to formulate selection indices, theoretical yield of alcohol (X_1) was considered as dependent character while other characters viz., brix per cent (X_2), sucrose per cent (X_3), commercial cane sugar per cent (X_4), juice purity per cent (X_5), pol per cent cane (X_6), total sugars per cent (X_7) and commercial cane sugar yield (X_8) were considered as independent variables. From the results, it is evident that to increase the alcohol yield selection should be mainly based on total sugars per cent as all the selection indices showing higher relative efficiency and genetic advance involved this trait. For indirect selection, the index involving the combination of five characters viz., brix per cent (X_2), sucrose per cent (X_3), juice purity per cent (X_5), pol per cent cane (X_6) and total sugars per cent (X_7) which exhibited maximum relative efficiency of 523.98 with genetic advance of 12.14 could be considered for selection schemes to improve theoretical yield of alcohol. Inclusion of commercial cane sugar yield to this index increased the relative efficiency to 602.98 and genetic advance of 13.97.

KEY WORDS: Selection indices, Sugarcane, Theoretical yield of alcohol

INTRODUCTION

Sugarcane, which is also considered as an important bio energy crop belongs to the category of C4 plants which converts the solar energy effectively into high quality and low cost raw materials for sugar and ethanol (Bruce *et al.*, 2005). Molasses and bagasse are the byproducts of sugar industry which form the feedstock for ethanol production and cogeneration respectively. National policy on biofuels proposed to scale up the blending from 5% to 20% by 2017. The target is difficult to achieve due to limited availability of bioethanol which to a greater extent comes from sugarcane molasses apart from a smaller proportion from grains. This necessitates significant increase in domestic ethanol production by developing varieties which yield higher ethanol.

The main objective of a selection programme is to shift the mean to a new peak by directional selection. Continuous selection in one character may result in a loss or gain in the other characters, which are also of equal importance. On the other hand, if selection is made for a number of characters, the efficiency of selection would be reduced. So the plant breeder will have to base his selection on a combination of a few important characters related to the main character under consideration in the form of a selection index by appropriate weightages assigned to the phenotypic values of each character so that the genetic gain in the character under consideration will be maximum without any loss in other important characters. Selection indices provide the means for making use of correlated characters for higher efficiency in selection for characters of low heritability. Selection index is a tool, which breeder can use successfully for selection on several characters simultaneously by discriminating the desirable ones on the basis of phenotypic performance.

MATERIAL AND METHODS

The present investigation was carried out at Agricultural Research Station, Perumallapalle (Acharya N.G. Ranga Agricultural University), situated in the Southern Agro-climatic Zone of Andhra Pradesh with seventy seven genotypes of sugarcane that were planted in a randomized block design with two replications during April, 2011. Each entry was planted in 2 rows of 5 m length spaced at a distance of 80 cm between rows with 4 three budded setts per meter as seed rate.

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Observations were recorded on each entry for the traits viz., no. of tillers at 120 DAP, shoot population at 180, 240 DAP, NMC at harvest, no. of green leaves at 90, 120, 240 DAP and at maturity, biomass per cane (kg), internode number, internode length (cm), stalk length (cm), stalk diameter (cm), stalk volume (cm^3), single cane weight (kg), fibre content (%), Brix (%), sucrose (%), CCS (%), juice purity (%), pol % cane, juice extraction (%), total sugars (%), fibre yield (tha^{-1}), CCS yield ($t\ ha^{-1}$), theoretical yield of alcohol (g/100ml) and cane yield ($t\ ha^{-1}$).

The technique of Discriminant function developed by Fisher (1936) was adopted to know the true genotypic worth of yield and its components and to have computational formulae for construction of selection indices which when applied to select plants can bring about effective improvement in yield compared to straight selection for yield. Smith (1936) has illustrated the use of discriminant function in plant selection. A number of different selection indices are constructed using 2, 3,……, n combination of characters. The expected genetic advance based on the composition of characters that was included for formulation of the various selection indices was calculated as per the formula of Robinson *et al.* (1951). The relative efficiency of each selection index formulated was calculated as per the formula given by Brim *et al.* (1959).

RESULTS AND DISCUSSION

Among eight characters that were used to formulate selection indices, theoretical yield of alcohol (X_1) was considered as dependent character while other characters viz., brix per cent (X_2), sucrose per cent (X_3), commercial cane sugar per cent (X_4), juice purity per cent (X_5), pol per cent cane (X_6), total sugars per cent (X_7) and commercial cane sugar yield (X_8) were considered as independent variables. The discriminant functions and the estimated values of genetic advance and relative efficiency for each combination of characters over straight selection for theoretical yield of alcohol are presented in Table 1 and briefly discussed below.

Out of two hundred and fifty five different selection indices formulated higher relative efficiency of 744.59 coupled with high genetic advance (17.25) was observed in the combination involving all the eight traits followed by the index based on seven characters excluding commercial cane sugar per cent (X_4) with a relative efficiency of 687.77 and genetic advance of 15.72.

Among single characters, total sugars per cent (X_7) was highly efficient with relative efficiency of 170.65 and high genetic advance of 3.95, compared to the direct selection based on theoretical yield of alcohol (X_1). Whereas among two character combinations, maximum relative efficiency of 268.97 was observed for the combination of juice purity per cent (X_5) and total sugars per cent (X_7) with a genetic advance of 6.23. However, in case of three character combinations, the combination involving sucrose per cent (X_3), juice purity per cent (X_5) and total sugars per cent (X_7) exhibited higher relative efficiency of 360.64 coupled with a genetic advance of 8.35.

Among four character combinations, theoretical yield of alcohol (X_1), sucrose per cent (X_3), juice purity per cent (X_5) and total sugars per cent (X_7) exhibited high relative efficiency of 445.34 coupled with a genetic advance of 10.32.

When indirect selection scheme excluding theoretical yield of alcohol is to be followed, the index involving the combination of five characters viz., brix per cent (X_2), sucrose per cent (X_3), juice purity per cent (X_5), pol per cent cane (X_6) and total sugars per cent (X_7) which exhibited maximum relative efficiency of 523.98 with genetic advance of 12.14 could be considered for selection schemes to improve theoretical yield of alcohol. Inclusion of commercial cane sugar yield to this index increased the relative efficiency to 602.98 and genetic advance of 13.97.

From the results it is evident that to increase the alcohol yield selection should be mainly based on total sugars per cent as all the selection indices showing higher relative efficiency and genetic advance involved this trait.

Scoring of sugarcane genotypes for theoretical yield of alcohol based on the best selection index is depicted in Figure 1. Selection of top ten percent of the genotypes (Table 2) based on the best selection index has shown 136.19% gain over population mean.

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Table 1. Discriminant functions, their Genetic Advance (GA) and Relative Efficiency (RE) over straight selection for Theoretical yield of alcohol

S. No.	Discriminant function	GA	RE
1	$Y = 0.92\ X_1$	2.32	100.00
2	$Y = 0.81\ X_5$	3.37	145.52
3	$Y = 0.92\ X_7$	3.95	170.65
4	$Y = 1.03\ X_1 + 0.87\ X_7$	6.21	268.15
5	$Y = 0.78\ X_5 + 0.97\ X_7$	6.23	268.97
6	$Y = 0.94\ X_7 + 0.96\ X_8$	6.00	259.00
7	$Y = 1.20\ X_1 + 0.78\ X_5 + 0.83\ X_7$	8.31	358.81
8	$Y = 1.55\ X_3 + 0.62\ X_5 + 0.92\ X_7$	8.35	360.64
9	$Y = 0.78\ X_5 + 0.98\ X_7 + 1.01\ X_8$	8.13	350.83
10	$Y = 0.99\ X_1 + 1.63\ X_3 + 0.59\ X_5 + 0.88\ X_7$	10.32	445.34
11	$Y = -0.17\ X_2 + 2.71\ X_3 + 0.50\ X_5 + 0.94\ X_7$	10.24	442.11
12	$Y = 1.60\ X_3 + 0.62\ X_5 + 0.94\ X_7 + 0.89\ X_8$	10.20	440.59
13	$Y = 0.96\ X_1 + -0.45\ X_2 + 3.10\ X_3 + 0.43\ X_5 + 0.91\ X_7$	12.12	523.10
14	$Y = 0.93\ X_1 + 1.68\ X_3 + 0.59\ X_5 + 0.94\ X_7 + 0.89\ X_8$	12.08	521.72
15	$Y = -0.33\ X_2 + 2.77\ X_3 + 0.50\ X_5 + 1.07\ X_6 + 0.96\ X_7$	12.14	523.98
16	$Y = 0.95\ X_1 + -0.64\ X_2 + 3.18\ X_3 + 0.42\ X_5 + 1.10\ X_6 + 0.94\ X_7$	13.93	601.58
17	$Y = 0.91\ X_1 + 0.68\ X_2 + 1.88\ X_3 + 0.63\ X_5 + 0.97\ X_7 + 0.90\ X_8$	13.90	600.09
18	$Y = 0.80\ X_2 + 1.43\ X_3 + 0.70\ X_5 + 1.22\ X_6 + 0.99\ X_7 + 0.89\ X_8$	13.97	602.98
19	$Y = 0.92\ X_1 + 0.64\ X_2 + 1.41\ X_3 + 1.50\ X_4 + 0.62\ X_5 + 1.12\ X_6 + 0.97\ X_7$	15.49	668.74
20	$Y = 0.89\ X_1 + 0.41\ X_2 + 1.92\ X_3 + 0.61\ X_5 + 1.26\ X_6 + 1.00\ X_7 + 0.89\ X_8$	15.72	678.77
21	$Y = 2.12\ X_2 - -0.38\ X_3 + 1.49\ X_4 + 0.92\ X_5 + 1.25\ X_6 + 1.01\ X_7 + 0.88\ X_8$	15.53	670.30
22	$Y = 0.86\ X_1 + 1.88\ X_2 + -0.11\ X_3 + 1.57\ X_4 + 0.84\ X_5 + 1.30\ X_6 + 1.04\ X_7 + 0.88\ X_8$	17.25	744.59

X_1 : Theoretical yield of alcohol X_2 : Brix percent X_3 : Sucrose percent
X_4 : Commercial cane sugar percent X_5 : Juice purity percent X_6 : Pol % cane
X_7 : Total sugars percent X_8 : Commercial cane sugar yield

Table 2. Top ranking genotypes (10%) based on the best selection index for Theoretical yield of alcohol in sugarcane

Rank	Theoretical yield of alcohol (g/100 ml)		
	Genotype	Mean	Index score
1	2010T-88	13.93	216
2	2010T-53	10.23	211
3	2010T-239	13.19	207
4	2010T-4	10.83	204
5	2010T-18	13.65	203
6	2010T-16	14.01	203
7	2010T-82	11.47	203
Mean of the above seven genotypes		12.47	
Population mean		9.16	
% gain over Population mean		136.19	

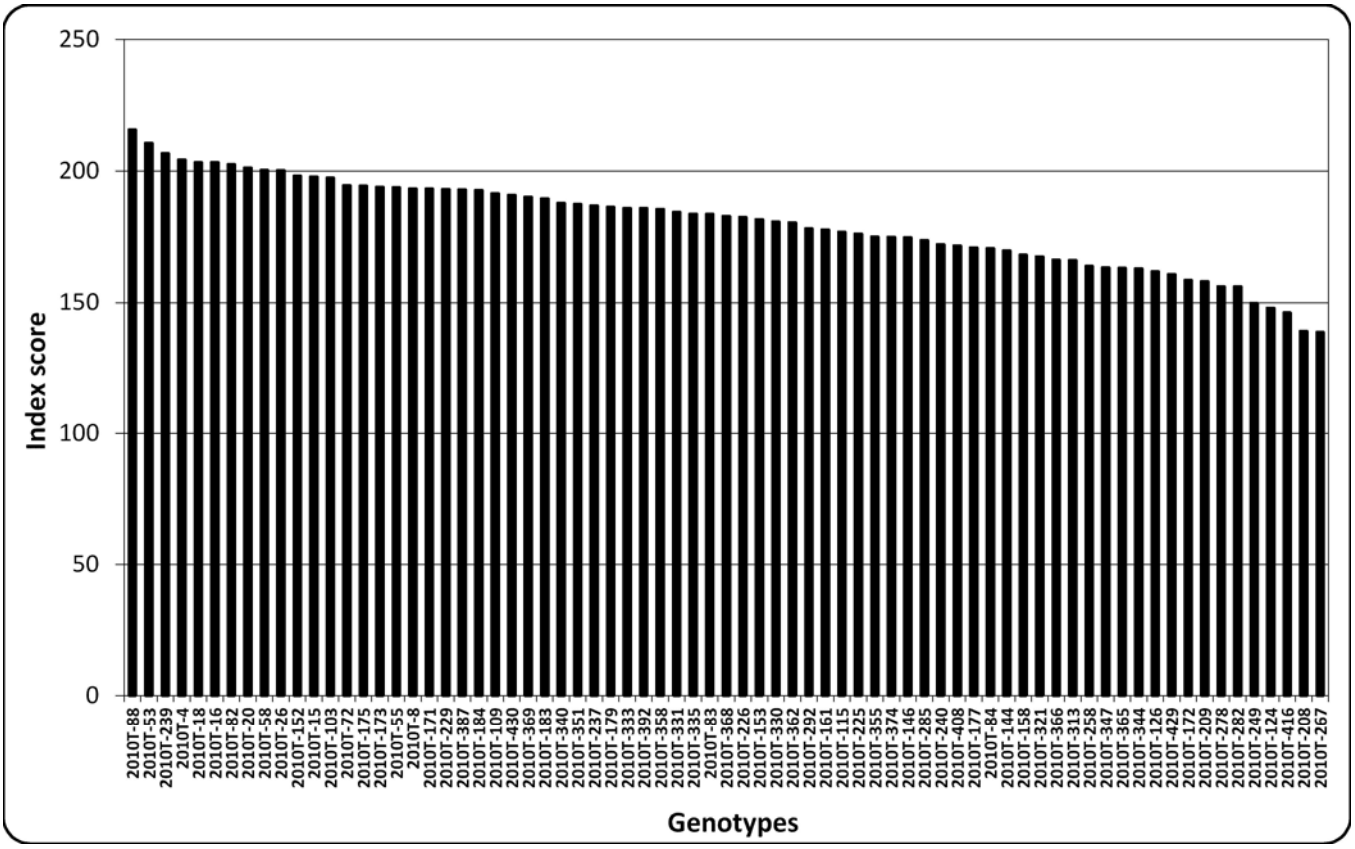

Fig. 1. Selection index score of sugarcane genotypes of theoretical yield of alcohol

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(Received on 23-03-2015 and revisedon 15-04-2015)

Andhra Pradesh J Agril. Sci : 1(1): 16-20, 2015

EVALUATION OF EARLY MATURING SUGARCANE CLONES FOR CANE YIELD, ITS COMPONENTS AND JUICE QUALITY PARAMETERS IN PLANT AND RATOON CROPS

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ABSTRACT

The performance of early maturing clones was assessed for cane yield, its components and juice quality parameters in two plant crops and ratoon crop during the year 2010-11 and 2011-12. The experiments were conducted at Agriculture Research Station, Perumallapalle, Chittoor, Andhra Pradesh. Ten sugarcane clones in early maturity group were tested against three standard checks. Two clones viz., 2006T3 and 2006T36 were observed to be significantly superior for cane and commercial cane sugar yield and red rot resistant compared to standards Co 94008, Co 85004 and Co 6907 in the first and second plant crops. In the ratoon crop also 2006T3 and 2006T36 clones were found superior for cane and sugar yields against the standards. Juice quality traits viz., sucrose %, commercial cane sugar % and purity % of new clones viz., 2006T3 and 2006T36 were also be superior over the standard checks. Red rot screening for the clones was done by plug method for three different pathotypes that are prevalent in the zone.

KEY WORDS: Cane yield, Juice Quality, Plant crop, Ratoon, Red Rot. Sugarcane

INTRODUCTION

Sugarcane (*Saccharum spp.* hybrids) is an important commercial crop and occupies an area of 2.0 lakh.ha in the Andhra Pradesh. It has a key role in the economic uplift of sugarcane growing farmers all over the country. To meet the needs of increasing population, crop production per unit area has to be increased as the possibility of increasing area under cultivation is meager. This is possible mainly through development of high yield potential varieties in addition to ideal agronomic practices and plant protection measures (Nair, 2009). Providing optimum soil moisture conditions throughout the crop growing period is therefore of paramount importance to realize higher yields (Sundara, 1998).Two clones viz., 2003V46 and 86V96 in early group are predominant covering about 75-80% of the total area in the south zone of Andhra Pradesh. Moisture stress is one of the major abiotic constraints of cane production in the zone. Among diseases, smut and red rot and borers and sucking pests among insect pests are the important biotic constraints. Cultivation of at least half a dozen clones in a particular sugar factory operational zone is essential so as to increase cane, sugar and jaggery yields and to extend cane crushing duration and to avoid genetic vulnerability. Keeping this in view, concerted and continuous efforts were made at Agricultural Research Station, Perumallapalle to evolve clones with high cane yield, juice sucrose and tolerant to major insect pests and diseases. Superior for cane yield, its components and also for juice quality traits. Through the present investigation an attempt has been made to identify sugarcane clones superior to the currently grown varieties for cane and sugar yields besides tolerance to red rot and smut.

MATERIAL AND METHODS

The present investigation was conducted with 10 clones in early group at Agricultural Research Station, Perumallapalle during 2010-11 and 2011-12 in two plant crops and ratoon crop. Each clone was grown in six rows of 5.0 m length with a spacing of 80 cm between rows. The design adopted was RBD with three replications. Recommended package of practices were followed in raising a healthy crop. Data were recorded on cane yield and juice quality parameters (Spencer and Meade 1963 and Meade and Chen, 1977) at harvest as per the standard procedures. Statistical analysis was carried out as suggested by Panse and Sukhatme (1978). Red rot screening was done by plug method for all the clones (Prasada Rao *et al.,* 1977). About 40 canes were inoculated by boring a hole at 3rd internode from ground level and injected with each pathotype and sealed with cotton. The

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inoculated canes were evaluated for the disease reaction based on the discriminant function value.

RESULTS AND DISCUSSION

Observations recorded on number of millable canes (NMC), cane yield and commercial cane sugar in plant and ratoon crops at harvest are presented in Table 1. Data on juice quality traits viz., brix (%), sucrose (%), purity (%) and CCS (%) recorded at harvest in plant and ratoon crops are given in Table 2. The results obtained are presented as detailed below.

Number of Millable Canes ('000/ha):

Among the test clones 2006T36 (104.0 and 92.7 thousands ha^{-1}) recorded significantly more number of millable canes over the standard Co94008 (85.0 and 72.4 thousands ha^{-1}) in I plant and ratoon crops, respectively (Table 1). However, 2006T8 recorded significantly more number of millable canes (100.8 thousands ha^{-1}) compared to all others test clones and best standard Co6907 (83.3 thousands ha-1) in ratoon crop. None of the test clones were found significantly superior over the standards for NMC in II plant crop.

Cane Yield (t ha^{-1}):

The comparative performance of early maturing sugarcane clones was judged against best standard Co 94008 and popular standard Co 6907. Cane yield ranged from 51.4 t ha^{-1} (2004A75) to 113.3 t ha^{-1} (2006T36) in test clones while standards Co 94008 and Co 6907 have recorded 60.8 and 50.7 t ha^{-1}, respectively in first plant crop (Table-1). In the second plant crop cane yield of test clones ranged from 108.4 t ha^{-1} (2004A75) to 150.2 t ha^{-1} (2006T19). The standard Co 94008 registered a cane yield of 129.3 t ha^{-1} (Table 1). Cane yields ranged from 71.1 t ha^{-1} (2004A75) to 136.6 t ha^{-1} (2006T3) among the test clones while standards Co 94008 and Co 6907 recorded 95.2 and 83.7 t ha^{-1}, respectively in ratoon crop. The clones 2006T3 (103.0 t ha^{-1} and 143.6 t ha^{-1}) and 2006T36 (113.3 t ha^{-1} and 140.8 t ha^{-1}) were found superior over the best standard Co94008 (60.8 and 129.3 t ha^{-1}) in first and second plant crops respectively. In the ratoon crop, 2006T3, 2006T36 and 2004A63 have recorded 136.6 t ha^{-1},135.6 t ha^{-1} and 132.2 t ha^{-1} of cane yields respectively and significantly superior over both standards Co94008 (83.7 t ha^{-1}) and Co6907 (95.2 t ha^{-1}).

Commercial Sugar Yield (t ha^{-1}):

Among the test clones CCS yield ranged from 6.1 (2004A75) to 11.7 t ha^{-1} (2006T36) in the first plant crop; from 12.8 (2004A75) to 18.6 t ha^{-1} (2006T3) in the second plant crop and from 9.1 (2004A75) to 17.0 t ha^{-1} (2006T36) in ratoon crop (Table 1). Between the two standards, Co94008 (7.8, 14.8 and 9.6 t ha^{-1}) was found superior for CCS yield in the first, second plant and ratoon crops, respectively. Two clones 2006T36 (11.7, 18.2 and 17.0 t ha^{-1}) and 2006T3 (11.4, 18.6 and 16.9 t ha^{-1}) recorded significantly higher CCS yields in the first, second plantand ratoon crops over both the standards. In the ratoon crop 2004A63 registered significantly higher CCS yield (over the best standards Co6907 (12.1 t ha^{-1}) in ratoon crop.

Juice Quality Traits:

Data on brix (%), sucrose (%), purity (%) and CCS (%) recorded at harvest in plant crops and ratoon crop are presented in Table 2. Brix percent varied from 19.1 (2006T36) to 21.0 (2004A63) with a mean value of 19.7 % in first plant crop. None of the test clones were found superior over the best standard Co94008 (20.3%). Percent juice sucrose ranged from 15.5(2006T36) to 17.5 (2004A63) in I plant crop compared to standards Co 94008 (18.3%) and Co 6907 (16.6%). The standard Co94008 recorded higher percent juice purity (90.0) and CCS percent (12.8) at harvest in the first plant compared to all the clones tested in the study.

In the second plant crop two clones viz., 2006T36 and 2006T23 (20.4%) recorded percent brix on par with the standard Co 94008 (19.1%). The test clones recorded juice sucrose ranging from 13.1% (2006T8) to 18.5% (2006T36) in the second plant crop. For percent juice sucrose and purity 2006T36 (18.5 and 90.6%) and 2006T3 (18.3 and 92.6%) were found recorded significantly superior to the standard Co94008 (16.7 and 87.4%). The clones 2006T36 (12.9%), 2006T3 (13.0%) and 2006T23 (12.7%) recorded significantly higher CCS values compared to the standard Co94008 (11.5%).

All the test clones except 2006T23 have registered higher mean values for percent brix, sucrose and CCS at harvest in ratoon crop compared to the standard Co94008 but on par with popular standard Co6907. The test clones and standards were found as par with each other for percent purity at harvest. Percent sucrose ranged from 16.8 (2006T23) to 18.5 (2006T36) in the ratoon crop among the test clones.

Table 1. Performance of early maturing sugarcane clones for NMC, cane and CCS yield at harvest

S. No.	Genotype	NMC (000' ha^{-1})			Cane yield (t ha^{-1})			CCS yield (t ha^{-1})		
		I plant	II plant	Ratoon	I plant	II plant	Ratoon	I plant	II plant	Ratoon
1	2006T36	104.0	83.7	92.7	113.3	140.8	135.6	11.7	18.2	17.0
2	2006T3	78.0	83.8	90.6	103.0	143.6	136.6	11.4	18.6	16.9
3	2006T8	81.0	90.5	100.8	77.4	145.3	96.0	9.3	13.1	11.8
4	2004A63	82.0	81.1	92.1	76.6	122.3	132.2	9.0	14.8	16.9
5	2006T23	89.0	88.7	82.6	75.9	127.3	98.0	8.5	16.1	11.4
6	2006T19	78.0	87.6	93.5	72.7	150.2	82.9	8.6	15.1	10.2
7	2004A55	90.0	80.4	83.2	64.6	109.3	92.8	7.5	13.2	11.7
8	Co94008 (S)	85.0	83.0	72.4	60.8	129.3	83.7	7.8	14.8	9.6
9	2004A75	65.0	72.4	51.8	51.4	108.4	71.1	6.1	12.8	9.1
10	Co6907(S)	84.0	-	83.3	50.7	-	95.2	5.7	-	12.1
	Mean	83.5	85.3	84.3	74.6	128.8	102.4	8.6	15.0	12.7
	CD at 5%	10.4	8.5	13.1	12.3	16.0	14.4	1.2	2.2	1.7
	SE m	3.5	2.8	4.4	4.1	5.3	4.8	0.4	0.7	0.6
	CV (%)	7.2	5.8	9.0	9.5	7.2	8.1	8.2	8.4	7.9

Table 2. Performance of early maturing sugarcane clones for juice quality parameters at harvest

S. No.	Genotype	Brix (%)			Sucrose (%)			Purity (%)			CCS (%)		
		I plant	II plant	Ratoon	I plant	II plant	Ratoon	I plant	II plant	Ratoon	I plant	II plant	Ratoon
1	2006T36	19.1	20.4	20.5	15.5	18.5	18.1	81.3	90.6	88.5	10.3	12.9	12.5
2	2006T3	19.5	19.8	20.3	16.4	18.3	17.9	84.0	92.6	88.5	11.1	13.0	12.4
3	2006T8	19.3	15.0	21.2	17.3	13.1	18.1	89.8	87.6	85.2	12.1	9.0	12.3
4	2004A63	21.0	19.9	21.0	17.5	17.6	18.5	83.3	88.4	87.9	11.8	12.2	12.8
5	2006T23	18.2	20.4	18.9	16.2	18.3	16.8	89.2	89.4	88.8	11.2	12.7	11.6
6	2006T19	19.7	18.8	20.2	17.2	15.2	17.8	87.4	80.8	88.3	11.8	10.0	12.3
7	2004A55	19.7	19.6	21.5	17.0	17.4	18.5	86.6	88.8	86.0	11.7	12.1	12.6
8	Co94008 (S)	20.3	19.1	19.2	18.3	16.7	16.7	90.0	87.4	87.4	12.8	11.5	11.5
9	2004A75	20.3	19.5	20.7	17.5	17.1	18.5	86.2	87.6	89.0	11.9	11.8	12.8
10	Co6907(S)	19.7	-	20.4	16.6	-	18.3	84.6	-	89.5	11.3	-	12.7
	Mean	19.7	19.2	20.4	17.0	16.9	17.9	86.2	88.3	87.9	11.6	11.7	12.4
	CD at 5%	1.4	1.2	1.0	1.1	1.3	0.6	NS	3.2	NS	1.0	1.0	0.6
	SE m	0.5	0.4	0.3	0.4	0.4	0.2	1.9	1.1	1.2	0.3	0.3	0.2
	CV (%)	4.2	3.7	2.8	3.8	4.5	2.1	3.8	2.1	2.4	4.8	5.1	2.6

NS: Non significant

Screening against Red rot disease:

Screening for red rot against major pathotypes viz., Cf261, Cf 419, Cf671 both by nodal method and plug methods indicated that the clone 2006T3is resistant against all the pathotypes through nodal method of testing. However, in the plug method 2006T3 showed resistant reaction against Cf 419, Cf671 pathotypes but susceptible reaction 261 pathotype. The clone 2006T36 was found resistant against all the pathotypes under nodal method of testing but resistant against Cf671 isolate and moderately resistant against Cf261 and Cf 419 isolates in plug method.

From the above results it can be concluded that new clones viz., 2006T3 and 2006T36 over found promising in early group. The clone 2006T3 is also resistant to red rot under plug and nodal method of red rot testing. It is also significantly superior for cane yield, per cent juice sucrose and CCS yield in plant and ratoon crops over the standards.

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(Received on 27-03-2015 and revised on 19-04-2015)

Andhra Pradesh J Agril. Sci : 1(1): 21-26, 2015

EFFECT OF DIFFERENT CONCENTRATIONS OF 2, 4-D AND BAP ON CALLOGENESIS IN SUGARCANE CLONES

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ABSTRACT

Studies were carried out to establish an efficient system for callus induction in two sugarcane clones (2008T42 and 2009T5) during 2012. Leaf rolls were used as explants for callus induction. Two growth regulators, 2, 4-D and BAP with different concentrations (1-5 mg l^{-1}) were used for callus induction. Cultures were placed in 24 hours dark at 24 ± 2°C with 70% relative humidity. The two sugarcane clones (2008T42 and 2009T5) exhibited better response for callus induction in 2, 4-D at 4 mg l^{-1} with minimum number of days taken for callus initiation (9.7 - 10.2), maximum number of explants inducing callus (6.00) and the highest callus induction frequency (100 per cent).

KEY WORDS: BAP, Callus induction, 2, 4-D, Leaf roll

INTRODUCTION

Sugarcane (*Saccharum officinarum*) is one of the most important cash crops in India majorly used to produce cheap food in the form of sugar and gur that further lends itself for energy production. In order to meet the demands there is a need to increase cane productivity as expansion of area may not be possible. Sugarcane succumbs to decline because of its clonal propagation and increased incidence of diseases and pests over years. One of the major reason for low productivity is lack of quality seed material. Plant regeneration through tissue culture technique would be a better alternative for improving the quality of seed thereby production. Callus production is an essential step in the use of tissue culture studies for various physiological phenomena inducing resistance against various biotic and abiotic stresses. Callus is an unorganized, proliferative mass of predominantly parenchyma cells. The pioneering work on *in vitro* studies in sugarcane was conducted by Nickell (1964) who established first sugarcane callus cultures from mature internodal parenchyma tissue. Heinz *et al*. (1977) reported callus formation from parenchyma tissue of shoot apex and leaves of *Saccharum* spp. on MS (Murashige and Skoog, 1962) medium containing coconut water (10 per cent) and 2, 4-D.

Studies have suggested that amongst all the media tested for callus induction and proliferation by different workers, the best medium was modified MS medium (Liu and Chen, 1974; Guiderdoni, 1986; Aftab *et al*., 1996 and Baksha *et al*., 2002). Role of auxins have also been studied for callus induction and proliferation. Nadar *et al*. (1978) found that embryogenic callus forms when auxin is added to the medium. On the other hand, no embryogenesis was observed in callus cultures on auxin-free media. Callus proliferation in modified MS medium with various levels of auxins and cytokinins in sugarcane was also reported by Bhansali and Singh (1982) and Zang *et al*. (1983). Studies have shown that amongst different auxins tested for callus induction, addition of 2, 4-D in the medium always produced better callus growth than any other growth regulator. Kulkarni (1989) reported that callus induction and proliferation from immature sugarcane leaves triggers on medium containing 2, 4-D. Karim *et al*. (2002) while working on two sugarcane varieties, (Isd-16 and Isd-28) observed that the highest percentage of callus induction was obtained on MS basal medium supplemented with 3.0 mg l^{-1} 2, 4-D and 10 per cent coconut milk. Similarly, Mamun *et al*. (2004) also found that among all the tested auxins (IAA, 2, 4-D, IBA, and NAA), the best performance for callus induction was obtained on 3.0 mg l^{-1} 2, 4-D. The present study was taken up to know the effect of different concentrations of 2, 4-D along with BAP on callogenesis in sugarcane clones.

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MATERIAL AND METHODS

Pre-release sugarcane clones, 2008T42 (mid late) and 2009T5 (early) were chosen for the present investigation during 2012 at ARS, Perumallapalli. The plants were raised and maintained under field conditions as per the recommended agronomic practices. These plants served as the source of explants for all the *in vitro* studies conducted during the course of investigation.

Disease free and young sugarcane tops of 2008T42 and 2009T5 were selected from the top portion of plant. Spindle from the top was excised after removing young leaves. The collected explants were partially trimmed off and treated with 0.5 g l^{-1} ascorbic acid and 1.0 g l^{-1} PVP (Poly vinyl pyrrolidone) mixture followed by washing with liquid detergent water containing a few drops of Tween-20 (20 ml l^{-1}) for 5-10 minutes. After that explants were kept in an aqueous mixture solution of bavistin (10 g l^{-1}) and streptomycin (1 g l^{-1}) for 10-15 minutes. These explants were washed with sterile deionizing water for 3-5 washings, each for 3-5 minutes. Sterilization was done first with sodium hypochlorite (3.0%) for approximately 10 minutes. They were then sterilized with ethyl alcohol (70%) for 30 seconds and washed with sterile distilled water for 2-3 times. These last two steps were performed inside a laminar flow hood to maintain the aseptic condition of the explant and to prevent the reintroduction of contaminating microbes.

The cultures were incubated in a culture room maintained at a temperature of 25 ± 2°C, relative humidity of 70 per cent and 16 hours of photoperiod with light intensity of 2500 lux. Subcultures were done every 2-3 weeks according to the need of the experiment. Different concentrations of 2, 4-D and BAP were tried individually such as 2, 4-D (1.0, 2.0, 3.0, 4.0 and 5.0 mg l^{-1}) and BAP (1.0, 2.0, 3.0, 4.0 and 5.0 mg l^{-1}) with MS basal medium for callus induction.

RESULTS AND DISCUSSION

Among different concentrations of 2, 4-D and BAP, mean number of explants that induced callus ranged from 0.33 to 6.00 (Table 1). Maximum number of explants (6.00) that induced callus was recorded with 4 mg l^{-1} of 2, 4-D (T_4 and T_9) and minimum number of explants (0.33) that induced callus was recorded with 1 mg l^{-1} of BAP (T_{11} and T_{16}) in both sugarcane clones, 2008T42 and 2009T5. Callus with respect to 2, 4-D, maximum number of explants that induced callus was observed with 4 mg l^{-1} (T_4 and T_9) in both 2008T42 and 2009T5 followed by 3 mg l^{-1} in 2009T5 (T_8) and minimum in 1 mg l^{-1} (T_1 and T_6) for two sugarcane clones. Whereas in case of BAP 5 mg l^{-1} (T_{15} and T_{20}) had recorded maximum number of explants that induced callus followed by 4 mg l^{-1} (T_{19}) Minimum number of explants induced callus in both 2008T42 and 2009T5 with 1 mg l^{-1} (T_{11} and T_{16}). The clone, 2009T5 exhibited better response for mean number of explants inducing callus in different concentrations of 2, 4-D. whereas 2008T42, showed better response in BAP. In both growth hormones 2, 4-D was found to be better for callus induction in 2008T42 and 2009T5.

Mean number of days taken for callus initiation ranged from 9.7 to 31.8 (Table 1). Among all the treatments maximum number days (31.8) taken for callus initiation was recorded with 1 mg l^{-1} of BAP (T_{11}) in 2008T42 and minimum number days (9.7) was recorded with 4 mg l^{-1} 2, 4-D (T_4) in 2008T42. The concentration of 4 mg l^{-1} of 2, 4-D (T_4 and T_9) had recorded minimum number of days taken for callus initiation in both the clones followed by 3 mg l^{-1} (T_4) and 5 mg l^{-1} (T_5) in 2008T42. In contrast, both the clones took maximum number of days with 1 mg l^{-1} and 2 mg l^{-1}. With respect to BAP maximum number of days taken for callus initiation was recorded at 1 mg l^{-1} (T_{11} and T_{16}) in both sugarcane clones followed by 2 mg l^{-1}. Whereas, minimum number of days for callus initiation was recorded at 5 mg l^{-1} of BAP in both the clones. A minimum mean number of days taken for callus initiation was recorded in 2, 4-D treatments than BAP treatments. Within the concentrations of 2, 4-D, 2008T42 recorded minimum number of days than 2009T5. The clone, 2009T5 was found to have taken minimum number of days for callus initiation with BAP treatments when compared with 2008T42.

Callus induction frequency ranged from 5.50 to 100 percent in different concentrations of 2, 4-D and BAP (Table 1). Among all treatments, 1 mg l^{-1} of BAP showed poor response towards callus induction as it accounted only 5.50 percent and the highest response was recorded (100 per cent) with 4 mg l^{-1} of 2, 4-D in both sugarcane clones. In case of 2, 4-D the concentration of 4 mg l^{-1} had recorded 100 per cent callus induction in 2008T42 and 2009T5 and the lowest frequency was recorded in 2008T42 (55.56 percent) and in 2009T5 (61.06 percent) with 1 mg l^{-1} of 2, 4-D. Whereas in case of BAP, the concentration of 5 mg l^{-1} recorded the highest callus induction frequency of 49.39 per cent in 2008T42 and 50.33 per cent in 2009T5. The lowest frequency was

Table 1. Effect of different concentrations of 2, 4-D and BAP on callus formation in sugarcane clones

Treatments	Variety	MS media + Growth Hormones	Mean no. of explants induced callusing	Callus induction frequency (%)	Mean no. of days for callus initiation
T_1	2008T42	2, 4-D 1 mg l^{-1}	3.33	55.56 (48.17)	15.9
T_2	2008T42	2, 4-D 2 mg l^{-1}	3.83	63.89 (53.04)	13.9
T_3	2008T42	2, 4-D 3 mg l^{-1}	5.33	88.89 (70.51)	12.5
T_4	2008T42	2, 4-D 4 mg l^{-1}	6.00	100.00 (90.00)	9.7
T_5	2008T42	2, 4-D 5 mg l^{-1}	5.00	83.33 (65.87)	12.7
T_6	2009T5	2, 4-D 1 mg l^{-1}	3.66	61.06 (51.36)	16.0
T_7	2009T5	2, 4-D 2 mg l^{-1}	4.33	72.22 (58.17)	14.5
T_8	2009T5	2, 4-D 3 mg l^{-1}	5.66	94.39 (76.26)	12.6
T_9	2009T5	2, 4-D 4 mg l^{-1}	6.00	100.00 (90.00)	10.2
T_{10}	2009T5	2, 4-D 5 mg l^{-1}	5.21	88.89 (70.51)	13.2
T_{11}	2008T42	BAP 1 mg l^{-1}	0.33	5.50 (13.55)	31.8
T_{12}	2008T42	BAP 2 mg l^{-1}	0.66	11.00 (19.36)	30.2
T_{13}	2008T42	BAP 3 mg l^{-1}	1.60	26.78 (31.14)	29.0
T_{14}	2008T42	BAP 4 mg l^{-1}	2.08	34.72 (36.08)	26.9
T_{15}	2008T42	BAP 5 mg l^{-1}	3.14	49.39 (44.63)	23.4
T_{16}	2009T5	BAP 1 mg l^{-1}	0.33	5.50 (13.55)	31.2
T_{17}	2009T5	BAP 2 mg l^{-1}	0.66	11.00 (19.36)	30.2
T_{18}	2009T5	BAP 3 mg l^{-1}	1.95	32.61 (34.88)	26.9
T_{19}	2009T5	BAP 4 mg l^{-1}	2.15	35.83 (36.75)	24.5
T_{20}	2009T5	BAP 5 mg l^{-1}	3.02	50.33 (45.77)	21.7
C.D at 5%			0.061	0.751	0.751
(±) SE(m)			0.021	0.262	0.260

Values in parentheses represent arc sine transformed values

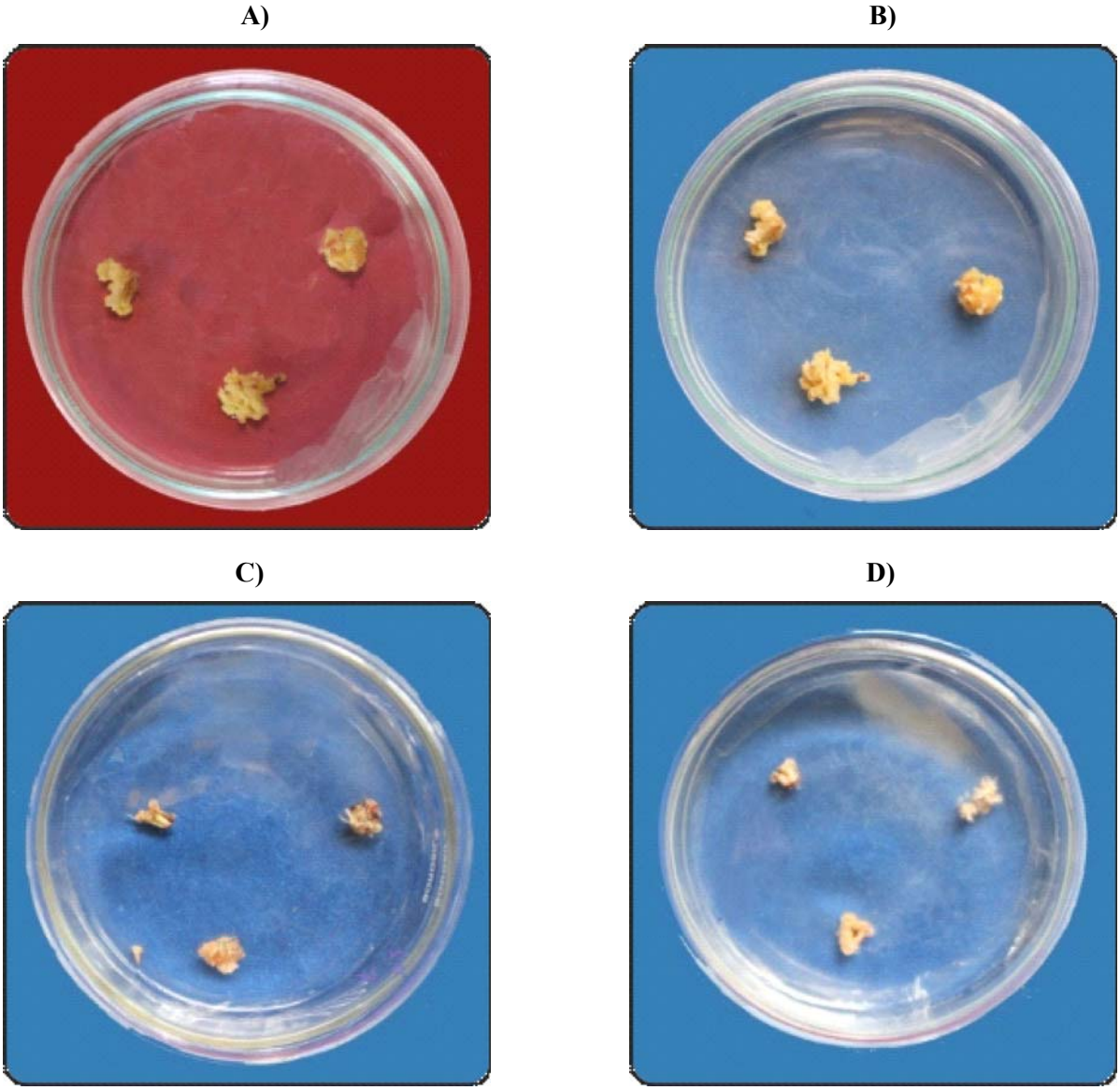

Fig. 1. A) Callus induction in 2008T42 at 4 mg l^{1} 2, 4-D; B) Callus induction in 2009T5 at 4 mg l^{-1} 2, 4-D; C) Callus induction in 2008T42 at 1 mg l^{-1} BAP; D) Callus induction in 2009T5 at 1 mg l^{-1} BAP

recorded as 5.50 per cent in both 2008T42 and 2009T5 at 1 mg l^{-1} of BAP. In both the clones, it was observed that callus induction frequency was maximum with 2, 4-D than BAP. The clone, 2009T5 exhibited superior response in both treatments of 2, 4-D and BAP than 2008T42.

The results revealed that the two sugarcane clones (2008T42 and 2009T5) exhibited better response with 2, 4-D than BAP in all hormonal treatments for callus induction with minimum number of days taken for callus initiation, maximum number of explants that induced callus and the highest callus induction frequency. Callus formation occurred in all the concentrations of 2, 4-D but in case of BAP it was poor in 1mg l^{-1} and 2 mg l^{-1} concentrations. The explants showed slight swelling at 1mg l^{-1} and 2 mg l^{-1} of BAP and subsequently dried. Thus it was observed that presence of auxin (2, 4-D) is essential for callus induction. Similar results were also reported by Islam *et al*. (1996) and Hossain *et al*. (1996). 2, 4-D was significantly effective in the initiation of callus for sugarcane clones. The development of callus from immature leaf roll explants is directly related to the presence of 2, 4-D which is a suitable growth hormone responsible for callus induction in most plant species in plant tissue culture work. This is similar to the findings

of Mamun *et al*. (2004) and Baksha *et al*. (2002). The production of callus at cut edge of explant may be due to the wound caused during the process of cutting which resulted in a synchronous cell division. This is a process of de-differentiation of organized tissue as was opined by Hamish and Sue (1989), Pellegrinechi *et al*. (2004), Qin *et al.* (2005) and Xing *et al*. (2010). Among all the treatments, 4 mg l^{-1} of 2, 4-D was proved to be the best for callus induction in sugarcane clones (Fig 1). The results are in agreement with results obtained by Chanwit (1994), Mannan and Amin (1999) and Tahir *et al*. (2011) on different genotypes of sugarcane. Callus induction was gradually enhanced with increase in concentrations of 2, 4-D. This observation was supported by Sani and Mustapha (2010), Qin *et al*. (2005) and Xing *et al*. (2010).

The results also revealed that there was slight genotypic difference in callus induction. The sugarcane clone 2009T5 showed better response than 2008T42 with different concentrations of the two hormones. Similar genotypic differences were also reported by Taylor et *al.* (1995) and Shahid *et al*. (2011). The number of days taken for callus induction decreased with increased concentrations of 2, 4-D and BAP. Number of explants initiating callus and callus induction frequency increased with increased concentration of 2, 4-D and BAP.

CONCLUSION

Callus induction as measured by minimum number of days taken for callus initiation (9.7 -10.2), maximum number of explants inducing callus (6.00) and the highest callus induction frequency (100 per cent) was higher with 4 mg l^{-1} of 2, 4-D than BAP in two sugarcane clones 2009T5 and 2008T42. The sugarcane clone 2009T5 showed better response than 2008T42 with different concentrations of the two hormones. Hence 4 mg l^{-1} of 2, 4-D can be considered as the basic requirement for callusing in sugarcane for proceeding further investigations like micropropagation and production of somaclonal variants.

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(Received on 28-04-2015 and revised on 10-05-2015)

Andhra Pradesh J Agril. Sci : 1(1): 27-29, 2015

EFFECT OF MICROBIAL PESTICIDES AGAINST THE LARVAE OF CITRUS LEAF MINER, *Phyllocnistis citrella* STAINTON IN CITRUS NURSERY

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ABSTRACT

The microbial pesticides viz., *Bacillus thuringiensis* (Berl.), *Beauveria bassiana* (Balsanco) Viegas, *Metarhizium anisopliae* (Metschnikoff) Sorkin, *Verticillium lecani* (Zimm.) Viegas and *Nomuraea rileyi* (Farlow) Samson were evaluated against the larvae of citrus leaf miner, *Phyllocnistis citrella* Stainton during 2010 at AICRP on Citrus, Tirupati. The results revealed that all the microbials proved pathogenic to citrus leaf miner larvae with varied mortality. *B. thuringiensis* was proved highly effective and recorded 96.76 per cent mortality on 10th day. In fungal treatments, the initial mortality was noticed on 6th day after treatment. *Nomuraea rileyi* offered superior control against citrus leaf miner by recording highest mortality of 79.36 per cent reduction in population. *M. anisopliae* also proved effective and occupied second position among the fungal pathogens (78.38%) and *B. bassiana* (64.79%) and *V. lecani* (59.17%) were proved less effective compared to *N. rileyi* and *M. anisopliae*.

KEY WORDS: Citrus, Citrus leaf minor, Microbial pesticides

INTRODUCTION

India is one of the major citrus producing countries in the world, sweet orange having an area of 21.9 lakh hectares with production of 262.9 tonnes annually with the productivity of 9.6 metric tonnes per hectare. In India, Andhra Pradesh occupies a prominent position covering an area of 4.58 lakh ha with an annual production of 686.6 lakh metric tonnes of fruits with productivity of 15.0 metric tones per hectare (Indian Horticulture Database - 2013). Pest problem is one of the major constraints in the citrus nurseries. According to Ramasubba Reddy *et al.,* (1989) 55 species of pests were reported on citrus in Chittoor district. Although a large number of pests attack citrus, citrus leaf miner (*Phyllocnistis citrella* Stainton) is one of the regularly occurring pests causing severe damage to nurseries and tender foliage of bearing trees. Though chemical control of insect pests offers effective results, indiscriminate application cause insect resistance, pest resurgence, secondary out break of pests and destruction of natural enemies. With a view of reduce adverse effects of chemical pesticides, certain microbials viz., *Bacillus thuringiensis* (Berl.), *Beauveria bassiana* (Balscano) Viegas, *Metarhizium anisopliae* (Metschnikoff) Sorkin, *Verticillium lecani* (Zimm.) Viegas and *Nomuraea rileyi* (Farlow) Samson were evaluated against *P. citrella* under field condition.

MATERIAL AND METHODS

Field studies were carried out at All India Coordinated Research Project on Tropical Fruits (Citrus), Tirupati during 2010 with six treatments, viz., *B.thuringiensis*, *B. bassiana*, *M. anisopliae*, *V. lecani* and *N. rileyi* and untreated check. The experiment was conducted on one year old sweet orange nursery in randomized block design with four replications. Each treatment consisted of bed size 2 × 1 m. The required quantity of powdered formulation (2 g L^{-1}) was mixed in water with surfactant labolene (1 ml L^{-1}) and used for spray. *N. rileyi* was mass multiplied on rice media and tested at spore suspension of 4 × 10^7 spores ml^{-1}. The observations on larval population were recorded on one day before spraying and 2, 4, 6, 8 and 10 days after spraying (DAS).

RESULTS AND DISCUSSION

Pathogenicity of microbials were tested against citrus leaf miner *Phyllocnistis citrella*. The data was presented in Table 1. *B. huringiensis* recorded initial mortality on 2nd day (35.43%) and the efficacy was increased 4 days after treatment (61.42%) and recorded 96.76 per cent mortality at 10 days after treatment (DAT). Among all the fungal treatments, *N. rileyi* recorded initial mortality

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Table 1. Effect of microbial pesticides against citrus leaf miner *Phyllocnistis citrella* larval population reduction (Field experiment) during 2010

S. No.	Treatments	Dosage	Precount	Population reduction (%)*				
				2 DAS	4 DAS	6 DAS	8 DAS	10 DAS
1.	*Bacillus thuringiensis*	2 g lit^{-1}	16.25	35.43 (36.53)	61.42 (51.61)	82.84 (65.54)[a]	90.51 (72.35)[a]	96.76 (79.65)[a]
2.	*Beauveria bassiana*	2 g lit^{-1}	18.00	0 (0.00)	0 (0.0)	31.29 (34.00)[c]	47.85 (43.77)[d]	64.79 (53.62)[c]
3.	*Verticillium lecanii*	2 g lit^{-1}	16.50	0 (0.00)	0 (0.00)	29.87 (33.13)[c]	45.18 (42.24)[d]	59.17 (50.29)[c]
4.	*Metarhizium anisopliae*	2 g lit^{-1}	18.00	0 (0.00)	0 (0.00)	39.40 (38.88)[b]	56.79 (48.85)[c]	78.38 (62.54)[b]
5.	*Nomuraea rileyi*	4×10^7 spore ml^{-1}	17.75	0 (0.00)	0 (0.00)	37.79 (37.93)[b]	61.15 (51.45)[b]	79.36 (63.33)[b]
6.	Untreated check	-		19.25	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
	CD at 5%			0.48	0.93	1.59	2.62	4.90

*Average of 4 replications
Figures in the parenthesis are angular transformations
DAS - Days after spraying

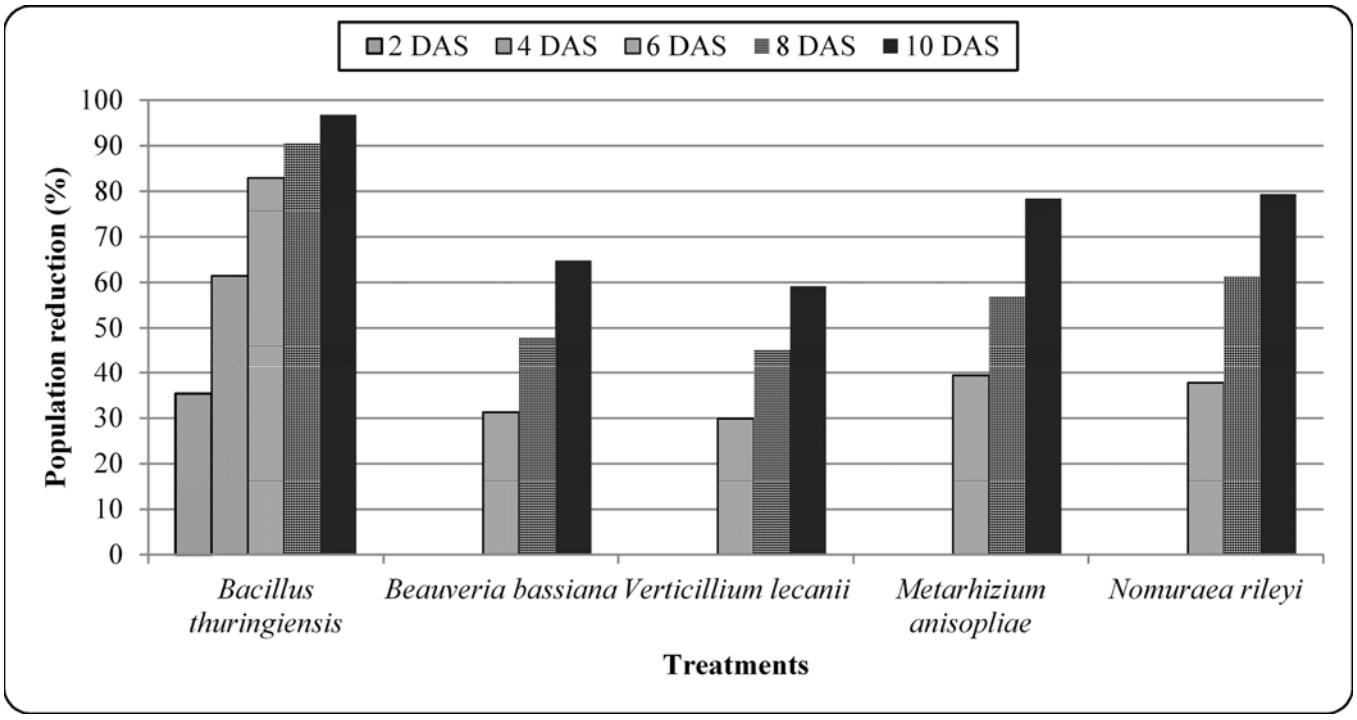

Fig. 1. Effect of microbial pesticides against citrus leaf miner *Phyllocnistis citrella* larval population reduction during 2010

on 6th day and highest population reduction on 10th day (79.36%). *M. anisopliae* also proved highly effective with 78.38 per cent mortality, while population reduction was comparatively low in *B. bassiana* (64.79%) in 10th day and *V. lecani* recorded 59.17 per cent mortality on 10th day. Among five fungal treatments *V. lecani* was found less effective and recorded low population reduction. The observations recorded on microbial pesticides revealed that *B. thuringiensis* infected larvae showed lack of mobility, rectal and oral discharge and the body colour changed rapidly from brown to black. The superiority of *B. thuringiensis* in the control of citrus leaf miner in the present study was supported with the findings of Carladias *et al.,* (2005) and Koteswara Rao (2004). Shapiro *et al.* (1998) reported that the organo silicon surfactant has direct or indirect toxicity and helps in the penetration of microbials against soft bodied insects and mites. Khyami - Horani and Atteyat (2002) reported that *B. thuringiensis* var. *kurstaki* showed highest toxicity after 3 days after application, when it was combined with sun spray oil or surfactant surfix. Observations were recorded on fungal treated larvae become limp and lost the elasticity. Two days after death, larval body became hardened and was covered with mycelium. Rajagopal *et al.,* (1988) made similar observation on the groundnut leaf miner larvae treated with *B. bassians*.

CONCLUSIONS

The microbial pesticides viz., *Bacillus thuringiensis* (Berl.), *Beauveria bassiana* (Balsanco) Viegas, *Metarhizium anisopliae* (Metschnikoff) Sorkin, *Verticillium lecani* (Zimm.) Viegas and *Nomuraea rileyi* (Farlow) Samson were evaluated against the larvae of citrus leaf miner, *Phyllocnistis citrella* Stainton. All the microbials proved pathogenic to citrus leaf miner larvae with different per cent mortality. *B. thuringiensis* was proved highly effective and recorded 96.76 per cent mortality on 10th day. In fungal treatments, the initial was observed mortality started on 6th day after treatment. *Nomuraea rileyi* offered superior control against citrus leaf miner by recording highest mortality of 79.36 per cent reduction in population. *M. anisopliae* also proved effective and occupied second position among the fungal pathogens (78.38%) and *B. bassiana* (64.79%) and *V. lecani* (59.17%) were proved less effective compared to *N. rileyi* and *M. anisopliae*.

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(Received on 23-03-2015 and revised on 14-04-2015)

Andhra Pradesh J Agril. Sci : 1(1): 30-32, 2015

EVALUATION OF CERTAIN NATURAL PRODUCTS AGAINST LARVAE OF CITRUS BUTTERFLY *Papilio demoleus* Lin.

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ABSTRACT

A field study was conducted to know the efficacy of various natural insecticides against larval population of citrus butterfly *P. demoleus* during 2011-12 at AICRP on Citrus, Tirupati. Among various natural insecticides Bt at both concentrations (0.005% and 0.025%) offered hundred percent mortality against citrus butterfly and retained its residual action upto ten days. The order of efficacy of rest of the treatments was NSKE (81.08%) azadirachtin (76.03%), neem soap (69.87%), pongamia oil (66.17%), pongamia soap (56.61%) and garlic extract (41.10%).

KEY WORDS: Citrus, Citrus butterfly, Natural products

INTRODUCTION

The genus "citrus" is unique in its diversity of forms and no other fruit can parallel to it. They are highly regarded for their nutritive value and economic significance. India is one of the principle citrus producing country in the world, having an area of 162 lakh ha with annual production of 12.31 lakh tonnes with productivity of 7.6 metric tonnes per ha. In India, Andhra Pradesh is prominent for citrus cultivation occupies a majestic position with an area of 42.7 lakh ha. having an annual production of 5.76 lakh tonnes of fruits with productivity of 13.5 metric tonnes per ha (Indian Horticulture database-2013).

Through out the world 823 species of different insect and mite pests were known to be associated with citrus (Ebeling, 1959). Out of these 165 species are important in India causing an estimated loss of 30 percent in yield (Pruthi and Mani, 1945). Among them, the citrus cater pillar *P. demoleus* can feed voraciously and cause extensive damage in the larval stage particularly to nursery plants and cause great loss to seedlings and young saplings leaving behind midribs only. Severe infestation resulted in entire defoliation of the tree (Butani and Jotwani, 1975). Though chemical control of insects offers quick results, indiscriminate use of insecticides lead to adverse effects, besides increasing the cost involved in plant protection with a view to reduce the negative effects of the chemical pesticides, certain natural insecticides were evaluated against *P. demoleus* under field conditions.

MATERIAL AND METHODS

To evaluate the efficacy of different natural insecticides against citrus butterfly, *P.demoleus* a field experiment was conducted at citrus improvement project on one and half year old Sathgudi sweet orange nursery plants during the year 2011-12. The experiment was conducted with nine treatments of natural insecticides in randomized block design with three replications in plot size 2 x 6 m for each treatment. An untreated check was maintained for comparative study. Each treatment was sprayed with three liters of spray solution using knap sack sprayer. The treatments imposed in the experiment were NSKE (5%), Azadirachtin (0.001%), neem soap (10 g lit^{-1}), pongamia oil (0.5 g lit^{-1}), Pongamia soap (10g lit^{-1}), garlic extract (20 g lit^{-1}), Bt (0.0025%) and (0.005%).

Larval population was recorded one day before spraying and at 1, 3, 5, 7, 10 and 14 days after spraying as post treatment counts. The larval mortality of butterfly was calculated for all the treatments and the data was subjected to statistical analysis.

Percent mortality was calculated by using the following formula

$$\text{Percent mortality} = \frac{\text{Number of larvae dead}}{\text{Initial laraval count}}$$

The percentages thus obtained were transformed into angular values and analyzed statistically.

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Table 1. Effect of Natural Insecticides on Larval Population of Citrus Butterfly on Sathgudi Sweet Orange (Curative Control) during 2011 and 2012

S. No.	Treatment	Concentration / dose (%)	Pre count population	Per cent larval mortality (Days after spraying)*					
				1	3	5	7	10	14
1.	Neem seed kernal extract (NSKE)	5	24.66	25.66 (30.40)	55.41 (48.10)	81.08 (63.51)	95.92 (78.32)	0.00 (0.00)	0.00 (0.00)
2.	Azadirachtin	0.0001	22.33	22.29 (28.18)	46.25 (42.82)	76.03 (60.67)	90.92 (72.44)	0.00 (0.00)	0.00 (0.00)
3.	Neem soap	10 g lit^{-1}	24.33	16.47 (23.97)	42.47 (40.69)	69.87 (56.37)	83.51 (66.03)	0.00 (0.00)	0.00 (0.00)
4.	Pongamia oil	0.5	23.00	10.35 (18.72)	26.83 (31.18)	56.61 (48.79)	61.14 (54.39)	0.00 (0.00)	0.00 (0.00)
5.	Pongamia soap	10 g lit^{-1}	22.66	13.27 (21.39)	33.81 (35.55)	66.17 (54.45)	70.60 (57.17)	0.00 (0.00)	0.00 (0.00)
6.	Garlic extract	20 g lit^{-1}	23.00	8.88 (17.36)	23.61 (29.06)	41.10 (39.87)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
7.	*Bacillus thuringiensis*	0.0025 (2.09×10^7)	21.33	46.80 (43.17)	85.88 (67.86)	100 (0.00)	100 (0.00)	100 (0.00)	0.00 (0.00)
8.	*Bacillus thuringiensis*	0.005 (4.23×10^7)	23.00	61.46 (51.65)	90.71 (72.24)	100 (0.00)	100 (0.00)	100 (0.00)	0.00 (0.00)
9.	Untreated check		21.66	-	-	-	-	-	-
	CD at 5%		10.08	5.86	4.62	7.81	1.12	-	-

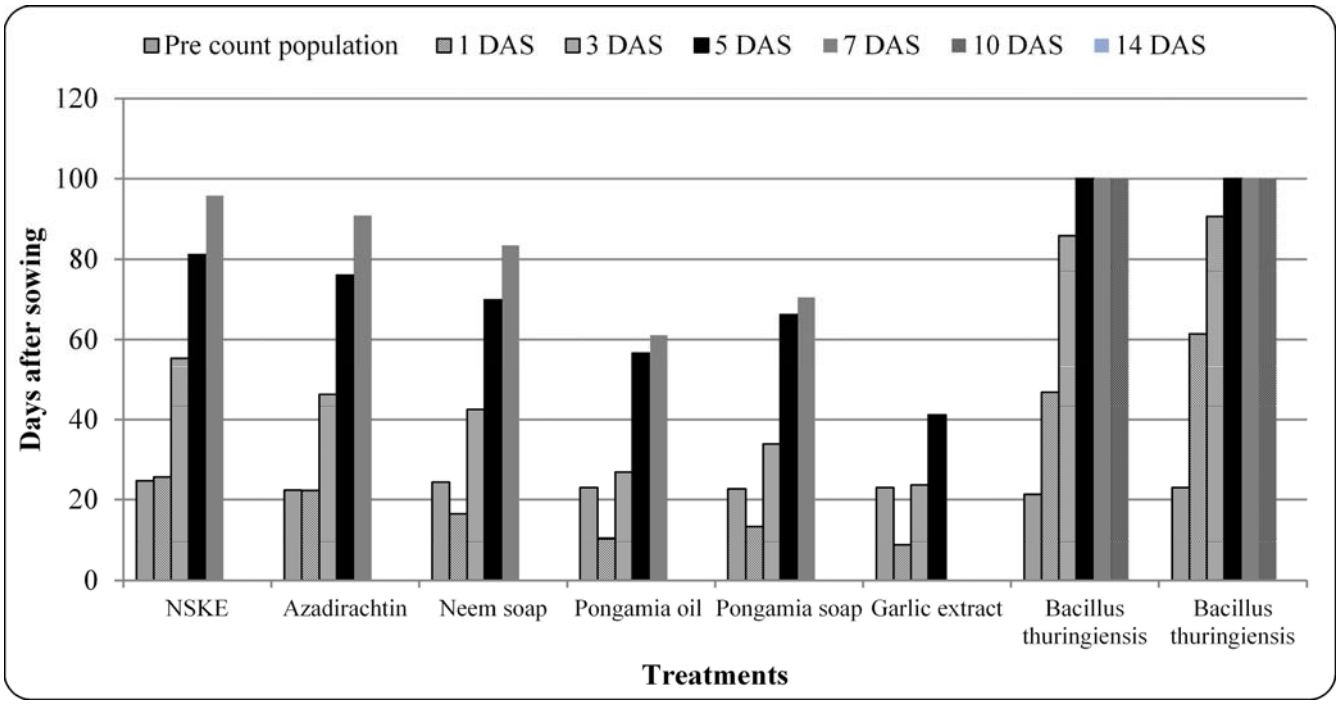

Fig. 1. Effect of Natural Insecticides on Larval Population of Citrus Butterfly on Sathgudi Sweet Orange

RESULTS AND DISCUSSION

The efficacy of insecticides was evolved by imposing the treatments after noticing butterfly larval damage. The data from Table 1 and Fig.1 revealed that all the insecticidal treatments were significantly superior to untreated check. At one day after spraying, the maximum population reduction was obtained in Bt 0.005 per cent (61.46%) followed by Bt 0.0025 per cent (46.80%). On third and fifth day also efficacy of all the insecticides was enhanced among which Bt at both concentrations offered hundred per cent mortality. Among botanicals NSKE (95.92%) was effective treatment followed by azadirachtin (90.92), neem soap (83.51%), pongamia soap (70.6%) and pongamia oil (61.14%). On all the days, garlic extract was found to be least effective treatment with only 41.10 per cent larval mortality. Except Bt, all other treatments lost their efficacy on seventh day, where as Bt (0.005% and 0.0025%) retained their residual action upto ten days. However on fourteenth day all the treatments lost their efficacy by recording new population of the pest. The superiority of *Bacillus thuringiensis* in the control of citrus butterfly *P. demoleus* in the present study was in agreement with the findings of Resham *et al.*(1986) and Johnson *et al.,* (1995). The effectiveness of neem products in controlling citrus butterfly was also reported by Chauke *et al.,* (1999).

ACKNOWLEDGEMENTS

The authors are grateful to the Head of Department of Entomology, ANGRAU (Tirupati) and AICRP on Tropical Fruits (Citrus) Tirupati for providing facilities.

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(Received on 23-03-2015 and revised on 14-04-2015)

Andhra Pradesh J Agril. Sci : 1(1): 33-38, 2015

POSITIVE INFLUENCE OF INTERCROPS ON COCCINELLID AND SPIDER FAUNA IN GROUNDNUT

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ABSTRACT

A field trial in RBD was conducted at S.V. Agricultural College, Tirupati to study the Positive influence of intercrops on coccinellid and spider fauna in groundnut during *kharif* 2011. The systems studied were groundnut + red gram, groundnut + castor (at 7 : 1 ratio), groundnut + cowpea, groundnut + field bean (at 6:1 ratio) and sole groundnut. Coccinellids and spiders were predominant during crop growth period. Various species of coccinellid predators were considered as a group, and their presence was recorded in all the cropping systems. All the spiders, irrespective of the family to which they belonged, were recorded together as one unit. Among the coccinellids, *Chelomenes sexmaculata* was the predominant predator which accounted for 70 per cent of the population. Spiders belonging to Lycosidae family were predominant. Population of coccinellids and spiders were increased up to 60 - 70 DAS and declined later. This may be due to availability of sufficient prey like aphids, jassids etc during vegetative stage of the crop. Change in microclimate due to shredded/shrinked foliage at later stages of the crop also may not favor the natural enemy fauna. The data showed that coccinellid population was comparatively high in groundnut + cowpea system (2.44 per plant). Aphids that prefer cowpea might have attracted the grubs and adults of coccinellids towards the crop, as coccinellids are the major predators of aphids. In the remaining intercrop systems also, significantly higher lady bird beetle population was observed. Spider population was comparatively higher in groundnut + field bean system (1.66 per plant) followed by groundnut + cowpea system (1.32 per plant). Other systems had 0.8-1.3 spiders per plant.

KEY WORDS: Coccinellids, Groundnut, Intercrop, Spiders, Sole crop.

INTRODUCTION

Groundnut, (*Arachis hypogaea* L.) is one of the major oilseeds cum valuable cash crops for millions of small scale farmers in the semi-arid tropics. It is the world's 4th most important source of edible oil and 3rd most important source of vegetable proteins. India has prime position in average area (4.93 million ha) and production (7.17 million tones) of groundnut. However, the productivity is low (1144 kg ha^{-1}) compared to that of USA (3000 kg ha^{-1}) and China (2600 kg ha^{-1}). Andhra Pradesh holds a key position with an area of 16.22 lakh ha and with production of 14.57 million tones and productivity of 898 kg ha^{-1} (Annual report, 2011 ANGRAU).

The insect pests of groundnut inflicts serious losses both directly as defoliators, sap suckers, root feeders etc and indirectly as vectors to dreaded viral diseases of the crop. More than 350 spp of insects damage the crop in different parts of world (Stalker and Campbell 1983).

Chemical control is being recommended with success but the awareness of deleterious effects of chemicals led to the thinking about alternatives to chemicals. Cultural operations in agriculture have well established history for their role in insect pest management. Of these, inter/mixed cropping systems have been considered as an important components and constitutes the most practical oriented approach. Intercropping can affect the microclimate of the agro ecosystem and ultimately produce an unfavorable environment for pests. Thomas (1991) reported that natural enemies of insect pests tend to be more abundant in intercrops than in monocrops, as they find better conditions, such as better spatial and temporal distribution of nectar, pollen and prey sources and more congenial micro habits for their special requirements thereby enhancing the biological control of crop pests. The present studies were carried out to find out the influence of some intercrops on the occurrence of natural enemies of insect pests of groundnut.

MATERIAL AND METHODS

A field experiment was conducted during *kharif*, 2011 with the groundnut variety Narayani at Wetland Farm, S.V. Agricultural College, Tirupati. The experiment was laid

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out in a Randomized Block Design (RBD) with five treatments and replicated four times in a plot size of 10 × 5 m. The crops viz., redgram (LRG-41), castor (local variety), cowpea (TPTC-8) and field bean (TFB-5) were used for intercropping with groundnut.

The treatments consisted of growing one row of red gram after every seven rows of groundnut (1:7), one row of castor after every seven rows of groundnut (1:7), one row of cowpea after every six rows of groundnut (1:6), one row of field bean after every six rows of groundnut (1:6) and a sole crop of groundnut. Sowing was done during first fortnight of July (6th July), 2011. All agronomic practices from sowing to harvesting were followed. The trial received no plant protection measures.

Various species of coccinellid predators were considered as a group, and their presence was recorded in all the cropping systems. All the spiders, irrespective of the family to which they belonged, were recorded together as one unit. The final pooled mean data was analyzed and presented.

The data was subjected to analysis of variance outlined by Panse and Sukhatma (1978) and statistical significance was tested by CD value.

RESULTS AND DISCUSSION

Observations on coccinellid and spider population

During the study period several coccinellids were observed viz., *Cheilomenes sexmaculata, Coccinella transversalis, Coccinella septumpunctata, Scymnus spp etc*. Among the coccinellids, *Chelomenes sexmaculata* was the predominant predator which accounted for 70 per cent of the population. Several spp of spiders were recorded in different cropping systems. Spiders belonging to Lycosidae family were predominant. The data on coccinellid and spider population is presented below.

At 20 DAS

High population of coccinellids of 0.79 per plant was observed in groundnut + cowpea intercropping system. Remaining systems recorded nearly 0.44 to 0.64 coccinellids per plant (Table 1).

Groundnut + field bean system recorded 0.75 spiders per plant where as other systems recorded 0.4 to 0.69 spiders per plant (Table 2).

At 30 to 40 DAS

Groundnut + cowpea and Groundnut + redgram systems recorded higher number of coccinellids (0.75 to 1.72 per plant) which were significantly different from remaining systems. Groundnut + field bean, groundnut + castor systems and sole groundnut recorded 0.50 to 1.12 coccinellids per plant (Table 1).

Spider population was also slightly increased in different treatments (Table 2).

At 50 DAS

The population of coccinellids was slightly increased in all the systems when compared to 40 DAS. Groundnut + cowpea system recorded high population i.e. 1.99 per plant followed by groundnut + redgram and groundnut + castor systems with 1.44 and 1.35 coccinellids have recorded respectively. Sole groundnut and groundnut + field bean only 0.94 to 1.27 coccinellids per plant (Table 1).

Comparatively high spider population was noticed in Groundnut + field bean system (2.15 per plant). In other systems, 1.05 to 1.88 spiders per plant were present (Table.2).

At 60 DAS

High population of coccinellids was noticed in groundnut + cowpea system i.e. 3.13 per plant and it is significantly different from other systems. Groundnut + redgram and groundnut +field bean consisted of 2.4 coccinellids per plant. Comparatively less population of 2.0 per plant was there in sole groundnut and groundnut + castor systems (Table 1).

Groundnut + field bean system recorded high population of spiders 3.18 per plant and it was significantly different from other systems. Groundnut + redgram and groundnut + cowpea systems recorded 2.1-2.3 spiders per plant. Sole groundnut and groundnut + castor systems recorded 1.2-1.5 spiders per plant (Table 2).

At 70 to 80DAS

At 70 DAS, the coccinellid population was increased. Groundnut + cowpea harboured highest population i.e. upto 5.60 per plant followed by groundnut + redgram system (4.75 per plant). Groundnut + field bean, sole groundnut and groundnut + castor recorded 3.4 -3.8 coccinellids per plant. At 80DAS, groundnut + cowpea system had 3.29 coccinellids per plant where as remaining systems recorded nearly 1.7 to 2.20 per plant (Table 1).

Spider population was slightly decreased at 70 and 80 DAS when compared to 60 DAS. Among all the

intercropping systems groundnut + fieldbean system recorded comparatively high spider population i.e. 2.0 per plant (Table 2).

At 90 DAS

The coccinellid population was decreased at 90 DAS when compared to 80 DAS. All the intercropping systems recorded nearly 0.8 to 1.72 coccinellids per plant (Table 1).

Spider population at 90 DAS was ranged from 0.4 to 1.0 per plant (Table 2).

Mean population at different intervals of data recorded

Days after sowing	*No. of coccinellids per plant	*No. of spiders per plant
20 (II FN of July)	0.59	0.56
30 (I FN of August)	0.79	0.79
40 (II FN of August)	1.14	1.12
50 (II FN of August)	1.39	1.52
60 (I FN of September)	2.46	2.09
70 (I FN of September)	4.23	1.40
80 (II FN of September)	2.14	1.06
90 (I FN of October)	1.18	0.69

*Mean of different cropping systems

The above data shows that, the population of coccinellids and spiders increased continuously from 20DAS up to 70 DAS and declined later. This may be due to availability of sufficient prey like aphids, jassids etc during vegetative stage of the crop. As the prey population decreased, predator population also declined due to lack of sufficient food. Change in microclimate due to shredded/shrinked foliage at later stages of the crop also may not favor the natural enemy fauna. Duffield (1993) noticed peak population of cocinellids on sorghum during early September.

Overall record of Coccinellids and spiders in in different intercropping systems

Treatments	*No. of coccinellids per plant	*No. of spiders per plant
Groundnut +redgram	1.85^{ab}	1.13^{bc}
Groundnut + castor	1.44^{b}	0.81^{bc}
Groundnut + cowpea	2.44^{a}	1.32^{ab}
Groundnut + field bean	1.63^{b}	1.66^{a}
Groundnut alone	1.34^{b}	0.87^{c}
Mean	1.74	1.16
SEm¶	0.48	0.19
CD 0.05%	1.50	0.36

*Mean at different intervals of data recorded.

The data in the above table shows that coccinellid population was comparatively high in groundnut + cowpea system (2.44 per plant). Aphids that prefer cowpea might have attracted the grubs and adults of coccinellids towards the crop, as coccinellids are the major predators of aphids. In the remaining intercrop systems also, significantly higher lady bird beetle population was observed.

Baskaran *et al.* (1993) reported that growing intercrops such as cowpea and pearl millet reduce pest damage and favours natural enemies on groundnut. Kennedy *et al* (1994) noticed that intercropping groundnut with pearl millet favours the predators and parasites of groundnut insect pests. Duffield and Reddy (1997) reported increased activity of coccinellids and spiders in leguminous intercrops. Surulivelu (2004) reported that Cowpea is a short–duration pulse crop which attracts aphids, thus increasing occurrence of coccinellids and multiplication of coccinellids and other predators in groundnut. (Srinivas rao 2007) stated that Coccinellids were significantly more abundant in pigeonpea with sorghum or greengram or groundnut systems.

Spiders were comparatively high in groundnut + field bean system (1.66 per plant) followed by groundnut + cowpea system (1.32 per plant). Other systems recorded 0.8-1.3 spiders per plant. The aggregation of predatory spiders at higher levels might be due to availability of sufficient food, shelter and congenial microclimate in the groundnut + field bean cropped area.

Singh *et al.* (1991) studied influence of intercropping on natural enemy complex in groundnut and reported that the population of spiders was higher in intercropping system than that of the sole crop. Wu (1991) reported that intercropping maize in cotton fields increased the population of Araneae, Coccinellidae and Chrysopidae significantly compared with control fields. Mahabaleshwar *et al*. (2003) noticed that average population of *C. carnea* and spiders were significantly high on cotton intercropped with lucerne, cowpea, and groundnut.

Gavarra and Raros (1975) found more predatory spiders and predatory coccinellids in groundnut and maize intercropping system than in sole crop of groundnut. Gyawali (1988) studied the effect of companion crops on the incidence of predatory spiders in rice and soybean fields in Nepal. The population densities of the predatory spiders were higher in the maize + soybean intercrop compared to the rice + soybean intercrop and soybean alone.

Table 1. Impact of intercropping of *kharif* groundnut on occurrence of coccinellid predators, 2011

Treatments	Mean number per plant								Mean
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS	
Groundnut +redgram	0.59 (1.10)[ab]	0.75 (1.17)[ab]	1.29 (1.42)[a]	1.44 (1.66)[ab]	2.46 (2.19)[ab]	4.75 (2.65)[b]	2.20 (1.65)[b]	1.29 (1.32)[ab]	1.85 (1.65)[ab]
Groundnut + castor	0.44 (0.83)[b]	0.65 (1.12)[ab]	0.94 (1.25)[ab]	1.35 (1.41)[ab]	2.12 (1.65)[c]	3.38 (1.99)[c]	1.74 (1.52)[b]	0.94 (1.09)[b]	1.44 (1.35)[b]
Groundnut + cowpea	0.79 (1.19)[a]	1.24 (1.45)[a]	1.72 (1.63)[a]	1.99 (1.85)[a]	3.13 (2.34)[a]	**5.60 (3.40)[a]**	3.29 (2.70)[a]	1.72 (1.53)[a]	**2.44 (2.03)[a]**
Groundnut + field bean	0.64 (1.12)[ab]	0.79 (1.18)[ab]	1.12 (1.32)[ab]	1.27 (1.37)[b]	2.43 (1.75)[bc]	3.86 (2.12)[bc]	1.79 (1.55)[b]	1.12 (1.22)[ab]	1.63 (1.45)[b]
Groundnut alone	0.46 (0.90)[ab]	0.50 (0.98)[b]	0.62 (1.09)[b]	0.94 (1.25)[b]	2.15 (1.66)[c]	3.50 (2.03)[c]	1.70 (1.42)[b]	0.82 (1.05)[b]	1.34 (1.29)[b]
Mean	0.59 (1.03)	0.79 (1.18)	1.14 (1.34)	1.39 (1.53)	2.46 (1.92)	4.23 (2.43)	2.14 (1.77)	1.18 (1.24)	1.74 (1.56)
SEm±	**0.40**	**0.43**	**0.46**	**0.48**	**0.56**	**0.67**	**0.51**	**0.46**	**0.48**
CD 0.05%	**1.25**	**1.31**	**1.40**	**1.47**	**1.73**	**2.06**	**1.59**	**1.41**	**1.50**

The values in Parenthesis are square root transformed values.
The values indicated by the same alphabet are statistically insignificant.

Table 2. Spider population in different intercropping systems of groundnut during *kharif*, 2011

Treatments	Mean number per plant								Mean
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	80 DAS	90 DAS	
Groundnut +redgram	0.54 (1.08)[ab]	0.69 (1.12)[ab]	1.16 (1.28)[bc]	1.39 (1.44)[b]	2.32 (2.38)[b]	1.28 (1.42)[b]	0.94 (1.21)[ab]	0.68 (1.12)[ab]	1.13 (1.38)[bc]
Groundnut + castor	0.45 (1.03)[ab]	0.59 (1.10)[ab]	0.91 (1.24)[bc]	1.06 (1.29)[b]	1.27 (1.38)[c]	0.96 (1.25)[b]	0.75 (1.07)[b]	0.46 (0.96)[ab]	0.81 (1.17)[bc]
Groundnut + cowpea	0.69 (1.14)[ab]	0.79 (1.19)[ab]	1.31 (1.59)[b]	1.88 (1.68)[b]	2.16 (2.26)[b]	1.65 (1.50)[b]	1.20 (1.35)[ab]	0.85 (1.21)[ab]	1.32 (1.49)[ab]
Groundnut + field bean	0.75 (1.16)[a]	0.95 (1.25)[a]	1.43 (2.01)[a]	2.15 (2.46)[a]	**3.18 (2.95)[a]**	2.10 (2.06)[a]	1.65 (1.50)[a]	1.09 (1.30)[a]	**1.66 (1.83)[a]**
Groundnut alone	0.38 (0.84)[b]	0.50 (0.91)[b]	0.79 (1.09)[c]	1.13 (1.32)[b]	1.53 (1.16)[c]	1.01 (1.27)[b]	0.78 (1.08)[b]	0.40 (0.90)[b]	0.87 (1.07)[c]
Mean	0.56 (1.05)	0.79 (1.11)	1.12 (1.44)	1.52 (1.64)	2.09 (2.03)	1.40 (1.50)	1.06 (1.24)	0.69 (1.09)	1.16 (1.39)
SEm±	**0.14**	**0.18**	**0.20**	**0.22**	**0.25**	**0.22**	**0.21**	**0.19**	**0.19**
CD 0.05%	**0.30**	**0.32**	**0.41**	**0.44**	**0.49**	**0.42**	**0.40**	**0.34**	**0.36**

The values in Parenthesis are square root transformed values
The values indicated by the same alphabet are statistically insignificant

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(Received on 23-03-2015 and revised on 14-04-2015)

Andhra Pradesh J Agril. Sci : 1(1): 39-42, 2015

PREPARATION OF GRAIN FORMULATIONS OF NOMURAEA RILEYI (FARLOW) SAMSON AND EVALUATION OF VIABILITY OF SPORES

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ABSTRACT

Grain formulations of *N. rileyi* were prepared by mass producing the fungus on six different grain media *viz.,* rice, wheat, jowar, bajra, maize and ragi for evaluating the viability of *N. rileyi* conidia during 2013-14. After observing full sporulation on grain media (20 days after inoculation), the spore mass along with media were dried, pulverized, sieved and packed in polythene bags. These formulations were stored at two different conditions *i.e.,* refrigeration (at 4ºC) and incubation (at 25ºC). The viability of *N. rileyi* conidia were recorded at monthly intervals upto 90 days. The results indicated that viability of spores decreased gradually with increase in storage period. Among the grain formulations tested, maize grain formulation has shown higher viability upto 90 days of storage (86.67 to 83.33 per cent germination). The lowest of 63.33-60 per cent germination of conidia was recorded with ragi grain formulation due to its low nutrient status. In rice, jowar, wheat grain formulations 66.67 to 76.67 per cent germination was noticed. Under the storage condition of refrigeration, slightly higher germination percentage was noticed in all the formulations.

KEY WORDS: Conidial germination, Days after storage, Grain formulations, Viability

INTRODUCTION

Among the various methods recommended for controlling of insect pests, biological control methods are inevitable and they are effective, ecofriendly and economical components of IPM. *Nomuraea rileyi* is an ideal entomopathogenic fungus and also an important mortality factor of many lepidopteran insects throughout the world (Lingappa and Patil, 2002). It occurs mainly in cooler months *i.e.,* in *rabi* season**.**

N. rileyi is unable to form epizootics under low relative humidity conditions with higher temperature. Development of suitable formulations of *N. rileyi* would be of significant importance to use against problematic lepidopteran insect pests in different crops grown in *rabi* season.

MATERIAL AND METHODS

Grain formulations of *N. rileyi* were prepared by using broken grains of sorghum, bajra, jowar, rice, wheat and ragi during 2013-14. Each grain of 30 g was soaked with one per cent yeast extract solution (30 ml 30 g^{-1}) for overnight, in plastic troughs (each grain separately in each trough). After soaking, the grains were filled in conical flasks of 250 ml capacity, then the flasks were plugged with cotton and autoclaved at 15 psi and 121°C for 30 minutes. After cooling, circular agar disc of 10 mm diameter was taken from the actively growing *N. rileyi* culture on SMAY plates and inoculated one into each bottle. The flasks were incubated in BOD chamber at 22°C.

After observing full sporulation on grain media (20 days after inoculation), the solid grains along with spore mass of *N. rileyi* was dried and grinded with a mixer grinder. It was sieved for removing coarse material. The material was separated into two halves after adding of 0.02 per cent of tween-20. One half was stored in refrigerator (at 4°C) and another half in incubator (at 25°C).

For testing the viability of conidia in each formulation, 0.5 gm of material was weighed separately and mixed with 100 ml of sterile distilled water (after adding 2-3 drops of Tween- 20) in 250 ml beakers. Later, this suspension was serially diluted for three times to get 1×10^5 spores ml^{-1} concentration. Two to three drops of spore suspension was placed in cavity slide. The cavity

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slide, was placed in the humidity chamber which was prepared by arranging moistened cotton in petriplates and it was incubated at 22°C. At 12 hours intervals, the spore suspension was observed under microscope for counting the germinated spores. The germination percentage of *N. rileyi* was calculated based on the number of spores germinated in spore suspension of each formulation. The germination tests were carried out at the time of storage and later at monthly intervals upto 90 days after storage (DAS).

RESULTS AND DISCUSSION

1. Viability of *N. rileyi* conidia in grain formulations stored at refrigerated conditions (at 4°C)

Thirty days after storage (30 DAS): Mean conidial germination was 86.67 per cent at 30 days after storage. Maize grain formulation recorded more than 90 (93.33) per cent of germination, where as rice and jowar grain formulations recorded 90 per cent of conidial germination with no significant difference. Wheat, bajra and ragi recorded 86.67, 83.33 and 76.67 per cent of conidial germination respectively.

Sixty days after storage (60 DAS): Only maize grain formulation recorded 90 per cent of conidial germination even after 60 days of storage, followed by 86.67, 83.33, 80, 76.67 and 70 in rice, jowar, wheat, bajra and ragi grain formulations respectively.

Ninety days after storage (90 DAS): Maize grain formulation was found superior among all the grain formulations by recording higher conidial germination of 86.67 per cent followed by rice grain formulation (80 per cent). Jowar, wheat and bajra recorded 76.67, 73.33 and 66.67 per cent of conidial germination respectively. The least conidial germination of 63.33 per cent was recorded with ragi grain formulation (Table 1).

2. Viability of *N. rileyi* conidia in grain formulations incubated at 25°C:

Thirty days after storage (30 DAS): The mean conidial germination recorded was 86.11 per cent at 30 days of storage. Maize grain formulation recorded 93.33 per cent of conidial germination followed by rice grain (90 per cent). Jowar and wheat grain formulations were statistically on par with each other by recording 86.67 per cent of conidial germination of *N. rileyi*, where as bajra and ragi grain formulations recorded 83.33 and 76.67 conidial germinations respectively (Table 2).

Sixty days after storage (60 DAS): All the formulations were statistically different to each other with respect to conidial germination. The mean conidial germination after 60 days of storage was 76.67 per cent. The highest conidial germination was recorded in maize (86.67 per cent)

Ninety days after storage (90 DAS): Maize grain formulation was found superior by recording 83.33 per cent of conidial germination followed by rice grain formulation (80 per cent). Least conidial germination (60 per cent) was recorded with ragi grain formulation. The viability of conidia in wheat and bajra grain formulation were 70 and 66.67 per cent. The mean conidial germination was 72.78 per cent, at 90 days of storage.

In the present study, the refrigerator stored grain formulations shown 4 per cent higher response with regard to viability at 90 days of storage, when compared to incubator stored formulations.

In both storage conditions *i.e.,* at incubator and refrigerator stored conditions, maize grain formulation showed higher viability when compared to other formulations. The superiority of maize grain to act as carrier material for *N. rileyi*, may be due to the higher (80 per cent 100 g^{-1}) carbohydrate and protein content (11 per cent 100 g^{-1}). Reddy (2008) recorded 13.7 per cent of moisture content 100 g^{-1}, carbohydrate content of 79 per cent 100 g^{-1} and protein content of 6.8 g 100 g^{-1} present in rice grains. In sorghum grains, 72.4 per cent of carbohydrate and 10.4 g 100 g^{-1} of protein were recorded.

Next best treatments after maize grain formulation were rice grain formulation and sorghum grain formulation which recorded 80 and 80, 76.67 and 76.67 per cent viability of *N. rileyi* conidia even after 3 months of storage in refrigerator and incubator stored conditions respectively.

Swetha (2010) reported that after 30 days of storage, corn flour mixed *N. rileyi* conidia (67.50%) showed relatively higher mortality of *Spodoptera litura* Fabricius larvae followed by broken rice flour (62.50%). After 3 months, they recorded 32.50 per cent and 25.00 per cent mortalities respectively.

Ragi grain formulation recorded least germination percentage of spores of *N. rileyi* in both storage conditions. This may be due to the fiber content (3.6 per cent 100 g^{-1}) present in ragi grains and also clumping of grains at the time of autoclaving of grain media. Kulkarni (1999) reported that less amylase content (6-18 per cent) and formation of clumping in ragi grain were responsible for

Table 1. Viability of *N. rileyi* in terms of germination of conidia in refrigerator stored grain formulations

Formulations	Per cent germination of *N. rileyi* spores		
	30 DAS	60 DAS	90 DAS
Maize	93.33[a] (75.10)	90.00[a] (71.62)	86.67[a] (68.64)
Rice	90.00[ab] (71.58)	86.67[ab] (68.62)	80.00[b] (63.45)
Jowar	90.00[ab] (71.58)	83.33[bc] (65.93)	76.67[c] (61.12)
Wheat	86.67[c] (68.64)	80.00[d] (63.44)	73.33[d] (61.13)
Bajra	83.33[d] (65.92)	76.67[e] (61.15)	66.67[e] (54.75)
Ragi	76.67[e] (61.15)	70.00[f] (56.79)	63.33[f] (52.73)
General mean	**86.67**	**81.11**	**74.44**
SE(m)	**0.83**	**0.73**	**0.74**
C.D.(0.05)	**2.31**	**2.03**	**2.06**

DAS: Days After Storage
The values are means of three replications.
Figures in the parentheses are angular transformed values.
Mean followed by same letter in the column do not differ significantly by DMRT (p = 0. 0 1)

Table 2. Viability of *N. rileyi* in terms of germination of conidia in incubator stored grain formulations

Formulations	Per cent germination of *N. rileyi* spores		
	30 DAS	60 DAS	90 DAS
Maize	93.33[a] (75.10)	86.67[a] (68.60)	83.33[a] (65.91)
Rice	90.00[ab] (71.67)	83.33[b] (65.91)	80.00[ab] (63.45)
Jowar	86.67[bc] (68.67)	80.00[c] (63.55)	76.67[b] (61.12)
Wheat	86.67[bc] (68.64)	73.33[d] (58.93)	70.00[c] (56.80)
Bajra	83.33[c] (65.91)	70.00[e] (56.80)	66.67[c] (54.75)
Ragi	76.67[d] (61.13)	66.67[f] (54.74)	60.00[d] (50.78)
General mean	**86.11**	**76.67**	**72.78**
SE(m)	**1.04**	**0.66**	**0.79**
C.D.(0.05)	**2.78**	**1.83**	**2.22**

DAS: Days After Storage
The values are means of three replications.
Figures in the parentheses are angular transformed values.
Mean followed by same letter in the column do not differ significantly by DMRT (p = 0. 0 1)

lower (interfered with efficient harvest of spores and thus led to low productivity) conidial yield production of *N. rileyi* in ragi grain formulation.

Ramegowda (2005) confirmed corn flour as more efficient inert material for preparation of *N. rileyi* formulation. He also reported that the broken rice flour also showed considerably higher larval mortalities of *Helicoverpa armigera* Hubner (47.00 to 62.50 per cent) upto two months, then reduced mortalities up to four months thereafter no mortalities were found.

Nankinga and Moore (2000) reported that application of *Beauveria bassiana* maize flour formulated wettable powder at the rate of 2×10^6 conidia per ha proved most effective in reducing the banana weevil (*Cosmopolites sordidus*) population by 65.72 per cent within 8 weeks after a single application.

Babi Neeraja (2008) reported that the crushed sorghum and rice grains with one per cent yeast extract comparatively as favorable food media for the faster as well as higher spore production of *N. rileyi* in 15 days period (2.4×10^9 and 2.1×10^9 spores ml^{-1} respectively). Maize and Bajra also produced considerably good sporulation. Ragi and wheat grains have proved inferior for spore production.

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(Received on 23-03-2015 and revised on 14-04-2015)

Andhra Pradesh J Agril. Sci : 1(1): 43-46, 2015

EFFICACY OF NEW INSECTICIDE IMIDACLOPRID FS 480 AS SEED DRESSER AGAINST THRIPS INCIDENCE ON GROUNDNUT

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ABSTRACT

Field experiment was conducted to evaluate "the efficacy of new insecticides as seed dresser against thrips incidence on groundnut" at farm, Agricultural Research Station, Kadiri, Andhra Pradesh during *kharif* 2010 in randomized block design with six treatments and four replications. Among 5 treatments, Imidacloprid 480 FS @ 1.0 ml kg^{-1} seed was found to be more effective in reduction of the thrips damage and also incidence of PSND/PBND followed by Imidacloprid 17.8 SL @2.0 ml kg^{-1}, Thiamethoxam 25 WG @2.0 g kg^{-1} seed as seed dresser than untreated control. However, the highest pod yield (245.8 kg ha^{-1}) was recorded in Imidacloprid 17.8 SL @ 2.0 ml kg^{-1} followed by Imidaclopri 480 FS @ 1.0 ml kg^{-1} seed.

KEY WORDS: Groundnut, Insecticides, Imidacloprid, Seed treatment, Sucking pests,

INTRODUCTION

Groundnut is one of the major oil seed crops, grown in a varied climatic condition in different states in India. The productivity of groundnut is quite low (1000 kg ha^{-1}) compared to that of USA (3000 kg ha^{-1}), China (2600 kg ha^{-1}), Argentina (2100 kg ha^{-1}) and Indonesia (1550 kg ha^{-1}) (National Research Center for Groundnut, 2005). The major groundnut growing regions in Andhra Pradesh are Rayalaseema region with 14.74 lakh ha (82-83%) and major area is grown under rainfed cultivation (95%) followed by Telangana region with 2.06 lakh ha (10%) and Andhra region with 1.15 lakh ha (6%).The average yields are very low in groundnut. The reason for low productivity of groundnut is due to biotic and abiotic stresses during crop growth period. Pests and diseases are the major biotic stresses affecting yield. Also among biotic stresses, viral diseases Peanut stem necrosis disease (PSND) and peanut bud necrosis disease (PBND) are causing major concern to the groundnut production.

In India, *Tobacco Streak Virus* (TSV) was first identified during 2000 on sunflower (Prasada Rao *et al*., 2000). Subsequently, TSV caused an epidemic on groundnut in the year 2000 and the loss was estimated to the tune of Rs. 300 crore (Reddy *et al*., 2002). Later the disease was named as peanut stem necrosis disease (PSND). The causal agent of peanut bud necrosis disease (PBND) in India was initially described as *Tomato spotted wilt virus* (TSWV) (Ghanekar *et al*., 1979). Subsequently, based on serological, physiochemical and thrips transmission studies, the causal organism of bud necrosis disease in India was identified as *Groundnut bud necrosis virus* (Reddy *et al*., 1992). During 1993, GBNV caused 70-90 % loss of groundnut yield at Mainpuri, India (Singh, 1995) and based on severity of bud necrosis disease, few hot spot locations have been identified in India *viz*., Latur (Maharashtra), Rajendranagar (Andhra Pradesh), Palem (Andhra Pradesh) and Raichur (Karnataka) (Basu, 1995). At Agricultural Research Station, Kadiri, incidence of PBND ranged from 10.0-20.0 % in *rabi* season (Directorate of Groundnut Research reports, 2005 - 2011).

Tospoviruses are vectored by several species of thrips (Thysanoptera: Thripidae) (Amin *et al*., 1981; Cho *et al*., 1988). The abundance of thrips in diverse cropping systems along with the broad host range of the Tospoviruses and lack of natural plant resistance to Tospoviruses have made their management extremely difficult (German *et al*., 1992). So far, 12 thrips species have been recorded as vectors of tospoviruses worldwide and *Frankliniella schultzei*, *Scirtothrips dorsalis*, *Thrips tabaci* and *Thrips palmi* are responsible for their spread and causing severe epidemics in Asia. Of these, *Thrips palmi* is the predominant vector species. It has been reported as the main vector of GBNV in India (Vijaya Lakshmi, 1994). Seed treatment with imidacloprid and thiamethoxam, protected cotton seedlings from thrips for at least 6 weeks from the onset of seed planting. Imidacloprid had a better efficiency against this sap

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sucking pest than thiamethoxam (Jehan and Nour El-Hoda, 2013). Singh *et al.* (2014) reported that among the seed treatments, imidacloprid @ 3 g kg^{-1} was most effective and provided maximum reduction in population of sucking pests, which was significantly equal to thiomethoxam and acetamiprid on Okra. The efficacy of different insecticidal seed treatments were tested against aphid, *Aphis craccivora* Koch, leafhopper, *Empoasca kerri* Pruthi, defoliator, *Spodoptera litura* (Fab.) and pod borer, *Helicoverpa armigera* (Hub.) on black gram (GailceLeo Justin *et al.,* 2015).

MATERIAL AND METHODS

A field experiment was conducted to evaluate the relative "efficacy of insecticides as seed dressers against thrips incidence on groundnut" at farm, Agricultural Research Station, Kadiri, Andhra Pradesh during *kharif* 2010 in randomized block design with six treatments of four replications. The groundnut variety K- 6 was used as test variety which is susceptible to the insect pests. The groundnut seed was treated with insecticides *viz.,*Imidacloprid 17.8 SL @ 2.0 ml kg^{-1} seed, Acetamipride 20 SP @ 2.0 g kg^{-1} seed, Fipronil 5 SC @ 4.0 ml kg^{-1} seed, Imidacloprid 480 FS @ 1.0 ml kg^{-1} seed (+ 5ml water), Thiamethoxam 25 WG @ 2.0 g kg^{-1} seed and untreated control 12.00 hours before sowing the seed and kept aside overnight. Imidacloprid 480 FS (Flowable Suspension) formulation is semi solid liquid. For uniform covering of 1 kg seed, 5.0 ml of water was added to 1.0 ml of Imidacloprid 480 FS formulation. The plot size was 5 x 4 m, plant to plant 10 cm distance and distance row to row 30 cm. Treated seed were dibbled in soil. All recommended package of practices were followed to raise good crop. Five plants were randomly selected from each plot for recording the observations. The incidence of thrips damage was recorded at 20, 30, 40, 50 and 60 days after sowing and incidence of PSND was recorded at 45, 65 days and before harvest of the crop.The per cent incidence of thrips damage in each treatment was calculated by using the formula and the data were analyzed statistically. Data on per cent damage were subjected to angular transformation before statistical analysis. The yield of groundnut was recorded from each plot and converted into yield per hectare.

RESULTS AND DISCUSSION

The early stage of groundnut crop is more vulnerable to viral infection of PSND / PBND through insect vector *i.e* thrips. Seed treatment with insecticides provide protection to crop upto 30 day from sucking insect damage and also protection from incidence of PSND in early stage. The data revealed that among five insecticidal seed treatments, Imidacloprid 480 FS @ 1.0 ml kg^{-1} seed was found to be more effective in reduction of thrips damage and also incidence of PSND/PBND (Table 1 and 2) followed by Imidacloprid 17.8 SL @ 2.0 ml kg^{-1}, Thiamethoxam 25 WG @ 2.0 g kg^{-1} seed as seed dresser against untreated control. The per cent damage of thrips was initially low (Table 1) as compared to untreated control later the incidence gradually increased. In general the incidence of PSND is more prevalent in the early stages of crop through insect vector than later stages. These results are corroborative with Singh *et al.* (2014) who reported that imidacloprid @ 3 g kg^{-1} was most effective and provided maximum reduction in population of sucking pests, seed germination %, numbers of fruit $plant^{-1}$, plant height, fruit damage and fruit yield, which was significantly equal to thiomethoxam and acetamiprid. Iqbal *et al.* (2013), studied the combination of seed-treatment with imidacloprid spray with detergent and insecticides spray. Seed treatment and spray with detergent did not show distinctive effect on the pests' population. While Imidacloprid and Thiomethoxam spray resulted maximum mortality of the jassid, followed by acetamiprid. Acephate resulted in the maximum control of thrips and was found the most effective insecticide followed by acetamiprid. Gailce Leo Justin *et al.* (2015), reported that the seed treatment with thiamethoxam 25 WG @ 3 g kg^{-1} of seed + spray with thiamethoxam 25 WG @ 0.4 g l^{-1} recorded the lowest population of aphids (1.60, 1.45 no. $plant^{-1}$) and leafhoppers (2.36, 2.12 no. $plant^{-1}$) followed by spraying of imidacloprid 17.8 SL @ 0.4 ml l^{-1} with 83.96, 87.45 and 66.13, 71.61 per cent reduction over control. Harish Kumar Netam *et al.* (2013) evaluated the bio-efficacy of Imidacloprid 600 FS. When applied as seed treatment at the rate of 0.75 g a.i kg^{-1} seed, it was most effective against the sucking pests upto four week of seed germination with least 6.71 insect $plant^{-1}$. It was followed by Imidacloprid 600 FS @ 0.60 g a.i. kg^{-1} seed and Thiamethoxam 70 WS @ 2.1 g a.i. kg^{-1} seed with 9.66 and 11.02 sucking pests $plant^{-1}$. PSND incidences was low in early stage of the crop and later on gradually increased (Table 2) and again decrease at before harvest of the crop. Highest pod yield (245.8 kg ha^{-1}) was recorded in Imidacloprid 17.8 SL @ 2.0 ml kg^{-1} seed followed by Imidacloprid 480 FS @ 1.0 ml kg^{-1} seed table (Table 2).

Table 1. Effect of new insecticides as seed treatment against thrips in Groundnut during *kharif* 2010

Treatments	% thrips damage				
	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS
T_1 : Imidacloprid 17.8 SL @ 2.0 ml kg^{-1} seed	32.2 (34.5)	65.9 (55.7)	79.1 (62.9)	68.5 (56.2)	82.3 (65.2)
T_2 : Acetamipride 20 SP @ 2.0 g kg^{-1} seed	43.2 (41.1)	67.1 (55.2)	80.6 (64.0)	69.1 (56.3)	82.0 (65.1)
T_3 : Fipronil 5 SC @ 4.0 ml kg^{-1} seed	37.5 (34.8)	64.9 (54.3)	84.6 (67.0)	69.9 (56.8)	81.2 (64.3)
T_4 : Imidacloprid 480 FS @1.0 ml kg^{-1} seed (+ 5 ml water)	26.4 (30.9)	58.9 (50.1)	77.0 (61.7)	67.2 (55.1)	82.9 (65.7)
T_5 : Thiamethoxam 25 WG @ 2.0 g kg^{-1} seed	39.7 (39.0)	63.9 (53.6)	79.9 (63.4)	71.7 (58.1)	83.0 (65.9)
T_6 : Untreated Control	43.5 (41.3)	70.9 (57.9)	84.8 (67.1)	74.6 (59.8)	81.1 (64.3)
SED ±	1.50	4.20	2.41	2.53	2.46
CD at 5%	3.20	8.93	5.15	5.40	5.26
CV	5.68	10.88	5.31	6.28	5.36

*Figures in parentheses are arc sin transformed values
DAS – Days After Sowing

Table 2. Effect of new insecticides as seed treatment against PSND in Groundnut during *kharif* 2010

Treatment	% incidence of PSND			Pod yield kg ha^{-1}
	45 DAS	65 DAS	95 DAS	
T_1 : Imidacloprid 17.8 SL @ 2.0 ml kg^{-1} seed	8.9 (17.3)	20.3 (26.2)	13.0 (21.1)	245.8
T_2 : Acetamipride 20 SP @ 2.0 g kg^{-1} seed	7.4 (15.7)	18.3 (25.1)	15.0 (22.4)	227.7
T_3 : Fipronil 5 SC @ 4.0 ml kg^{-1} seed	11.3 (19.2)	25.0 (29.3)	14.1 (22.0)	230.0
T_4 : Imidacloprid 480 FS @1.0 ml kg^{-1} seed (+ 5 ml water)	9.2 (17.6)	16.7 (23.8)	10.1 (18.5)	240.0
T_5 : Thiamethoxam 25 WG @ 2.0 g kg^{-1} seed	7.9 (16.3)	41.8 (40.2)	15.1 (22.8)	231.8
T_6 : Untreated Control	15.4 (22.2)	42.9 (40.8)	19.1 (25.6)	212.5
SED ±	1.96	4.73	2.34	29.88
CD at 5%	4.19	10.08	4.99	63.69
CV	16.80	21.64	15.01	18.27

*Figures in parentheses are arc sin transformed values
DAS – Days After Sowing

CONCLUSION

Among five insecticidal seed treatments, Imidacloprid 480 FS @ 1.0 ml kg^{-1} (+5 ml water) seed was found to be more effective in reduction of the thrips damage and also incidence of PSND/PBND followed by Imidacloprid 17.8 SL @ 2.0 ml kg^{-1}, Thiamethoxam 25 WG @ 2.0 g seed as seed dresser against untreated control. However, the highest pod yield (245.8 kg ha^{-1}) was recorded in Imidacloprid 17.8 SL @ 2.0 ml kg^{-1} followed by Imidaclopri 480 FS @ 1.0 ml kg^{-1} seed.

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(Received on 08-05-2015 and revised on 15-05-2015)

Andhra Pradesh J Agril. Sci : 1(1): 47-53, 2015

FOLIAR APPLICATION OF AMINO ACIDS TO ALLEVIATE TERMINAL MOISTURE STRESS IN GROUNDNUT (*Arachis hypogia* L)

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ABSTRACT

The Present investigation was carried out at S. V. Agricultural College & RARS, Tirupati to know the effect of amino acids in alleviation of terminal moisture stress in groundnut (*Arachis hypogia*).The results revealed a considerable significant variation in all morphological, physiological and yield parameters. Among the different treatments glutamine 200 ppm followed by arginine 200 ppm recorded significantly highest pod yields (kg ha^{-1}). A significant positive correlation was observed between SCMR and total chlorophyll content. Foliar spray of amino acids caused increased chlorophyll content; high SCMR values and moderate SLA resulted in better crop yield under moisture stress. The role of amino acids in remobilization of resources needs further investigation.

KEY WORDS: Amino acids, Alanine, Arginine, Glutamine, Groundnut, Foliar application, Terminal moisture stress

INTRODUCTION

Groundnut (*Arachis hypogea* L.) is one of the important oil seed crops grown in India. Andhra Pradesh ranks second in the country both in area (13.07 lakh hectares) and production (8.4 lakh tons) of groundnut with an average productivity of 646 kg per hectare (http://www.indianstat.com). Rayalaseema zone of Andhra Pradesh consisting of four districts (Chittoor, Kurnool, Kadapa and Ananatapur) is a predominant groundnut growing region where more than 70 per cent area falls under rain fed condition.

Groundnut in Andhra Pradesh is cultivated in an area of 1.6 m ha during rainy season (*kharif*) and 0.3 m ha in post rainy season (*rabi*). Terminal moisture stress is a common phenomenon under post rainy season which adversely affects the growth and development of the crop (ICRISAT, 2008). Moisture stress if occurs during 50-80 DAS causes severe yield reduction as this period coincides with pod filling and pod maturation in groundnut.

Different approaches were used to reduce the damage caused by drought such as selection of genotypes for higher water use efficiency, use of different growth regulators (GA_3. IAA and Cytokines), seed treatment with osmoprotectants (Muna *et al*., 2013), foliar application of 1 per cent KCl, exogenous application of organic compounds such as amino acids (Ardebili *et al*., 2012) etc.

Amino acids are the building blocks in the synthesis of proteins and are involved in plant growth and development. Amino acids are crucial in stimulation of cell growth, act as a buffer, provide a source of carbon and energy, involved in the synthesis of other organic compounds such as amines, alkaloids, vitamins, enzymes and terpenoids (Abdel Aziz *et al*., 2010). The yield contributing characters and quality of plants could be improved by application of putriscine or glutamine (Amin *et al*., 2011).

Of late a range of products are commercially available in the name of growth promoters. Amino acid formulations, mixtures of nutrients, hydrolyzed proteins, triacontonol, humic acid, sea weed extracts and brassinolides are proposed as commonly used growth promoters (Thomas *et al*., 2009). Foliar application of amino acids for drought alleviation was studied by several workers earlier (Rao *et al*., 2012 and Ali, 2007). Thus the objective of the present study was to know the effect of exogenous application of amino acids for alleviation of terminal moisture stress situation in post rainy season cultivation of groundnut.

MATERIAL AND METHODS

A field experiment was conducted at Department of Crop Physiology, S. V. Agricultural College and RARS, Tirupati during *rabi* 2013-14 (January to April).

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Groundnut variety 'Dharani' was selected for the study whose duration was 110 days. The experiment was laid out in a Randomized block design with 13 treatments replicated thrice. To know the effect of amino acids on alleviation of terminal moisture stress in groundnut the following treatments were foliar applied.

T_1 : Water spray

T_2 : Urea solution(1%)

T_3 : Activzyme* (0.1 %)

T_4 : Lihocin** (0.1 %)

T_5 : Arginine 100 ppm

T_6 : Glutamine 100 ppm

T_7 : Alanine 100 ppm

T_8 : Arginine 200 ppm

T_9 : Glutamine 200 ppm

T_{10} : Alanine 200 ppm

T_{11} : (Arginine+ Glutamine+ Alanine) 100 ppm

T_{12} : (Arginine+ Glutamine+ Alanine) 100 ppm + 1% Urea

T_{13} : Control (without any foliar spray)

(* and **Activzyme and Lihocin are commercial products of Modicare Ltd and BASF India ltd respectively)

The experiment was conducted in sandy clay loam soil with a plot size of 2X3 mt following standard package of practices. The spacing adopted was 30X10 cm. Need based irrigations were given, however, the crop was irrigated to field capacity at 45 DAS and then there was no irrigation provided between 50-80 DAS. Treatments were foliar applied on 65th day after sowing i.e 20 days after the last irrigation. By the time the soil reached to its permanent wilting point. The amino acids used for foliar application were procured from Sd Fine chemicals limited (Mumbai, India).

Morphological and physiological observations were recorded 15 days after imposition of the treatments. Destructive sampling of 5 plants from each replication was done. Data on plant height, SCMR (SPAD Chlorophyll meter Reading), SLA (Specific Leaf Area) and number of pegs per plant total drymatter per plant were recorded. Yield attributes *viz*., number of filled pods and unfilled pods, 100 kernel weight (gm), shelling per cent, harvest index and pod yield were recorded at harvest. Chlorophyll content was calculated by the formulae given by Arnon (1949) through DMSO method.

The experimental data were analyzed by the method of analysis of variance following RBD as per the procedure outlined by Panse and Sukhtame (1985). Significance was tested by comparing F-value at 5 % level of probability wherever F- test was significant.

RESULTS AND DISCUSSION

a) Growth parameters

There were significant differences observed among different treatments for SCMR, SLA & chlorophyll content. SCMR values were significantly highest in T_9 (Glutamine 200 ppm) (44.8) which was at par with T_2 (Urea solution (1%)) (43.4) followed by T_8 (Arginine 200 ppm), T_1 (water spray), T_7 (Alanine 100 ppm), T_6 (Glutamine 100 ppm), T_5 (Arginine 100 ppm) and T_8 (Lihocin 0.1 %). However, T_3 (Activzyme 0.1 %), T_{10} (Alanine 200 ppm), T_{11} ((Arg + Glu + Ala) 100 ppm) and T12 ((Arg + Glu + Ala) 100 ppm + 1 % Urea) were found to be non significant compared to control (38.0) (Table 1).

SCMR is an indication of leaf nitrogen status. Reddy *et al.* (2003) reported a positive correlation between SCMR and total chlorophyll content as well as SCMR and seed yield in groundnut genotypes. Higher SCMR value was due to high nitrogen content. Higher the nitrogen more is the chlorophyll content per unit leaf area leads to better photosynthetic efficiency and more carbon gain. A significant positive correlation between SCMR and chlorophyll content was also observed in the present study (Fig 1). Limited water supply usually causes a reduction in chlorophyll content. Being positively correlated with yield (Zaharieva *et al*., 2001) relatively high chlorophyll content may contribute to the plant productivity under stress conditions. Exogenous application of amino acids like Tryptophan, Methonine, Cystein and Proline were reported to increase Chlorophyll –a, chlorophyll-b and total chlorophyll content (Al.Qubaie, 2012).

A clear negative correlation was observed between SCMR and SLA values (Fig 2). Among different treatments T_{11} (Arg + Glu + Ala) (100 ppm) (251.1cm^{2}g^{-1}), T_{13} (Control) (249.9 cm^{2}g^{-1}), T_{10} (Alanine 200 ppm) (238.2 cm^{2}g^{-1}) recorded significantly higher SLA values. Low SLA values were recorded by T_5 (Arginine 100 ppm) (181.2 cm^{2}g^{-1}) followed T_9 (Glutamine 200 ppm) (179.3

cm^2g^{-1}), T_1 (water spray) (175.4 cm^2g^{-1}) T_6 (Glutamine 100 ppm) (171.3 cm^2g^{-1}), T_2 (Urea solution (1%)) (170.5 cm^2g^{-1}), T_4 (Lihocin 0.1 %) (168.5 cm^2g^{-1}), T_8 (Arginine 200 ppm) (168.0 cm^2g^{-1}), T_7 (Alanine 100 ppm) (167.8 cm^2g^{-1}) and T_{12} ((Arg + Glu + Ala) 100 ppm + 1% Urea) (165.3 cm^2g^{-1}). According to Renuka Devi *et al.* (2009), the groundnut genotypes under moisture stress condition with lower SLA and high SCMR values recorded higher yields.

SLA had a positive correlation with pod yield. Further a negative correlation between SLA and transpiration efficiency was also explained (Wright *et al.,* 1993). In the present study also it was observed that the treatment with high SCMR values, high chlorophyll content, low to moderate SLA showed positive correlation with pod yield. (Table 2).

b) Yield and Yield components

In the present study significantly higher number of filled pods were observed with T_9 (Glutamine 200 ppm) (11.2) followed by T_{10} (Alanine 200 ppm) (10.6), T_{12} ((Arg + Glu + Ala) 100 ppm + 1 % Urea) (10), T_5 (Arginine 100 ppm) (9.8) and T_8 (Arginine 200 ppm) (9.6) (Table 2). Moisture stress decreased the pod yield significantly, primarily due to reduction in number of pods per plant (41.2 %) followed by kernel weight (22.5 %) and number of seeds per pod (20.4) (Reddy *et al.,* 2003). Further, Bootang *et al.* (2010) reported that under moisture stress, reduction in 100 kernel weight though significant were not severe, ranging from 57.9 to 52.9 gm on an average. In the present study it was ranged between 31.9 to 44.4 gm. Among the different treatments T_9 (Glutamine 200 ppm) (44.4 gm), T_2 (Urea solution (1%)) (44.4 gm) and T_8 (Alanine 200 ppm) (42.3 gm) recorded significantly higher test weight (Table 2). The yield decrease in the present study due to moisture stress at the most critical stage of crop growth was around 51 per cent to 84 per cent when it was calculated on the basis of potential yield (35-37q ha^{-1}).

Higher shelling percentage is desirable in groundnut as it denotes high source-sink relationship. Moisture stress at pod development phase decrease the shelling percentage more significantly than other stages (Ramesh Babu *et al.,* 1984). Ramana Rao (1994) reported that shelling percentage in groundnut under simulated drought condition was 62.5 per cent and 66.5 per cent under adequately irrigated condition. Reshma (2014), reported that the shelling percentage of groundnut cultivar 'dharani' under early *kharif* situation was 73 per cent. In the present study shelling percentage was ranged from 72.6 to 82.2 per cent. Among the different treatments significantly higher shelling percentage was observed in T_9 (Glutamine 200 ppm) (82.2) followed by T_7 (Alanine 100 ppm) (82.5) and T_4 (Lihocin (0.1 %) (80.2) (Table 2).

Cultivars with vigorous early growth relatively large biomass accumulation and capacity for remobilization of stored assimilates to reproductive sinks might be adapted to drought stress (Wright and Rao, 1992). In the present study total dry matter at harvest was significantly high in T_8 (Arginine 200 ppm) (21.44) followed by T_9 (Glutamine 200 ppm) (21.39) and T_{10} (Alanine 200 ppm) (19.44). Besides a moderately high HI *viz*. 33.5, 35.5 and 36.4 was also observed with these treatments. It might be due to the increased remobilizing capacity of the assimilates assisted by amino acids.

CONCLUSION

Significantly highest pod yields (kg ha^{-1}) were recorded in T_9 (Glutamine 200 ppm) (1846.3 kg ha^{-1}) followed by T_8 (Arginine 200 ppm) (1643.7 kg ha^{-1}) and T_{12} (Arg + Glu + Ala 100 ppm) (1619.7 kg ha^{-1}) (Table.2). Foliar spray of amino acids caused increased chlorophyll content, high SCMR values and moderate SLA. They further might helped in increased total dry matter. The role of amino acids in remobilization of photosynthetic reserves for increased yields needed a further thorough investigation.

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Table 1. Effect of amino acids on morphological and physiological parameters of groundnut

S. No	Treatments	Plant Height (cm)	No. of pegs	SCMR	SLA (cm^2/gm)	Chlorophyll content (mg/g)
1	Water spray	27.1	11.6	41.1	175.4	2.34
2	Urea solution (1%)	32.8	10.7	43.4	170.5	2.78
3	Water spray 0.1 %	27.3	13.0	38.3	225.2	1.84
4	Lithocin 0.1 %	37.2	11.9	39.9	168.5	2.15
5	Argenine 100 ppm	31.4	12.2	40.2	181.2	2.31
6	Glutamine 100 ppm	27.9	10.3	40.2	171.3	2.38
7	Alanine 100 ppm	30.8	10.4	41	167.8	2.5
8	Argenine 200 ppm	35.6	15.4	42.1	168	2.55
9	Glutamine 200 ppm	35.1	16.2	44.8	179.3	2.8
10	Alanine 200 ppm	29.2	14.5	38.8	238.2	1.81
11	Arg + Glu + Ala 100 ppm	31.1	14.1	36.8	251.1	1.71
12	Arg + Glu + Ala 100 ppm + 1 % Urea	32.3	14.0	39.4	165.3	2.04
13	Control	35.2	12.9	38	249.9	1.73
	Mean	31.8	12.9	40.3	193.2	2.2
	SEM	1.15	1.0	0.5	6.0	0.11
	CD (5%)	3.36	3.0	1.5	17.5	0.33
	CV (%)	6.3	13.9	2.3	5.4	8.80

Table 2. Effect of amino acids on yield parameters of groundnut

S. No	Treatments	No. of Filled Pods	No. of Unfilled Pods	TDM/pl (g)	100 kernel weight (g)	Shelling (%)	Harvest index (%)	Pod yield (kg ha^{-1})
1	Water spray	8.4	3	13.19	35.6	81.0	36.6	1205.5
2	Water spry + 1 % Urea	7.4	3.9	16.20	44.4	76.1	36.4	1151.7
3	Water spray 0.1 %	8.4	1.4	14.24	31.9	78.6	32.9	615.5
4	Lithocin 0.1 %	6.8	2.6	13.87	33.8	80.2	31.4	627.3
5	Argenin 100 ppm	9.8	2.1	17.95	41.3	78.5	35.8	1292.3
6	Glutamin 100 ppm	7.8	2.8	13.24	38.6	77.7	34.6	957.3
7	Alanine 100 ppm	6.1	1.3	13.54	38.0	82.5	32.8	1198.8
8	Argenin 200 ppm	9.6	2.4	21.44	41.5	81.4	33.5	1643.7
9	Glutamin 200 ppm	11.2	4.3	21.39	44.4	82.2	35.5	1846.3
10	Alanin 200 ppm	10.6	3.9	19.44	42.3	72.6	36.4	1517.9
11	Arg+Glu+Ala 100 ppm	8.3	5.8	15.90	38.5	77.6	33.5	748.0
12	Arg+Glu+Ala 100 ppm + 1 % Urea	10	2.7	15.34	35.9	75.7	37.9	1619.7
13	Control	6.7	3.4	13.70	38.2	76.4	33.4	1050.9
	Mean	8.5	3.0	16.1	38.8	78.5	34.7	1190.4
	SEM	0.55	0.31	1.45	1.3	1.8	1.3	33.8
	CD (5%)	1.6	0.92	4.22	3.9	5.3	1.8	98.7
	CV (%)	11.1	18	15.50	6.0	4.0	6.4	4.9

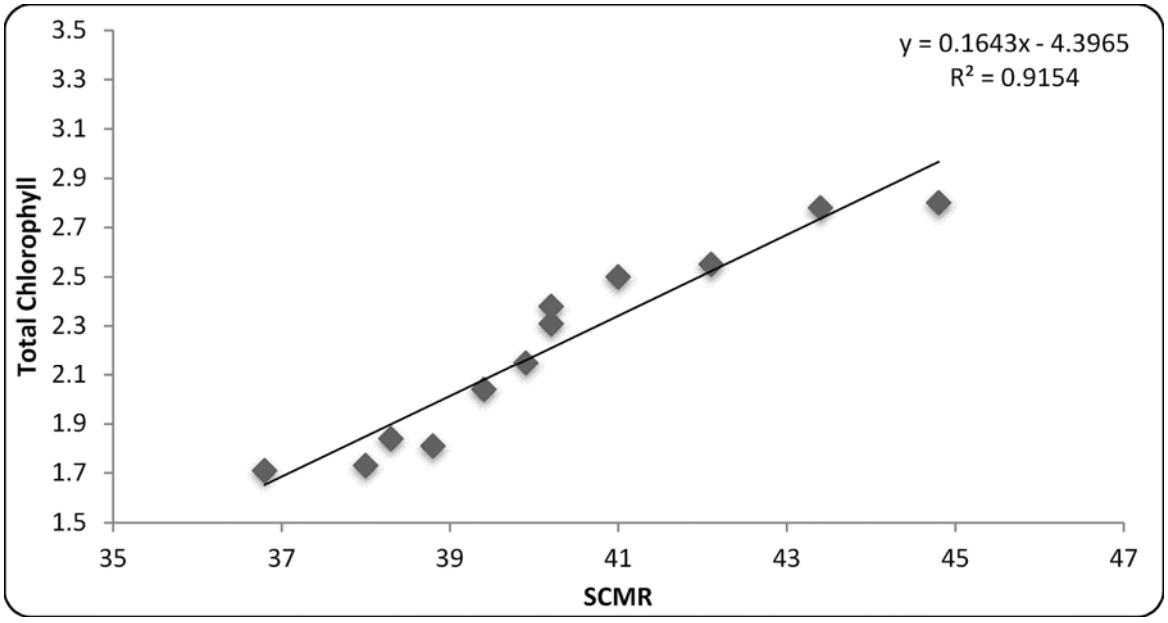

Fig. 1. Correlation between SCMR and total chlorophyll

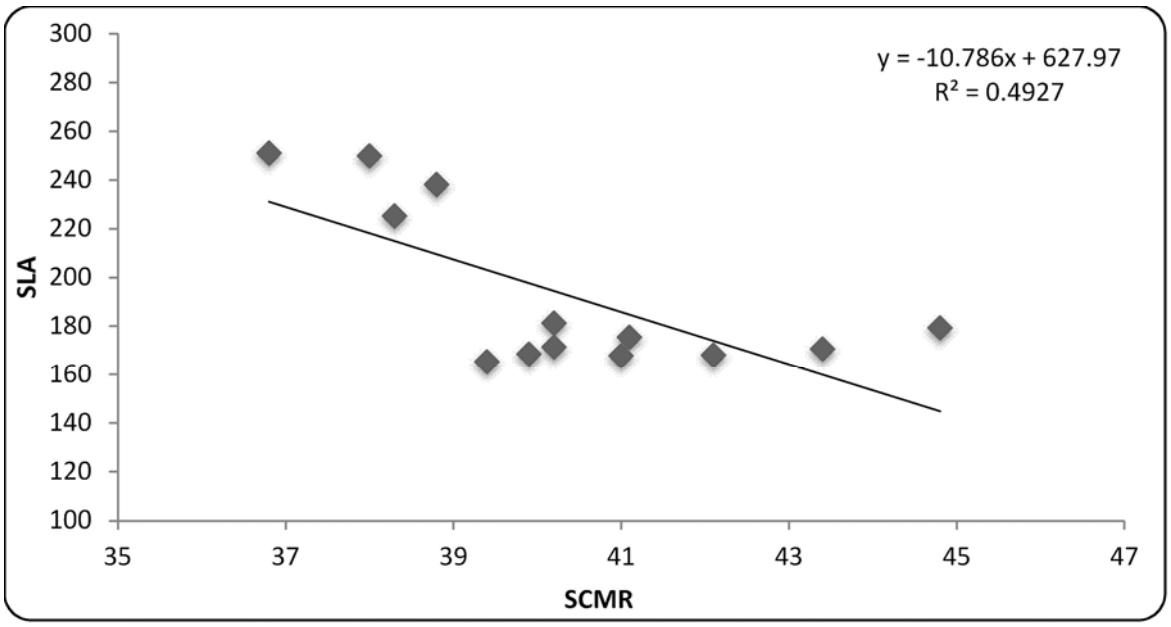

Fig. 2. Correlation between SCMR and SLA

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(Received on 18-04-2015 and revised on 30-04-2015)

Andhra Pradesh J Agril. Sci : 1(1): 54-56, 2015

PROSPECTS OF INCREASING INCOME AND EMPLOYMENT THROUGH ADOPTION OF IMPROVED TECHNOLOGY: A LINEAR PROGRAMMING APPROACH

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ABSTRACT

The present study was undertaken in Kadapa district of Andhra Pradesh state, with the overall objective of enquiring into the economic aspects of the impact of modern technology on income and employment. The total sample comprised 60 randomly selected cultivators from four villages of Obulavaripalli mandal of Kadapa district. The findings indicated that the adoption of recommended technology had resulted in higher income even with the available funds. The returns and employment could be increased further and reach maximum attainable levels with the additional credit facilities for adopting recommended technology.

KEY WORDS: Employment. Farm returns, Improved technology, Linear programming technique, Optimum farm plans

INTRODUCTION

Indian agriculture is known for its ability of providing employment, livelihood, food, nutritional and ecological securities. Agriculture contributes 14.2 per cent to the gross domestic product of India. About 60 per cent of the country's population ekes out their livelihood from this sector of the economy. The importance of agriculture in India prevails amidst the fast growing secondary and tertiary sectors. To compete with these sectors, the income from the agriculture must be increased which can be possible by rational use of resources and by raising production on the farms through the adoption of new technology. The present study was undertaken with the overall objective of enquiring into the economic aspects of the impact of modern technology on income and employment.

MATERIAL AND METHODS

The present study was conducted in Obulavaripalli mandal of Kadapa district, Andhra Pradesh. From the mandal four villages were selected, which had highest gross cropped area. From each village, ten small and ten large farmers were selected. Thus the total number of farmers selected for the present study was 80. The data regarding existing farm resources and input output coefficients were collected through a schedule especially designed for this study.

Two types of crop production activities were included in the model. The first group of crop activities indicated the production technology that was followed currently by the farmers whereas the other group of crop activities represented recommended technology as suggested in improved cultivation practices for high yields. The information regarding the crop production activities with existing technology was obtained from the selected respondents, whereas the information regarding recommended technology for various crops was obtained from the Regional Agricultural Research Station, Tirupati.

The linear programming technique which maximizes farm returns from various crop activities subject to the various constraints has been used as an analytical tool. This technique was also used by Shareef and Murthy (2001), Prasad (2004) for developing optimum plans. The model used was

$$\text{Maximise } Z = \sum_{j=1}^{n} C_j X_j$$

$$j = 1 \text{ to } n \text{ activities}$$

Subject to following constraints

1. $\sum_{j=1}^{n} a_{ij} X_j \geq b_i$ (i = 1, …….K)
2. $\sum_{j=1}^{n} a_{ij} X_j \leq b_i$ (i = K+1,……. m)
3. $\sum_{j=1}^{n} a_{ij} X_j = b_i$ (i = m+1, ……. v)
4. X_j , $b_i \geq 0$ (non negativity constraint)

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where,

Z = is the objective function to be maximized in the year.

C_j = is the value or price of jth activity during *kharif* and *rabi* seasons of the year.

X_j = is the unit of jth production activity during *kharif* and *rabi* seasons of the year.

a_{ij} = amount of ith resource required by j^{th} activity

b_i = quantity of ith resource

With the help of the above linear programming analysis, the following four optimum plans were developed for both small and large farms.

Model 1: The technology considered in this model was based on the practices followed by the sample farmers in production of crops. Cash availability of the farmers was restricted to owned funds.

Model 2: The technology consider in this model was existing technology. It is similar to model 1 but for the complete relaxation of the loan amount available to farmers.

Model 3: This model is similar to model 1 except that the recommended technology was incorporated in place of existing technology. Model 3 results indicate the income increasing possibilities by a switch over to the recommended technology even at the existing level of funds.

Model 4: It is similar to model 2, except that the recommended technology was incorporated in the place of existing technology. This model was designed to assess the effect of modern technology in conjunction with adequate capital on income and employment.

RESULTS AND DISCUSSION

A comparison of net farm returns between models designed at existing technology (Model 1) and at recommended technology (Model 3) with available funds shows impact of technology under restricted capital and a similar comparison of models with borrowed capital (Model 2 and Model 4) shows the impact of technology under unlimited capital. The results of these comparisons are presented in Table 1.

The programme designed at recommended technology with limited capital helped large farmers to realize an income of ₹ 1,67,611.60 as against ₹ 46,361 realized by small farmers. Due to the adoption of recommended technology small and large farmers realized an increased income of ₹ 927 (2.04%) and ₹ 33,038.10 (24.55%) respectively over the optimum plans developed at the current technology with owned funds and this reflects the impact of technology under capital constraint.

The existing technology with adequate capital helped small and large farmers to realize ₹ 50, 459 and ₹ 1, 50,480.40 respectively as net farm returns. The results of models developed at recommended technology with relaxed borrowing revealed that it was possible to get net farm returns of ₹ 64, 815 and ₹ 1, 92,515.70 for small and large farmers respectively. These returns were higher by ₹ 14, 356 (28.45%) and ₹ 42, 035.30 (27.93%) over the net farm returns obtained from model 2 for small and large farmers. This indicates the influence of technology on income under relaxed borrowing.

Impact of technology on employment of small and large farmers is presented in Table 2. The effect of technology under limited capital condition can be known by comparing models 1 and 3. The adoption of recommended technology with available funds led to decrease in the labour use by 3.47 man days, 33.51 womandays and 8.34 bullockdays over the labour use in the existing technology on small farms.

In the case of large farms, the adoption of recommended technology even under limited capital led to increase employment to the extent of 22.46 mandays, 40.51 woman days and 3.21 hours tractor use over the optimum model 1.

A comparison of models 2 and 4 indicates the impact of technology on employment under unlimited capital condition. In model 4 labour use was higher by 7.02 mandays, 44.05 womandays and 9.85 hours of tractor use over model 2 on small farms. Model 4 provided an additional employment of 18.46 mandays, 96.30 womandays and 8.94 hours of tractor use over model 2 on large farms.

CONCLUSION

From the above discussion, it may be inferred that the recommended technology had significant effect on net farm returns of both the categories of farmers under limited and unlimited capital conditions. However, the effect of technology was relatively more when it was associated with adequate capital. It is interesting to note that impact of technology was more on large farms compared to small farms under limited capital while the

Table 1. Impact of technology on net farm returns of small and large farms (in Rupees)

Category /Model	Limited capital			Unlimited capital		
	Model-1	Model-3	Change over Model-1	Model-2	Model-4	Change over Model - 2
Small farmers	45,434.00	46,361.00	927.00 (2.04)	50,459.00	64,815.00	14,356.00 (28.45)
Large farmers	1,34,573.50	1,67,611.60	33,038.10 (24.55)	1,50,480.40	1,92,515.70	42,035.30 (27.93)

Note: Figures in parentheses indicate percentages

Table 2. Impact of technology on employment of small and large farms

Category / Model	Limited capital				Unlimited capital			
	Model-1	Model-3	Change Over Model-1		Model-2	Model-4	Change Over Model-2	
			Absolute	Per cent			Absolute	Per cent
1. Small farmers								
Mandays	46.80	43.33	-3.47	-7.41	55.78	62.80	7.02	12.58
Womandays	171.33	137.82	-33.51	-19.55	190.33	234.38	44.05	23.14
Bullockdays	14.29	5.95	-8.34	-58.36	17.72	5.80	-11.92	-67.27
Tractor hours	4.76	8.34	3.58	75.21	5.69	15.54	9.85	173.11
2. Large farmers								
Mandays	141.80	164.26	22.46	15.84	160.83	179.29	18.46	11.47
Womandays	508.87	549.38	40.51	7.96	562.30	658.60	96.30	17.13
Bullockdays	26.61	17.99	-8.62	-32.39	33.28	23.72	-9.56	-28.73
Tractor hours	36.75	39.96	3.21	8.73	42.15	51.09	8.94	21.21

same was more on small farms under unlimited capital environment. The findings in this aspect were found in conformity with the findings of Deoghare (1997), Gajanana and Sharma (1990), Jagtar et.al. (1990), Sreelakshmi (1995). The results showed that the labour employment could be increased by introducing modern technology along with credit facilities.

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(Received on 25-04-2015 and revised 10-05-2015)

Andhra Pradesh J Agril. Sci : 1(1): 57-60, 2015

CONSTRUCTION OF SCALE TO MEASURE A WRITTEN DOCUMENT BY SEMANTIC DIFFERENTIAL TECHNIQUE

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ABSTRACT

Writing is an important tool for communication. It not only helps in conveying message to the intended reader but also, possess the qualities of permanence, confidence building, reinforcement and qualitative comprehension. In our day to day life, we are effectively utilizing this tool for speedy dissemination of messages. The quality of any written communication has been judged effectively with the help of an appropriate measuring instrument. In this connection, an attempt was made to construct a scale to measure the written document. Semantic differential is a type of a rating scale designed to measure the connotative meaning of objects, events, and concepts or attitudes. It permits the researcher to measure both the direction and the intensity of respondents' attitudes. Hence, the semantic differential technique was used to construct a scale to measure the written document. A total of twenty items were selected in the final scale of a written document.

KEYWORDS: Measurement, Semantic differential technique, Scale, Written document

INTRODUCTION

Writing is a skill that is required in many contexts throughout our life. It is the most important tool in communication. It not only helps in conveying message to the intended reader but also, possess the qualities of permanence, confidence building, reinforcement and qualitative comprehension. In our day to day life, we are effectively utilizing this tool for speedy dissemination of messages. How efficiently an individual writes a document is reflected through the extent of satisfaction received by the end-users in terms of awareness obtained, knowledge gained and extent of comprehension realized about the subject as well as the application of the same in their real life situation. Hence the quality of a written document needs to be prioritized by the individuals.

Ample research was taken up to study different factors contributing for evaluating the quality of a written document. Each factor will have its own importance in attracting the readers to read the document. In general, if readers read any written document, they will make a subjective judgment of the document based on certain criteria as part of their perception. But it may not give an accurate judgment of the quality of document. To have more objective and accurate judgment of a written document an attempt was made to develop a scale by using semantic differential technique. This scale will act as a means for measuring any written statement more accurately, comprehensively and qualitatively.

MATERIAL AND METHODS

The study was carried out during the year 2014-15. Semantic differential is a type of a rating scale designed to measure the connotative meaning of objects, events, and concepts or attitudes. This technique was developed by Osgood *et al.* (1957). It permits the researcher to measure both the direction and the intensity of respondents' attitudes. The purpose of this technique is to measure the various facets of meaning represented by adjectives. Meaning is a very general term and it includes the various reactions of people towards an object. There are three facets of meaning – denotation, connotation and association. The Semantic Differential Scale is a measure of mainly connotative facet of meaning. Connotation indicates the sentiment and feeling of persons about any object. (Arun Kumar Singh, 2009). In this scale the concept is usually rated on the seven point scale having bipolar adjectives at the two extremes.

In the present study "Written Document" is chosen as the concept. As a first step all the items that can fit into the scale of the concept were collected from thorough review of literature, professionals' observations and personal experiences. A total of 20 items were collected and appropriate bipolar adjectives were assigned for all

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the items which are categorized under three kinds of factors viz., Evaluative (E), Potency (P) and Activity (A) which are the major areas of measuring of the concept under Semantic Differential Scale (Osgood and others discovered these three factors). The three factors along with some examples of bipolar adjective pairs are shown below:

S. No.	Factor	Bipolar Adjective Pairs
1	Evaluative (E)	Good -Bad, Fair-Unfair, Clean-Dirty etc…
2	Potency (P)	Strong-Weak, Large-Small, Hard-Soft, Dominant-Submissive etc...
3	Activity (A)	Hot-Cold, Fast-Slow, Active-Passive, Tense-Relaxed etc...

Each factor is a cluster of adjectives and represents three dimensions of meaning along which a concept can be measured. These are technically known as semantic spaces. Of all these factors 'E' factor is the strongest because the pairs of adjectives of this factor have sharp bipolar extremes i.e., all pairs have very clear-cut positive and negative extremes.

Then these items were given to 100 judges and obtained the responses on a four point continuum viz., "Highly relevant, moderately relevant, slightly relevant and less relevant" with the scores 4, 3, 2 and 1 respectively. For each item the maximum possible score for the judgment of present concept by each judge is 80 and the minimum score possible is 20. After getting total score on all items for all judges, they were arranged in descending order. Then 25 percent of the judges with the highest total scores and 25 percent of the judges with the lowest total scores were taken, which are called as high group and low group respectively. These two groups are known as criterion groups. 't' value for each statement was calculated by using mean scores obtained for each item by the judges of high and low group (Sagar Mondal and Ray, 1999). The formula to calculate t value is as follows:

$$t = \frac{\left(\overline{X}_H - \overline{X}_L\right)}{\sqrt{\hat{\imath}\left(X_H - \overline{X}_H\right)^2 . \hat{\imath}\left(X_L - \overline{X}_L\right)^2} / \sqrt{n(n-1)}}$$

where,

$\overline{X}_H$ = mean score on a given statement for the high group

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

here,

$$\hat{\imath}\left(X_H - \overline{X}_H\right)^2 = \hat{\imath} X_{H^2} - \frac{\Sigma(X_H)^2}{n_H}$$

$$\hat{\imath}\left(X_L - \overline{X}_L\right)^2 = \hat{\imath} X_{L^2} - \frac{\Sigma(X_L)^2}{n_L}$$

$$\overline{X}_H = \frac{\Sigma X_H}{n_H}$$

$$\overline{X}_L = \frac{\Sigma X_L}{n_L}$$

$$n = n_L = n_H$$

Calculation of t value for evaluating the difference in the mean response to the item by a high and low group: For First Item

Response category	Low Group			
	X	F	fX	fX^2
HR	4	20	80	320
MR	3	5	15	45
SR	2	0	0	0
LR	1	0	0	0
		25	95	365
		n_L	ΣX_L	ΣX_L^2

Response category	Low Group			
	X	F	fX	fX^2
HR	4	24	96	384
MR	3	1	3	9
SR	2	0	0	0
LR	1	0	0	0
		25	99	393
		n_H	ΣX_H	ΣX_H^2

$$n = 25$$

$$\overline{X}_H = 99/25 = 3.96$$

$$\overline{X}_L = 95/25 = 3.8$$

$$\left(\overline{X}_H - \overline{X}_L\right) = 0.16$$

$$\Sigma\left(X_H - \overline{X}_H\right)^2 = 393 - \frac{(99)^2}{25} = 0$$

$$\Sigma\left(X_L - \overline{X}_L\right)^2 = 365 - \frac{(95)^2}{25} = 0.96$$

$$\Sigma\left(X_H - \overline{X}_H\right)^2 . \Sigma\left(X_L - \overline{X}_L\right)^2 / n(n-1) = 0.008$$

$$\sqrt{\Sigma\left(X_H - \overline{X}_H\right)^2 . \Sigma\left(X_L - \overline{X}_L\right)^2 / n(n-1)} = 0.091$$

$$t_1 = 1.759$$

Note: HR- Highly Relevant, MR- Moderately Relevant, SR- Slightly Relevant and LR-Less Relevant.

The 't' values for remaining items were also calculated by following the same procedure. The value of t is a measure of the extent to which a given item differentiates between the high and low groups. As an approximate rule of thumb, we may regard any 't' value equal to or greater than 1.75 as indicating that the average response of the high and low groups to an item differs significantly, provided 25 or more subjects are present in high group and also in the low group. The items were arranged in the rank order according to their 't' values. Then all the 20 items with the largest 't' values were selected for the scale. Reliability of the items was found out using split-half method and also found the validity of the items. (Edwards, 1997). Finally the 20 items along with their bipolar adjectives, 't' values and factors are shown in the Table 1.

Table 1. 't' values and factors of the selected twenty items along with their bipolar adjectives

S. No.	Item	t value	Factor
1	First sentence (Gripping –Boring)	8.049845	E
2	Sentences (Long –Short)	7.457111	P
3	Clear and easy layout (Difficult –Simple)	7.154967	P
4	Avoiding repetition of words/ sentences (More – Less)	7.10969	P
5	Content (Precise –Vague)	7.102996	E
6	Conclusions and recommendations (Relevant – Irrelevant)	6.725382	E
7	Jargon (Used- Not used)	6.295146	E
8	Spelling and punctuation (Correct –Incorrect)	6.195416	E
9	Use of illustrations (Appropriate- Inappropriate)	5.709971	E
10	Content with an exact use of words (Concise- Long-winded)	5.647964	P
11	Elegance (Neat- Messy)	5.259006	E
12	Sequence of information (Logical –Illogical)	4.813084	E
13	Formatting of the content (Proper –Improper)	4.64758	E
14	Paragraphs (Prolonged- Brief)	4.488746	P
15	Use of voice (Active -Passive)	4.451991	A
16	Catchy and stand out title - Forgettable & unnoticeable title	4.328451	E
17	Hand writing (Impressive- Unimpressive)	2.279212	E
18	Highlight the important points (Focused - Not Focused)	2.106966	A
19	Short, concrete, simple & familiar words - Long, indeterminate complex & unfamiliar words	1.792516	P
20	Subject and purpose (Clear- Unclear)	1.759765	E

Table 2. Semantic differential scale to measure attribute of a written document

S. No.	Item	Adjective	Continuum							Adjective	Factors
			+3	+2	+1	0	-1	-2	-3		
1	First sentence	Gripping								Boring	**E**
2	Content	Precise								Vague	**E**
3	Conclusions and recommendations	Relevant								Irrelevant	**E**
4	Jargon	Used								Not used	**E**
5	Spelling & punctuation	Correct								Incorrect	**E**
6	Use of illustrations	Appropriate								Inappropriate	**E**
7	Elegance	Neatness								Messiness	**E**
8	Sequence of information	Logical								Illogical	**E**
9	Formatting of the content	Proper								Improper	**E**
10	Title	Catchy and stand out								Forgettable and unnoticeable	**E**
11	Hand writing	Impressive								Unimpressive	**E**
12	Subject and purpose	Clear								Un clear	**E**
13	Content	Concise								Long-winded	**P**
14	Paragraphs	Brief								Prolonged	**P**
15	Sentences	Short								Long	**P**
16	Layout	Simple								Difficult	**P**
17	Repetition of words/ sentences	Less								More	**P**
18	Short, simple, concrete and familiar words									Long, complex, indeterminate and unfamiliar	**P**
19	Words	Active								Passive	**A**
20	Important points	Focused								Not Focused	**A**

Finally the concept is written on a separate sheet of paper (preferably in the top-middle of the bipolar adjectives) with the same set of scales and the subject is asked to rate the concept as he or she sees them. By assigning a set of integer values, such as +3, +2, +1, 0, –1, –2, –3, to the seven gradations of each bipolar scale, the responses can be quantified under the assumption of equal-appearing intervals. This is shown in the Table 2.

These scale values, in turn, can be averaged across respondents to develop semantic differential profiles. Semantic Differential data can be analyzed for one individual as well as for a group of individuals. The scores on the individual scales are first located and then summed up to find out the mean of the set of scores. (Arun Kumar Singh, 2009).

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(Received on 23-03-2015 and revised on 14-04-2015)

Andhra Pradesh J Agril. Sci : 1(1): 61-66, 2015

UTILIZATION OF INTER-PERSONAL LOCALITE SOURCES OF INFORMATION BY RICE GROWERS

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ABSTRACT

With a view to know the utilization and credibility of various inter-personal localite sources as perceived by the rice growers, the study was conducted with an Ex-post facto research design in SPSR Nellore district of Andhra Pradesh over a randomly drawn sample of 120 rice growing farmers as respondents. The results of the study revealed that with regard to obtaining information related to technical and non-technical aspects farmers preferred the various inter-personal localite sources in the ranking order of Adarsha Rythu (1st), Neighbours (2nd), Progressive farmers (3rd) and Friends (4th) respectively. Similarly information related to Govt. policies/schemes order of preference was Village Revenue Officer (1st), Adarsha Rythu (2nd) and Progressive farmer(3rd). Further, the distribution of respondents with regard to obtaining information related to technical, non-technical aspects, the various inter-personal localite sources which farmers considered as most credible and the extent of use of these sources in the ranking order of Adarsha Rythu (1st), Progressive farmers (2nd), Neighbours (3rd) and Input dealers (4th) respectively. Similarly information related to Govt. policies/schemes the order of preference pertaining to credibility of the information sources was Adarsha Rythu (1st), Village Revenue Officer (2nd) and Progressive farmers (3rd) as perceived by the rice growers.

KEY WORDS: Inter-Personal Localite Sources, Rice Farmers, Utilization and Credibility,

INTRODUCTION

Information is considered as a vital resource, along with land, labour, capital and skills. People need information for their day-to-day activities and for the development of their environment and their selves. Information serves as the cornerstone of successful socio-economic development because it plays a key role in decision making. Access to reliable, timely and relevant information can help significantly and in many ways to reduce farmers' risk and uncertainty, empowering them to make good decisions. Information is vital for increasing production and improving marketing and distribution strategies (Oladele, 2006). Hence timely, relevant, and accurate information collection is crucial to farmers. Information also opens windows of sharing experiences, best practices, sources of financial aids and new markets. Present Extension system is already under pressure due to wide ratio between the extension worker and farmers. In this situation, it is very difficult to provide latest information and farm technologies to the farmers in short time. To solve such problems, cost effective and efficient information support systems like Inter-personal localite, Inter-personal cosmopolite and Mass media sources/ Impersonal cosmopolite sources are very much required. Keeping in view the factual position, it was felt necessary to investigate the information source utilization pattern by the rice farmers.

MATERIAL AND METHODS

The study was conducted with an expost- facto research design to study the information source utilization pattern of rice farmers. The SPSR Nellore district of Andhra Pradesh was purposively selected for the study because maximum number of rice farmers was involved in rice farming and having agriculture as main occupation. SPSR Nellore district comprises of 46 mandals out of which four mandals namely Nellore, Venkatachalam, Allur and Vidavalur mandals were purposively selected for the study. From each of the selected mandals, two villages were selected based on random sampling procedure. Thus, totally eight villages were selected for the study. A total sample of 120 rice farmers were selected by selecting 15 farmers from each village through simple random sampling procedure. Keeping in view the objectives of

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the study, a well structured interview schedule was developed and pretested. This was administered to sample respondents through personal investigation. The study was carried out during the year 2013-14.

RESULTS AND DISCUSSION

Frequency of use of inter-personal localite sources of information:

From the table 1, it is clear that Adarsha Rythus (Mean score, 2.88), Neighbours (Mean score, 2.78), Progressive farmer (Mean score, 2.54), Friends (Mean score, 2.47), Input dealers (Mean score, 2.15) and Relatives (Mean score, 1.89) were the major inter-personal localite sources of information used by majority of the selected rice growers for obtaining information related to technical aspects of rice production and were accorded 1st, 2nd, 3rd, 4th, 5th and 6th ranks respectively.

Data shown in Table 1 further revealed that in obtaining information by the rice farmers related to non-technical aspects also the same trend was observed. Adarsha Rythus (Mean score, 2.93), Progressive farmers (Mean score, 2.85), Neighbours (Mean score, 2.45) and Input dealers (Mean score, 2.32) were the major inter-personal localite sources of information for obtaining information related to non-technical aspects like agricultural inputs availability, credit & finance management, marketing and weather forecasting and were accorded 1st, 2nd, 3rd and 4th ranks respectively.

Above results depicted the emergence of leadership from among the farming community. Adarsha Rythu is one of such category appointed by the government. They are specialized in certain subject matter areas hence were having command and recognition in the society, also in connection with maximum fellow farmers. Similarly the same situation with progressive farmers. They are also treated as special one among the farming community. Cosmopolite behavior makes them more acceptable in the society. The innate quality they possess is innovativeness that updates them with latest technologies. Respondents believed that Adarsha Rythus and progressive farmers as source of information because of the above reasons.

Further respondents believed that their neighbors as source of information, which ranked 2nd position among inter-personal localite sources. The basic factor to reach such high figure might be that the respondents believe on neighbors considering that they never provide unrealistic information. Since their social relationship has its own past and future apart from present. Next in the rank order were friends. Trust or credibility is the major factor behind consultation of friends. The reliable information delivered by friends to friends makes their friendship long lasting. Input dealers carry latest information but at times they exploit farmers as their main intention is profit making in their business. Relatives were contacted by an extent of 32.50 per cent as they were not always within their proximity.

Data shown in Table 1 indicated that in obtaining information by the rice farmers related to Govt. policies/ schemes from among the various inter-personal localite sources, Village Revenue Officer (Mean score, 2.93) was most regularly contacted channel and accorded 1st rank. Adarsha rythus (Mean score, 2.89) and Progressive farmers (Mean score, 2.43) were also contacted by the rice farmers for seeking information on Govt. policies/ schemes and were accorded 2nd and 3rd ranks. The Village Revenue Officer is considered as the village level officials who carry latest developments in government sector, hence, respondent farmers were in regular contact with village revenue officer for obtaining information regarding government policies/schemes. As mentioned earlier, Adarsha Rythus and Progressive farmers being easily accessible in the villages itself and due to their cosmopolite behaviour might have contributed towards the extent of their contact by the rice farmers to obtain information related to Govt. policies/ schemes. The finding was in line with the findings of Kumar *et al.* (2012)

Extent of use of Inter-Personal Localite Sources of Information:

From the Table 2 it is clear that with regard to extent of use information related to technical aspects from the various inter-personal localite sources, the information obtained from the Adarsha Rythu (Mean score, 1.97) was considered most credible and accorded 1st rank. Extent of use information obtained from Village Adarsha Rythu (Mean score, 1.96), Neighbours (Mean score, 1.91), Progressive farmer (Mean score, 1.90), Input dealers (Mean score, 1.78), Relatives (Mean score, 1.61) and Friends (Mean score, 1.55) were the major inter-personal localite sources of information used by the majority of selected rice growers in obtaining information related to technical aspects of rice production and were accorded 2nd, 3rd, 4th, 5th and 6th ranks respectively.

Thorough analysis of the Table revealed that farmers preference for getting information is based on the credibility of the source as they perceived based on the person/authority's general image. It is clear from the results that the usage of information with regard to technical aspects Adarsha Rythu was considered as the most credible source and ranked first. This might be due to the fact that he is one of the agent specially selected by the government who in turn frequently undergoes special trainings that were conducted by the State Department of Agriculture. Hence, most of the farmers felt that he is one among them who is having the most relevant information required by them. Another reason behind was that the farmers remain more time in contact with Adarsha Rythu. Adarsha ryrthu mostly used and adopt new technology on his field, which can easily be seen by the other farmers with their own eyes and may easily be implemented in the same situation on their fields.

Next preference was given to the information given by neighbours and progressive farmers. These sources were considered as the most credible inter personal localite sources of information utilized by the rice growers. This might be due to their easy accessibility and approach by the farmers. It is quite natural that he/she would like to have the moral support from his neighbours. Thus, the fellow farmers were the important source for the spread of an innovation. Information provided by Input dealers and relatives was occupied 4th and 5th ranks respectively with regard to information use. This might be due to the reason that the visits made by the rice growers to the input agencies to get their inputs would pave way for gathering information regarding the cultivation aspects. Before adoption of any new practice getting reinforcement from their own relatives is quite natural. This might be the reason for using the information obtained from the relatives.

Data shown in Table 2 further reveled that in obtaining information related to non- technical aspects from the personal localite sources also the same trend was observed. Adarsha rythu (Mean score, 1.93), Progressive farmers (Mean score, 1.88), Neighbours (Mean score, 1.61) and Input dealers (Mean score, 1.44) were the major inter-personal localite sources of information considered as credible by the rice farmers in using the information related to non-technical aspects like agricultural inputs availability, credit & finance management, marketing and weather forecasting.

With regard to non-technical aspects usage of information from the various sources also rely on the same reason that the Adarsha rythu and Progressive farmers both were frequently in touch with the officials of the state department of agriculture. Hence, farmers feel that the information from these sources will have authenticity. As mentioned earlier, accessibility of a particular source of information has its bearing on the extent of its use by the farming community. Neighbours and input dealers being easily accessible in the village itself or adjacent villages in case of input dealers (as they are business oriented always available in the shops) might have contributed towards the extent of use of information obtained from these sources in the study area.

Data shown in Table 2 with regard to extent of use information related to Government policies/schemes from the various inter-personal localite sources, the information obtained from the Adarsha Rythu (Mean score, 1.97) was considered most credible and accorded 1st rank. Information obtained from Village Revenue Officer (Mean score, 1.93) and Progressive farmers (Mean score, 1.65) was also considered by the rice farmers and was given 2nd and 3rd ranks respectively with regard to extent of use. This finding was inline with the findings of Meean *et al.* (2011).

Information related to Govt. policies/schemes most of the farmers depend on the information obtained from the Adarsha Rythu as he is considered as the 'key informant' in disseminating the relevant information within no time. Information from the Village Revenue Officer was next preferred by the farmer due to the reason that he is one of the representatives of the village governance and was considered as most credible source of getting information regarding Govt. policies/schemes. As mentioned earlier the information obtained from the progressive farmers was also considered as next credible source by most of the rice farmers.

CONCLUSION

With regard to obtaining information related to technical and non-technical aspects farmers preferred the various inter-personal localite sources in the ranking order of Adarsha Rythu (1st), Neighbours (2nd), Progressive Farmers (3rd) and Friends (4th) respectively. Similarly information related to Govt. policies/schemes order of preference was Village Revenue Officer (1st), Adarsha Rythu (2nd) and Progressive Farmer (3rd). Further, the

Table 1. Frequency of use of Inter-personal localite sources by the rice farmers

Type of information	Information source	Frequency of use								Total score	Mean score	Rank
		Regularly		Occasionally		Rarely		Never				
		F	%	F	%	F	%	F	%			
I. TECHNICAL ASPECTS												
1) Soil testing 2) Land preparation (Nursery and Main field)	Neighbours	98	81.66	18	15	4	3.33	-	-	334	2.78	II
3) Selection of variety 4) Seed rate	Progressive farmers	77	64.16	34	28.33	6	5	3	2.5	305	2.54	III
5) Seed treatment 6) Fertilizer management	Adarsha rythu	106	88.33	14	11.67	-	-	-	-	346	2.88	I
7) Irrigation management 8) Weed management	Input dealers	52	43.33	42	35	18	15	8	6.66	258	2.15	V
9) Plant protection measures 10) Farm mechanization	Friends	63	52.5	51	42.5	6	5	-	-	297	2.47	IV
11) Post-harvest technology 12) Seed production	Relatives	39	32.5	48	40	14	11.66	19	15.83	227	1.89	VI
II. NON-TECHNICAL ASPECTS												
1) Agrl. inputs availability	Progressive farmers	106	88.33	10	8.33	4	3.33	-	-	342	2.85	II
2) Credit and finance management	Adarsha rythu	112	93.33	8	6.67	-	-	-	-	352	2.93	I
3) Marketing	Neighbours	85	70.83	20	16.66	-	-	15	12.5	295	2.45	III
4) Weather forecasting	Input dealers	73	60.83	24	20	12	10	11	9.16	279	2.32	IV
III. GOVT. POLICIES/ SCHEMES												
1) Crop insurance	Adarsha rythu	107	89.16	13	10.83	-	-	-	-	347	2.89	II
2) Electricity	Village Revenue Officer	112	93.33	8	6.67	-	-	-	-	352	2.93	I
3) Subsidies on agrl. inputs 4) Crop compensation	Progressive farmers	66	55	47	39.17	-	-	7	5.83	292	2.43	III

Table 2. Extent of use of Inter-personal localite sources by the rice farmers

Type of information	Information source	Extent of use						Total score	Mean score	Rank
		Fully used		Partially used		Not used				
		F	%	F	%	F	%			
I. TECHNICAL ASPECTS										
1) Soil testing 2) Land preparation (Nursery & Main field)	Neighbours	110	91.67	10	8.33	-	-	230	1.91	II
3) Selection of variety 4) Seed rate	Progressive farmers	109	90.83	11	9.17	-	-	229	1.90	III
5) Seed treatment 6) Fertilizer management	Adarsha rythu	116	96.66	4	3.34	-	-	236	1.96	I
7) Irrigation management 8) Weed management	Input dealers	94	78.34	26	21.66	-	-	214	1.78	IV
9) Plant Protection Measures 10) Farm Mechanization	Friends	73	60.83	41	34.17	6	5	187	1.55	VI
11) Post-Harvest technology 12) Seed Production	Relatives	87	72.5	20	16.66	13	10.84	194	1.61	V
II. NON-TECHNICAL ASPECTS										
1) Agrl. inputs availability	Progressive farmers	106	88.33	14	11.67	-	-	226	1.88	II
2) Credit & finance management	Adarsha rythu	112	93.33	8	6.67	-	-	232	1.93	I
3) Marketing	Neighbours	81	67.5	32	26.66	7	5.84	194	1.61	III
4) Weather forecasting	Input dealers	64	53.33	45	37.5	11	9.17	173	1.44	IV
III. GOVT. POLICIES/ SCHEMES										
1) Crop insurance	Adarsha rythu	117	97.5	3	2.5	-	-	237	1.97	I
2) Electricity	Village Revenue Officer	112	93.33	8	6.67	-	-	232	1.93	II
3) Subsidies on agrl. inputs 4) Crop compensation	Progressive farmers	78	65	42	35	-	-	198	1.65	III

distribution of respondents with regard to obtaining information related to technical, non-technical aspects, the various inter-personal localite sources which farmers considered as most credible and extent of use of these sources in the ranking order of Adarsha Rythu (1st), Progressive Farmers (2nd), Neighbours (3rd) and Input Dealers (4th) respectively. Similarly information related to Govt. policies/schemes the order of preference was Adarsha Rythu (1st), Village Revenue Officer (2nd) and Progressive Farmers (3rd) as felt by the rice growers.

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(Received on 10-04-2015 and revised on 27-04-2015)

Andhra Pradesh J Agril. Sci : 1(1): 67-72, 2015

PROFILE CHARACTERISTICS OF SRI FAMERS IN NAGAPATTINAM DISTRICT OF TAMIL NADU

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ABSTRACT

Rice is an important staple food crop for the Asian region and India is center of origin with a wide variability. As rice alone consumes 63% of the total irrigated area in Tamil Nadu state, necessitated the need for developing the alternative methods of its cultivation to reduce the stress on this dwindling natural resource. SRI (System of Rice Intensification) is a suitable alternative method of cultivating rice which not only reduces water usage and external inputs like fertilizers but also has a better yield potential. In spite of many concerted efforts since 2000, by Dr. Thiyagarajan of Tamil Nadu Agricultural University, Department of Agriculture, and NGOs, the spread of SRI with in Tamil Nadu was relatively slow. The results of the study revealed that, majority of the respondents belonged to middle age group (56.67%) having middle school level of education (25.00%) with medium farming experience (64.00%). Majority of the respondents had undergone trainings (56.67%), had medium level of economic orientation (72.50%), risk orientation (75.00%), scientific orientation (64.00%), management orientation (65.83%), innovativeness (59.17%) and achievement motivation (65.00%).

KEY WORDS: Profile characteristics, SRI technology, SRI farmers

INTRODUCTION

India is one of the largest producers of Rice in the world; however, Rice cultivation in recent times has suffered from several interrelated problems. Increased yields achieved during the green revolution through input intensive methods of high water and fertilizer use in well-endowed regions are showing signs of stagnation and concomitant environmental problems due to salinization and water-logging of fields (the grain bowls of India Punjab and Haryana are some of the areas worst affected). In other parts there have been social conflicts between water users in several canal-irrigated areas due to the water intensive nature of the crop. In the meantime in Tamil Nadu farmers started to adopt System of Rice Intensification (SRI) by replacing the conventional method.

MATERIAL AND METHODS

Ex-post facto research design was followed in the investigation. The study was conducted in Nagapattinam district of Tamil Nadu. Nagapattinam district was purposively selected for the study because it is one of the leading rice producing districts of Tamil Nadu as it lies in the Cauvery Delta zone and also it ranked first in SRI paddy coverage for the period of 2011-12 in the Tamil Nadu. Out of eleven blocks from the Nagapattinam district four blocks were purposively selected to represent the north and southern parts of the districts according to the highest area under SRI. Three villages from each selected block were purposively selected according to the highest area under SRI. From each village 10 farmers were selected by following simple random sampling procedure, thus making a total of 120 respondents. Extent of adoption of SRI technology by the respondents was studied by a well-structured and pre-tested schedule developed for the study. The study was carried out during the year 2011-12.

RESULTS AND DISCUSSION

The SRI farmers were distributed into different categories based on their selected profile characteristics and the results were presented in the Table 1.

Age

Majority (56.67%) of the respondents were found in the middle age category followed by 31.67 per cent in the old age category and only 11.66 per cent fell under young age category. From the above findings, it could be

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understood that majority of the respondents were found to be in middle and old age categories. The possible reason might be that a large portion of the younger generation didn't prefer agriculture as they turned towards industries, IT and management. The above findings corroborate with the findings of Santhi (2006).

Education

Majority of the respondents were educated upto middle school level (25.00%) and high school education (24.17%), followed by higher secondary (15.83%) and primary school (14.17%) education. Notably 11.67 per cent of the respondents were functionally literate. Few respondents (5.83%) belonged to collegiate. A meagre portion (3.33%) of them was illiterate. This might be because of the availability of the higher secondary schools and Arts and Science College in the study area. Only one-tenth of the respondents fell under functionally literate to illiterate level of education. Most of them found to be middle to old aged. This could have been the possible reason for the various education levels observed in the study.

Farming Experience

Majority (64.17%) of the SRI farmers had medium level of farming experience followed by high (18.33%) and low (17.50%). This might be due to the fact that majority of the respondents belonged to middle and old age categories. Hence most of the respondents had medium to high level of farming experience.

Land Holding

From Table 1 it is evident that 42.50 per cent of the respondents were medium farmers followed by semi-medium (24.16%), small (20.00%), marginal (6.67%) and big (6.67%) farmers. The possible reason might be that in the recent times most of the families are of nuclear system and joint family system is gradually fading away. This resulted in fragmentation of land among the family members. As the capital investment in farming was rising, more and more farmers showed interest towards the conversion to commercial ventures.

Training Undergone

Majority (56.67%) of the respondents had received only one training followed by two trainings (35.00%), no training (6.67%) and three and above (1.67%) trainings. The possible reason for this might be that the duration of the training was half day or one day. Most of the farmers were trained at least once. Efforts made by State Department of Agriculture to conduct effective training programmes at local level, had attracted even old aged farmers. Hence most of the respondents belonged to medium to low training undergone categories. There is every need on the part of the officials and extension agencies to organize more number of need based trainings to encourage the participation of all age groups of farmers.

Social Participation

The little more than three-fourth (78.33%) of the respondents had medium level of social participation followed by low (15.00%) and high (6.67%) levels. It could be concluded that, very few SRI farmers had enrolled as members in Self-Help Groups, Agricultural co-operative credit societies, Milk co-operative societies and Gram panchayat and others were concentrating on their own business. This might be the possible reason for their medium to low level of social participation. This result is in agreement with Santhi (2006).

Extension Contact

Majority (67.50%) of the respondents had medium extension contact followed by high (18.33%) and low (14.17%) levels of extension contact. The possible reason for the medium level of extension contact could be that majority of the respondents were lured by the subsidies. A sizable portion of them who lie in first two of the adopter categories were keen in keeping touch with department officials and they had high level of extension contact. Extension machinery had been forced to take this programme to the farmers and the performance of them was quite significant in taking the SRI to them. In fact the extension personnel played major role in this regard and their work was laudable. This might be the possible reason for the medium followed by the high levels of extension contact. This result is in agreement with Ramesh and Govind (2004).

Economic Orientation

Nearly three–fourth (72.50%) of the SRI farmers had medium level of economic Orientation followed by low level (18.33%) and high level (9.17%) of economic Orientation. This might be due to the common truth that the respondents had the urge for more monetary profit per unit area and naturally that would have motivated the farmers to adopt SRI cultivation practices. This finding is

in accordance with the findings of Kiran and Shenoy (2010).

Scientific Orientation

More than half (64.17%) of SRI farmers possessed medium level of scientific orientation followed by low (20.00%) and high level (15.83%) of scientific orientation. This might be due to the respondent's level of education, the number of trainings attended and extension contact. These factors ultimately lead to more faith on technology and contribute for medium to high level of scientific orientation. This finding is in line with the findings of Sangeetha (2005).

Management Orientation

Majority (65.83%) of the respondents had medium management orientation followed by low (19.17%) and high (15.00%) levels of management orientation. Management orientation is the ability of the farmer in scientific farm management in planning, production and marketing. Majority of the farmers being medium to old aged were having higher levels of farming experience. From the vast experience of farming they were good in planning and production aspects of farm management. This could be the probable reason for the medium level of management orientation. But it was observed that majority did not know about planning, marketing and record keeping aspects of farm management. This result is in agreement with Ramu (2005).

Innovativeness

Majority (59.17%) of the respondents had medium innovativeness followed by high (22.50%) and low (18.33%) levels of innovativeness. The possible reasons might be that majority of the farmers involved in farming were of medium to old aged category and further innovativeness is generally associated with younger age. But it was observed that the farmers because of their better educational status and extension contact were curious about SRI cultivation.

Achievement Motivation

Majority (65.00%) of the respondents had medium achievement motivation followed by low (19.17%) and high (15.83%) levels of achievement motivation. The probable reason for this might be that majority of the SRI farmers had medium level of education. Since it is a new technology, the respondents who had experienced the benefits of this technology previously might have opted for SRI cultivation. This finding is in line with Ramu (2005).

Mass media Exposure

Majority (66.66%) of the respondents had medium mass media exposure followed by low (24.17%) and high (9.17%) levels of mass media exposure. This trend might be due to the fact that majority of the respondents were small farmers with medium level of education. Though almost every household possessed television, they were not keen on watching television. Like this they did not pay much attention to print media despite the availability at lower rate. Hence they showed meagre interest towards print media, educational films, and agricultural programmes in television etc. This finding is in line with Hemanthkumar (2002).

Risk Orientation

Majority (75.00 %) of the SRI farmers had medium level of risk orientation followed by low (14.17%) and high (10.83%) levels of risk orientation. This shows that the young, educated and interested respondents with medium levels of scientific orientation and innovativeness were ready to face the risk while adopting the SRI technology. This finding is line with the findings of Subramanyam (2002).

CONCLUSION

The results showed that majority of the respondents belonged to middle age group having middle school level of education with medium farming. Majority of the respondents had undergone trainings, had medium levels of economic orientation, risk orientation, scientific orientation, management orientation, innovativeness and achievement motivation.Hence, there is an immediate need to promote SRI method of cultivation, focusing more on imparting the principles of SRI during the training programmes and demonstrations, skill development among rural youth and farmers.

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Table 1. Profile characteristics of SRI farmers

(n=120)

S. No.	Category	Frequency	Percentage	Mean	S.D.
1.	**Age**				
1.	Young (35 and below)	14	11.66		
2.	Middle (36 to 55 years)	68	56.67	-	-
3.	Old (56 years and above)	38	31.67		
	Total	**120**	**100.00**		
2.	**Education**				
1.	Illiterate	4	3.33		
2.	Functionally illiterate	14	11.67		
3.	Primary school	17	14.17		
4.	Middle school	30	25.00	-	-
5.	High school	29	24.17		
6.	Higher secondary	19	15.83		
7.	Collegiate	7	5.83		
	Total	**120**	**100.00**		
3.	**Farming Experience**				
1.	Low	21	17.50		
2.	Medium	77	64.17	23.52	14.28
3.	High	22	18.33		
	Total	**120**	**100.00**		
4.	**Land Holding**				
1.	Marginal farmer	8	6.67		
2.	Small farmer	24	20.00		
3.	Semi-medium farmer	29	24.16	-	-
4.	Medium farmer	51	42.50		
3.	Big farmer	8	6.67		
	Total	**120**	**100.00**		
5.	**Training Undergone**				
1	No training	8	6.67		
2	One training	68	56.67		
3	Two trainings	42	35.00	2.08	1.69
4	Three and above trainings	2	1.66		
	Total	**120**	**100.00**		
6.	**Social Participation**				
1.	Low	18	15.00		
2.	Medium	94	78.33	5.55	2.46
3.	High	8	6.67		
	Total	**120**	**100.00**		
7.	**Extension contact**				
1.	Low	17	14.17		
2.	Medium	81	67.50	6.55	1.94
3.	High	22	18.33		
	Total	**120**	**100.00**		

S. No.	Category	Frequency	Percentage	Mean	S.D.
8.	**Economic motivation**				
1.	Low	22	18.33	25.18	1.87
2.	Medium	87	72.50		
3.	High	11	9.17		
	Total	**120**	**100.00**		
9.	**Scientific orientation**				
1.	Low	24	20.00	22.51	2.88
2.	Medium	77	64.17		
3.	High	19	15.83		
	Total	**120**	**100.00**		
10.	**Management orientation**				
1.	Low	23	19.17	46.95	3.50
2.	Medium	79	65.83		
3.	High	18	15.00		
	Total	**120**	**100.00**		
11.	**Innovativeness**				
1.	Low	22	18.33	18.53	2.12
2.	Medium	71	59.17		
3.	High	27	22.50		
	Total	**120**	**100.00**		
12.	**Achievement Motivation**				
1.	Low	23	19.17	19.60	2.13
2.	Medium	78	65.00		
3.	High	19	15.83		
	Total	**120**	**100.00**		
13.	**Mass Media exposure**				
1.	Low	29	24.17	4.62	1.44
2.	Medium	80	66.66		
3.	High	11	9.17		
	Total	**120**	**100.00**		
14.	**Risk Orientation**				
1.	Low	17	14.17	15.02	1.46
2.	Medium	90	75.00		
3.	High	13	10.83		
	Total	**120**	**100.00**		

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(Received on 18-04-2015 and revised on 05-05-2015)

Andhra Pradesh J Agril. Sci : 1(1): 73-77, 2015

STATISTICAL ANALYSIS AND FORECASTING OF RICE BACTERIAL LEAF BLIGHT (BLB) BASED ON CLIMATE FACTOR IN SPSR NELLORE DISTRICT OF ANDHRA PRADESH

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ABSTRACT

This paper presents the rice Bacterial Leaf Blight (BLB) severity and the influence of climatic factors in rice growing in SPSR Nellore district of Andhra Pradesh. The data analysis on BLB incidence with the climate factors in standard weeks of rice growing seasons from 2003 to 2013 revealed that the rainfall distribution varied greatly within rice growing seasons and also over years. The average minimum temperature 23°C, average maximum temperature 29°C, morning relative humidity (81 – 97%) and evening relative humidity (66-90%) observed during crop seasons over years. The BLB severity during the years 2003, 2004, 2005 and 2008 was mild to moderate and during 2009 and 2011 was high. Analysis of 11 years (2003-2013) weather data revealed that the days with RH > 91%, temperature (20°C-31°C) and weekly rainfall are the most critical factors in the development of BLB incidence. The correlation studies revealed that, among the climate variables minimum temperature exhibits negative correlation. Rainfall, maximum temperature, morning relative humidity and evening relative humidity were positively correlated while wind velocity imparted significant positive correlation with bacterial leaf blight infestation. The different combinations of climate factors are found to be useful in the prediction of rice blast through MLR and Logistic regression models. The ANOVA carried out for testing the significance between standard weeks/varieties with respect to BLB incidence.

KEY WORDS: ANOVA, Bacterial leaf blight, Climate factors, Logistic regression, MLR models,

INTRODUCTION

Bacterial leaf blight (BLB), is the major bacterial disease of rice caused by *Xanthomonas oryzae* pv. *oryzae* (ex Ishiyama) Swings *et al*. (1990) is found in most irrigated, rainfed and deep water temperate and tropical rice growing areas. The Blight of rice affect filling of the grains and emergence of panicles. Bacterial leaf blight is devastating and can cause yield losses from 20 to 74 per cent in South-East Asia and India.

Adhikari *et al.* (1994) reported that, bacterial leaf blight progression was highly correlated with environmental factors. Highly significant ($p < 0.01$) correlation was demonstrated between Area Under the Disease Progress Curve (AUDPC) in Philippines during the 1998 and 1990 seasons. Kapoor *et al*. (2004) reported that, the rainfall and distribution varied significantly within growing seasons during 1979-1999. The average monthly temperature (18 – 28°C) and RH (>90%) for more than 9 hours was within the optimum range for disease development. Umer Jamshed *et al*. (2008) concluded that disease severity almost produced high correlation coefficients with monthly average relative humidity and total precipitation both of which dictate leaf wetness duration. Henderson *et al*. (2007) concluded that, of the 12 weather variables examined from potato producing regions across Southern Idaho, two were significant in predicting disease occurrence in the logistic model.

The construction of disease forecasting system, it is imperative to know weather conditions conducive for incidence and spread of particular disease on rice crop. Hence an attempt has been made to generate information for disease forecasting using weather factors.

MATERIAL AND METHODS

The secondary data pertaining to bacterial leaf blight (BLB) incidence on various rice varieties collected from the field experiments conducted under irrigated conditions during *Rabi*, *Kharif* and early *Kharif* season at Agricultural Research Station, Nellore along with climate factors data

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from 2003 to 2013. To work out the relationship between weather parameters and BLB incidence and to forecast BLB incidence, the data was analysed by using the various statistical techniques *viz.,* Simple statistics, Correlation, Multiple Linear Regression (MLR), Logistic Regression and ANOVA. The data was analysed by using SAS 9.3 software.

RESULTS AND DISCUSSION

The data analysis on bacterial leaf blight (BLB) incidence with the weather factors in standard weeks of rice growing seasons from 2003 to 2013 revealed that the rainfall distribution varied greatly within rice growing seasons and also over years. The average minimum temperature 23°C, average maximum temperature 29°C, morning relative humidity (81 – 97%) and evening relative humidity (66 – 90%) observed during crop seasons over years. The BLB severity during the years 2003, 2004, 2005 and 2008 was mild to moderate and during 2009 and 2011 was high. Analysis of 11 years (2003-2013) weather data revealed that the days with RH > 91%, temperature (20°C – 31°C) and weekly rainfall are the most critical factors in the development of BLB incidence (Table 1).

The analysis for the 2009 *kharif* weekly data on bacterial leaf blight (BLB) infestation and weather factors revealed that there exists positive correlation with minimum temperature (0.27), morning relative humidity (0.53) and wind velocity (0.05) while evening relative humidity (0.67) exhibits significant positive correlation. Rainfall (-0.08) and maximum temperature (-0.35) are negatively correlated with the bacterial leaf blight infestation. The MLR model was developed with respect to these factors with $R^2 = 0.74$.

The data analysis pertaining to the *rabi* 2011 for the rice variety NLR 34242 revealed that, among weather parameters wind velocity (0.28) showed positive correlation and the factors rainfall (-0.26) and maximum temperature (-0.61) exhibited negative correlation while minimum temperature (-0.68), morning relative humidity (-0.76) and evening relative humidity (-0.78) exhibit significant negative correlation. From the multiple regression equation it was observed that the influence of weather factors on bacterial leaf blight infestation is 99%.

Overall for the years 2003-2013, correlation studies revealed that, among the climate variables minimum temperature (-0.28) exhibits negative correlation. Rainfall (0.10), maximum temperature (0.2), morning relative humidity (0.4) and evening relative humidity (0.2) were positively correlated while wind velocity (0.52) imparted significant positive correlation with bacterial leaf blight infestation. The MLR model was developed with respect to these factors with $R^2 = 0.58$ (Table 2). The predictions of BLB incidence were shown in Figure 1.

As per the Pathology seasonal incidence data (*Kharif* 2010); analysis of the data pertaining to the bacterial blight incidence on four rice varieties (NLR 34449; NLR 34242; MTU 1010; and BPT 5204), and the impact of different dates of sowing (20th Sept 2010 through 20th Oct 2010 at 10 days interval) revealed that, the bacterial blight incidence was noticed only in the variety BPT 5204. When BPT 5204 was sown on 20th Sept 2010, the variety completely escaped the disease incidence. However, for other three dates of sowing under study, the disease incidence was ranged maximally from 10 to 50%. The other three varieties were completely escaped the disease in all dates of sowing. The disease incidence is not uniform in all the four varieties under study (Table 3).

The logistic regression model was fitted for development of Bacterial leaf blight of various standard weeks. The validation for the year 2013, the probability of BLB development in the 51 and 52nd weeks (December 17th – December 31st) is found to be P (z =1) = 0.0046 < 0.5. Hence, the model reveals that, the probability of occurrence of BLB infestation in the 51 and 52nd standard weeks of the year 2013 is low and the same (no incidence) was recorded in the year 2013. Therefore, the model will be useful for predicting the presence and absence of BLB disease (Table 4).

The analysis of variance on occurring of bacterial leaf blight infestation established that there is significant difference between the varieties (NLR 34449, NLR 34242, MTU 1010, BPT 5204) and between the standard weeks 44, 45, 47 and 5 (October 29th – January 7st) in the year 2008. Almost the same results were established in the year 2009 for the varieties (NLR 34449, NLR 34242, MTU 1010, BPT 5204) and standard weeks 43, 44, 45 and 47 (October 22nd – November 25th) (Table 5). Among four varieties high BLB incidence were noticed on NLR 34449 followed by NLR 34242 variety and low incidence noticed on the MTU 1010 variety. Among four standard weeks, in the 45th week high BLB incidences were noticed. The distribution of BLB incidence for different varieties/ standard weeks were shown in the Figure 2 and 3.

Table 1. Simple Statistics for bacterial leaf blight during the years 2003 to 2013

Variable	N	Mean	Std Dev	Minimum	Maximum
BLB	11	26.58	14.42	0.0013	45.00
Rainfall	11	70.77	111.21	1.20	392.60
Tmax	11	28.52	1.54	26.18	30.83
Tmin	11	22.63	1.72	19.86	24.96
RH FN	11	91.06	4.15	81.43	97.00
RH AN	11	75.97	8.48	66.43	90.00
WV	11	5.51	0.83	3.70	6.53

Table 2. Multiple regression functions for the prediction of bacterial leaf blight

Year	Variety	Equation	R^2
2009 (*Kharif*)	NLR 34242	$-316.18 + (-0.16)X_1 + (2.15)X_2 + (2.45)X_3 + (2.7)X_4 + (-0.15)X_5 + (-4.5)\ X_6$	0.74
2011 (*Rabi*)	NLR 34242	$294.43 + (-0.38)X_1 + (-10.05)X_2 + (6.07)X_3 + (-0.12)X_4 + (-1.82)X_5 + (3.16)\ X_6$	0.99
2003-2013	(Polled)	$0.36 + (0.55)X_1 + (0.27)X_2 + (0.29)X_3 + (0.41)X_4 + (0.71)X_5 + (0.16)\ X_6$	0.58

Table 3. Bacterial blight incidence of various varieties rice in different dates of sowing (*kharif'* 2010)

Variety	Dates of Sowing (% Bacterial blight maximum)			
	20-9-2010	30-9-2010	10-10-2010	20-10-2010
NLR 34449	0.00	0.00	0.00	0.00
NLR 34242	0.00	0.00	0.00	0.00
MTU 1010	0.00	0.00	0.00	0.00
BPT 5204	0.00	**50.00**	**50.00**	10.00

Table 4. Logistic regression function of climate factors with bacterial leaf blight incidence for the standard weeks 51 and 52nd

Disease	Equation	R^2
Blight	$290.6 + (4.85)X_1 + (4.02)X_2 + (-28.9)X_3 + (0.49)X_4 + (2.06)X_5$	0.99

Table 5. Analysis of variance between varieties and standard weeks on BLB incidence in 2008 and 2009

Year	Source	DF	SS	Mean Square	F Value	Pr > F
2008	Varieties	3	229.6712	76.5570	4.78	0.0294
	Standard weeks	3	196.4991	65.4997	4.09	0.0436
2009	Varieties	3	61.1613	20.3871	3.48	0.0636
	Standard weeks	3	751.3288	250.4429	42.75	<.0001

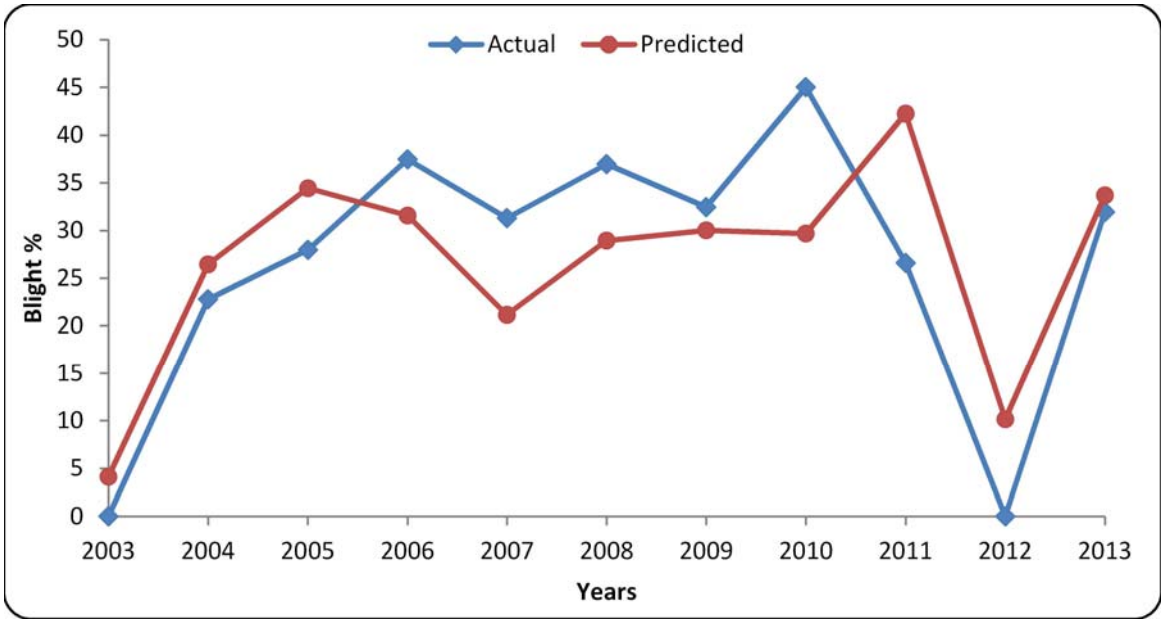

Fig. 1. Actual and predicted of BLB incidence

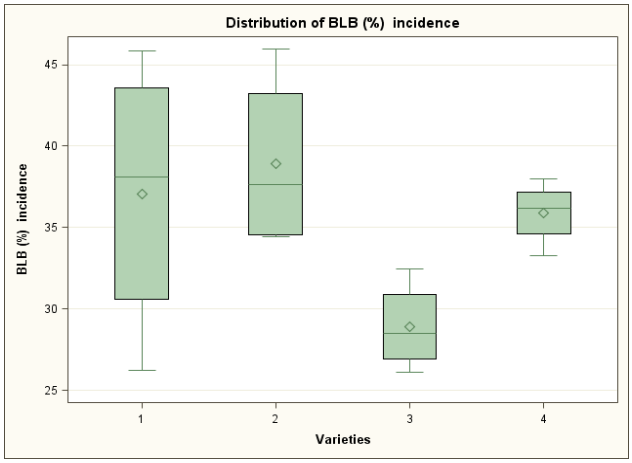

Fig. 2. Distribution of BLB incidence for different varieties in the year 2008

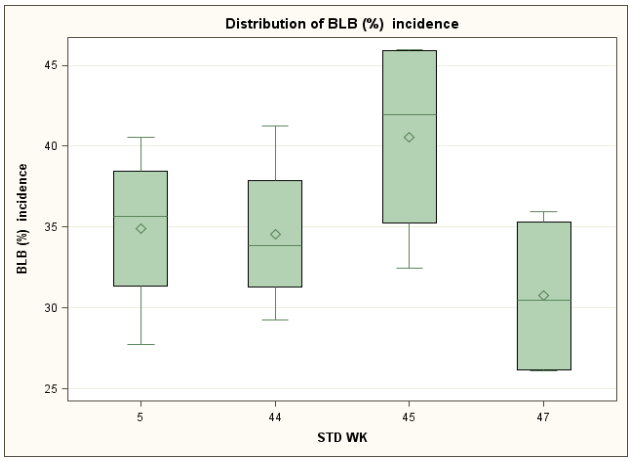

Fig. 3. Distribution of BLB incidence in different standard weeks in the 2008

Finally it concludes that, the different combinations of climate factors are found to be useful in the prediction of rice BLB. During 45th standard week (5th – 11th September) high BLB incidence were noticed and low incidence noticed on MTU 1010 variety under recorded climatic conditions. The developed MLR models for within year and between years and logistic models were found to be useful in the prediction of BLB diseases incidence. Such information helps the farmer's to minimize the losses in crop yield due to disease. Early warnings allow timely and need-based application of disease control measures and prevent application of unnecessary interventions.

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(Received on 18-04-2015 and revised on 28-04-2015)