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GENETIC VARIABILITY STUDIES IN PIGEONPEA [*Cajanus cajan* (L.) Millsp.]

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ABSTRACT

Thirty-nine pigeonpea genotypes were evaluated for variability, heritability and genetic advance under rainfed condition during *Kharif* 2015 at International Crop Research Institute for Semi-Arid Tropics (ICRISAT). The analysis of variance showed significant differences among the genotypes for all the characters studied, indicating that there was high variability among the genotypes. Grain yield (t ha^{-1}) has exhibited high genotypic and phenotypic coefficient of variation, thus indicates that this character is governed by genetic factors and possible improvement through selection. Whereas, plant height, number of primary branches $plant^{-1}$, number of secondary branches $plant^{-1}$, number of pods $plant^{-1}$ and 100-seed weight obtained moderate estimates at both levels. This may imply that there is a scope of improvement in these characters. High heritability combined with high genetic advance as percent of mean was obtained for characters *viz.,* days to 50% flowering, plant height, number of primary branches $plant^{-1}$, number of secondary branches $plant^{-1}$, no. of pods $plant^{-1}$, 100-seed weight and grain yield (t ha^{-1}). This indicates that the heritability was due to additive gene effects and selection would be promising for these characters.

INTRODUCTION

Legumes are the oldest cultivated crops shown by pre-historic records and today they are considered second to cereals in supplying the major nutrients required for a balanced human diet (ICRISAT, 2012). Among the legumes, pigeonpea [*Cajanus cajan* (L.) Millsp.] belongs to the family *Leguminoceae*a, and is a woody-perennial, deep rooted anddrought-tolerant crop which is used in diverse ways such as food, feed, fodder, medicine, and fuel wood. Pigeonpea seeds are rich source of high-quality protein, which ranges between 18% and 25%. Besides its nutritional value it has also the capability to maintain soil fertility, (Varshney, 2010) as the fallen leaves from the plant provide vital nutrients to the soil and the plant itself enriches soil through symbiotic nitrogen fixation. Globally, in 2014 the area, production and productivity were approximately 6.23 million hectares, 4.74 metric tons and 762.4 kg ha^{-1} (FAOSTAT, 2015). India is the main producer with over 100 cultivars, accounted for 63.74% of world production (FAOSTAT, 2015).

India leads the world production of pigeonpea but it is also the largest consumer and importer in the world. Despite being the largest producer, because of rising demand caused by growth of population, low productivity, biotic and abiotic stresses. India is importing 4-5 lakh tons of pigeonpea every year from other countries just to satisfy the domestic demand. Therefore there is a need to enhance the productivity of pigeonpea by developing high yielding genotypes. As one of the strategies, information regarding genetic variability of the given germplasm can be exploited to identify high yielding genotypes that may give a good yield in different soil and environmental conditions (Kaur *et al.*, 2007). The estimate of genetic parameters such as genotypic variability, phenotypic variability, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (h^2) and genetic advance (GA) are useful for the efficient selection and improvement in any of breeding program. Thus, this study was conducted to assess the importance of phenotypic and genotypic variability, phenotypic and genotypic coefficient of

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variation, heritability in broad sense $h^2_{(bs)}$ and expected genetic advance to provide more information that may improve yield characters.

MATERIAL AND METHODS

The study was conducted in the black soil precision farming research fields of International Crops Research Institute for the Semi-arid Tropics (ICRISAT), Patancheru, Telangana, during *kharif* season, 2015. ICRISAT is located at an altitude of 545 m, 17.53°N latitude and 78.27°E longitude and the experimental material consisted of thirty-nine pigeonpea genotypes; they were sown on the 13th of July, 2015. Total rainfall at the site of experiment during the duration of the study between July to December was 424.29 mm and maximum and minimum temperatures recorded was 32.32°C and 14.53°C, respectively. The experiment was arranged in alpha lattice design with two replications; each genotype was sown in two rows of four meter length with 75 cm and 30 cm between rows and plant to plant respectively. All recommended agronomical practices were followed for growing a good crop. Five competitive plants were randomly selected from each plot and each replication for recording the data on plant height (cm), number of primary branches plant^{-1}, numbers of secondary branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight (g), and grain yield^{-1} (t ha^{-1}). For 50% flowering and days to maturity observations were taken on plot basis.

Data Analysis

The data collected on individual characters were subjected to the method of analysis of variance using restricted maximum likelihood estimation (REML) procedure considering replication and genotypes as fixed effects and block nested with replicates as random effects except for three variables (number of pods plant^{-1}, number of seeds pod^{-1} and 100-seed weight) where block effect was treated to achieve convergence. Square root transformation has been applied before ANOVA for count variables to attain residual normality. The phenotypic and genotypic coefficients of variation were estimated according to the method suggested by Burton and Devane (1953). Broad sense heritability (h^2) expressed as the percentage of the ratio of the genotypic variance (5Øß^{2}g) to the phenotypic variance (5Øß^{2}p) was computed as described by Piepho *et al.* (2007). Genetic advance (GA) and genetic advance as percent of mean (GAM) was estimated according to the method illustrated by Johnson *et al.* (1955). All statistical analyses was performed using SAS 9.4 software (SAS Institute Inc.,2015).

RESULTS AND DISCUSSION

Analysis of Variance (Table 1) revealed significant differences among the genotypes for the nine characters studied, indicating presence of significant variability which can be exploited through selection. The magnitude of the phenotypic coefficient of variation (PCV) was slightly higher than the corresponding genotypic coefficient of variation (GCV) for most of the characters indicated least influence of environment in the expression of these traits. The differences between them for most of the characters were small indicating high prospects through selection.

The genetic parameters *viz.*, genotypic and phenotypic coefficients of variation, heritability in broad sense (h^2) and genetic advance as percent of

Table 1. Analysis of variance of nine quantitative characters in thirty-nine pigeonpea genotypes

	Days to 50% flowering		Days to maturity		Plant height at maturity		SQRT Number of primary branches plant^{-1}		SQRT Number of secondary branches plant^{-1}		Grain yield(t ha^{-1})	
Fixed	F value (df)	P value	F value (df)	P value	F value (df)	P value	F value (df)	P value	F value (df)	P value	F value (df)	P value
Replication	4.73(1)	0.1785	5.99(1)	0.0202	0.47(1)	0.5591	0.00(1)	0.9965	44.12(1)	0.0951	0.00(1)	0.9827
Entry	118.22**(38)	<.0001	131.00**(38)	<.0001	22.74**(38)	<.0001	12.21**(38)	<.0001	104.09**(38)	<.0001	28.52**(38)	<.0001
Random	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Block(Rep.)	0.1462	0.3368	0.0787	0.4212	12.4201	16.6247	0.0151	0.0187	-0.0008	0.0022	0.0036	0.0045
Residual	2.1362	0.5164	3.2236	0.7808	63.1360	15.3860	0.0630	0.0153	0.0244	0.0059	0.0154	0.0037

Table 1 Continued……..

	SQRT					
	Number of pods plant^{-1}		Number of seeds pod		100-Seed weight	
Fixed	F value(df)	P value	F value(df)	P value	F value(df)	P value
Replication	0.21(1)	0.6527	0.01(1)	0.9119	3.95(1)	0.0549
Block(Rep.)	0.53(38)	0.7155	0.40(38)	0.8080	0.15(38)	0.9628
Entry	38.16**	<.0001	3.99**	<.0001	12.14**	<.0001
Random	Estimate	SE	Estimate	SE	Estimate	SE
Residual	0.3876	0.0940	0.0015	0.0003	0.6428	0.1559

** Significant at 0.01

Table 2. Estimate of genetic parameters for yield, and its attributing characters in pigeonpea

	RANGE							
CHARACTERS	MEAN	MIN.	MAX.	GCV	PCV	h^2_{bs}	GA	GAM
				(%)	(%)	(%)		(%)
Days to 50% flowering	110.56	75.01	124.21	10.26	10.30	99.08	23.26	21.04
Days to maturity	151.63	107.00	168.44	9.62	9.65	99.16	29.91	19.73
Plant height at maturity	193.99	109.06	237.16	13.89	14.19	95.37	54.10	27.89
SQRT_Number of primary branches plant^{-1}	4.61	3.12	5.72	13.36	13.11	91.50	1.20	26.22
SQRT_Number of secondary branches plant^{-1}	7.22	4.86	9.36	16.71	16.78	99.06	2.47	34.25
SQRT_Number of pods^{-1}	16.02	7.68	21.61	17.02	7.24	97.19	5.53	34.52
SQRT_Number of seeds pod^{-1}	1.93	1.81	2.08	2.58	2.97	73.74	0.08	4.51
100-Seed weight	10.42	7.34	19.25	18.46	19.24	91.20	3.76	36.16
Grain yield (t ha^{-1})	1.46	0.53	2.52	31.62	32.19	96.13	0.93	63.75

Minimum (Min), Maximum (Max), Genotypic (GCV) and phenotypic (PCV) coefficients of variation, broad sense heritability (h^2_{bs}), expected genetic advance (GA) and genetic advance as percent of mean (GAM).

mean (GAM) are presented in Table 2. High PCV and GCV was recorded in grain yield (t ha^{-1}) (32.19%, 31.62%), which indicate potential for effective selection (Burton, 1957). A moderate value of both phenotypic and genotypic coefficient variation has been observed for plant height at maturity (14.19%,13.89%), number of primary branches $plant^{-1}$ (13.11%, 13.36%), number of secondary branches $plant^{-1}$ (16.78%, 16.71%), number of pods $plant^{-1}$ (17.24%, 17.02%), and 100-seed weight (19.24%, 18.46%) indicating the limitation of selection for the improvement of these characters. Similar results were obtained by Vohra *et al*., (2014), Naik *et al.,* (2013) and Linge *et al*., (2010) for these characters. Whereas, days to 50% flowering (10.30%, 10.26%), days to maturity (9.65%, 9.62%) and number of seeds pod^{-1} (2.97%, 2.58%) had a low estimates of PCV and GCV which means that selection is not rewarding. These results were in conformity with that of Bhadru (2010) and Linge *et al.* (2010); Rao and Rao *et al.* (2015) and Singh *et al.* (2013).

An estimate of genotypic coefficients of variation alone is not sufficient to assess the heritable variation. Therefore, estimates of heritability and genetic gain should be considered together (Johnson *et al*., 1955). High heritability values with high genetic advance as percent of mean were observed in characters *viz.,* days to 50% flowering (99.08%, 21.04%), plant height (95.37%, 27.89%), number of primary branches $plant^{-1}$ (91.50%, 26.22%), number of secondary branches $plant^{-1}$ (99.06%, 34.25%), number of pods $plant^{-1}$ (97.19%, 34.52%), 100-seed weight (91.20%, 36.16%) and grain yield (t ha^{-1}) (96.13%, 63.75%). Similar results were reported by Shuny *et al*., (2013), Vanishree *et al*. (2013), Saroj *et al*. (2013), Shreelakshmi *et al*. (2010). This is due to additive gene effect in which these characters should be given more importance in breeding programs. While, days to maturity (99.16%, 19.73%) had a high heritability in conjunction with moderate genetic advance as percent of mean. Therefore, this character may not be considered important. Likewise, for number of seeds pod^{-1} (73.74%, 4.51%) showed high heritability with low genetic advance as percent of mean, indicated that selection in this character is not effective.

CONCLUSIONS

It may be concluded that the characters grain yield (t ha^{-1}) which recorded high PCV and GCV, whereas, days to 50% flowering, plant height, number of primary branches $plant^{-1}$, number of secondary branches $plant^{-1}$, number of pods $plant^{-1}$, 100-seed weight which had shown high heritability with high genetic advance as percent of mean can be improved through efficient breeding method like pedigree method.

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POST HARVEST SOIL FERTILITY AND BIOLOGICAL STATUS EFFECTS ON SORGHUM PRODUCTIVITY AS INFLUENCED BY PRECEDING LEGUMES, NITROGEN LEVELS AND IRRIGATION SCHEDULES

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ABSTRACT

The present investigation (2012-2014) explored the possibility of exploiting the beneficial effects of growing dhaincha and its *in situ* incorporation at flowering in *kharif* as a preceding crop to improve the soil physical, chemical and biological status. The experiment was carried out in strip – split plot design with three replications. Four strips of treatments including dhaincha, greengram and cowpea raised as preceding *kharif* legumes along with fallow are taken as main plot treatments. During *rabi*, sorghum was grown in split plot design taking strips of *kharif* crops as main plots, four irrigation schedules assigned to sub – plots and four nitrogen levels *viz.,* 0, 30, 60 and 90 kg ha^{-1} to sub - sub plots. Initially the soil was slightly alkaline by in situ incorporation at flowering in *kharif* as a preceding crop followed by irrigation (at the critical stages) at panicle initiation, boot leaf, anthesis and milking stage of the grains and application of nitrogen 60 kg ha^{-1} reduced the pH and EC. The microbial population *viz.,* bacteria, fungi and actinomycetes were found in large number in the rhizosphere of sorghum in response to the preceding *kharif* legumes. Higher bacteria (74 × 106 CFUg^{-1} of soil), fungi (15 × 104 CFUg^{-1} of soil) and actinomycetes (33 × 103 CFUg^{-1} of soil) were found with green manuring *i.e.* dhaincha *in situ* incorporation in preceding *kharif* season. Highest microbial population was observed with irrigation at four critical stages. The microbial population in rhizosphere of sorghum increased significantly (bacteria: 22-60 × 106), (fungi - 05 - 14 × 104) and (actinomycetes: 13-28 × 103) with application of nitrogen 30 to 60 kg N ha^{-1} and thereafter the increase was insignificant. Higher grain yield of sorghum was obtained by growing dhaincha for green manure or greengram for seed with four irrigations at critical phases of panicle initiation, booting, anthesis and milk stage along with application of 60 kg N ha^{-1}.

INTRODUCTION

Nutrients contained in organic manures are released more slowly and stored for a long time in the soil, ensuring a long residual effect (Sharma and Mitra, 1988), which support better root development leading to higher crop yields (Mahajan, 2007). Safety of environment as well as public health is also an important reason for advocating increased use of organic materials (Hazra, 2007).However, the use of organic manure alone, cannot sustain the cropping system due to unavailability of required quantities and their relatively low nutrient content (Palm *et al.*, 1997). Application of chemical fertilizers in conjunction with organic/ green manures will sustain and maintain the productivity of soil. Therefore, it is necessary to find out integration various organic/ green manures with chemical fertilizers in order to find out the most effective combination. *Kharif* legumes fix up atmospheric N in soil and their inclusion in the crop rotation helps in improving physico-chemical and biological properties of soil (Sharma *et al.*, 1986).

Hence, a strategy of integrated use of nitrogen through fertilizer in combination with any amount of cheaper organic source which is abundantly available should be tried to satisfy the higher nitrogen requirement of the crop in order to produce higher yields without impairing the soil health. Organic manures and crop residues have been proved to be viable components of nitrogen management, which can supplement and successfully replace costly fertilizer nitrogen. Therefore, a study was conducted to maximize the productivity and economic returns of the *kharif* legumes – *rabi* sorghum cropping sequence, by developing appropriate and viable nitrogen management practices, without any degradation of soil health.

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MATERIAL AND METHODS

A field experiment was conducted at the research farm of Indian Institute of Millets Research (IIMR) (formerly Directorate of Sorghum Research), Rajendranagar, Hyderabad to study the post harvest soil fertility and biological status as influenced by preceding legumes, nitrogen levels and irrigation schedules for two consecutive years (2012-2013 and 2013-2014). The study was taken up in a strip-split plot design with three replications. Four strips of treatments including dhaincha, greengram and cowpea raised as preceding *kharif* legumes along with fallow are taken as main plot treatments. Four irrigation schedules (I_1: Irrigation at panicle initiation, I_2: Irrigation at panicle initiation and booting, I_3: Irrigation at panicle initiation, booting and anthesis and I_4: Irrigation at panicle initiation, booting, anthesis and milk stages) assigned to sub – plots and four nitrogen levels (0, 30, 60 and 90 kg ha^{-1}) to sub – sub plots, respectively. Before sowing of *kharif* crops and *rabi* sorghum and after harvest of sorghum, soil samples were collected as per treatment upto 30 cm depth and analysed. In order to assess the fluctuations in the microbial status of the preceding *kharif* legumes-*rabi* sorghum field, soil samples were collected after incorporation / before sowing *rabi* sorghum, at 50% flowering and at harvest during 2012-13 and 2013-14, the microbial studies were enumerated.

Microbial Studies Methodology

Soil samples were collected at 0-15 cm depth in five locations and pooled as such when wet. The samples were diluted serially by transferring 10g to a 250ml Erlenmeyer flask containing 90 ml of sterile distilled water and the contents were shaken in a rotary shaker for 10 minutes. Using sterile pipette, 10ml of the suspension was transferred to 90ml of sterile water and likewise serial dilutions were continued using sterile distilled water till 10^{-3}, 10^{-4}, 10^{-5} and 10^{-6} were obtained. Aliquots of 1ml of appropriate dilution were plated. Total bacteria were enumerated in nutrient agar, fungi in Martin's Rose Bengal agar, actinomycetes in Kenknight's agar. The plates were incubated at a room temperature of 30 ± 2°C and counts were made after 3 days for bacteria, 3-5 days for fungi and 7 days for actinomycetes. Microbial biomass carbon was estimated by the method of Nunan *et al.* (1998).

RESULTS AND DISCISSION

Soil Fertility

The data on physico-chemical properties of the soil influenced by different treatments are presented in table 1 and 2. Initially, the soil was slightly alkaline (7.7) pH. The salt content was normal having E.C of 0.38 dS m^{-1} and had a low of 0.23% organic carbon. The fertility status was low in terms of available nitrogen (162 kg ha^{-1}), medium in available phosphorus (29.2 kg P_2O_5 ha^{-1}) and potassium (282.8 kg K_2O ha^{-1}). The pH and E.C. were reduced due to the incorporation of *dhaincha* before sowing and after harvesting of sorghum during both the years. It is considered that the crop residues are important in maintaining the soil resources at optimum level because these are the major sources of carbon inputs (Singh *et al.*, 2005). However, the organic carbon content did not change before and after harvest of sorghum due to the incorporation of the foliage of dhaincha and green gram or the stubbles of cow pea. The lack of response to improvement in organic carbon could be ascribed to the tropical climate and the period of two years is too short time to notice a change. The mass of legumes incorporated in the soil increased the available nitrogen to more than the initial value before sowing sorghum during both the years. The legumes depleted the available P and K less than the initial value. The soil nutrient pool had

Table 1. Influence of preceding *kharif* legumes, irrigation and nitrogen levels on soil physico chemical properties before r*abi* sorghum - 2012 and 2013

Treatment	pH		E.C (dS m^{-1})		O.C (%)		Available Nutrients (kg ha^{-1})					
							N		P_2O_5		K_2O	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Preceding legumes in *kharif*												
C_1: Dhaincha	7.4	7.2	0.30	0.27	0.26	0.28	178.7	189.4	29.3	30.8	285.4	288.5
C_2: Greengram for seed	7.5	7.3	0.30	0.28	0.25	0.27	167.2	157.0	28.4	29.2	266.5	271.9
C_3: Cowpea for fodder	7.4	7.4	0.31	0.30	0.23	0.25	164.6	152.7	25.6	26.3	254.6	266.5
C_4: Fallow	7.7	7.4	0.31	0.31	0.23	0.23	162.8	155.1	25.8	24.7	253.9	242.1
S Em ±	0.05	0.05	0.01	0.03	0.01	0.01	0.57	0.57	0.14	0.14	1.13	1.27
CD at 5%	NS	NS	NS	NS	NS	NS	1.9	2.0	0.4	0.5	4.1	4.5
Irrigation schedules												
I_1: Panicle initiation	7.5	7.3	0.30	0.28	0.24	0.25	168.3	162.3	26.3	27.4	256.7	260.8
I_2: PI and booting	7.5	7.3	0.30	0.28	0.25	0.26	167.8	165.5	27.9	27.2	263.2	264.9
I_3: PI, boot ,anthesis	7.6	7.4	0.31	0.29	0.25	0.24	169.0	169.3	27.4	28.3	267.9	269.7
I_4: PI, boot, anth, milk	7.5	7.3	0.30	0.28	0.24	0.24	169.1	166.7	27.2	27.8	272.7	274.6
S Em ±	0.05	0.05	0.01	0.01	0.07	0.01	0.50	0.35	0.21	0.14	1.63	1.70
CD at 5%	NS	NS	NS	NS	NS	NS	1.8	1.3	0.6	0.6	5.6	5.9
Nitrogen (kg ha^{-1})												
N_1: No Nitrogen	7.6	7.4	0.31	0.30	0.24	0.26	163.9	162.6	26.4	27.3	257.0	259.4
N_2: 30	7.6	7.4	0.30	0.30	0.25	0.26	167.2	167.3	27.2	28.2	269.0	270.9
N_3: 60	7.5	7.3	0.30	0.29	0.24	0.25	171.9	170.6	27.5	27.6	268.7	264.3
N_4: 90	7.5	7.4	0.29	0.29	0.25	0.24	169.2	175.8	27.3	28.0	265.8	259.4
S Em ±	0.18	0.18	0.01	0.01	0.01	0.01	4.88	5.02	0.64	0.78	6.86	7.92
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	13.9	1.9	2.2	19.3	22.3
Interaction												
***Kharif* legumes × Irrigation**												
S Em ±	0.13	0.13	0.01	0.01	0.01	0.01	1.63	1.84	0.35	0.42	3.39	3.96
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
***Kharif* legumes × Nitrogen**												
S Em ±	0.64	0.62	0.03	0.03	0.02	0.02	16.90	17.33	2.40	2.76	23.90	27.51
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation × Nitrogen												
S Em ±	0.64	0.62	0.03	0.03	0.02	0.02	16.90	17.33	2.40	2.76	23.97	27.65
CDat 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
***Kharif* legumes × Irrigation × Nitrogen**												
S Em ±	0.18	0.18	0.01	0.01	0.01	0.01	4.88	5.02	0.64	0.78	6.86	7.92
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Initial	**7.7**		**0.38**		**0.23**		**162.0**		**29.2**		**282.8**	

relatively less quantity of available N, P and K in all the treatments after the harvest of sorghum in the first year. The available N, P and K then increased due to the addition of fresh mass of the legumes in the second year. Sorghum exhausted these nutrients leaving behind relatively low quantities in the soil after its harvest. The available N was significantly higher than the initial quantity due to the incorporation of dhaincha when compared to the haulms of green gram or stubbles of cowpea. However, the available P and K reduced to less than the initial quantity, but higher quantity of P and K was present in *in situ* incorporation of dhaincha and was significantly superior to other *kharif* legumes. Biederbeck *et al.* (1996) observed that about three months after green manure incorporation, the soil mineral N (NO_3 – N plus NH_4 – N) levels in the 0 – 0.6 m depth were similar for green manure and fallow. Tamboli *et al.* (2011) observed that the incorporation of cow pea and cultivation of sorghum in *rabi* increased the OC and available nitrogen after five years of experimentation.

Grain Yield

Perusal of the data (Tables 2) indicated that significantly higher grain yield (2511 kg ha^{-1} in 2012 and 3024 kg ha^{-1} in 2013) of sorghum was obtained by incorporation of the entire biomass of dhaincha grown in the preceding *kharif*. Lowest grain yield was with sorghum when grown after *kharif* fallow (2409 and 2930 kg ha^{-1} in 2012 and 2013, respectively). Grain yield of sorghum was comparable to the crop grown after cowpea for fodder or greengram for seed. However, during the year 2013, sorghum preceded by dhaincha recorded the higher grain yield, which was however comparable with crop grown after greengram or cowpea. Lowest grain yield of sorghum was recorded when grown after fallow which was however on par with cowpea or greengram as preceding crops. Preceding legumes might have added nitrogen to sorghum through fixation and mineralization of their biomass in soil through root nodules, roots, leaves *etc.* to benefit higher grain yield of succeeding *rabi* sorghum. These benefits probably accrued through cumulative positive influence on vegetative growth, dry matter per plant, number of grains $panicle^{-1}$ and ear head weight, and nutrient uptake which in turn probably was the result of relatively faster decomposition of dhaincha. The beneficial effects of *kharif* legumes on *rabi* sorghum were also reported by Pawar *et al.* (1995), Nagre and Chandrasekhar (1988). Mishra *et al.* (2011) also reported that green manure of dhaincha increased the production of sorghum compared to the yield from fallow - sorghum.

Among preceding legumes, significantly higher grain yield was noticed with the crop preceded by dhaincha green manuring might be attributed to less lignin content, more favorable narrow C:N ratio and high N content of dhaincha which caused faster N mineralization leading to high N availability. In view of the above facts beneficial effects of legume crop residues may also ascribed to the apparent agronomic advantage from green manures. These results are in accordance with Tamboli *et al.* (2011) and Rosegrant and Roumossel (1987). Similarly, in the earlier investigations Sabale *et al.* (1981) and Pol *et al.* (1982) recorded higher grain yield of sorghum preceding blackgram than greengram. The usefulness of N_2 fixing legumes and their positive impact on soil fertility by enhancing nitrogen availability and thereby benefitting a cereal crop grown in the subsequent season was confirmed by Armstrong *et al.* (1999) and Sanginga (2003).

Microbial Population

Microbial population *i.e.,* bacteria, fungi and actinomycetes in rhizosphere of sorghum revealed that irrespective of treatments soil bacteria, fungi and

Table 2. Influence of preceding *kharif* legumes, irrigation and nitrogen levels on soil physico chemical properties after *rabi* sorghum - 2012 and 2013

Treatment	pH		E.C(dSm^{-1})		O.C (%)		Available Nutrients (Kg ha^{-1})						Grain yield (kg ha^{-1})	
							N		P_2O_5		K_2O			
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
Preceding legumes in *kharif*														
C_1: Dhaincha	7.3	7.0	0.29	0.27	0.27	0.28	161.7	176.5	25.4	25.7	258.4	269.3	2511	3024
C_2: Greengram for seed	7.2	7.1	0.31	0.27	0.26	0.27	152.0	160.4	24.3	24.3	242.7	252.3	2446	2942
C_3: Cowpea for fodder	7.3	7.3	0.30	0.28	0.24	0.27	138.9	148.8	22.1	22.4	214.4	226.5	2389	2947
C_4: Fallow	7.5	7.5	0.32	0.30	0.24	0.24	138.1	145.5	21.6	20.3	210.2	223.4	2409	2930
S Em ±	0.07	0.07	0.03	0.02	0.01	0.01	0.50	0.50	0.14	0.14	1.06	1.06	17.0	24.8
CD at 5%	NS	NS	NS	NS	NS	NS	1.6	1.6	0.4	0.4	3.6	3.7	59	85
Irrigation schedules														
I_1: Panicle initiation	7.3	7.2	0.28	0.28	0.25	0.24	147.5	165.7	20.2	21.7	225.4	229.3	2338	2870
I_2: PI and booting	7.3	7.3	0.28	0.28	0.24	0.25	147.0	167.3	22.6	22.1	229.5	236.7	2413	2929
I_3: PI, boot,anthesis	7.4	7.4	0.29	0.29	0.25	0.24	148.0	171.4	23.0	23.4	233.4	242.5	2477	2997
I_4: PI, boot, anth, milk	7.3	7.3	0.28	0.28	0.26	0.24	148.2	170.7	24.4	23.7	237.4	233.3	2528	3047
S Em ±	0.07	0.07	0.03	0.02	0.01	0.01	0.42	0.50	0.14	0.14	1.34	1.34	13.4	6.4
CD at 5%	NS	NS	NS	NS	NS	NS	1.5	1.8	0.5	0.5	4.7	4.9	46	22
Nitrogen (kg ha^{-1})														
N_1: No Nitrogen	7.4	7.3	0.29	0.29	0.24	0.23	140.2	160.7	21.3	22.1	225.2	232.9	2039	2466
N_2: 30	7.4	7.2	0.28	0.28	0.25	0.24	144.6	165.2	23.0	23.4	230.5	238.4	2380	2886
N_3: 60	7.3	7.3	0.28	0.28	0.25	0.25	149.6	171.2	22.9	22.9	234.6	243.3	2650	3222
N_4: 90	7.3	7.3	0.26	0.26	0.24	0.24	156.2	176.7	23.8	24.7	232.3	247.2	2686	3269
S Em ±	0.21	0.21	0.01	0.01	0.01	0.01	3.89	4.53	0.64	0.64	6.29	6.58	54.5	57.3
CD at 5%	NS	NS	NS	NS	NS	NS	10.9	12.6	1.8	1.8	17.8	18.6	188	199
Interaction														
***Kharif* legumes × Irrigation**														
S Em ±	0.14	0.14	0.01	0.01	0.01	0.01	1.34	1.27	0.35	0.35	3.18	3.32	46.0	64.4
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
***Kharif* legumes × Nitrogen**														
S Em ±	0.64	0.64	0.01	0.03	0.02	0.02	13.65	15.63	2.19	2.19	22.14	22.84	190.9	204.4
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation × Nitrogen														
S Em ±	0.64	0.64	0.01	0.03	0.02	0.02	13.65	15.63	2.19	2.26	22.21	22.91	189.5	199.4
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
***Kharif* legumes × Irrigation × Nitrogen**														
S Em ±	0.21	0.21	0.01	0.01	0.01	0.01	3.89	4.53	0.64	0.64	6.29	6.58	54.5	57.3
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

actinomycetes reached its maximum value at 50% flowering and declined thereafter during both the years of study. The total bacteria, fungi and actinomycetes were found in large number in the soil during *Kharif* season of the year 2013. However, it varied with the fallow and cropping period. Microbial population in the rhizosphere of sorghum in response to the preceding *kharif* legumes was higher *i.e.,* bacteria (74 × 10^6 $CFUg^{-1}$ of soil), fungi (15 × 10^4 $CFUg^{-1}$ of soil) and actinomycetes (33 × 10^3 $CFUg^{-1}$ of soil) with green manuring *i.e.* dhaincha *in situ* incorporation in preceding *kharif*. Statically on par results were observed with preceding cowpea for fodder and green gram for seed. However, lowest microbial population was recorded when the soil was left fallow preceeding to *rabi* sorghum. Beare *et al.* (1996) reported increase in microbial population with incorporation of green manure crops. Sushila and Gajendra Giri (2000) reported increased microbial population in the rhizosphere of wheat in the presence of organic manure. Tamboli *et al.* (2011) observed that the application of green manuring increased the organic carbon content of soil, and directly influences the microbial growth. The results also revealed that microbial count was the highest at the time of 50 % flowering for total bacteria, fungi, actinomycetes.

Among four irrigation schedules at panicle initiation, booting, anthesis and milking stages, anthesis stage recorded highest number of microbes *i.e.* bacteria (57 - 66 X 10^6 $CFUg^{-1}$ of soil), fungi (12 - 14 X 10^4 $CFUg^{-1}$ of soil) and actinomycetes (24 - 28 X 10^3 $CFUg^{-1}$ of soil), in the rhizosphere of sorghum followed by irrigation at panicle initiation, booting and anthesis. Higher microbial population with scheduling of irrigation four times during critical phases might be due to higher moisture content during crop growth period which directly influences the microbial growth. Similar trends were observed during both the years of experimentation. The microbial population in rhizosphere of sorghum increased significantly (bacteria: 22-60 × 10^6 $CFUg^{-1}$ of soil), (fungi - 05 - 14 × 10^4 $CFUg^{-1}$ of soil) and (actinomycetes: 13-28 × 10^3 $CFUg^{-1}$ of soil) with application of nitrogen 30 to 60 kg N ha^{-1} and thereafter the increase was insignificant.

Microbial Biomass Carbon

It is evident from the results (Tables 3 to 6) that during both the years of study irrespective of the treatments in the rhizosphere of sorghum, soil microbial biomass carbon reached its maximum at 50% flowering. Microbial biomass carbon differed with fallow significantly with different legumes grown preceding to *rabi* sorghum. Among them, incorporation of entire foliage of dhaincha at 50% flowering recorded highest microbial biomass carbon followed by green gram for seed and cowpea for fodder respectively and the lowest when the soil was left fallow preceding to *rabi* sorghum. The microbial population directly influenced the microbial biomass carbon in the soil and nutrient uptake which inturn probably was due to the faster decomposition of dhaincha. The green manure incorporation provided the substrate for different microflora and inorganic compounds. Azamal *et al.* (1996) and Sridevi *et al.* (2003) reported a marked increase in microbial biomass following incorporation of crop residues.

Irrigation schedules had an explicit influence on the microbial biomass carbon. The irrigation at critical stages *i.e.* panicle initiation, booting, anthesis and milking stage recorded highest microbial biomass. It might be due to the high moisture content in the

Table 3. Soil bacteria x 10^6 CFU g^{-1} of soil at different stages as influenced by irrigation and nitrogen levels preceded by *kharif* legumes

Treatment	After incorporation / before sowing *rabi* sorghum		At 50% flowering		At harvest	
	2012	2013	2012	2013	2012	2013
Preceding legumes in *kharif*						
C_1: Dhaincha	24	29	61	74	42	50
C_2: Greengram for seed	21	25	43	61	30	36
C_3: Cowpea for fodder	21	23	43	53	29	39
C_4: Fallow	20	19	28	39	21	25
S Em ±	0.21	0.28	0.28	0.35	0.21	0.28
CD at 5%	0.7	0.9	1.0	1.2	0.7	0.9
Irrigation schedules						
I_1: Panicle initiation	21	23	32	47	25	33
I_2: PI and booting	22	23	37	51	28	35
I_3: PI, booting and anthesis	22	24	50	63	33	40
I_4: PI, booting, anthesis and milk stage	22	24	57	66	37	43
S Em ±	0.07	0.07	0.07	0.14	0.14	0.14
CD at 5%	0.2	0.2	0.3	0.4	0.5	0.5
Nitrogen (kg ha^{-1})						
N_1: No Nitrogen	20	22	40	50	28	35
N_2: 30	22	23	43	57	30	37
N_3: 60	22	24	46	60	32	39
N_4: 90	23	24	46	61	32	39
S Em ±	0.50	0.71	0.99	1.34	0.85	1.06
CD at 5%	1.4	NS	2.8	3.7	2.3	3.0
Interaction						
***Kharif* legumes × Irrigation**						
S Em ±	0.42	0.57	0.78	0.85	0.42	0.85
CD at 5%	NS	NS	NS	NS	NS	NS
***Kharif* legumes × Nitrogen**						
S Em ±	1.77	2.33	3.54	4.67	2.90	3.75
CD at 5%	NS	NS	NS	NS	NS	NS
Irrigation × Nitrogen						
S Em ±	1.77	2.33	3.47	4.60	2.83	3.75
CD at 5%	NS	NS	NS	NS	NS	NS
***Kharif* legumes ×Irrigation × Nitrogen**						
S Em ±	0.50	0.64	0.99	1.34	0.85	1.06
CD at 5%	NS	NS	NS	NS	NS	NS

● Initial : 16 ×10^6 CFU g^{-1} of soil

Table 4. Soil fungi ×10^4 CFU g^{-1} of soil at different stages as influenced by irrigation and nitrogen levels preceded by *kharif* legumes

Treatment	After incorporation /before sowing *rabi* sorghum		At 50% flowering		At Harvest	
	2012	2013	2012	2013	2012	2013
Preceding legumes in *kharif*						
C_1: Dhaincha	5	7	12	15	9	10
C_2: Greengram for seed	5	6	11	13	8	9
C_3: Cowpea for fodder	4	5	10	12	7	7
C_4: Fallow	3	5	8	11	5	6
S Em ±	0.07	0.07	0.07	0.07	0.07	0.14
CD at 5%	0.2	0.2	0.3	0.3	0.3	0.4
Irrigation schedules						
I_1: Panicle initiation	4	6	9	12	6	7
I_2: PI and booting	4	5	10	12	6	8
I_3: PI, booting and anthesis	5	6	11	14	7	8
I_4: PI, booting, anthesis and milk stage	5	6	12	14	9	10
S Em ±	0.07	0.07	0.07	0.07	0.03	0.07
CD at 5%	0.2	0.3	0.3	0.3	0.12	0.2
Nitrogen (kg ha^{-1})						
N_1: No Nitrogen	4	6	10	12	6	8
N_2: 30	5	6	10	13	7	8
N_3: 60	5	6	11	14	8	9
N_4: 90	5	6	11	13	7	9
S Em ±	0.14	0.14	0.21	0.28	0.14	0.21
CD at 5%	0.3	0.4	0.7	0.9	0.4	0.6
Interaction						
***Kharif* legumes × Irrigation**						
S Em ±	0.21	0.28	0.21	0.28	0.28	0.35
CD at 5%	NS	NS	NS	NS	NS	NS
***Kharif* legumes × Nitrogen**						
S Em ±	0.42	0.50	0.85	1.06	0.57	0.78
CD at 5%	NS	NS	NS	NS	NS	NS
Irrigation ×Nitrogen						
S Em ±	0.42	0.50	0.85	1.06	0.57	0.71
CD at 5%	NS	NS	NS	NS	NS	NS
***Kharif* legumes ×Irrigation × Nitrogen**						
S Em ±	0.14	0.14	0.21	0.28	0.14	0.21
CD at 5%	NS	NS	NS	NS	NS	NS

- Initial : 04 ×10^4 CFU g^{-1} of soil

Table 5. Soil Actinomycetes $\times 10^3$ CFU g^{-1} of soil at different stages as influenced by irrigation and nitrogen levels preceded by *kharif* legumes

Treatment	After incorporation / before sowing *rabi* sorghum		At 50% flowering		At Harvest	
	2012	2013	2012	2013	2012	2013
Preceding legumes in *kharif*						
C_1: Dhaincha	17	21	26	33	18	22
C_2: Greengram for seed	13	18	22	28	16	19
C_3: Cowpea for fodder	13	16	20	23	16	15
C_4: Fallow	10	13	16	21	10	13
S Em ±	0.07	0.07	0.07	0.14	0.14	0.14
CD at 5%	0.2	0.2	0.3	0.5	0.4	0.5
Irrigation schedules						
I_1: Panicle initiation	12	18	17	24	12	15
I_2: PI and booting	13	17	20	25	14	17
I_3: PI, booting and anthesis	14	17	23	28	16	18
I_4: PI, booting, anthesis and milk stage	15	17	24	28	18	19
S Em ±	0.07	0.07	0.14	0.14	0.07	0.07
CD at 5%	0.2	0.2	0.5	0.4	0.9	0.2
Nitrogen (kg ha^{-1})						
N_1: No Nitrogen	13	16	20	24	13	15
N_2: 30	13	17	21	26	15	17
N_3: 60	14	17	22	28	16	19
N_4: 90	14	18	21	27	16	18
S Em ±	0.28	0.42	0.50	0.71	0.35	0.42
CD at 5%	0.8	1.1	1.5	2.0	0.9	1.3
Interaction						
***Kharif* legumes × Irrigation**						
S Em ±	0.21	0.21	0.21	0.35	0.35	0.42
CD at 5 %	NS	NS	NS	NS	NS	NS
***Kharif* legumes × Nitrogen**						
S Em ±	1.06	1.41	1.84	2.48	1.20	1.56
CD at 5%	NS	NS	NS	NS	NS	NS
Irrigation × Nitrogen						
S Em ±	1.06	1.41	1.84	2.48	1.20	1.56
CD at 5%	NS	NS	NS	NS	NS	NS
***Kharif* legumes ×Irrigation × Nitrogen**						
S Em ±	0.28	0.42	0.50	0.71	0.35	0.42
CD at 5%	NS	NS	NS	NS	NS	NS

- Initial: 12 $\times 10^3$ CFU g^{-1} of soil

Table 6. Soil microbial biomass carbon μg g^{-1} of soil at different stages as influenced by irrigation and nitrogen levels preceded by *kharif* legumes

Treatment	After incorporation / before sowing *rabi* sorghum		At 50% flowering		At harvest	
	2012	2013	2012	2013	2012	2013
Preceding legumes in *kharif*						
C_1: Dhaincha	324	341	464	468	367	380
C_2: Greengram for seed	255	279	355	366	279	293
C_3: Cowpea for fodder	237	253	322	360	272	281
C_4: Fallow	213	210	269	257	236	235
S Em ±	0.92	1.13	0.78	0.85	0.28	0.04
CD at 5%	3.2	3.8	2.6	3.0	1.1	0.14
Irrigation schedules						
I_1: Panicle initiation	252	262	267	306	217	240
I_2: PI and booting	248	258	325	339	271	280
I_3: PI, booting and anthesis	253	267	392	390	317	316
I_4: PI, booting, anthesis and milk stage	275	296	427	416	349	352
S Em ±	0.57	1.06	0.99	0.92	0.28	0.04
CD at 5%	2.0	3.6	3.4	3.3	1.1	0.14
Nitrogen (kg ha^{-1})						
N_1: No Nitrogen	246	256	325	335	267	266
N_2: 30	260	271	355	364	289	301
N_3: 60	266	278	376	389	311	324
N_4: 90	256	277	353	362	287	299
S Em ±	4.95	5.94	7.92	8.20	5.52	6.29
CD at 5%	13.8	16.6	22.2	23.0	15.5	17.7
Interaction						
***Kharif* legumes x Irrigation**						
S Em ±	3.47	4.03	2.19	2.62	1.70	0.14
CD at 5 %	NS	NS	NS	NS	NS	NS
***Kharif* legumes x Nitrogen**						
S Em ±	17.11	20.65	27.51	28.50	19.09	21.78
CDat 5%	NS	NS	NS	NS	NS	NS
Irrigation x Nitrogen						
S Em ±	17.11	20.58	27.51	28.50	19.09	21.78
CD at 5%	NS	NS	NS	NS	NS	NS
***Kharif* legumes x Irrigation x Nitrogen**						
S Em ±	4.95	5.94	7.92	8.20	5.52	6.29
CD at 5%	NS	NS	NS	NS	NS	NS

soil which directly influenced the microbial population and also improved the organic compounds in the soil which in turn increase the microbial biomass carbon. The results are in conformity with Rangaswami and Venkatesam (1964). They reported that high moisture content proliferates the microflora which increases the microbial biomass carbon.

Highest microbial biomass carbon in the rhizosphere of sorghum was recorded with application of nitrogen 30 to 60 kg N ha^{-1} and thereafter the increase was insignificant. The highest microbial biomass carbon recorded with 60 kg N application at flowering stage was 376 and 389 µg g^{-1} of soil during 2012 and 2013, respectively. Similarly, Singh (1991) reported that application fertilizer in rice - lentil crop rotation has increased the soil microbial biomass carbon. The interactions owing to combined influence of different treatments were not significant on the microbial population and microbial biomass carbon at different stages of crop growth.

The incorporation of organic matter regenerates depleted soil resources and promote sustainable food production. Kumar and Goh (2000) reported that the decomposition of crop residues is a microbial - mediated progressive break down of organic materials with ultimate end products of carbon and nutrients released into the biological circulation. The green manure of dhaincha in the present investigation perhaps activated the soil biota, improved the soil physical properties and released the nutrients especially the depleting micronutrients in addition to the major and secondary nutrients. Incorporation of crop residues alters the soil environment, which in turn influences the microbial population and activity in the soil and subsequent nutrient transformations. If all the factors are ideal for fast decomposition, it is likely to release about 60.0 kg N ha^{-1} in the first year and 64.0 kg ha^{-1} in the second year. This is mineralized slowly and released into the soil for availability to the crop later in a period of 3 to 5 years. Ladd *et al.* (1983) reported that about 20% of the mineralized nitrogen is likely to be available to the succeeding crop. Harris *et al.* (1994) reported that < 30% N is contributed by the decomposed green manures to the following crop. Large amounts of legume were retained in the soil mostly in organic forms. Hence, it is expected that utmost 12 - 18 kg N ha^{-1} might have been added to the soil organic pool by dhaincha in the present investigation. This is meager to improve the fertility status of soil nitrogen in a short time. The contribution of low nitrogen at the expense of land, labour and inputs by this green manure cannot be undermined. Though in little quantities, it adds all other essential nutrients including the depleted and needed micronutrients. It improves the soil biological activities to enrich the soil quality. Its role is universally recognized to improve the soil physical properties also. Singh *et al.* (2005) reported that the crop residues - the harvest remnants of the previous crop - play an essential role in the cycling of nutrients. Incorporation of crop residues alters the soil environment, which in turn influences the microbial population and activity in the soil and subsequent nutrient transformations.

The incorporation of mature and less succulent foliage with depleted nutrients, dried and fallen leaves of greengram after picking of pods was perhaps not sufficient to improve the crop growing conditions for sorghum in a relatively short time as that of dhaincha in the present investigation. The addition of stubbles alone after the harvest of cowpea fodder was also not sufficient to build up fast microbial activity and improve the soil. Ascertaining dissimilar potential of legumes, Gaikwad *et al.* (1993) recorded significant increase in grain and fodder yield of sorghum preceding cowpea than blackgram, soybean or fallow in medium black soil having low OC of 0.42%. Bangar *et al.* (2003) on the other hand recorded significant increase in grain and fodder yield of sorghum preceding fallow than the cultivation of blackgram, greengram or soybean in vertisol having a moderate status in OC (0.54%) but low level of 143 kg N ha^{-1}. Larue and Patterson (1981) inferred from an extensive review that there was not a single legume crop for which agronomists had valid estimates of symbiotic nitrogen fixation rate.

CONCLUSIONS

The present investigation clearly illustrates that *in situ* incorporation at flowering in *kharif* as a preceding crop followed by irrigation (at the critical stages) at panicle initiation, boot leaf, anthesis and milking stages of the grains and application of nitrogen 60 kg ha^{-1} increased the nutrient uptake of crop there by their nutrient value as food for man and fodder for cattle. It could be inferred that *rabi* sorghum preceded by dhaincha for green manure or greengram for seed with four irrigations at critical phases of panicle initiation, booting, anthesis and milk stage along with application of 60 kg N ha^{-1} has resulted in higher yield. Further, it also increases the microbial population and microbial biomass in the soil which in turn increases the soil fertility and ultimately increasing their production.

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EVALUATION OF DIFFERENT *BRASSICA* SPECIES AND ONION FOR THEIR BIOFUMIGATION EFFECT AGAINST *Rhizoctonia solani* f. sp. *sasakii in vitro*

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ABSTRACT

Glucosinolate-containing *Brassica* spp. is known to release volatilic isothiocyanates (ITCs) which are toxic to different pathogens. The chemistry involved in the biofumigation can be attributed to the action of myrosinases on the glucosinolates (GLS) thereby releasing ITCs, thiocyanates, nitriles, oxalidine, dimethyl sulphide, methanethiol among other compounds.The present study was taken up to evaluate different Brassica spp and onion for their biofumigation effect against *Rhizoctonia solani* f. sp. *sasakii in vitro.* Among different brassica species, macerated mustard plant parts are effective in inhibition of radial growth and sclerotial production of *Rhizoctonia solani* f. sp *sasakii*. In all tested concentrations there was a positive association between increase of volumes and the rate of radial growth suppression.

INTRODUCTION

Soil-borne plant diseases can severely limit crop production and are traditionally controlled by the use of pesticides, among which methyl bromide has been the most widely used. Restrictions on the use of these pesticides due to the damage they cause in the environment, has prompted a search for new plant protection methods. The use of plant material from several species within the family Brassicaceae has been successfully exploited and is potentially a very interesting alternative way for the management of soil-borne plant pathogens. Among these brassica species, cabbage, cauliflower, mustard have been the focus of interest and recent studies have shown that biomass or seed meal from brassicas has a suppressive effect on some soil pathogens. In Andhra Pradesh, maize crop is cultivated in an area of 0.99 Mha with 4.23 mt production and 4257 kg ha^{-1}. of different fungal diseases affecting maize cultivation, banded leaf and sheath blight (BLSB) incited by *Rhizoctonia solani* f.sp. *sasakii* Exner (*Thanatephorus sasakii* (Shirai) Tu & Kimbrough) (Tu and Kimbre, 1978) is an economically significant disease causing huge losses in all crop growing areas of the world. The main objective of the present study was to evaluate the disease-suppressive effect of brassica and non-brassica crop onion against *R. solani* f. sp. *sasakii in vitro.*

MATERIAL AND METHODS

Brassica spp contain glucosinolate compounds which release volatile isothiocyanates (ITCs) by hydrolysis with myrosinase enzyme and are toxic to different plant pathogens hence the present study was conducted during the year 2014-15 at Regional Agricultural Research Station, Lam, Guntur to evaluate the potential of different *Brassica* spp to release isothiocyanates by the maceration of different plant parts against *R. solani* f. sp. *sasakii* causal organism of banded leaf and sheath blight disease in maize *in vitro* conditions.

Crushed Plant Material Method : Studies were conducted *in-vitro* based on the method established by Kirkegaard *et al*. (1996). The biofumigant crops *viz*., cabbage, cauliflower, mustard and onion crops local varieties were grown in pots in

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green house conditions. Whole plants were harvested at flowering time, roots washed free of soil, shoots and roots were separated. Plant material was dried on absorbent paper. Later, leaves, shoots and roots of each species were taken separately, then coarsely chopped and then thoroughly macerated with a mortar and pestle. Additional water was not added to the plant material other than that contained in the tissues themselves. Aliquots of the macerated tissue were immediately placed on the lids of inverted PDA plates. *R. solani* f. sp. *sasakii* plugs were cut from the edge of an actively growing culture and placed on the inverted bottom of the PDA plate. Control plates were also inverted, but no biofumigant material was added. Plates were sealed with parafilms and incubated at 26 ^{0}C in the dark. The radial growth (average of two planes) of the pathogen was determined when cultures in the control plates were near the edge of the dish (90 mm), or 4 d after the addition of the plug. Treatments were replicated thrice. Biofumigant material was added @ 1.0 g, 5.0 g and 10 g plate^{-1} (90mm diameter) as roots, shoots, leaves or roots+ shoots+ leaves (additive) or 0g per plate for the control. Percent inhibition of the radial growth of pathogen was calculated (Vincent, 1927).

RESULTS AND DISCUSSION

This study was to assess the potential of biofumigation using three Brassica crops including *Brassica oleracea*, *B. campestris, B. juncea* and onion against *R. solani in vitro*. Compared with other tested crops, *B. juncea* showed more inhibitory effect against the pathogen. Different concentrations of these compounds inhibited mycelial growth of the

Table 1. Effect of volatiles released from macerated root tissue of different *Brassica* spp at different concentrations against radial growth and sclerotial production of *Rhizoctonia solani* f. sp. *sasakii*

Treatment	Radial growth of *R. solani* (mm) after 3 days			Percent inhibition of sclerotial production after 15 days		
	Dose of root tissue macerated			Dose of root tissue macerated		
	1 g	5 g	10 g	1 g	5 g	10 g
Cabbage	46 (48.9)	22 (75.6)	20 (47.8)	33.3	40.7	54.3
Cauliflower	51 (43.3)	27 (70.0)	20 (77.8)	34.7	50.0	62.3
Mustard	25 (72.2)	17 (81.1)	11 (87.8)	52.7	70.7	87.3
Onion	68 (24.4)	41 (54.4)	27 (70.0)	22.0	34.0	40.3
Control	90	90	90	0.0	0.0	0.0
	S. Em ±	**CD at 5%**		**S. Em ±**	**CD at 5%**	
Main	0.3	0.1		0.27	0.38	
Sub	0.3	0.8		0.21	0.30	
Interaction	0.6	1.9		0.47	0.66	

Figures in parenthesis are per cent inhibition over control

pathogen *in vitro* when applied as macerated tissue. A positive relationship was observed between different plant tissue concentrations and growth inhibition percentage. It was evident from the results that the tissues of local *Brassica* crops release glucosinolates and can be used against *R. solani* for growth inhibition.

Macerated Root Tissue

Mustard roots showed the highest inhibitory effect on growth *of R. solani* and reduced the radial growth by 72.2 to 87.8% compared to other Brassica crops. Maximum sclerotial formation was inhibited in mustard root tissue @10g, (87.3%) when compared with control (Table 1). In all the tested concentrations there was a positive association between increase of volumes and the rate of growth suppression.

Macerated Shoot Tissue

The results of effect of volatile inhibitors produced from macerated shoot tissue showed that all the tested Brassica crops were significantly able to reduce radial growth and sclerotia formation of the *R. solani* compared to untreated control (Table 2). Maximum inhibition of radial growth (77.8%) was observed in mustard @10g followed by cabbage (58.9%) and cauliflower (50.0%). The least inhibition effect on radial growth was observed in case of onion (26.7%).

Table 2. Effect of volatiles released from macerated shoot tissue of different *Brassica* spp at different concentrations against radial growth and sclerotial production of *Rhizoctonia solani* f.sp*. sasakii*

Treatment	Radial growth of *R. solani* (mm) after 3 days			Per cent inhibition of sclerotial production after 15 days		
	Dose of shoot tissue macerated			Dose of shoot tissue macerated		
	1 g	5 g	10 g	1 g	5 g	10 g
Cabbage	51 (43.3)	41 (54.4)	37 (58.9)	24.7	31.0	37.7
Cauliflower	61 (32.2)	55 (38.9)	45 (50.0)	31.7	37.7	46.0
Mustard	40 (55.6)	27 (70.0)	20 (77.8)	48.7	55.0	67.0
Onion	86 (4.4)	77 (14.4)	66 (26.7)	17.7	21.3	29.3
Control	90	90	90	0.0	0.0	0.0
	S. Em ±	**CD at 5%**		**S. Em ±**	**CD at 5%**	
Main	0.3	1.0		0.49	1.42	
Sub	0.3	0.7		0.38	1.10	
Interaction	0.6	1.9		0.85	2.78	

Figures in parenthesis are per cent inhibition over control

Furthermore, the least inhibition effect against sclerotia formation was observed in onion (17.7%, 21.3% & 29.3 % inhibition) whereas, mustard was the most effective crop with inhibition of 48.7%, 55.0% and 67% when compared with control at all the three concentrations tested *i.e.*, 1g, 5g and 10g, respectively.

Macerated Leaf Tissue

After 3 days of incubation, the results showed that the effect of volatile inhibitors produced from fresh macerated leaf tissues against *R. solani* growth was significantly different from untreated control (Table 3). In addition, the number of sclerotia after 15 days was reduced in all concentrations compared to control treatment (Table 3). Maximum inhibition of radial growth (86.7%) was observed in mustard @ 10g followed by cabbage (48.9%). The least inhibition effect on radial growth was observed in cauliflower (41.1%) followed by onion (43.3%) whereas, other crops showed statistically significant growth inhibition. Maximum inhibition of sclerotial production was observed in mustard (52.7%, 60.3% &72.3%) followed by cauliflower (37%, 42.3% & 56%) whereas least inhibition of sclerotial production was observed in onion (21.3%, 28% & 32.7%) at all the three concentrations *i.e.*, 1g, 5g and 10g, respectively.

Table 3. Effect of volatiles released from macerated leaf tissue of different *Brassica* spp at different concentrations against radial growth and sclerotial production of *Rhizoctonia solani* f.sp. *sasakii*

Treatment	Radial growth of *R. solani* (mm) after 3 days			Percent inhibition of sclerotial production after 15 days		
	Dose of leaf tissue macerated			Dose of leaf tissue macerated		
	1 g	5 g	10 g	1 g	5 g	10 g
Cabbage	53 (41.1)	49 (45.6)	46 (48.9)	34.3	42.3	51.7
Cauliflower	69 (23.3)	61 (32.3)	53.1 (41.1)	37	42.3	56
Mustard	33 (63.3)	27 (70.0)	12 (86.7)	52.7	60.3	72.3
Onion	71 (21.1)	60 (33.3)	51.3 (43.3)	21.3	28.0	32.7
Control	90	90	90	0.0	0.0	0.0
	S. Em ±	**CD at 5%**		**S. Em ±**	**CD at 5%**	
Main	0.5	2.0		0.44	1.27	
Sub	0.7	1.6		0.34	0.98	
Interaction	1.2	4.0		0.76	2.47	

Figures in parenthesis are per cent inhibition over control

Macerated whole plant tissue

Macerated mustard whole plant tissue showed maximum inhibition of radial growth and sclerotia formation of *R. solani*. The growth inhibition percentage was recorded as 71.1%, 78.9% and 88.9% at 1g, 5g and 10g, respectively. Additionally, mustard was also able to reduce the sclerotial formation considerably in all concentrations with statistically similar results (Table 4). In case of onion, least inhibitory effect (24.4%) on radial growth was observed in 1g, 40%, and 54.4 % in 5 and 10g, respectively. The volatile materials inhibited sclerotial formation by 48.7%, 56% & 69.3% in mustard at 1g, 5g and 10 g, respectively.

There is a great deal of variation among different species of Brassicas with regard to their biofumigation potential. In this study, it is clear that tissues of mustard, cabbage and cauliflower release glucosinolates which were able to inhibit the growth of *R. solani*. Sclerotia are principal surviving structures under adverse conditions (Adams, 1975). In addition to suppression of radial growth of *R. solani* inhibition of sclerotia was also considered for evaluation of Brassica crops. This study showed that volatile materials produced from Indian cultivars of Brassica crops were significantly able to reduce sclerotial formation in *R. solani*.

Table 4. Effect of volatiles released from macerated whole plant tissue of different *Brassica* spp at different concentrations against radial growth and sclerotial production of *Rhizoctonia solani* f. sp. *sasakii*

Treatment	Radial growth of *R. solani* (mm) after 3 days			% inhibition of sclerotial production after 15 days		
	Dose of whole plant tissue macerated			Dose of whole plant tissue macerated		
	1 g	5 g	10 g	1 g	5 g	10 g
Cabbage	41 (54.4)	27 (70.0)	20 (77.8)	28.7	37	50.3
Cauliflower	50 (44.4)	35 (61.1)	25 (72.2)	34.7	41.3	53.3
Mustard	26 (71.1)	19 (78.9)	10 (88.9)	48.7	56	69.3
Onion	68 (24.4)	54 (40.0)	41 (54.4)	17.7	24	30
Control	90	90	90	0	0	0
	S. Em ±	**CD at 5%**		**S. Em ±**	**CD at 5%**	
Main	0.3	0.8		0.27	1.08	
Sub	0.2	0.7		0.39	0.84	
Interaction	0.5	1.6		0.64	2.10	

Figures in parenthesis are per cent inhibition over control

In the laboratory assays volatiles released from macerated roots of mustard, cabbage and cauliflower crop were more effective than shoot tissue in suppressing the radial growth and sclerotial production of *R. solani* and this corresponded well with bioassay results showing that roots had a greater potential to release higher concentrations, and a wider diversity of ITCs than shoots. This concurs with previous research showing that concentrations of GSLs in roots are mostly higher or similar to those in shoots, and that roots release a greater quantity of aromatic ITCs than shoots (Kirkegaard and Sarwar, 1998). However, shoots contribute proportionally more to the total biomass of biofumigant crops than roots, and this makes them an important source of ITCs. The macerated roots from mature biofumigant plants were more suppressive to an indicator pathogen than those from immature plants and this finding is in accordance with the report of Mattner *et al.* (2008), in case of *R. fragaria* the causal organism of strawberry root rot, macerated root tissue was six times more effective than shoot tissue in radial growth inhibition.

Results from this laboratory study suggest that the suppression of *R. solani* was most marked at high rates of biofumigant material. At high doses of all the plant parts tested, volatiles from the biofumigant crop were lethal to *R. solani*. These observations are in agreement with previous researchers which have shown that mustard contain higher levels of glucosinolates than most other Brassica species and also produces some of high antimicrobial forms of isothiocyanates and clearly demonstrated the suppressive effect of allyl-isothiocyanate on *R. solani* and *Pythium ultimum* in a controlled laboratory study (Charron and Sams, 1999; Smolinska and Horbowicz, 1999). In addition, Indian mustard tissues showed more inhibitory effect against sclerotial formation compared to other Brassica crops. Although inhibition of fungal growth by Brassica GSLs has been reported previously (Walker *et al.,* 1937), Indian mustard tissues were more effective than canola and Ida gold field mustard tissues.

In the present study the volatiles released from different parts of mustard plant were more effective in inhibiting the radial growth and sclerotia formation of *R. solani* and this result corroborated the reports of several workers. Mayton *et al.* (1996) demonstrated that allyl isothiocyanate released from macerated *Brassica juncea* cv. Cutlass tissue completely suppressed *in vitro* growth of five common plant pathogens; *Pythium ultimum*, *Rhizoctonia solani*, *Verticillium dahliae*, *Verticillium alboatrum*, and *Colletotrichum coccodes* under *in vitro* conditions. Kasuya *et al.* (2006) demonstrated that dried *Brassica rapa* plant residue was suppressive to *R. solani* in pot assays and mycelial growth assays *in vitro*. Larkin and Griffin (2007) reported that volatiles released from chopped leaf material of Brassica crops and barley inhibited growth of *Rhizoctonia solani*, with Indian mustard resulting in nearly complete inhibition (80–100%) *in vitro* assays. A key factor contributing to the observed variability in biofumigation's effectiveness is related to the balance between added carbon as a nutrient source for pathogens and the resulting ITCs, which act as pesticides on those pathogens.

CONCLUSIONS

Among different brassica species, macerated mustard plant parts are effective in inhibition of radial growth and sclerotial production of *Rhizoctonia solani* f. sp *sasakii*. In all tested concentrations there was a positive association between increase of volumes and the rate of radial growth suppression.

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STUDIES ON GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE FOR YIELD, YIELD COMPONENTS AND QUALITY TRAITS IN PEANUT STEM NECROSIS TOLERANT GROUNDNUT GENOTYPES (*Arachis hypogaea* L.)

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ABSTRACT

Fifty genotypes of groundnut were evaluated for their genetic variability, heritability and genetic advance for a set of 15 characters during *kharif,* 2015. Analysis of variance revealed the presence of highly significant differences among the genotypes for all characters indicating sufficient variability in the material studied. High PCV and GCV were observed for kernel yield plant^{-1}, pod yield plant^{-1} and haulm yield plant^{-1}. High heritability was observed for SPAD Chlorophyll Meter Reading at 60 days after sowing, protein content, plant height, kernel yield per plant, pod yield per plant and 100 kernel weight. High genetic advance as % of mean was observed for kernel yield, pod yield, haulm yield and protein content indicating that these traits were mainly governed by additive gene effects and response to selection could be affected for further improvement of pod yield through simple selection.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oil and protein producing legume crop and belongs to family *Fabaceae*. India is the largest groundnut grower (44.46 lakh ha) and second producer (71.81 lakh tones) after China with a yield of 1615 kg ha^{-1}. Andhra Pradesh occupies third place in production in India. The productivity of Andhra Pradesh is very low against Indian productivity of 1615 kg ha^{-1} and world productivity of 1675.9 kg ha^{-1}. The low productivity can be attributed to factors such as erratic rainfall, incidence of pests and diseases in addition to cultivation of low yielding varieties. Among biotic stresses limiting the productivity of groundnut, Peanut stem necrosis was initially observed as an epidemic resulting in complete death of young groundnut plants during the *kharif,* 2000 in Anantapur district of Andhra Pradesh leading to heavy losses. Hence, there is need to develop resistance to the disease with high yield and quality.

Heritability of variability is an important parametre which determines the extent of expressivity of a trait in a set of environments or agro-climatic conditions. Therefore, heritability estimates are useful in predicting genetic advance under different intensities of selection. High heritability estimates together with high genetic advance are more valid for selection than heritability estimates alone (Johnson *et al.*, 1955). Hence, considering these aspects, genetic variability, heritability and genetic advance as percent of mean studies were initiated with PSND tolerant groundnut genotypes in the present investigation.

MATERIAL AND METHODS

The material for the present study comprised of 50 groundnut genotypes, grown in a randomised block design with two replications at Agricultural Research Station, Kadiri during *kharif,* 2015. Each treatment was sown in two rows of 5m length by adopting a spacing of 30cm X 10cm. Observations were recorded on randomly chosen five competitive plants for 15 characters *viz.,* days to 50 percent flowering, plant height (cm), number of filled pods plant^{-1}, total pods plant^{-1}, number of seeds pod^{-1}, mature kernel percent, haulm yield plant^{-1} (g), pod yield plant^{-1} (g), kernel yield plant^{-1} (g), shelling

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percent, harvest index percent, 100 kernel weight , SPAD Chlorophyll Meter Reading (SCMR) at 60 days after sowing, oil content and protein content. The character days to 50 percent flowering was recorded on per plot basis. Analysis of variance was carried out as per the suggested method. The phenotypic and genotypic co-efficient of variation (Burton, 1952), heritability in broad sense and genetic advance as percent of mean (Johnson *et al.*, 1955) were also computed as per the procedure.

RESULTS AND DISCUSSION

The analysis of variance for 15 characters in 50 genotypes revealed that the genotypes differed significantly for all the characters indicating the existence of sufficient variability in the material studied (Table 1). The estimates of mean, range, variance, phenotypic and genotypic coefficient of variation (PCV, GCV), heritability in broad sense, genetic advance and genetic advance as percent of mean for fifteen characters of fifty genotypes of

Table 1. Analysis of variance for fifteen quantitative characters in 50 genotypes of groundnut

S. No.	Characters	Mean squares		
		Replications (df:1)	Genotypes (df:49)	Error (df:49)
1.	Days to 50% flowering	4.84	9.61**	1.59
2.	Plant height (cm)	2.43	21.65**	1.58
3.	No of filled (mature) pods plant^{-1}	0.32	13.27**	1.75
4.	Total pods plant^{-1}	1.21	16.22**	2.14
5.	No of seeds pod^{-1}	0.00	0.01	0.00
6.	Mature kernels (%)	1.00	28.68**	10.57
7.	Haulm yield plant^{-1} (g)	0.00	28.20**	3.59
8.	Pod yield plant^{-1} (g)	0.11	21.68**	2.31
9.	Kernel yield plant^{-1} (g)	0.06	9.43**	0.95
10.	Shelling percentage (%)	0.45	121.33**	63.65
11.	Harvest index (%)	0.00	0.01	0.00
12.	100 kernel weight (g)	0.13	52.68**	5.42
13.	SPAD Chlorophyll meter reading (SCMR) at 60 DAS	0.02	58.94**	0.77
14.	Oil content (%)	0.17	7.94**	0.86
15.	Protein content (%)	0.16	54.52**	2.30

** Significant at 1% level

groundnut were furnished in Table 2. The wider range was for the characters. Highest range was noted for shelling percent (44.06 % to 79.23 %), whereas the range was found to be least for number of seeds pod $^{-1}$(1.44 to 1.72).The phenotypic co-efficient of variation was of high magnitude than the genotypic coefficient of variation for all the characters indicating the influence of environment in the expression of these traits (Table 2). Similar kind of observations were reported by Korat *et al.* (2009), Rajesh *et al.* (2012) which corroborates the findings of present study.

Higher magnitude of PCV and GCV of 28.97 percent and 26.17 percent, respectively for kernel yield plant^{-1} followed by pod yield plant^{-1} (28.76 and 25.84) and haulm yield plant^{-1} (23.94 and 21.07). Similar kind of high variability for kernel yield plant^{-1} was reported by John *et al.* (2008), Nandini *et al.* (2011), Srivalli *et al.* (2013), Shukla and Rai (2014) and Ramana *et al.* (2015). The high estimates of variability obtained for pod yield plant^{-1} were similar to the reports of Mahalakshmi *et al.* (2005), John *et al,* (2008), Nandini *et al.* (2011), Srivalli *et al.* (2013) and Ramana *et al.* (2015). The findings are in conformity with the findings of Injeti *et al.* (2008) for number of filled pods plant^{-1}.

In the present study, high heritability was recorded ranging from 97% for SPAD Chlorophyll Meter Reading at 60 days after sowing to 72% for days to 50% flowering indicating least influence of environment on the genetic expression of the characters under study. The estimates of heritability alone will not be of much value for selection and

Table 2. Mean, coefficients of variation, heritability (broad sense) and genetic advance as per cent of mean for 15 characters in 50 groundnut genotypes

Sl. No.	Character	Mean	Range		Coefficient of Variation		Heritability (Broad sense) (%)	Genetic Advance as percent of mean (%)
			Min.	Max.	Genotypic	Phenotypic		
1.	Days to 50% flowering	32.20	28.50	37.50	6.22	7.35	72	13.88
2.	Plant height (cm)	21.78	13.90	31.30	14.54	15.65	86	35.67
3.	No of filled pods plant^{-1}	13.59	9.20	20.80	17.66	20.17	77	40.80
4.	Total pods plant^{-1}	15.75	11.50	22.40	16.84	19.24	77	38.92
5.	No of seeds pod^{-1}	1.58	1.44	1.72	3.08	4.25	53	5.90
6.	Mature kernels (%)	79.42	71.00	86.50	3.79	5.58	46	6.79
7.	Haulm yield plant^{-1} (g)	16.65	11.22	27.04	21.07	23.94	77	48.94
8.	Pod yield plant^{-1} (g)	12.05	7.48	20.80	25.84	28.76	81	61.27
9.	Kernel yield plant^{-1} (g)	7.87	5.04	14.25	26.17	28.97	82	62.43
10.	Shelling percentage (%)	65.98	44.06	79.23	8.14	14.58	31	12.00
11.	Harvest index (%)	0.54	0.31	0.70	14.54	16.33	79	34.19
12.	100 kernel weight (g)	38.08	28.32	47.74	12.44	13.79	81	29.61
13.	SPAD Chlorophyll meter reading (SCMR) at 60 Days after sowing	40.06	28.85	49.80	13.46	13.64	97	35.07
14.	Oil content (%)	50.21	42.52	52.99	3.75	4.18	80	8.87
15.	Protein content (%)	27.56	12.50	39.50	18.54	19.34	92	46.92

genetic gain should be considered in conjunction with heritability estimates (Johnson *et al.,* 1955) to estimate realized genetic improvement possible in the character through simple selection methods. High heritability and high genetic advance as percent of mean estimates were registered for kernel yield plant^{-1} (82%, 62.43%), followed by pod yield plant^{-1} (81%, 61.27%), haulm yield plant^{-1} (77%, 48.94%), protein content (92%, 46.92%), number of filled pods plant^{-1} (77%, 40.80 %), total pods plant^{-1} (77%, 38.92%), plant height (86%, 35.67%), SPAD Chlorophyll Meter Reading (SCMR) at 60 DAS (97%, 35.07%), harvest index (79%, 34.19%) and 100 kernel weight (81%, 29.61). The reports of high heritability coupled with high genetic advance as percent of mean for kernel yield plant^{-1}, pod yield plant^{-1}, haulm yield plant^{-1}, total pods plant^{-1} and 100 kernel weight by Patil *et al.* (2014) were in conformity with findings of the present study.

High heritability coupled with moderate genetic advance as percent of mean was observed for the traits days to 50 percent flowering (72%, 13.88%) and shelling percent(35.67%, 12.00%)indicated non-additive gene effects in their genetic control and simple selection methods may not be rewarding to effect further genetic gain in these traits. The results were in accordance with the earlier reports of Thakur *et al.* (2013). Hybridization followed by selection in later generations of segregating populations would be effective to capitalize both additive and non-additive gene effects observed in these traits. On the contrary, high heritability and low GAM was observed for oil content (80% and 8.87%), number of seeds pod^{-1} (53%, 5.90%) and sound mature kernel percent (46% and 6.79%) indicating that high heritability was due to favourable influence of environment rather than genotypic effects and selection for such traits may not be rewarding.

CONCLUSIONS

Kernel yield plant^{-1}, pod yield plant^{-1} and haulm yield plant^{-1} recorded high PCV, GCV, heritability (broad sense) and genetic advance as percent of mean indicating that these characters are being governed by additive gene action and simple selection could be used for their improvement. On the other hand, days to 50 percent flowering, SCMR at 60 DAS and plant height exhibited moderate to low GCV, PCV, high heritability and moderate to low genetic advance. Hence, inter mating of selected genotypes could be suggested to generate variability followed by selection in later generations for superior segregants for the above characters.

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GROWTH AND YIELD OF BAJRA HYBRID AS INFLUENCED BY SPACING AND NITROGEN LEVELS IN RAINFED ALFISOLS

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ABSTRACT

A field experiment was conducted to study the response of bajra hybrid (ABH-1) to spacing and nitrogen levels in alfisols of scarce rainfall zone under rainfed conditions during *kharif,* 2015-16 at Agricultural Research Station, Ananthapur. The experiment was laid out in Factorial Randomized Block Design and replicated thrice. The results revealed that bajra sown at 60cm x 15cm produced higher growth, yield attributes, yield and economics. Among different nitrogen levels, application of 80 kg N ha^{-1} resulted in tallest plants and 60 kg N ha^{-1} produced higher dry matter production. Application of 100 kg N ha^{-1} produced higher leaf area and leaf area index, yield attributes, whereas, grain yield was higher with application of 60 kg N ha^{-1} and straw yield was higher with application of 80 kg N ha^{-1}. Higher gross, net returns and B:C ratio was recorded with application of 40 kg N ha^{-1} compared to 60, 80 and 100 kg N ha^{-1} which in turn comparable to each other.

INTRODUCTION

Bajra (Pearlmillet) the world's hardiest warm season cereal crop is an indispensable arid and semi arid crop of India cultivated as dual purpose (food and feed) crop in over 8.3 mha ranking fourth among total cereals. Further, the nutritional value of bajra offers much scope to development of value added products in new health conscious consumer segments as it contains more fibre and is good for diabetic and heart patients. It is the richest sources of nutrition, especially iron, calcium and zinc among cereals and hence can provide all the nutrients at the least cost compared to wheat and rice. Pearl millet is efficient in its utilization of moisture and has a higher level to that than jowar and maize.

Water stress decreased water potential, transpiration efficiency, rate of stomatal conductance, photosynthesis efficiency of flag leaves. The application of balance nutrients and their better utilization under moisture condition for enhancing growth, yield and yield attributing parameters of crops is important factor under rainfed condition. Fertilization of crop enhance water use efficiency, controlling soil erosion by promoting rapid and vigorous growth of crop to check runoff and increases the water holding capacity of soil. Application of nitrogen helps in better vegetative growth of plants, phosphorous stress condition. Potassium increase the potential and improving the quality of grains.

Bajra is an exhaustive crop that requires more nitrogen. The productivity of the crop is very low (25-26 q ha^{-1}) due to imbalance application of fertilizers, adopting improper intrarow spacing, uncertain and erratic distribution of rainfall. Nitrogen is the major nutrient required by bajra and has shown variable growth and yield response to N application (Gascho *et al.,* 1995). Generally, bajra has been known for growing under low N management several studies showed that N application can increase pearlmillet production efficiency (Singh *et al*., 2010). Nitrogen use efficiency (NUE) of bajra is higher than many other crops, increasing the rate of N fertilization does not always accompany a corresponding increase in grain yield (Muchow, 1988).

Ananthapur district is the second most drought - affected district of India. It receives around 500 mm rainfall annually. In this district, agriculture is predominantly dependent on rainfall which is very

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erratic and uncertain. Being located in the scarce rainfall zone of Andhra Pradesh, it does not get the full benefit of either the southwest or northeast monsoon. In this region bajra is an important crop that produces food and fodder within a short period of 85 to 90 days for resource poor farmers. Quantity of nitrogen requirement depends on the inherent fertility status of the soil, season and planting pattern besides several other factors. There is a need to improve yields of bajra hybrid by refining the existing agronomic practices. Keeping these in view, present experiment was conducted to study the response of bajra hybrid to spacing and nitrogen levels under rainfed condition.

MATERIAL AND METHODS

A field experiment was conducted to study the response of bajra hybrid to spacing and nitrogen levels in alfisols of scarce rainfall zone under rainfed conditions during *kharif,* 2015 at Agricultural Research Station, Ananthapur. The soil of the experimental site was red sandy loam with shallow depth, low in organic carbon (0.34%) and low in available nitrogen (138 kg ha^{-1}), medium in available phosphorous (28 kg ha^{-1}) and potassium (215 kg ha^{-1}). The experiment consisted of three spacings (S_1: 30 cm x 15 cm, S_2: 45 cm x 15 cm and S_3: 60 cm x 15 cm) and five nitrogen level treatments *viz.*, N_1: Control (No N), N_2: 40 k ha^{-1}, N_3: 60 kg ha^{-1}, N_4: 80 kg ha^{-1} and N_5: 100 kg ha^{-1}. The experiment was laid out in a factorial RBD with three replications. The experimental field was prepared by working with a tractor drawn disc plough and then tractor drawn cultivator was drawn along the field. The individual plots were laid out according to the layout plan. Healthy seed of bajra hybrid (ABH-1) with good germination percent (95%) was used for sowing purpose. ABH–1 (Ananthapuramu Bajra Hybrid-1) is a pre released hybrid developed at the Agricultural Research Station, ANGRAU, Ananthapuramu and ready for release in the state of Andhra Pradesh for farmers' cultivation. The seeds were sown by dibbling method in furrows at a depth of 5cm. As per the treatments half of the N, entire P_2O_5 and K_2O were applied at the time of sowing in the form of urea, single super phosphate(SSP) and muriate of potash(MOP), respectively. Remaining half N was applied at 30 DAS depending on rainfall event. Thinning and gap filling was done for maintaining optimum plant density.Weeding and hoeing were taken up depending on the intensity of weeds at critical stages of crop weed competition. All other cultural practices kept normal and uniform for all treatments. At harvest, five plants were randomly selected from each treatment for recording growth and yield parameters. The crop was harvested from a uniform net plot (5 m x 5 m) in all treatments for recording grain and straw yields which were expressed in kg ha^{-1}. Labour charges, cost of inputs were worked out to compute the cost of cultivation. Gross returns were calculated based on local market price of bajra and net returns by subtracting the total cost of cultivation from gross returns.

RESULTS AND DISCUSSION

Growth

Plant height of bajra increased progressively with advance in the age of the crop (Table 1). Plant height measured 30, 60 DAS and at harvest was not significantly influenced by the adopted spacing. However, maximum plant height was recorded with 45 cm x 15 cm at 30 DAS. The trend was changed and the crop spaced at 30 cm x 15 cm and 60 cm x

Table 1. Growth of bajra as influenced by spacing and nitrogen levels in rainfed alfisols

Treatments	Plant height (cm)			DMP (g $plant^{-1}$)			Leaf area (cm^2)		Leaf Area Index	
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	30 DAS	60 DAS
Spacing										
S1: 30cm x 15cm	43.7	85.2	98.2	25.9	36.4	53.2	319	466	0.71	1.04
S2: 45cm x 15cm	45.3	81.6	97.9	25.3	38.5	56.7	323	532	0.48	0.79
S3: 60cm x 15cm	44.8	84.6	98.5	25.6	38.5	60.1	341	657	0.38	0.73
S.Em ±	0.83	1.94	2.89	1.7	1.66	2.41	43.9	76.5	0.015	0.04
CD at 5%	NS	NS	NS	NS	NS	NS	15.2	26.4	0.043	0.12
N levels (kg ha^{-1})										
N1: Control (No N)	45.8	80.4	90.3	22.8	34.2	53.9	278	403	0.46	0.62
N2: 40 kg ha^{-1}	45.1	81.8	101.5	23.4	37.3	53.4	324	499	0.53	0.78
N3: 60 kg ha^{-1}	42.5	85.9	94.8	26.9	39.5	60.2	297	564	0.49	0.87
N4: 80 kg ha^{-1}	43.8	85.4	102.8	28.3	38.8	59.3	362	603	0.57	0.93
N5: 100 kg ha^{-1}	46.3	84.9	101.7	25.8	39.5	57.4	378	690	0.61	1.06
S.Em ±	1.07	2.21	2.13	1.19	1.14	1.07	11.9	34.1	0.019	0.05
CD at 5%	NS	NS	6.1	3.4	3.3	3.1	34.5	98.8	0.056	0.15
Interaction (S X N)	5.4	NS	NS	NS	NS	NS	59.7	NS	0.097	NS

15 cm recorded the maximum plant height at 60 DAS and at harvest, respectively. This result is contradictory to with Maas *et al*. (2007) who reported that plant height significantly increased with wider row spacing. Plant height measured at 30 and 60 DAS was not differed significantly due to different levels of nitrogen. These results are in agreement with the findings by Maas *et al.* (2007) in which plant height did not differ due to nitrogen rates. This indicates that nitrogen rate had no direct effect on plant biomass of pearl millet hybrid used in this study. However, at harvest, plant height was significantly influenced by nitrogen levels. Maximum plant height was recorded with 80 kg N ha^{-1} which was comparable with that of 100 and 40 kg N ha^{-1}. Interaction effect due to adopted spacing and applied level of nitrogen was found significant only at 30 DAS, while at other stages, it was found not significant.

Dry matter production of bajra observed to increase progressively with advance in the age of the crop. Dry matter production measured at 30, 60 DAS and at harvest did not differ significantly due to adopted spacing. Nitrogen levels has exerted significant influence on dry matter production at 30, 60 DAS and at harvest. At 30 DAS, the crop supplied with 80 kg N ha^{-1} recorded the highest dry matter production which was comparable with 60 and 100 kg N ha^{-1}. The trend was changed at 60 DAS, higher dry matter production recorded with 60 and 100 kg N ha^{-1} was comparable with 40 and 80 kg N ha^{-1}. At harvest, highest dry matter production was recorded with 60 kg N ha^{-1} which was comparable with 80 and 100 kg N ha^{-1}. Nitrogen is the main component of the protoplasm that involves in various metabolic processes *viz.*, photosynthesis, stimulation of cell division and elongation (Ali, 2010), which might have caused the increase in dry matter accumulation (Ayub *et al., 20*09). Interaction effect of spacing and nitrogen levels on dry matter production was found not significant.

Leaf area was significantly influenced by spacing at 30 and 60 DAS. Among different spacings, significantly the highest leaf area was recorded with 60 cm x 15 cm compared to 30 cm x 15 cm and 45 cm x 15 cm which in turn comparable to each other at 30 DAS. At 60 DAS, 60 cm x 15 cm recorded significantly higher leaf area compared to 30 cm x 15 cm and 45 cm x 15 cm with significant disparity between both of them. Leaf area was significantly influenced by nitrogen levels at 30 and 60 DAS. Among different nitrogen levels, application of 100 kg N ha^{-1} and 80 kg N ha^{-1} recorded significantly higher leaf area compared to other treatments at 30 DAS and 60 DAS.

Leaf area index was significantly influenced by spacing at 30 and 60 DAS. The crop spaced at 30cm x 15 cm recorded significantly higher leaf area index compared to 45cm x 15 cm and 60cm x 15 cm with significant disparity at 30 DAS. Leaf area index was significantly influenced by nitrogen levels at 30 and 60 DAS. Among different nitrogen levels, 100 kg N ha^{-1} and 80 kg N ha^{-1} found significantly superior to all other treatments which were comparable with each other. The interaction effect was found significant at 30 DAS while at 60 DAS, it was found non- significant. Higher plant height, dry matter production, leaf area and leaf area index was observed with the application of higher nitrogen levels. While all these parameters were at their lowest value with no nitrogen application. It could be attributed to the fact that higher nitrogen

Table 2. Yield components and yield of bajra as influenced by spacing and nitrogen levels in rainfed alfisols

Treatments	Number of tillers $plant^{-1}$	Number of panicles $plant^{-1}$	Panicle length (cm)	Single panicle weight (g)	Grain weight $panicle^{-1}$ (g)	Threshing (%)	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	HI	Gross Returns (Rs ha^{-1})	Net Returns (Rs ha^{-1})	B: C ratio
Spacing													
S1: 30cm x 15cm	1.91	1.56	18.8	23.7	16.1	68.1	8.28	2720	3078	0.45	40803	28573	2.34
S2: 45cm x 15cm	1.93	1.56	18.7	23.6	15.2	65.1	8.12	2828	3019	0.48	42433	30203	2.46
S3: 60cm x 15cm	2.24	1.75	19.4	26.2	17.2	65.4	8.81	2988	3344	0.49	44825	32595	2.67
S.Em ±	0.13	0.09	0.39	0.98	0.66	2.02	0.27	97.9	83.9	0.009	1468	1468	0.12
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	243	0.027	NS	NS	NS
N levels (kg ha^{-1})													
N1: Control (No N)	1.82	1.42	18.9	23.1	15.5	62.9	7.79	2431	3034	0.45	36473	24968	2.17
N2: 40 kg ha^{-1}	1.96	1.58	18.7	23.9	15.2	65.4	7.86	2790	3142	0.47	46256	34233	2.85
N3: 60 kg ha^{-1}	2.11	1.62	19.2	24.8	16.1	67.1	8.47	3083	3048	0.50	41861	29581	2.41
N4: 80 kg ha^{-1}	2.07	1.69	19.2	24.6	16.1	66.2	8.96	2964	3354	0.47	44466	31924	2.54
N5: 100 kg ha^{-1}	2.26	1.87	18.9	26.3	18.2	69.5	8.93	2958	3157	0.48	44376	31578	2.47
S.Em ±	0.18	0.12	0.5	0.78	0.63	2.61	0.35	126.4	91.2	0.012	1896	1896	0.16
CD at 5%	NS	0.35	NS	2.26	1.84	NS	NS	366	268	NS	5494	5494	NS
Interaction (S X N)	NS	NS	NS	NS	4.26	NS	NS	NS	NS	NS	NS	NS	NS

levels might have accelerated the synthesis of more chlorophyll and amino acids and stimulated the cellular activity, which is useful for the process of cell division, meristematic growth coupled with cell enlargement, resulting in production of larger leaves which ultimately leads to enhanced dry matter accrual.

Yield Attributes

The variability in spacing has not exerted any significant influence on number of tillers and panicles plant^{-1}, panicle length, single panicle weight, grain weight panicle^{-1}, test weight and threshing percent (Table 2). Number of tillers plant^{-1} was not significantly influenced by nitrogen levels. A similar observation was reported by Eric Obeng *et al.* (2012) that application of 0, 40, 80 and 120kg N ha^{-1} did not show significant difference in the number of tillers in pearl millet. However, highest number of tillers plant^{-1} was recorded with 100kg N ha^{-1} followed by 60kg N ha^{-1}. The lowest values were recorded with control treatment (No nitrogen application). This is in line with the findings by Pandey and Sinha (2010) who reported that application of nitrogen fertilizer at right time (split) and at higher level enhances many aspects of plant physiological stages involving photosynthesis, root growth and development, tallness or elongation of structural tissues such as stalk in cereals.

Number of panicles plant^{-1} was higher with application of 100 kg N ha^{-1} which was comparable with 80, 60 and 40 kg N ha^{-1} and significantly superior over control which recorded lowest number of panicles plant^{-1}. These results were contradictory to Eric Obeng *et al.* (2012) who reported that nitrogen rates 0, 40, 80 and 120 kg N ha^{-1} did not show any significant difference for number of panicles. Panicle length was not significantly influenced by different nitrogen levels. Variation in single panicle weight was significant due to different nitrogen levels. Maximum single panicle weight recorded with 100 kg N ha^{-1} was comparable with 60 and 80 kg N ha^{-1} and found significantly superior over 40 kg N ha^{-1} and control. Grain weight panicle^{-1} was significantly influenced by different nitrogen levels tested. Maximum grain weight panicle^{-1} was recorded with 100 kg N ha^{-1} which was significantly superior to all other treatments. The interaction effect was found significant due to adopted plant density and applied nitrogen level. The crop spaced at a wider row spacing of 60cm recorded maximum grain weight panicle^{-1} with application of 100 kg N ha^{-1}. The improvement of single panicle weight and grain weight panicle^{-1} with progressive increase of nitrogen levels was also reported by Ali (2010). Threshing percent was not significantly influenced by nitrogen level.

Grain, Straw Yield and Harvest Index

Grain yield was not significantly influenced by variable spacing. This is in line with Shekhawat *et al.* (1972) who observed that bajra yields were not significantly affected by the adopted spacing. Maximum grain yield recorded with 60 kg N ha^{-1} was comparable to lower level of 40 kg N ha^{-1} and higher level of 80 kg N ha^{-1} and 100 kg N ha^{-1}. The lowest grain yield was registered with control treatment. It was observed that grain yield increased with increase in nitrogen level from 0 to 60 kg ha^{-1} but further increase of N until 100 kg ha^{-1} did not result in further increase in grain yield. Similar results were reported by Hassan and Bibinu (2010).The interaction effect due to adopted spacing and applied levels of nitrogen on grain yield was found not significant.

Straw yield was significantly influenced by the adopted spacing. The crop spaced at spacing of 60cm x 15cm registered the highest straw yield compared to 30cm x 15 cm and 45cm x 15 cm. Among different levels of nitrogen tried, highest straw yield was recorded with 80 kg N ha^{-1} compared to 40 and 100 kg N ha^{-1} with significant parity. The interaction effect was found to be non significant with spacing and different levels of nitrogen. The crop spaced at 60cm x 15cm recorded highest harvest index which was on par with 45cm x 15 cm spacing. The lowest harvest index was recorded with 30cm x 15cm spacing. Among different levels of nitrogen, highest harvest index was recorded with 60 kg N ha^{-1}.The interaction effect was found to be non significant with adopted spacing and different levels of nitrogen.

Economics

Gross, net returns and B:C ratio were not significantly influenced by spacing. Among nitrogen levels, higher gross returns, net returns and B:C ratio was recorded with application of 40 kg N ha^{-1} compared to 60, 80 and 100 kg N ha^{-1} which in turn comparable to each other. The higher economic returns might be due to higher grain and straw yields registered under higher nitrogen levels.

CONCLUSIONS

From the above results, it can be concluded that bajra hybrid can be grown at an inter row spacing of 45cm or 60cm to get higher grain yield and net returns under rain fed conditions. Though, application of 60 and 80kg N ha^{-1} resulted in higher grain and straw yield, application of 40kg N ha^{-1} is optimum because of higher net returns and B:C ratio.

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FIELD EVALUATION OF *BT* COTTON HYBRIDS AGAINST CERTAIN SUCKING PESTS AND FOLIAR DISEASES

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ABSTRACT

Fifty *Bt* cotton hybrids were evaluated during 2011 – 2012 against sucking pests and foliar diseases under unprotected conditions to identify those with multiple resistance. Counts of leaf hoppers, thrips, white flies and aphids on 10 plants, at random, were recorded at weekly intervals. Reaction of these hybrids to Alternaria leaf spot and bacterial blight was recorded by adopting zero (0) to 4 scale and percent disease intensity was calculated. In case of tobacco streak virus (TSV) disease, percent incidence was recorded. Twelve *Bt* cotton hybrids were resistant to sucking pests and 26 hybrids were resistant to foliar diseases. Six hybrids *viz.*, Ajeet 155, Indra Vajra, Jackpot BG II, Mallika BG II, Sandeep and Pratheek BG II were resistant to both sucking pests and foliar diseases. Hybrids with no/ low incidence of sucking pests (Rakhi BG II, Ajit 155, Indra Vajra, Jackpot BG II, Kanak BG II etc) showed resistance to TSV disease. Four hybrids *viz.*, Ajit 155, Dr Brent BG II, Neeraja BG II and SWCH 4769 BG II recorded more than 20q ha^{-1}, besides tolerance to the sucking pests and foliar diseases. Therefore, farmers are advised to grow best *Bt* cotton hybrids with multiple pest and disease tolerance to reduce cost of cultivation and increase net returns.

INTRODUCTION

Cotton is one of the most important commercial crops of the world. Sucking pests pose a serious problem in *Bt* cotton. The estimated loss due to sucking pests is up to 21.20 percent (Dhawan and Sidhu, 1986; Dhawan *et al.*, 1988). Leaf hoppers are reported to cause 18.78 percent decline in cotton yield (Ali, 1992). Chavan *et al.* (2010) reported 28.13 percent avoidable yield loss due to major sucking pests in cotton. Cotton crop is affected by fungal, bacterial and viral diseases. In India, foliar diseases have been estimated to cause yield losses up to 20 to 30 percent (Mayee and Mukewar, 2007). Leaf spot/ blight caused by *Alternaria macrospora* Zimm. is the most commonly occurring disease in Andhra Pradesh causing losses to the tune of 38.23 percent in cotton variety LRA 5166 (Bhattiprolu and Prasada Rao, 2009). Bacterial blight of cotton caused by *Xanthomonas axonopodis* pv *malvacearum* (Smith) is an economically important disease in Andhra Pradesh causing losses to the tune of 22.0% to 36.34% (Monga *et al.*, 2013; Bhattiprolu, 2013). Tobacco Streak Virus (TSV) on cotton has been occurring regularly in *Bt* cotton hybrids.

The low productivity of cotton in Andhra Pradesh is attributed to cultivation of more than 60 per cent of cotton under rainfed conditions by small and marginal farmers. Plant protection costs constitute considerable part of cost of cultivation. Developing low cost technologies will help to reduce the burden of poor tenant farmers. Management of pests and diseases through use of resistant varieties/ hybrids constitutes an important strategy of integrated plant protection. Identification of resistant sources goes in this direction. A number of *Bt* hybrids developed in India, to manage the bollworms are being cultivated by farmers. However, these *Bt* cotton hybrids need to be protected from sucking pests as well as important diseases. It is necessary to evaluate these hybrids to identify the resistant ones to major sucking pests and foliar diseases so that farmers can choose the best ones for cultivation. With this objective the present studies was taken up.

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MATERIAL AND METHODS

A field experiment was conducted at Regional Agricultural Research Station, Lam, Guntur during the year 2011 - 2012. Fifty *Bt* cotton hybrids were sown in randomized block design with two replications, each composed of four rows, at a spacing of 105 cm x 60 cm. Infector row technique was employed to supplement the natural disease pressure. Each entry was sandwiched between infector rows of susceptible variety LRA 5166. In addition, two boarder rows of LRA 5166 were raised around the field. Recommended agronomic practices were adopted and these hybrids were evaluated against sucking pest incidence and foliar diseases under unprotected conditions. Counts of leaf hoppers, thrips, white flies and aphids per three leaves per plant, taking one leaf from the top, middle and the bottom portions, on 10 plants at random, were recorded at weekly intervals; mean counts at peak incidence were calculated and hybrids were grouped accordingly. With respect to diseases, five plants at random were tagged from each plot and 10 leaves, three leaves at bottom, four in the middle and three at the top of each plant were scored at peak intensity by using disease grades (Table 1). Depending on the scores collected, percent disease intensity (PDI) was calculated by using the formula by Wheeler (1969) as given below:

$$\text{PDI} = \frac{\text{Sum of all the numerical ratings}}{\text{Total number of leaves scored} \times \text{Maximum disease grade}} \times 100$$

In case of tobacco streak virus (TSV) percent disease incidence was recorded as follows

$$\text{Percent disease incidence} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

Depending upon the grade of infection the hybrids were categorized into immune, resistant, moderately resistant or susceptible and susceptible groups (Sheo Raj, 1988). Yield data was recorded and hybrids were divided into five groups *viz.*, hybrids yielding <5q ha^{-1}; 5 -10q ha^{-1}; 10-15q ha^{-1}; 15 - 20q ha^{-1} and >20q ha^{-1}.

RESULTS AND DISCUSSION

Three *Bt* cotton hybrids *viz.*, Dr Brent BG II, Ajeet 155 and Rakhi BG II recorded lowest number of leaf hoppers 0.51, 0.53 and 0.73, respectively, while 37 *Bt* hybrids showed mean incidence of 1.85

Table 1. Scale adopted for cotton diseases

Scale	Grade	% leaf area infected		Percent disease incidence
		Bacterial blight	Alternaria leaf spots	Tobacco streak virus disease
0	Immune	Completely free from disease	Completely free from disease	0
1	Resistant	Up to 5%	Up to 5%	0.1 to 5.0%
2	Moderately resistant	6 to 10%	6-20%	5.1 to 10.0
3	Moderately susceptible	11 to 20%	21-40%	10.1 to 20.0%
4	Susceptible	>20%	>40%	>20.0%

Table 2. Reaction of *Bt* cotton hybrids to sucking pests

Sucking Pest	Grouping of *Bt* hybrids		
Leaf hoppers	MEAN-SD (0.84)	MEAN±SD	MEAN+SD (2.86)
	Dr Brent BG II, Ajeet 155, Rakhi BG II	Pancham BG II, Sudarshan BG II, Brahma, Trinetri BG II, Neeraja BG II, SWCH 4708 BG II, SWCH 4746 BG I, Mahathma BG II, SWCH 4731 BG II,, SWCH 4769 BG II, Siddu BG II, Sandeep, Dhanno BG II, Big boss BG I, Hanuman BG II, Jadoo KCH 14 K59, Bullet BG II, Jackpot BG II, Bunny BG II, Mallika Gold, Bhadra, Sabbar Gold BG II, Chiranjeevi BG II, RCH 533 BG II, RCH 665 BG II, RCH 668 BG II, Srinidhi BG I, Prachanda BG II, Taakath BG II, Mahi BG II, Jai BG II, VICH 15 BG II, VICH 301 BG II, Ganesh BG II, Dyna BG II, Kanak BG II, Bhaskar BG II	Pratheek BG II, Vahini BG II, VICH 5 BG II, Aasha BG II, Rudra BG II, Mallika BG II, RCH 2 BG II, Ankur 3034 BG I, Rasi 530 BG II, Indra Vajra
Aphids	MEAN-SD (0.53)	MEAN±SD	MEAN+SD (5.33)
	-	Brahma, Neeraja BG II, Mahathma BG II, SWCH 4731 BG II, SWCH 4769 BG II, Siddu BG II, Aasha BG II, Hanuman BG II, Jadoo KCH 14 K59, Bullet BG II, Jackpot BG II, Bunny BG II, Mallika Gold, Bhadra, Ajeet 155, Sabbar Gold BG II, Chiranjeevi BG II, RCH 2 BG II, RCH 533 BG II, RCH 665 BG II, RCH 668 BG II, Srinidhi BG I, Rasi 530 BG II, Vahini BG II, Prachanda BG II, Taakath BG II, Rudra BG II, Mahi BG II, Jai BG II, Ankur 3034 BG I, Indra Vajra, VICH 5 BG II, VICH 301 BG II, Ganesh BG II, Mallika BG II, Dyna BG II, Kanak BG II, Bhaskar BG II	Pancham BG II, Dr Brent BG II, Sandeep, Sudharshan BG II, Rakhi BG II, Dhanno BG II, Pratheek BG II, SWCH 4708 BG II , Big boss BG I, Trinetri BG II, SWCH 4746 BG I, VICH 15 BG II
Thrips	MEAN-SD (0.28)	MEAN±SD	MEAN+SD (2.42)
	RCH 2 BG II, Indra Vajra	Brahma, Pratheek BG II, Trinetri BG II, Dr Brent BG II, Neeraja BG II, Rakhi BG II, SWCH 4708 BG II, Siddu BG II, Sandeep, Dhanno BG II, Aasha BG II, Big boss BG I, Jadoo KCH 14 K59, Bullet BG II, Jackpot BG II, Bunny BG II, Mallika Gold, Bhadra, Ajeet 155, Sabbar Gold BG II, Chiranjeevi BG II, RCH 533 BG II, RCH 665 BG II, RCH 668 BG II, Srinidhi BG I, Rasi 530 BG II, Vahini BG II, Prachanda BG II, Taakath BG II, Rudra BG II, Ankur 3034 BG I, VICH 5 BG II, VICH 15 BG II, VICH 301 BG II, Ganesh BG II, Mallika BG II, Dyna BG II, Kanak BG II, Bhaskar BG II	Pancham BG II, Mahathma BG II, Hanuman BG II, Sudharshan, SWCH 4731 BG II, Mahi BG II, SWCH 4746 BG I, SWCH 4769 BG II, Jai BG II
Whitefly	MEAN-SD (0.48)	MEAN±SD	MEAN+SD (1.60)
	Pratheek BG II, Jackpot BG II, Jai BG II, Dr Brent BG II, Sabbar Gold BG II, Mallika BG II, Sandeep, Rasi 530 BG II	Sudarshan BG II, Trinetri BG II, SWCH 4708 BG II , Mahathma BG II, SWCH 4731 BG II, SWCH 4769 BG II, Siddu BG II, Dhanno BG II, Aasha BG II, Big boss BG I, Hanuman BG II, Jadoo KCH 14 K59, Bullet BG II, Bunny BG II, Mallika Gold, Bhadra, Ajeet 155, Chiranjeevi BG II, RCH 2 BG II, RCH 533 BG II, RCH 668 BG II, Srinidhi BG II, Vahini BG II, Prachanda BG II, Taakath BG II, Rudra BG II, Mahi BG II, Ankur 3034 BG I, Indra Vajra, VICH 5 BG II, VICH 15 BG II, VICH 301 BG II, Ganesh BG II, Dyna BG II, Kanak BG II, Bhaskar BG II	Pancham BG II, Neeraja BG II, SWCH BG I 4746, Brahma, Rakhi BG II, RCH-665 BG II

(Table 2). According to Prasad and Hari Prasada Rao (2008) both *Bt* and non *Bt* versions of Mallika, Proagro 368 and Bunny hybrid were found moderately resistant against leaf hoppers with low seasonal mean incidence among the hybrids, while RCH 2 *Bt* , RCH 2 non *Bt* and RCH 20 *Bt* were found more prone to the leaf hoppers. Mahi BG II, Ankur 3034 BG II and Bunny BG II were tolerant to leaf hoppers while Mahi BG II, VICH 301 BG II, Dyna BG II, Bunny BG II, Ankur 3034 BG II and Ankur Jai BG II were tolerant to thrips (Nagrare *et al.*, 2014). Thirty *Bt* cotton hybrids showed mean incidence of 2.93 aphids per three leaves. Two entries, RCH 2 BG II and Indravajra were free from thrips whereas 39 *Bt* cotton hybrids recorded mean incidence of 1.35 (Table 2). Ankur Jai BG II and VICH 301 BG II were found tolerant to both leaf hoppers and thrips (Nagrare *et al.,* 2014). Significantly highest ($P<0.01$) population of leaf hoppers was recorded on Sindh1 followed by *Bt* cotton, Shahbaz, Niab -78 and Hari dost (Abdul Ghani

Table 3. Reaction of *Bt* cotton hybrids to diseases

Scale	Grade	Disease reaction of hybrids		
		Alternaria leaf spot	Bacterial blight	Tobacco Streak Virus Disease
0	Immune	Nil	Nil	Pratheek BG II, Neeraj BG II, Mallika BG II
1	Resistant	Ganesh BG II	Pratheek BG II, Big boss BG I	Rakhi, SWCH 4708 BG II, Big boss BG I, Sandeep, Siddu BG II, SWCH 4769 BG II, SWCH 4731 BG II, Mahathma BG II, Chiranjeevi BG II, Ajeet 155, Bhadra NCS 9029, Bunny BG II NCS 145, Jackpot BG II, Bullet BG II, Rasi 530 BG II, Rudra BG II, Mahi BG II, Jai BG II, Ankur 3034 BG I, Indra Vajra, Kanak BG II, Bhaskar BG II
2	Moderately resistant	Brahma, Neeraja BG II, SWCH 4746 BG I, Big Boss BG I, Aasha BG II, SWCH 4769 BG II, SWCH 4731 BG II, Mahathma BG II, Bullet BG II, Srinidhi BG I, Rasi 530 BG II, Vahini BG II,Prachanda BG II 144, Taakath BG II 118, Rudra BG II, Jai BG II, Indra Vajra, VICH 5 BG II, VICH 301 BG II, Mallika BG II, Dyna BG II	Sudarshan BG II, Brahma, Dr Brent BG II, Neeraja BG II, SWCH 4746 BG I, Hanuman BG II, RCH 533 BG II, RCH 2 BG II, Bullet BG II, RCH 665 BG II, RCH 668 BG II, Indra Vajra, Mallika BG II	Pancham BG II, Sudarshan BG II, Brahma, Trinatri BG II, Dr Brent BG II, SWCH 4746 BG I, Jadoo KCH 14 K59, Hanuman BG II, Dhanno BG II, RCH 533 BG II, Sabbar Gold BG II, Mallika Gold NCS 859, RCH 665 BG II, RCH 668 BG II, Vahini BG II, Taakath BG II, VICH 5 BG II, VICH 15 BG II, VICH 301 BG II, Ganesh BG II, Dyna BG II
3	Moderately Susceptible	Pancham BG II, Sudarshan BG II, Pratheek BG II, Trinatri BG II, Dr Brent BG II, Rakhi, SWCH 4708 BG II, Jadoo KCH 14 K59, Hanuman BG II, Dhanno BG II, Sandeep, Siddu BG II, RCH 533 BG II, RCH 2 BG II, Chiranjeevi BG II, Sabbar Gold BG II, Ajeet 155, Bhadra NCS 9029, Mallika Gold NCS 859, Bunny BG II NCS 145, Jackpot BG II, RCH 665 BG II, RCH 668 BG II, Mahi BG II, Ankur 3034 BG I, VICH 15 BG II, Kanak BG II, Bhaskar BG II	Pancham BG II, Rakhi, SWCH 4708 BG II, Jadoo KCH 14 K59, Aasha BG II, Sandeep, Siddu BG II, SWCH 4769 BG II, SWCH 4731 BG II, Mahathma BG II, Chiranjeevi BG II, Sabbar Gold BG II, Ajeet 155, Mallika Gold NCS 859, Srinidhi BG I, Rasi 530 BG II, Vahini BG II, Prachanda BG II, Taakath BG II, Rudra BG II, Mahi BG II, Jai BG II, Ankur 3034 BG I, VICH 5 BG II, VICH 15 BG II, Ganesh BG II, Dyna BG II, Kanak BG II	Aasha BG II, Prachanda BG II
4	Susceptible	Nil	Trinatri BG II, Dhanno BG II, Bhadra NCS 9029, Bunny BG II NCS 145, Jackpot BG II, VICH 301 BG II, Bhaskar BG II	Srinidhi BG I

Table 4. Yield-wise categorization of *Bt* cotton hybrids under unprotected conditions

S. No	Yield range ($q\ ha^{-1}$)	*Bt* cotton hybrids
1	< 5	Ankur 3034 BG I, VICH 5 BG II
2	5 - 10	Sudarshan BG II, Pratheek BG II, Trinetri BG II, Aasha BG II, Big boss BG II, Hanuman BG II, Sabbar Gold, RCH 2 BG II, RCH 533 BG II, RCH 665 BG II, RCH 668 BG II, Srinidhi BG I, Rasi 530 BG II, Vahini BG II, Rudra BG II, Mahi BG II, Jai BG II, Indra Vajra, VICH 15 BG II, Ganesh BG II, Mallika BG II
3	10 - 15	Pancham BG II, Brahma, SWCH 4708 BG II, Siddu BG II, Sandeep, Dhanno BG II, Jadoo KCH 14 K59, Bullet BG II, Bunny BG II, Chiranjeevi BG II, Prachanda BG II, Taakath BG II, VICH 301 BG II, Dyna BG II, Bhaskar BG II
4	15 - 20	Dr Brent BG II, Rakhi BG II, Mahathma BG II, SWCH BG II 4731, SWCH BG I 4746, Jackpot BG II, Kanak BG II
5	> 20	Bhadra, Mallika Gold, Ajeet 155, Neeraja BG II, SWCH BG II 4769

Lanjar *et al.*, 2014). With respect to whitefly, eight *Bt* cotton hybrids *viz.*, Sabbar Gold (0.17), Rasi BG II (0.35), Pratheek BG II (0.37), Jackpot BG II (0.40), Mallika BG II (0.40), Sandeep (0.40), Jai BG II (0.46) and Dr Brent BG II (0.46) showed lower number of white flies while 36 *Bt* cotton hybrids recorded mean incidence of 1.04 per three leaves. *Bt* cotton variety *BT* 3701 was relatively resistant to white fly, thrips and leaf hoppers (Bhai Khan Solangi *et al.*, 2014).

Alternaria leaf spot was lowest in Ganesh BG II (3.33%) and highest in Jadoo KCH 14 K59 (34.72%). Two *Bt* hybrids *viz.*, Pratheek BG II and Big boss BG I expressed resistant reaction to bacterial blight while three hybrids including Pratheek BG II, Mallika BG II and Neeraja BG II were free from Tobacco Streak Viral disease (Table 3). Seven hybrids *viz.*, Brahma, Dr Brent BG II, Neeraja BG II, SWCH 4746 BG I, Bullet BG II, Indra Vajra, and Mallika BG II showed moderately resistant reaction to both Alternaria leaf spot and bacterial blight diseases. Bhattiprolu and Prasad (2011) reported resistant nature of MRC – 7201 BG II (Neeraja BG II) to Alternaria leaf spot, while Mallika Gold *Bt* 2, Mallika *Bt* 2 and Mallika *Bt* were moderately resistant.

Twenty- four hybrids showed less than five percent TSV incidence. Tulasi 144 BG II, Kohinoor *Bt*, Tulasi Non *Bt*, Super Kanaka *Bt*, NECR – 2RC (F1), Brahma BG II were free from TSV infection (Bhattiprolu and Prasad, 2011).Yield data showed that five *Bt* cotton hybrids *viz.*, Bhadra, Mallika Gold, Ajeet 155, Neeraja BG II, SWCH 4769 BG II produced more than 20 $q\ ha^{-1}$ (Table 4). Seven hybrids *viz.*, Dr Brent BG II, Rakhi BG II, Mahathma BG II, SWCH 4731 BG II, SWCH 4746 BG I, Jackpot BG II and Kanak BG II yielded between 15 to 20 $q\ ha^{-1}$ while 15 *Bt* cotton hybrids gave 10 to 15 $q\ ha^{-1}$. Twenty - one *Bt* cotton hybrids recorded 5-10 $q\ ha^{-1}$ in comparision to <5 $q\ ha^{-1}$ in two hybrids namely Ankur 3034 BG I and VICH 5 BG II. Similar yields were recorded in Dyna BG II, VICH 301 BG II and Mahi BG II (Nagrare *et al.,* 2014).

CONCLUSIONS

Small and marginal as well as tenant farmers who cultivate cotton under rainfed conditions may choose best *Bt* hybrids with resistance to sucking pests and diseases for cultivation to reduce the cost of plant protection by preventing indiscriminate use of pesticides and thus net returns can be enhanced.

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EVALUATION OF CERTAIN INSECTICIDE MOLECULES AGAINST MITE, *Polyphagotarsonemus latus* Banks ON CAPSICUM

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ABSTRACT

Field and poly house experiments were conducted to evaluate the new insecticides for the management of mite, *Polyphagotarsonemus latus* Banks on capsicum. Among the seven insecticides, mean of two seasons under field conditions reveal that, post count population was lower with spiromesifen (0.62 mites leaf^{-1}) followed by diafenthiuron (4.08 mites leaf^{-1}), triazophos (5.73 mites leaf^{-1}) and thiamethoxam (9.43 mites leaf^{-1}) which were superior over rest of the treatments and untreated check (17.60 mites leaf^{-1}). Under poly house condition, population was less with spiromesifen (0.06 mites leaf^{-1}) followed by diafenthiuron (2.21 mites leaf^{-1}), triazophos (3.68 mites leaf^{-1}) and thiamethoxam (5.30 mites leaf^{-1}) which were superior over untreated check (11.33).Comparision of efficacy of insecticides, there was significant difference in percent reduction of population over untreated check after each spray. The percent reduction and mortality in mite population were high in poly house (spiromesifen, flubendiamide and spinosad) compared to open field.

Capsicum (*Capsicum annuum* L. var. grossum Sendt.) is also called as bell pepper or sweet pepper and is one of the popular and remunerative annual herbaceous vegetable crop. It is different from chilli (*Capsicum annuum* L. var. longum) in size, shape, capsanthin content, usage and belongs to the family Solanaceae. It is known by other names such as *shimla mirch* and green pepper. In India, it is cultivated in an area of 30,000 ha with production of 1.71 lakh tons (National Horticultural Board, 2015). Jharkand is the major capsicum cultivating state with an area of 1,960ha and production of 0.2 lakh tons. In Telangana state, in and around Hyderabad, Rangareddy, Medak districts and in Andhra Pradesh state, Guntur, Chittoor, Ananthapur are the major capsicum cultivating districts. Among the biotic factors, insect pests reduce the quality of produce and even a small blemish on the fruit will drastically reduce its market value.

Butani (1976) reported over 20 insect species on chillies (*Capsicum* spp.) from India of which mite, *Polyphagotarsonemus latus* Banks is the most damaging pest under field and poly house conditions (Barwal, 2004 and Kaur *et al.*, 2010). Estimated crop loss of 40 to 60 tons ha^{-1} of capsicum when the crop was not subjected to insecticidal control (Reddy and Kumar, 2006). In order to control the mite and get higher market price, farmers are indiscriminately using insecticides. As capsicum is consumed fresh there is a need to minimize the pesticide residues in marketable capsicum. Hence, the present study was conducted to find effective insecticide to manage the mite on capsicum.

MATERIAL AND METHODS

Field and poly house experiments were conducted in 2013-14 and 2014 -15 at Horticultural Garden, College of Agriculture, Rajendranagar, Hyderabad to evaluate the new insecticides for the management of mite, with leading popular capsicum variety Royal Wonder of Seminis Pvt. Ltd. The experiments were conducted in Randomized Block Design (RBD) with three replications. Capsicum seedlings raised in the nursery were transplanted at age of 40 days in the main field by adopting a spacing of 45cm X 30cm and 30cm X 30 cm in poly house conditions. Plot size was maintained 6m X 6m. All

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the recommended agronomical practices were implemented to raise crop except plant protection measures against pod borers.

The selected insecticides belonging to different groups *viz.,*Organophosphates (Triazophas), Neonicotinoids (Thiamethoxam), Microbialinsecticide (Spinosad,), Thiourea derivatives (Diafenthiuron), Diamides (Chlorantraniliprole), Pthalic acid diamides (Flubendiamide)andKetones (Spiromesifen) along with untreated control were evaluated for two years. First spray was initiated when the population reached Economic Threshhold levels (ETL) (mite –1 No. leaf^{-1}) and second spray was given at seven days after first spray(Kumar *et al.*, 2007). A total of three sprays were applied during the entire experimentation in both the seasons. Same procedure was followed in both the open field and poly house conditions.

Observations on population of mites were recorded in ten randomly tagged plants, from five terminal leaves (two from top, two from middle and one from bottom) per plant. Pre count (one day before spray) and post count (1,3,5 and 7 days after spray) of the insects was recorded by using destructive sampling procedure. Percent reduction over control was calculated by using the following formula (Flemming and Retnakaran, 1985).

$$\text{Percent population reduction} = 1- \frac{\text{(Post treatment population in treatment)}}{\text{(Pre treatment population in treatment)}} \times \frac{\text{(Pre treatment population in untreated control)}}{\text{(Post treatment population in untreated control)}} \times 100$$

Table 1. Details of Insecticide treatments used

Treatment No.	Common Name of Insecticide	Dosage (g or ml a.i.ha^{-1})	Trade Name and Formulation	Source of Supply
T_1	Spinosad	75	Tracer 45 SC	M/s Dow Agro Sciences Limited., India.
T_2	Flubendiamide	60	Fame 480 SC	M/s Bayer Crop Sciences Limited, Mumbai.
T_3	Chlorantraniliprole	60	Coragen 20 SC	M/s DuPont Agro Chemicals Limited,Mumbai.
T_4	Diafenthiuron	400	Pegasus 25 WP	M/s Syngenta India Limited, Mumbai
T_5	Spiromesifen	96	Oberon 240 SC	M/s Bayer Crop Sciences Limited, Mumbai.
T_6	Thiamethoxam	50	Actara 25 WG	M/s Syngenta India Limited, Mumbai
T_7	Triazophos	96	Hostathion 40 EC	M/s Cheminova India Limited, Mumbai
T_8	Untreated Check	--	---	--

Pre count (1 DBS) and post count (mean of 1,3,5 and 7 DAS) population and percent reduction over control were calculated after each spray. Cumulative mean of three sprays in 2013-14 and 2014-15 under open and poly house conditions and pooled mean of two years are represented in tables and discussed here under.Leaf Curl Index (LCI) was recorded one day before and 10 days after each spray following the methodology of Kumar *et al.*(1996) (Table 2).

Table 2. Scoring procedure for mite damage

S.No	Score	Symptom
1	0	No symptoms
2	1	1-25% leaves plant^{-1} showing curling
3	2	25-50% leaves plant^{-1} showing curling, moderately damaged
4	3	51-75% leaves plant^{-1} showing curling, heavely damaged, malformation of growing points and reduction in plant height
5	4	>76% leaves plant^{-1} showing curling,severe and complete destruction of growing points, drastic reduction in plant height , defoliation and severe malformation

RESULTS AND DISCUSSION

Open Field Conditions

Pooled mean of 2013 -14 and 2014-15: The overall cumulative mean efficacy of the treatments against mite, *P. latus* during the 2013-14 and 2014-15 under open field conditions are presented in Table 3 . Mean mite population in pre count ranged from5.46 to 15.88 and post count population was lower with spiromesifen (0.62 mites leaf^{-1}) followed by diafenthuiron (4.08 mites leaf^{-1}), triazophos (5.73 mites leaf^{-1}) and thiamethoxam (9.43 mites leaf^{-1}) which were superior over rest of the treatments and untreated check (17.60 mites leaf^{-1}). The descending order of efficacy of the other treatments were chlorantraniliprole (12.84 mites leaf^{-1}), flubendiamide (14.69 mites leaf^{-1}) and spinosad (15.21 mites leaf^{-1}) which were found to be on par with over untreated check (17.60 mites leaf^{-1}). The highest percent reduction of mite population was recorded in spinosad (97.29%) followed by diafenthiuron(71.32%), triazophos (61.31%) and thiamethoxam (43.45%)which were on par with each other and superior over rest of the treatments and untreated check. The other treatments that followed in the ascending order of efficacy were chlorantraniliprole (20.60%), flubendiamide (13.42%) and spinosad (11.21%) which were found to be superior over untreated check.The mean LCI of two years revealed that, LCI at one DBS (1.53) was reduced to 0.69 at 10 DAS in spiromesifen treated plants followed by diafenthiuron (1.78 to 1.09) and triazophos (2.03 to 1.72). Whereas, LCI was increased from one DBS to 10 DAS in flubendiamide (2.48 to 2.71), chlorantraniliprole (2.49 to 2.70), thiamethoxam (2.50 to 2.67), spinosad (2.52 to 2.73) and untreated control (2.72 to 3.00) (Table 3).

Table 3. Cumulative efficacy of certain insecticide molecules against mite, *P. latus*on on capsicum under open field conditions during 2013-14 and 2014-15 (Pooled mean)

T.No	Treatments	Dose (g or ml ha^{-1})	Pooled mean of 2013-14 and 2014-15 (Mean no. of mites $leaf^{-1}$)			Leaf curl index (LCI) (Mean 2013-14 and 2014-15)	
			Pre count (1 DBS)*	Post count (Mean of 1,3,5,7 DAS)*	Percent Reduction$	1 DBS	10 DAS
T_1	Spinosad 45 SC	125	14.75 (3.96)	15.21 $(4.02)^{ab}$	11.21 $(19.55)^{d}$	2.52(1.87)	2.73(1.93)a
T_2	Flubendiamide 480 SC	200	13.46 (3.80)	14.69 $(3.96)^{ab}$	13.42 $(21.48)^{d}$	2.48(1.86)	2.71(1.92)a
T_3	Chlorantraniliprole 20 SC	200	12.09 (3.61)	12.84 $(3.72)^{ab}$	20.60 $(26.48)^{d}$	2.49(1.86)	2.70(1.92)a
T_4	Diafenthiuron 25 WP	750	8.18 (3.03)	4.08 $(2.25)^{d}$	71.32 $(57.59)^{b}$	1.78(1.66)	1.09(1.44)b
T_5	Spiromesifen 22.9 SL	750	5.46 (2.54)	0.62 $(1.27)^{e}$	97.29 $(80.49)^{a}$	1.53(1.59)	0.69(1.30)b
T_6	Thiamethoxam 25 WG	150	11.95 (3.39)	9.43 $(3.23)^{bc}$	43.45 $(41.22)^{c}$	2.50(1.87)	2.67(1.91)a
T_7	Triazophos 40 EC	1250	9.40 (3.22)	5.73 $(2.59)^{cd}$	61.31 $(52.78)^{c}$	2.03(1.74)	1.72(1.64)ab
T_8	Untreated check	--	15.88 (3.97)	17.6 $(4.19)^{a}$	0.00e	2.72(1.87)	3.00(1.88)a
		SEm$\pm$	0.23	0.48	3.38	0.20	0.41
		CD at 5%	0.73	1.42	11.73	0.44	1.25
		CV (%)	11.04	14.51	16.80	15.67	12.68

#No.of mites/leaf, mean of five leaves per plant, ten plants per replication, three replications per treatment.
* Figure in the parenthesis are square root transformed values. $ Figure in the parenthesis are Arc-sin transformed values.
DBS : Days Before Spray., DAS : Days After Spray., NS : Non significant
DOS :I[st]Spray :6-12-2013; II[nd]Spray 13-12-2013 and III[rd] Spray :21-12-2013
DMRT : Means followed by a common letter are not significantly different (P= 0.05)

The results obtained from both years of open field experiment showed that, spiromesifen was superior over rest of the treatments by recording lower mean no.of mites per leaf (0.62) and mean reduction of mite population (97.29%). Spiromesifen is a tetraonic acid derivative insecticide and acaricide effective against *P. latus* (Elbert *et al.,* 2005).The present results are in concurrence with Varghese and Mathew (2013) who tested certain insecticides and acaricides against chilli mite, *P.latus.* Spiromesifen 45 SC @ 100 g a.i.ha^{-1} and propargite 57 EC @ 570 g a.i. ha^{-1} were found to be effective in reducing chilli mite population.

Similarly, the efficacy of spiromesifen 45 SC at 100 g a.i.ha^{-1} in reducing chilli mite in comparison to other insecticides was reported by Nagaraju *et al.* (2007).The efficacy of spiromesifen 45 SC at 120 g a.i.ha^{-1} in reducing chilli mite in comparision to dicofol 18.5 EC @ 185 g a.i.ha^{-1} was reported by Kavitha *et al.* (2006). Spiromesifen 45 SC @ 120 g a.i.ha^{-1} showed long lasting efficacy by reducing the leaf curl damage from 41.8 percent to 12.5 percent without producing any phytotoxicity. These reports are in line with the present findings.The present findings are also in conformity with the findings of Seal and Klassen (2006) who reported the effectiveness of spiromesifen @ 300 - 400 ml ha^{-1}in reducing the incidence of chilli thrips in Scotch Bonnet variety of chilli.

In the present study, the next best treatment was diafenthiuron @ 400 g a.i ha^{-1}in reducing the mean mite population (4.08 mites leaf^{-1}) with increased mean percent reduction of population (71.32%). The present results are in concurrence with Srinivas *et al.* (2002), Dhandapani *et al.* (2003) who reported that the diafenthiuron 600 g a.i ha^{-1} brought down the eggs and active stages of *P.latus* by 90 - 95 percent followed by fenzaquin 125 g a.i ha^{-1}. Bifenthrin and fenpropathrin were found to be less effective against *P.latus.*

Thiamethoxam @ 50 g a.i ha^{-1} which showed significant superiorityin reducing the mean mite population (5.73 mites leaf^{-1}) with increased mean percent reduction of population (61.31%).Triazophos is an organophosphate and belongs to acetylcholinesterase (AChE) inhibitor group. Triazophos is a broad-spectrum insecticide and acaricide with contact and stomach action. It is non-systemic, but penetrates deeply into plant tissues. The present findings are in line with Mahalingappa *et al.* (2008) who evaluated the bio-efficacy of certain insecticides against mite, *(P. latus*) infesting chilli and concluded that triazophos 0.08% was most effective against mites. Nagaraju *et al.* (2002) reported that the triazophos 40 EC (0.15%), dicofol 18.5% (0.25%) and triazophos 40 EC (0.15%) alternated with Neemark (0.50%) at an interval of 15 days was found to be effective in reducing leaf curl disease by recording highest yield (19.97 q ha^{-1}). Kandasamy *et al.* (1987) found the triazophos 0.04% to be effective insecticide against chilli mite and in reducing the population by 89.00 -93.70 percent. Triazophos @ 750 g a.i.ha^{-1}was found highly effective in reducing the mite incidence for 7-14 days after spray and recorded the highest yield compared to thiodicarb @ 750g a.i.ha^{-1} and fenezaquin @ 200 g a.i.ha^{-1} in chilli ecosystem (Ahmed *et al.,*2000).Treatments with triazophos gave the highest yields (>3.25t ha^{-1}), followed by phosalone and amitraz in chilli (Rajashri

Table 4. Cumulative efficacy of certain insecticide molecules against mite, *P. latus*on on capsicum under poly house conditions during 2013-14 and 2014-15 (Pooled mean)

S.No	Treatments	Dose (g or ml ha^{-1})	Pooled mean of 2013-14 and 2014-15 (Mean no. of mites $leaf^{-1}$)			Leaf curl index (LCI) (Mean 2013-14 and 2014-15)	
			Pre count (1 DBS)*	Post count (Mean of 1,3,5,7 DAS)*	Per cent Reduction$	1 DBS	10 DAS
T_1	Spinosad 45 SC	125	8.08 $(3.01)^{ab}$	8.34 $(3.05)^{ab}$	19.67 $(26.31)^{d}$	1.63(1.62)	1.67(1.63)a
T_2	Flubendiamide 480 SC	200	8.06 $(3.01)^{ab}$	8.24 $(3.04)^{ab}$	20.04 $(26.58)^{d}$	1.62(1.61)	1.75(1.65)a
T_3	Chlorantraniliprole 20 SC	200	8.22 $(3.03)^{ab}$	8.42 $(3.06)^{ab}$	19.11 $(25.37)^{d}$	1.67(1.63)	1.76(1.66)a
T_4	Diafenthurion 25 WP	750	4.28 $(2.29)^{cd}$	2.21 $(1.79)^{cd}$	79.12 $(62.78)^{b}$	0.91(1.38)	0.36(1.16)b
T_5	Spiromesifen 22.9 SL	750	2.66 $(1.91)^{d}$	0.06 $(1.03)^{d}$	99.55 $(86.11)^{a}$	0.57(1.25)	0.00(1.00)b
T_6	Thiamethoxam 25 WG	150	6.26 $(2.69)^{abc}$	5.30 $(2.51)^{abc}$	59.23 $(50.29)^{c}$	1.91(1.70)	2.09(1.75)a
T_7	Triazophos 40 EC	1250	5.58 $(2.56)^{bcd}$	3.68 $(2.07)^{bcd}$	59.82 $(50.64)^{c}$	1.33(1.52)	0.93(1.38)ab
T_8	Untreated check	--	8.67 $(2.99)^{a}$	11.33 $(3.51)^{a}$	0.00^{e}	2.05(1.67)	2.33(1.76)a
		SEm±	0.20	0.15	1.54	0.16	0.11
		CD at 5 %	0.64	0.46	4.72	NS	0.36
		CV (%)	13.48	10.43	16.51	14.19	15.97

#No.of mites $leaf^{-1}$, mean of five leaves $plant^{-1}$, ten plants $replication^{-1}$, three replications $treatment^{-1}$.

* Figure in the parenthesis are square root transformed values. $ Figure in the parenthesis are Arc-sin transformed values.

DBS : Days Before Spray., DAS : Days After Spray., NS : Non significant

Dos: I[st]spary: 21-12-2013; II[nd] spray 28-12-2013; III[rd]spray: 4-1-2014. DMRT : Means followed by a common letter are not significantly different (P= 0.05)

Table 5. Bioefficacy of certain insecticide molecules against mite, *P.latus*on on capsicum under open and poly-house conditions during 2013-14

T.No	Treatments	Dose (g or ml ha^{-1})	Percent Reduction of mite population 2013-14		Percent Reduction of mite population 2014-15	
			Open field	Poly house	Open field	Poly house
T_1	Spinosad 45 SC	125	13.58(21.61)*a	21.58(27.66)d	8.83(17.28)^{*c}	17.75(24.90)^{d}
T_2	Flubendiamide 480 SC	200	18.01(25.10)de	22.08(28.01)d	8.83(17.28)^{c}	18.00(25.09)^{d}
T_3	Chlorantraniliprole 20 SC	200	32.71(34.87)de	20.32(26.78)d	8.49(16.93)^{c}	17.90(24.40)^{d}
T_4	Diafenthurion 25 WP	750	79.47(63.03)a	76.62(61.05)b	63.17(52.61)^{b}	81.62(64.58)^{b}
T_5	Spiromesifen 22.9 SL	750	94.84(80.33)bc	99.10(84.52)a	99.74(87.04)^{a}	100.00(90.00)^{a}
T_6	Thiamethoxam 25 WG	150	43.70(41.13)ab	42.56(39.94)c	43.19(41.06)^{b}	75.90(60.57)^{b}
T_7	Triazophos 40 EC	1250	68.82(56.03)cd	64.62(53.47)b	53.80(48.17)^{b}	55.01(47.85)^{c}
T_8	Untreated check		0.00e	0.00e	0.00c	0.00e
	SEm+		2.43	3.84	3.84	1.59
	CD at 5%		7.44	11.77	11.07	4.87
	CV %		10.75	16.56	16.56	16.53

* Figures in the parenthesis are Arc-sin transformed values.
DMRT : Means followed by a common letter are not significantly different (P= 0.05)

et al., 1991).These findings confirm the present results that triazophos 40 EC @ 1250 ml ha^{-1} was effective insecticide against mites on capsicumunder open field conditions.The insecticides spiromesifen, diafenthiuron, thiamethoxam and triazophos reduced the incidence of mite population up to seven days after spraying, while in others an increase the mite population after spray.

Polyhouse Conditions

Pooled mean of 2013-14 and 2014 -15: The results with regards to overall cumulative mean efficacy of the treatments against mite, *P. latus* during the two years under open field conditions are presented in Table 4. Mean mite population in pre count ranged from 2.66 to 8.67 and post count population was less with spiromesifen (0.06 mites $leaf^{-1}$) followed by diafenthiuron (2.21 mites $leaf^{-1}$), triazophos (3.68 mites $leaf^{-1}$) and thiamethoxam (5.30 mites $leaf^{-1}$) which were significantly superior over untreated check (11.33). The descending order of efficacy with the other treatments was flubendiamide (8.24 mites $leaf^{-1}$), spinosad (8.34 mites $leaf^{-1}$) and chlorantraniliprole (8.42 mites $leaf^{-1}$) which were at par with untreated check (11.33 mites $leaf^{-1}$).

The percent reduction over untreated check in order of efficacy of insecticides along with the highest percent reduction of mite population was recorded in spiromesifen (99.55%) followed by diafenthiuron (79.12%), triazophos (59.82%) and thiamethoxam (59.23%), which was found to be significantly superior over rest of the treatments and untreated check. The other treatments that followed in the descending order of efficacy were flubendiamide (20.04%), spinosad (19.67%) and chlorantraniliprole (19.11%) which were found to be significantly superior over untreated check. The efficacy of above insecticides has already been discussed under open field conditions.

The mean LCI of two years revealed that, LCI at one DBS (1.57) was reduced to 0.00 at 10 DAS in spiromesifen treated plants followed by diafenthiuron (0.91 to 0.36) and triazophos (1.33 to 0.93). Whereas, LCI was significantly increased from one DBS to 10 DAS in flubendiamide (1.62 to 1.75), spinosad (1.63 to 1.67), chlorantraniliprole (1.67 to 1.76), thiamethoxam (1.91 to 2.09), and untreated control (2.05 to 2.33)(Table 4).

In comparision of efficacy of insecticides against mite, *P.latus* under open field and poly house conditions during 2013-14, there was difference in percent reduction of population over untreated check after each spray. The percent reduction in mite population was high in poly house (spiromesifen, flubendiamide and spinosad) compared to open field (Table 5). However, during 2014-15, all the insecticides caused greater mortality under poly house conditions compared to open field (Table 5).

CONCLUSION

Spiromesifen 22.9 SL @ 96 g a.i ha^{-1} and diafenthiuron 25 WP @ 400 g a.i $ha^{-1}$are effective in controlling the mite, *P.latus* on capsicum.

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EFFECT OF DIFFERENT LEVELS OF DEFOLIATION ON INFLORESCENCE SAP YIELD AND TENDER FRUIT ENDOSPERM YIELD IN PALMYRAH (*Borassus flabellifer* L.)

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ABSTRACT

Palmyrah palm adorns the dry landscape of the semi arid tropics of Tamil Nadu, Andhra Pradesh, Odisha, West Bengal, Karnataka and Maharastra. Palmyrah trees thrive in non-agricultural lands, on the banks of streams, rivers, canals, undulating hill slopes and sandy lands which are normally unfit for cultivation. Inflorescence sap (Neera) is the top most economic produce of palmyrah. For the convenience and easy access during inflorescence sap tapping, farmers are defoliating more than ninety percent of the leaves and as a result the inflorescence sap yields are drastically getting reduced. To know the effect of defoliation on inflorescence sap and tender endosperm (Nungu) yields in palmyrah a study was conducted at Horticultural Research Station, Pandirimamidi with four different levels of defoliation *i.e.*, 30%, 50%, 70% and 90% defoliation from the years 2010 to 2012. The control plants were left without defoliation. Data was recorded on different parameters like inflorescence sap yield (neera), days for initiation of flowering after defoliation, number of bunches plant^{-1}, number of inflorescences tapped and mean yield of tender fruit endosperm /bunch (kg). The results revealed that total yield of inflorescence sap was highest in 30% defoliated palms (194.8 l) followed by Control (158.8 l) in male palms. In female palms also 30% defoliated palms recorded the highest inflorescence sap (210.5 l) followed by Control (193.6 l). Lowest inflorescence sap yields was recorded with 90% defoliated palms in both male(119.5 l) and female(105.4 l) palms. The yield of tender fruit endosperm (Nungu) per bunch was maximum in control palms (2.16 kg/bunch) which were followed by 30% defoliated palms (1.95 kg). Minimum tender fruit endosperm yield per bunch was recorded with 90% defoliated palms (0.98 kg). The number of fruit bunches produced plant^{-1} was maximum (8.61) in control plants followed by 30% defoliated palms (7.96). Minimum number of bunches were recorded with 90% defoliated palms.

INTRODUCTION

Palmyrah palm (*Borassus flabellifer.* L.) the Asian variety is the native of Indian subcontinent and South East Asia and belongs to the genus *Borassus* with six species of fan palms. It is an important multipurpose tree of great utility, grows extensively in southern part of India and in most of the tropical countries. Palmyrah palm is described as the single most useful plant and engages human labour in the industries around it irrespective of gender and age. It is easily cultivated and also found to grow wild. The growth of the tree is very slow and it takes from 15 to 30 years to bear. The Palmyrah palm is a large tree growing up to 30 m high and the trunk may have a circumference of over 1.5 meters at the base. The trunk is grey robust and corrugated by the semi circular scars of fallen leaves. The tree can be easily recognised by its gigantic fan shaped leaves. There may be 25-40 fresh leaves which are leathery, grey green, fan-shaped, 1-3 meters wide and folded along the midrib and they spring at the top in a clump (Annual Reports of AICRP on Palms, 2012). They are usually very tough and have thick stalks. Like all *Borassus* species, *Borassus flabellifer* is dioecious. The male and female flowers are held by two different trees and never in one tree. Both male and female trees produce spikes of flowers but only the female plant bears the fruits. The male flowers are small and appear in densely clustered spikes and females are solitary, developing into large, brown, roundish fruits. The male flowers are smaller than the female flowers. Among the various edible uses of the palm, the sweet sap

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tapped from the inflorescence for making palm sugar and palm jaggery is of prime importance. Ponnuswami and Kavino (2006) reported that palm juice known as neera is tapped from male and female inflorescence of the palm. Sap exuding from the cut inflorescence (spathe) is collected and commercially exploited in many Asian countries (Kandaiah and Kokulathasan, 1987). The endosperm of the young fruit, like tender coconut, is a delicacy in summer. Among all, inflorescence sap (neera) is the top most important economic produce exploited from the palm. Before initiating tapping, leaves in the crown are defoliated indiscriminately without having any idea on the role of leaves on the inflorescence sap yield and as a result the inflorescence sap yields are drastically reduced. Hence, it was felt there is a need to study the effect of various levels of defoliation on the inflorescence sap yield and also the tender endosperm (nungu) yield.

MATERIAL AND METHODS

The study was carried out at Horticultural Research Station, Pandirimamidi under the scheme AICRP on Palms. The main objective to know the effect of different levels of defoliation on inflorescence sap (Neera) and tender endosperm (Nungu) yields in palmyrah. The trial was conducted from 2009 to 2012 with male and female palms available in the farm. The design was Randomized block design with five replications. The treatments studied were T1 with 30% defoliation, T2 with 50% defoliation, T3 with 70% defoliation, T4 with 90% defoliation and T5 with No defoliation (Control). Defoliation was carried out in the month of October in all the blocks as per the treatments. Emergence of inflorescences began in the month of November and extended till January. Tapping was resorted to and continued up to the end of April every year. Data was recorded on different parameters *viz.,* inflorescence sap yield (neera), days for initiation of flowering after defoliation, number of bunches per plant, number of inflorescences tapped, length of matured leaf stalk, mean number of fruits per bunch, average weight of bunch, average weight of fruits in bunch and mean yield of nungu/bunch. Data was recorded both on male and female palms separately. Data recording was done thrice in a day for inflorescence sap during the entire tapping period. However, for other parameters the data recording was done at the end of the tapping period. The statistical analysis of the yield data was carried out as per the procedure given by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Male Palmyrah Palm

The results from the data (Table. 1) collected from male palmyrah palms indicated that the lowest number of days for initiation of flowering after defoliation was recorded in control treatment (24.2 days) which was significantly superior over other treatments. However, the highest number of days taken for initiation of flowering after defoliation was recorded with 90% defoliation treatment (52.7 days). The tapping period was recorded maximum with the 30% defoliation treatment (82 days) which is significantly superior over other treatments. The minimum tapping period was recorded with 70% defoliation treatment (43.5 days). The mean number of inflorescences tapped were maximum with 30% defoliation treatment (9.2 numbers) which is on par with control and 90% defoliation. The maximum inflorescence sap yield was recorded with 30% defoliation treatment (194.8l) which is significantly superior over other treatments. The minimum amount of inflorescence sap was recorded with 90% defoliation treatment (119.5l). The reason for the high neera yield in the 30% defoliation treatment palms

Table 1. Effect of different levels of defoliation on the inflorescence sap yield of male palms

Treatment	Days for initiation of flowering after defoliation	No. of days tapped (Duration)	Mean no. of inflorescences tapped	Length of matured leaf Stalk (cm)	Total inflorescence sap yield (l tree^{-1})
Male palms					
30% Defoliation	33.7	82.0	9.2	163.2	194.8
50% Defoliation	48.5	52.2	7.5	182.5	136.5
70% Defoliation	50.7	43.5	7.7	167.7	130.3
90% Defoliation	52.7	50	8.2	150.5	119.5
Control(No defoliation)	24.2	74.2	8.7	171.7	158.8
Sem±	2.13	2.49	0.38	4.98	5.87
CD @ 5 %	6.64	7.52	1.17	15.08	17.75

may be due to high photosynthetic efficiency because of the minimum defoliation taken up on the palms and with 30% defoliation cleaning of the crown was done which have facilitated proper growth and development of the spathe. The increased number of days tapped and the more number of inflorescences produced in 30 % defoliation treatment might also have resulted in in increased inflorescence sap yields. Ponnuswami and Kavino (2006) reported that the palmyrah palm KVIC 10 recorded the highest yield of 337.0 l of neera with a tapping duration of 92 days.

Female Palmyrah Palm

a) Inflorescence sap

The results from the data (Table. 2) collected from female palmyrah palms indicated that the lowest number of days for initiation of flowering after defoliation was recorded in control treatment (20 days) which is on par with 30% defoliation treatment and 70% defoliation treatment. However, the highest number of days taken for initiation of flowering after defoliation was recorded with 50% defoliation treatment (40 days). The maximum tapping period was recorded with control (86 days) which is significantly superior over other treatments. Ponnuswami and Kavino (2006) reported that the palmyrah palm KVIC 10 recorded the maximum yield of 337.00l of neera with a tapping duration of 92 days. The minimum tapping period was recorded with 70% defoliation treatment (44.7 days). The number of inflorescences tapped was maximum with control *i.e.*, no defoliation treatment (11.75 numbers) which is significantly superior over other treatments. The least number of inflorescences tapped was recorded in the treatment of 70% defoliation (7.25). The maximum inflorescence sap yield was recorded with 30% defoliation treatment (210.5l) which is on par with control treatment (193.6l). The reason for the high neera yield in the 30% defoliated palms might be due to high photosynthetic efficiency because of the minimum defoliation taken up on the palms and cleaning of the crown which might have facilitated proper growth and development of the inflorescence. The mean number of inflorescences and the tapping duration was also found high in 30% defoliated palms compared to the other treatments which in turn

Table 2. Effect of different levels of defoliation on the inflorescence sap yield of female palms

Treatment	Days for initiation of flowering after defoliation	No. of days tapped (Duration)	Mean no of inflorescences tapped	Length of matured leaf Stalk (cm)	Total inflorescence sap yield (l $tree^{-1}$)
Female palms					
30% Defoliation	25.6	75.0	10.2	181.0	210.5
50% Defoliation	40.0	59.2	8.5	190.9	178.3
70% Defoliation	26.5	44.7	7.2	165.5	153.8
90% Defoliation	39.5	53.2	8.2	172.8	105.4
Control(No Defoliation)	20.0	86.0	11.7	180.6	193.6
Sem±	2.84	3.80	0.48	4.48	9.44
CD @ 5 %	8.58	11.63	1.46	13.55	28.56

resulted in increased inflorescence sap yields. 30% defoliation was necessary to increase the neera and nungu yield in palmyrah (Nainar and Marichamy, 2009).The minimum quantity of inflorescence sap was recorded with 70% defoliation treatment (153.8l).

b) Fruit yield and tender fruit endosperm

Apart from recording of the neera yield in male palms, yields of tender fruit endosperm (Nungu) are also recorded in female palms (Table. 3). Highest tender fruit endosperm yield (2.1kg $bunch^{-1}$) was recorded with the control (no defoliation) which is on par with 30% defoliation (1.9kg $bunch^{-1}$). The reason for recording maximum tender fruit endosperm yield might be due to more number of leaves retained on the tree and therefore had more photo synthetic activity which in turn resulted in increased yields of tender fruit endosperm in the trees left without any defoliation and 30 % defoliated trees. 30% defoliation was necessary to increase the neera and tender fruit endosperm yield in palmyrah (Nainar and Marichamy, 2009). 90% defoliation treatment had recorded the minimum (0.98kg $bunch^{-1}$) tender fruit endosperm yields. Mean number of bunches $plant^{-1}$ and the average weight of bunch were recorded maximum with control treatment (no defoliation) and was on par with the 30% defoliation treatment. The minimum number of bunches and the lowest average weight of bunch is recorded with 90% defoliation treatment. The

Table 3. Effect of different levels of defoliation on the tender fruit endosperm yield in female palms

Treatment	Mean no. of bunches $plant^{-1}$	Mean No of fruits $bunch^{-1}$	Average weight of bunch (kg)	Average weight of fruits in bunch (kg)	Mean yield of tender fruit endosperm $bunch^{-1}$ (kg)
30% defoliation	7.9	15.4	15.6	13.0	1.9
50% defoliation	6.6	16.1	14.6	12.4	1.5
70% defoliation	6.8	15.4	14.1	11.5	1.5
90% defoliation	6.2	10.7	7.0	5.7	0.9
Control(No defoliation)	8.6	17.1	16.7	14.0	2.1
Sem±	0.22	0.56	0.66	0.62	0.18
CD @ 5 %	0.67	1.71	1.99	1.89	0.55

mean number of fruits per bunch and the average weight of fruits bunch^{-1} was recorded maximum with no defoliation treatment which are on par with 30% defoliation and 50% defoliation treatments. However the minimum number of fruits bunch^{-1} and the minimum average weight of fruits bunch^{-1} were recorded with 90% defoliation treatment.

CONCLUSIONS

In both male and female palmyrah palms indiscriminate removal of the leaves for various purposes of usage or for the convenience of the climbers during the period of tapping ultimately result in decreased inflorescence sap and tender fruit endosperm yields due to the reduced photosynthetic area. The mean number of inflorescences and the duration of tapping was also found high in both male and female palms in which 30 % defoliation was taken up. Defoliating the leaves up to 30% or leaving the trees without any defoliation resulted in increased yields in male and female palms in terms of inflorescence sap and tender fruit endosperm yield over other treatments. Defoliating the trees beyond 30% level will drastically reduce yields of inflorescence sap and tender fruit endosperm and hence cannot be recommended.

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VULNERABILITY ASSESSMENT TO CLIMATE CHANGE IN KRISHNA RIVER BASIN DISTRICTS OF ANDHRA PRADESH AND TELANGANA STATES

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ABSTRACT

In the present paper vulnerability index was constructed by considering exposure, sensitivity and adaptive capacity. Principal component analysis was used in assessing the vulnerability index for the districts of Krishna river basin in Andhra Pradesh and Telangana. More than 60 percent of the area is vulnerable in the districts and Ananthapur district is highly vulnerable with an overall index of 5.15. Krishna district is less vulnerable in the basin with an index -3.61.The adaptation strategies from the highly vulnerable areas can be studied and implemented in the less vulnerable areas to minimize the impacts of climate change over the coming years. It is also important that climate awareness and capacity building of stakeholders become an integral part of the development programs at all levels.

INTRODUCTION

The concept of vulnerability was emerged in the recent years as a cross-cutting theme in research on the human dimensions of global environmental change (Polsky *et al*., 2003). Nowadays, it is being more widely used in various research traditions and especially in the context of climate change (Adger, 2006; Smit and Wandel, 2006; Palanisami *et al*., 2015). It is applied largely to map the vulnerability of societies, ecology, natural and biophysical systems and guide in developing adaptation measures. The implication is that vulnerability of countries and societies to the effects of climate change depends not only on the magnitude of climate stress, but also on the sensitivity and capacity of affected societies to adapt or cope with such stress. In the context of climate change there are many studies on vulnerability and definitions vary according to the perception of the researchers (Adger, 1999; Watson *et al*., 1996; Kasperson *et al*., 2002).Vulnerability has three components: exposure, sensitivity and adaptive capacity (IPCC, 2007). Exposure can be interpreted as the direct danger (*i.e*., the stressor), and the nature and extent of changes to a region's climatic variables (e.g. temperature, precipitation and extreme weather events). Sensitivity describes the human-environmental conditions that can worsen the hazard, ameliorate the hazard or trigger an impact. Adaptive capacity represents the potential to implement adaptation measures that help avert potential impacts.

The first two components together represent the potential impact and adaptive capacity is the extent to which these impacts can be averted. Thus, vulnerability is potential impact (I) minus adaptive capacity (AC). This leads to the following mathematical equation for vulnerability:

$$V = f(I - AC)$$

Adaptive capacity allows livelihoods to counteract the sensitivity of farmers and thus reduces their vulnerability. Scientific studies in the context of adaptive capacity and vulnerability due to the climatic changes are available (Patt *et al*., 2005; IPCC, 2007). Adaptation options are also widely available; however, more extensive research is lacking to reduce the vulnerability to future climate changes. It is often the poor that are most vulnerable to such climatic changes (Mendalsohn *et al*., 2006). With this backdrop, the present articleprovides information on various methods for constructing vulnerability index, data requirement, analytical methods and its application.

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MATERIAL AND METHODS

The districts falling under Krishna river basin of Andhra Pradesh and Telangana states were selected for the study to apply the selected model during 2013-14.The Krishna River Basin (KRB) is largely semi-arid where the average rainfall is 800 mm ranging from 300 to 1000mm. Failure in the monsoons due to the climate change affects the cropping pattern of the basin. In such conditions farmers react to shift their cropping pattern, adapt to water conservation practices, short duration varieties, drill new bore wells, etc. Hence, to construct the vulnerability index and bring out the major climate change factors contributing to the income of the farmers, 10 districts (*viz*., Anantapur, Guntur, Ranga Reddy, Khammam, Krishna, Kurnool, Mahabubnagar, Nalgonda, Warangal, Prakasam) falling into the KRB of Andhra Pradesh and Telangana state was selected for the study. Secondary data for 30 years (1979-2008) on climate, land utilisation, agriculture, livestock, population, infrastructure etc was collected in 2011 from statistical records of Directorate of Economics and Statistics, Hyderabad.The annual rainfall, maximum and minimum temperatures, drought weeks for the past 10 years and percentage of irrigated land was selected from the exposure component. The rural population density in the districts, percent of small and marginal farmers, land use and fallow information with cropping intensity was used in the sensitivity component as they are mostly affected by climate changes. The adaptive capacity to the climatic factors depends on the literacy rate in the district, farm size, infrastructure, crop yield and livestock as secondary source of income. The infrastructure has six components (finance & markets, education, Health of human and animals, transport, communications and power) with various indicators to construct the index. Similarly, farm infrastructure index covers farm machinery, man power, area under irrigation and power consumption components from all the districts in the basin.

Construction of vulnerability index consists of several steps. First is the selection of study area which consists of several regions. In each region a set of indicators were selected for each of the three component of vulnerability. The indicators are selected based the availability of data, personal judgmentand previous research. Since vulnerability is dynamic over time, it is important that all the indicators relate to the particular year are chosen. If vulnerability has to be assessed over years then the data for each year for all the indicators in each region must be collected.

Data Arrangement

For each component of vulnerability, the collected data was then arranged in the form of a rectangular matrix with rows representing regions and columns representing indicators. Let there be M regions/districts and let us say we have collected K indicators. Let X_{ij} be the value of the indicator *j* corresponding to region *i*. Subsequently, the matrix will have M rows and K columns as shown in Table 1.It should be noted that this type of arrangement of data is usually done in statistical analysis of survey data.

Normalization of Indicators Using Functional Relationship

Obviously the indicators will be in different units and scales. The methodology used in UNDP's Human Development Index (HDI) (UNDP, 2002) is followed to normalize them. That is, in order to obtain figures which are free from the units and also to standardize their values, first they are normalized so that they all lie between 0 and 1. Before doing this, it is important to identify the functional relationship between the indicators and vulnerability. Two types of functional relationships are possible: vulnerability increases with

Table 1. Matrix for data arrangement

Region/District	Indicator					
	1	2	.	J	.	K
1	X_{11}	X_{12}	.	X_{1j}	.	X_{1K}
2	.	.	.	.	.	.
.	.	.	.	.	.	.
I	X_{i1}	X_{i2}	.	X_{ij}	.	X_{iK}
.	.	.	.	.	.	.
M	X_{M1}	X_{M2}	.	X_{Mj}	.	X_{MK}

increase (decrease) in the value of the indicator. Assume that higher the value of the indicator more is the vulnerability. For example, suppose we have collected information on change in maximum temperature or change in annual rainfall or diurnal variation in temperature. It is clear that higher the values of these indicators more will be the vulnerability of the region to climate change as variation in climate variables increase the vulnerability. In this case we say that the variables have ↑ functional relationship with vulnerability and the normalization is done using the formula

$$y_{ij} = \frac{X_{ij} - \underset{i}{Min}\{X_{ij}\}}{\underset{i}{Max}\{X_{ij}\} - \underset{i}{Min}\{X_{ij}\}}$$

where M in X_{ij} and Max X_{ij} are the minimum and maximum of (X_{i1}, X_{i2},...X_{in}),respectively. It is clear that all these scores will lie between 0 and 1. The value 1 will correspond to that region with maximum value and 0 will correspond to the region with minimum value.

On the other hand, consider adult literacy rate. A high value of this variable implies more literates in the region and so they will have more awareness to cope with climate change.Hence, the vulnerability will be lower and adult literacy rate has ↓ functional relationship with vulnerability. For this case the normalized score is computed using the formula.

$$y_{ij} = \frac{\underset{i}{Max}\{X_{ij}\} - X_{ij}}{\underset{i}{Max}\{X_{ij}\} - Min\{X_{ij}\}}$$

It can be easily checked that $x_{ij} + y_{ij} = 1$ so that y_{ij} can be calculated as $y_{ij} = 1 - x_{ij}$. Thus, while constructing the vulnerability index sufficient care must be applied to take into account the direction of functional relationship of each variable to vulnerability.

Method of Construction of Vulnerability Index

After computing the normalized scores the index can be constructed by giving either equal weights to all indicators/components or unequal weights. There are two methods in which equal weights are given, simple average of the scores and Patnaik and Narayan method (Patnaik and Narayanan, 2005). In unequal weights, experts' judgement, Iyengar and Sudarshan (1982) methods can be used. Since data for the construction of vulnerability indices are multivariate in nature, it is possible to apply multivariate statistical analysis tools to obtain weights for the indicators and for classification of regions. Below, briefly describedone such technique used for analysis.

Principal Component Analysis (PCA)

PCA is a multivariate technique for finding patterns in data of high dimension. Once the pattern hidden in data is identified, PCA helps to compress the data by reducing the number of dimensions without much loss of information. In the language of Linear Algebra it is a linear transformation of the original variables. PCA allows us to compute a linear transformation that maps data from a high dimensional space to a lower dimensional space. In original data variables may be correlated and PCA help to transform them into uncorrelated variables.

Let there be M regions and we have data on each one of the K indicators. Then PCA extracts K linear functions, called 'principal components' as follows:

$$P_1 = \alpha_{11}X_1 + \alpha_{12}X_2 + \ldots \alpha_{1K}X_K$$
$$P_2 = \alpha_{21}X_1 + \alpha_{22}X_2 + \ldots \alpha_{2K}X_K$$
$$. \quad . \quad . \qquad\qquad . \quad . \quad .$$
$$P_K = \alpha_{K1}X_1 + \alpha_{K2}X_2 + \ldots \alpha_{KK}X_K$$

The first principal component accounts for the largest proportion of the total variation of all the indicator variables. The second principal component accounts for the second largest proportion and so on. In practice only the first few components are sufficient to account for a substantial proportion of the total variation. Since, the first Principal Component extracts maximum variance, Gberibouo and Ringler (2009) has used it to construct the vulnerability of South African farming sector. Since, PCA technique is statistically sound, the same methodology has been followed in the present study to construct vulnerability indices. Only the first principal component has been used for construction of VI and the districts/regions can be ranked based on the VI scores with rank 1 corresponding to maximum vulnerability. However, for a meaningful characterization of the different stages of vulnerability, suitable fractile classification from an assumed probability distribution is needed. Since the VI scores can be positive or negative, normal distribution has been used with 20%, 40%, 60% and 80% percentile points.

RESULTS AND DISCUSSION

A search in the literature was made to identify the indicators for inclusion under each component of vulnerability, *viz*., 'exposure', 'sensitivity' and 'adaptive capacity'. Based on the availability of data the following 17 variables were included for the present study (Table 2 and Table 3).Correlation between the 17 selected indicators was analysed (Annexure 1). The correlation coefficients range between -0.983 (between percentage of small and marginal farmers and farm size) and 0.85 (between percentage change in maximum temperature and agricultural output index) and most of the correlation coefficients are statistically significant. These high correlations between variables justify application of multivariate data reduction technique (PCA).The eigen values and the corresponding eigen vectors were computed using MATLAB software package. The eigen values greater than 1 are 7.7, 3.77, 1.96 and 1.41. These eigen values cumulatively accounted for 87.3% of the total variation of all the 17 indicators. The first eigen value alone accounted for 45.3% of the total variation.The component loadings are the correlation between the indicators and the first eigen vector scores (Table 4). It can be seen that most of the indicators have strong correlation with the scores. For example, in the case of number of severe droughts, the correlation coefficient is 0.732 which is highly significant and higher the number of severe droughts, more will be vulnerability. Similarly, farm infrastructure has a correlation coefficient of -0.437 which indicates that vulnerability has an inverse relationship with farm infrastructure.

Table 2. Indicators selected for the vulnerability index from three components

Component	Indicator		Functional Relationship with Vulnerability**
Exposure	1	Percentage change in the annual rainfall* (V1)	↑
	2	Percentage change in maximum temperature * (V2)	↑
	3	Percentage change in minimum temperature * (V3)	↑
	4	Number of severe drought weeks for the past 10 years (V4)	↑
	5	Percentage of irrigated land (V5)	↓
Sensitivity	1	Land degradation index (V6)	↑
	2	Rural population density (V7)	↑
	3	Crop diversification index*** (V8)	↓
	4	Percentage of small and marginal farmers (V9)	↑
Adaptive capacity	1	Rural literacy rate (V10)	↓
	2	Average farm size (V11)	↓
	3	Agricultural output index (V12)	↓
	4	Infrastructure index*** (V13)	↓
	5	Farm Infrastructure index*** (V14)	↓
	6	Percentage of HYV area (V15)	↓
	7	Milch animals (V16)	↓
	8	Poultry population per '000 ha(V17)	↓

Note: 1) *Absolute value, 2) ** ↑ indicates that vulnerability of the region increases (decreases) with the increase (decrease) in the value of the indicator. The symbol ↓ indicates that vulnerability of the region increases (decreases) with the decrease (increase) in the value of the indicator,3) *** provides the variables included and the methodology of construction.

The vulnerability indices under each component of vulnerability, overall vulnerability index and the ranks of the districts under each component are presented in Table 5. It indicates that out of the nine districts, Anantapur district occupies rank 1 in terms of vulnerability under all the three components and also overall vulnerability (Table 5). Anantapur was highly vulnerable because of scare rainfall conditions and moreover it was frequently effected by droughts. The second rank is occupied by Kurnool in terms of sensitivity, adaptive capacity and over all vulnerability. Krishna district is least vulnerable among the districts belonging to KRB. It has a very less vulnerability index of -3.612, where the adaptive strategies can be gone through and implemented in the highly vulnerable areas. Table 6 gives the Spearman's correlation coefficients between the rankings of the three components of vulnerability. The results conclude that the rankings have very high correlation under the three components.

The overall vulnerability index scores can be used to classify the districts in terms of vulnerability. However, for a meaningful characterization of the different stages of vulnerability, suitable fractile classification from an assumed probability distribution is needed. A probability distribution suitable for this

Table 3. Correlation Matrix of variables included in vulnerability index construction

	V1	*V2*	*V3*	*V4*	*V5*	*V6*	*V7*	*V8*	*V9*	*V10*	*V11*	*V12*	*V13*	*V14*	*V15*	*V16*	*V17*
V1	1																
V2	-0.30	1															
V3	0.03	-0.57	1														
V4	0.50	-0.68	0.39	1													
V5	-0.50	0.69	-0.50	-0.82	1												
V6	-0.65	0.25	-0.44	-0.26	0.45	1											
V7	-0.27	0.55	-0.65	-0.27	0.63	0.49	1										
V8	-0.52	0.11	0.00	-0.27	0.05	0.48	0.01	1									
V9	-0.41	0.77	-0.36	-0.53	0.81	0.53	0.68	0.11	1								
V10	-0.45	0.47	-0.58	-0.35	0.69	0.64	0.80	-0.21	0.66	1							
V11	0.47	-0.80	0.43	0.67	-0.90	-0.54	-0.68	-0.15	-0.98	-0.68	1						
V12	0.04	0.85	-0.78	-0.68	0.63	0.14	0.45	-0.08	0.54	0.41	-0.61	1					
V13	0.40	0.07	0.13	-0.38	0.27	-0.64	-0.23	-0.44	-0.02	-0.23	-0.04	0.30	1				
V14	-0.35	-0.13	0.00	-0.32	0.54	0.47	0.22	0.31	0.36	0.23	-0.41	-0.12	0.13	1			
V15	-0.55	0.47	-0.28	-0.68	0.81	0.69	0.45	0.47	0.78	0.47	-0.83	0.36	0.02	0.77	1		
V16	0.07	0.68	-0.35	-0.57	0.38	-0.06	-0.11	-0.17	0.35	0.08	-0.40	0.78	0.40	-0.27	0.19	1	
V17	-0.41	0.06	-0.15	0.16	0.13	0.79	0.48	0.56	0.45	0.34	-0.38	-0.18	-0.76	0.42	0.51	-0.41	1

Table 4. Coefficients of the first eigen vector, their standard errors and the component loadings

S.No.	Variable	Coefficients of the first eigen vector	Standard Error	Component Loadings
1	Percentage Change in rainfall	0.204	0.143	0.565
2	Change in maximum temperature	-0.281	0.119	-0.780
3	Change in minimum temperature	0.221	0.123	0.612
4	No. of severe drought weeks	0.264	0.123	0.732
5	Percentage irrigated land	0.330	0.071	-0.915
6	Land degradation index	-0.249	0.151	-0.692
7	Rural population density	-0.264	0.104	-0.731
8	Crop diversification index	0.093	0.174	-0.259
9	Percentage of marginal and small farmers	-0.323	0.060	-0.897
10	Rural literacy rate	0.271	0.098	-0.753
11	Average farm size	-0.342	0.045	0.950
12	Agriculture output index	0.238	0.163	-0.659
13	Infrastructure index	-0.028	0.205	0.078
14	Farm-infrastructure index	0.158	0.156	-0.437
15	Percentage of HYV area to GCA	0.307	0.089	-0.853
16	Milch animals	0.130	0.193	-0.361
17	Poultry population per ‘000 ‘ha’	0.153	0.200	-0.425

Table 5. Vulnerability index of the districts under KRB of Andhra Pradesh and Telangana

District	Exposure		Sensitivity		Adaptive Capacity		Overall	
	Index	Rank	Index	Rank	Index	Rank	Index	Rank
Anantapur	1.910	1	1.213	1	2.032	1	5.155	1
Guntur	-1.111	8	-0.705	8	-1.424	9	-3.240	8
Ranga Reddy	0.612	3	-0.675	7	-0.100	5	-0.162	5
Khammam	-0.287	6	0.232	4	-0.061	4	-0.116	4
Krishna	-1.293	9	-1.030	9	-1.289	8	-3.612	9
Kurnool	0.188	5	0.766	2	1.220	2	2.175	2
Mahabubnagar	0.703	2	0.389	3	0.784	3	1.876	3
Nalgonda	0.244	4	0.005	5	-0.567	6	-0.318	6
Warangal	-0.966	7	-0.195	6	-0.596	7	-1.757	7

Note: Prakasam district excluded in the analysis due to lack of data on all the selected indicators

Table 6. Spearmans correlation coefficient for the three components

Components	Exposure	Sensitivity	Adaptive Capacity
Exposure	1		
Sensitivity	0.733	1	
Adaptive Capacity	0.800	0.933	1

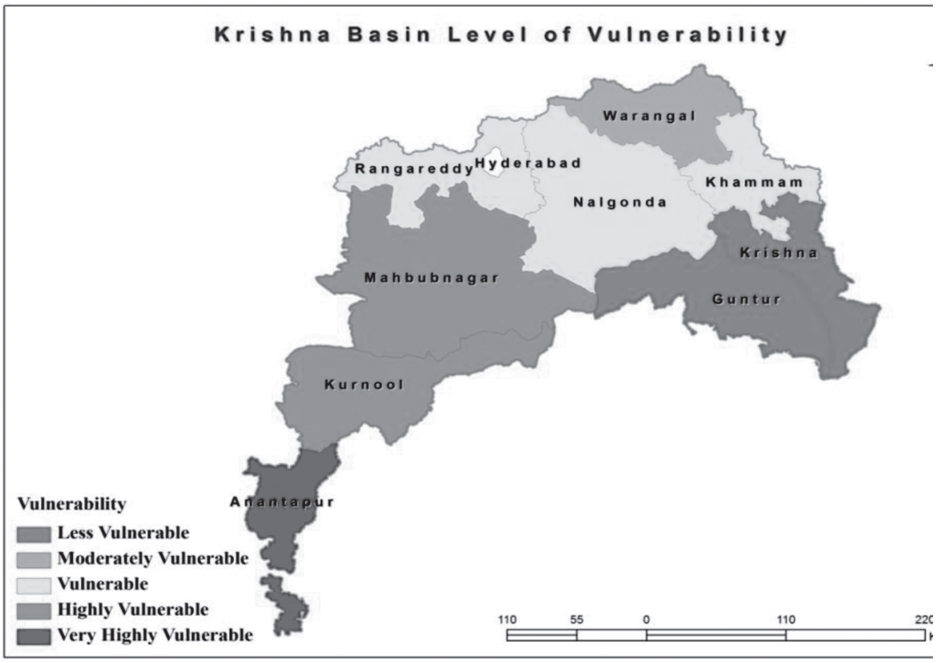

Fig. 1. Classification of districts in terms of vulnerability to climate change

purpose is the Beta distribution, which is generally skewed and takes values in the interval (0,1). The linear intervals were considered such that each interval has the same probability weight of 20 percent. These fractile intervals were used to characterise the stages of vulnerability, *viz.*, less vulnerable, moderately vulnerable, vulnerable, highly vulnerable, and extremely vulnerable (Fig. 1). Majority of the districts fall in the category of vulnerable to very highly vulnerable (66 %). The vulnerabilityclassification can help in making further studies in a specific area on the impact assessment and prioritise the adaptive strategies.

CONCLUSIONS

More than half of the districts under the Krishna river basin of Andhra Pradesh and Telangana state are vulnerable to the climate changes (seven out of nine districts). Vulnerability indices indicated that Kurnool and Mahabubnagar were highly vulnerable and Anantapur district is very highly vulnerable. Guntur and Krishna districts were less vulnerable. Since climate change will result in yield and income loss, it is important to introduce different adaptation measures such as change in the cropping pattern, change in the varieties, investment in supplementary irrigation (Young *et al.*, 2014). The districts that are more vulnerable should be given priority for introducing such interventions.Given the priority for investment, policy makers can start with highly vulnerable areas and then move to less vulnerable areas thus minimizing the impact of climate change over the years. It is also important that climate awareness and capacity building become an integral part of the development programs at all levels. Data base on key climate variables should be maintained at all levels of the districts (such as block and village) so that estimation of the vulnerability at micro level will be possible wherein it is possible to devise appropriate scoping strategies.

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AN ECONOMIC ANALYSIS OF ADOPTION OF PRICE FORECASTS AND ITS IMPACT ON DECISION MAKING IN CHILLI FARMING

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ABSTRACT

The present study (2014-15) was conducted in Guntur district of Andhra Pradesh to analyse the factors influencing adoption of price forecasts and to study the impact of price forecasts on decision making of the chilli farmers. The study revealed that education level, possession of communication assets by farmers, average annual income of farmers and source of market intelligence to farmers were the significant factors influencing the adoption of price forecasts by farmers. Price forecast was found to have positive impact on farm decision making. The impact of adoption of price forecasts was high in case of decision on quantity of chilli to sell followed by decision on storage of produce, allotting the area of land for chilli. The impact was also observed in case of decision regarding selection of crops time of harvesting and time of sowing.

INTRODUCTION

The price instability and uncertainty in agriculture pose a significant challenge to decision makers in proper planning for production and marketing crops to minimize risk (Shamsudin and Arshad, 1999). Price forecast, therefore, is vital to facilitate efficient decisions and it plays a major role in coordinating the supply and demand of agricultural commodities. Forecasting involves making estimates of the future values of variables of interest using past and present information. Price volatility of cash crops is found to have severely inhibited investment in the sector and destabilized the earning of small holders (Rangachary, 2006). Thus, in order to bring about price stabilization in cash crops and benefit the farmers with regard to farm income, price forecasting has been carried out as one of the mechanisms of price stabilization by the Government of India. However, in recent days a question has aroused regarding the practical utility of the price forecast and its impact on decision making of the farmers. Hence, the present study is being carried out in order to reveal the after effects of price forecasting.

MATERIAL AND METHODS

Sample Selection

The study was conducted during the year 2014-15 and Multi-stage stratified random sampling technique was used for the study.Guntur district was purposively selected as it was having the highest area under chilli and also highest production and productivity of chilli in Andhra Pradesh. It contributes 25.45 percent of overall chilli production in India. Out of 57 mandals in Guntur district two mandals - Sattenapalle and Medikonduru – were selected purposively as they were having highest area under chilli and also nearer to the district headquarter, where the chilli market yard as well as maximum number of cold storages were located. From each mandal two villages, having maximum area under chilli, were selected.

Selection of Respondents

Chilli farmers, who were progressive and adopted price forecasts were identified from the data available with various institutes such as Regional Research Station, Agricultural Market Intelligence Cell of State Agricultural University. Thus, list of adopters and non- adopters for selected villages was prepared

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and for each village 15 adopters and 15 non-adopters were selected in random from the list. A Total of 120 farmers were selected for the study.

Analysis of Adoption of Price Forecasts

A Binary Logit Regression Model was used to determine the factors that influence farmers' adoption of price forecasts. The Binary Logit Model based on the cumulative logistic probability function is computationally easier to use than the Probit models and was used in this study (Pindyck and Rubinfeld, 1981). The cumulative logistic probability model is specified as:

$$P_i = F(Z_i) = 1 + \frac{1}{1 + e^{-(\alpha + \sum \beta_i x_i)}}$$

Where i = 1, 2, 3,....., ..,n

Where P_i is the probability that an individual is adopting price forecasts, X_i are the explanatory variables; and b_i are parameters to be estimated. The log odds of the probability is given by:

$$\log\left(\frac{p_i}{1 - p_i}\right) = Z_i = \alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k$$

The Binary Logit Model is used to determine the effect of the explanatory variables on farmers' adoption of price forecasts. The dependent variable is a binary variable representing the adoption of price forecasts (1) and otherwise (0). For this study, above equation is expressed implicitly as

$APF = a + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8 X_8 + b_9 X_9 + u_i$

Where, APF = Adoption of price forecasts (if, yes=1 or no=0)

X_1 = Age of household head (years)

X_2 = Level of education of household head (Illiterate = 1, Primary school = 2, Secondary school = 3, College = 4)

X_3 = Communication assets (if, yes=1 or no=0)

X_4 = Farm size (hectares)

X_5 = Productivity (Q/ha.)

X_6 = Average annual income (Rs.)

X_7 = Cost of cultivation (Rs./ha.)

X_8 = Source of intelligence (if, yes=1 or no=0)

X_9 = Awareness about price forecasts (if, yes=1 or no=0)

$b_1, b_2 \ldots b_{11}$ are parameters corresponding to estimated variables' coefficients.

u_i is the error term and consists of unobservable random variables.

Analysis of Farm Decision Making

To know the decision taken by farmers based on price forecasts, first 6 prominent farm decisions were identified and each sample farmer was asked to rank the identified farm decision based on the price forecasts. The ranking was given in the following manner.

Rank 1 = Decision completely based on price forecasts

Rank 2 = Decision partially based on price forecasts

Rank 3 = Decision not based on price forecasts

Thus, ranking given by 60 farmers for each farm decision were recorded and tabulated. From the tabulated data, the impact of price forecasts in decision making was studied using tabular analysis.

RESULTS AND DISCUSSION

Analysis of Adoption of Price Forecasts by Farmers

The parameters of binary logistic regression model were estimated using SPSS statistical package (Version 16) and the results are presented in Table 1 to estimate the factors influencing adoption of price forecasts. The results show that the possession of communication assets by farmers, farm size, average annual income of the farmers and source of market intelligence to farmers are the significant factors influencing the adoption of price forecasts by farmers.

Hosmer-Lemeshow chi-square test divides the data into several groups based on expected probability values, then computes a chi-square from observed and expected frequencies of subjects falling in the two categories of the binary response variable within these groups. Large chi-square values (and correspondingly small p-values) indicate a lack of fit for the model. In table 1 the Hosmer-Lemeshow chi-square test for the final warranty model yields a p-value of 0.910 and chi-square value 3.363 thus suggesting a model with good predictive value. Chi-square value (71.852) is also significant at 1% level which indicates well fit for the model. Nagelkerke's-R^2 (0.601) is pseudo R^2 indicating moderately strong relationship of the model. Table 1 also shows that education level is significant and has positive coefficient. This implies that increase in the educational level of farmers has positive effect over the adoption of price forecasts.

Possession of communication assets by farmers is significant at 5% level and positively influences the tendency of adoption of price forecasts by farmers. This means that with increase in communication assets with farmers there will be increasing trend in the adoption of price forecasts by farmers. This may be due to the reason that with increase in the possession of effective communicative tools with farmers their knowledge on various market innovations increases and it will have a significant effect on the adoption of price forecasts. This is in accordance with the report by Vadivelu and Kiran

Table 1. Binary logit regression estimates of factors influencing the adoption of price forecasts by farmers

Variables	Co-efficient	Standard error	p-value
Constant	-35.402	4793	0.994
Age of the farmer	0.024	0.032	0.455
Education level	0.755*	0.477	0.013
Communication assets	1.328*	0.53	0.012
Farm size	0.193	0.387	0.618
Productivity	0.005	0.027	0.857
Average annual income	0.653*	0	0.032
Cost of cultivation	0	0	0.502
Source of market intelligence	0.357*	0.179	0.047
Awareness on price forecasts	29.357	4793	0.995
Hosmer-Lemeshow Chi-square	3.363		
Chi-square	71.852**		
Nagelkerke R Square	0.601		

Note: * significant at 5 % level of significance and
** significant at 1% level of significance
Source: Field survey data (Primary data)

(2013).Average annual income of the farmers is significant and its coefficient is positive which indicates the positive influence of the average annual income on adoption of price forecasts. Thus, with one unit increase in average annual income the log odds of the probability of adoption of price forecasts increases by 0.653.

The coefficient of source of market intelligence is positive and significant which implies that with increase in a unit of source of market intelligence, log odds of the probability of adoption of price forecasts by farmers increase by 0.357. This could result from the fact that accessibility to different sources of market intelligence to farmers gives them better market outlook and thus influencing their adoption of price forecasts.

Farm Decisions Made Based on Price Forecasts by Adopters

The average of ranks given to each decision by adopters of price forecasts based on the level of decision making is presented in Table 2. The lower the average value given for a decision the more is the effect of future price in decision making and vice versa.

Table 2. Average ranks given by farmers to farm decisions made based on price forecasts

S.No.	Farm decision	Adopters (Avg. rank) n = 60	Rank
1	Storage	1	I
2	Quantity to sell	1.52	II
3	Allotting the area of land for chilli	1.87	III
4	Time of harvesting	2.12	IV
5	Selection of crops	2.45	V
6	Time of sowing	2.86	VI

Source: Field survey data (Primary data)

The impact of adoption of price forecasts was high in case of decision on storage where the average rank given was 1 followed by decision on quantity to sell (average rank = 1.52) which is in accordance with Raghuram (2010). The reason was farmers stored red chillies in cold storage godowns after harvesting and drying until they get the expected price for their produce and also decide upon the quantity to sell based on the price prevailing in market. They sold all of their produce once the expected and forecasted price was realized.

Price forecasts had also much impact on decision making regarding allotting the area of land for chilli (average rank = 1.87). The result is in accordance with Mustafa *et al.* (2006) and time of harvesting, where the average rank given was 2.12. This implies that based on pre-sowing price forecasts, farmers decide the area to be allotted for the crop and they decide the time and number of pickings of red chillies based on pre-harvest forecasts. The ranks given for decisions on selection of crops and time of sowing were 2.45 and 2.86, respectively which implies less impact of price forecasts in these decisions.

CONCLUSIONS

It is concluded from the study that education level, possession of communication assets by farmers, average annual income of the farmers and source of market intelligence to farmers were the significant factors influencing the adoption of price forecasts by farmers. The impact of adoption of price forecasts was high in case of decision on storage where the average rank given was 1 followed by decision on quantity to sell (average rank = 1.52). Price forecasts had also much impact in decision making regarding allotting the area of land for chilli (average rank = 1.87) and time of harvesting where the average rank given was 2.12. The impact was also observed in decision regarding selection of crops (average rank = 2.45) whereas, it has less impact in case of time of sowing (average rank given was 2.86).

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PERCEPTION OF YOUTH IN FARMING TOWARDS DIFFERENT FARM ENTERPRISES

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ABSTRACT

The findings of the present study conducted in the year 2015 revealed that majority of youth perceived high profitability for dairy enterprise followed by other enterprises. The marketing opportunities were vast for dairy enterprise. According to the youth, investment for poultry was very less and also the management of poultry was found to be very simple compared to other enterprises. They perceived labour intensity as very high for vegetables. Among all the farm enterprises by-products of dairy were more efficiently utilized. The large majority of the youth in farming had perceived that availability of subsidies was maximum for dairy followed by other farm enterprises. Input availability was more for agriculture followed by other farm enterprises. It was also observed that the risk involved was high for orchards. Overall, Agriculture was perceived as the most efficient enterprise followed by dairy, vegetable, poultry, sheep and plantation. Orchards cultivation was perceived as the least efficient enterprise by the youth in farming.

INTRODUCTION

Agriculture along with its allied sectors is unquestionably the largest livelihood provider in India, mostly in the rural areas. According to Annual Report of Indian Council of Agricultural Research 2014-15, the share of crop husbandry in total rural employment declined from 75 percent in 2004- 05 to 56 percent in 2011-12. The decline was much faster in animal husbandry and other farm activities. Anuradha *et al.* (2014) in their report on “State of Indian Farmers” revealed that 83.00 percent of the farmers considered agriculture as their main occupation and about 32.00 percent of them do work other than farming for additional household income. Satapathy and Mishra (2011) witnessed that majority (82.59%) of the rural youth perceived seed production as a major profitable enterprise, followed by vegetable farming (81.25%), growing of scented rice (76.25%), oil seed production (73.75%), goat rearing (67.50%), floriculture (65.00%), raising of planting materials (48.75%), fingerling production (47.50%), agro-service center (35.00%) and finally agro-processing unit (22.50%). Arowolo *et al.* (2013) indicated that 35.00 percent of the youth felt that cattle rearing is unattractive, followed by traditionally – operated (32.00%), long-time business (20.70%), too labour intensive (6.00%), low – income output (4.00%) and 2.70 percent of them had given no response. Preethi and Nataraju (2014) found that majority (46.67%) of the farm youth had high level of perception, whereas 30.00 and 23.33 percent of farm youth had medium and low level of perception towards agriculture respectively. Sarju *et al.* (2015) revealed that hundred percent of farming youth perceived that agricultural income not fulfills their basic needs. Due to lack of any other income option, majority (92.00%) of them were practicing farming as occupation. Majority (85.00%) of them accepted that ‘dislike to farming as occupation for their children’ followed by ‘poor technology transfer regarding agricultural innovation was the main cause of non adoption’ (73.71%).

The youth of India is diverse in ethnicity, religion and socio-economic backgrounds. Such diversity necessitates customized initiatives to meet needs and activate their untapped potential. This pool of youth population is a decisive factor in determining our nation’s destiny. The phenomenal rise in the youth population has made India the youngest nation and

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one of the top human resource metrics in the world. It is vital to utilise this demographic dividend and channelize the youth and their creative energies for nation-building. Hence,India should capitalise to invest on this young pool of HR in India and divert their involvement towards farming. In this context, the rural youth has to concentrate on allied sectors in order to sustain in agriculture as well as to achieve lucrative profits. Hence, this research paper projected the perception of youth towards different farm enterprises as an important objective of the study.

MATERIAL AND METHODS

The study was conducted in the year 2015 and *ex-post-facto* research design was followed in the present investigation. The lottery method of simple random sampling procedure was followed to select the sample size. The Andhra Pradesh state was chosen as the locale of the study. One district from each region was selected, thus, constituting a total of three districts. The selected districts were Kurnool (from Rayalaseema region), Nellore (from Coastal region) and Vizianagaram (from North Coastal region). Four mandals from each district were selected, constituting to a total of twelve mandals. Two villages from each mandal were selected, making a total of twenty four villages. From each of the selected village, ten youth in farming were selected, thus constituting a total of 240 respondents. The list of districts, mandals and villages is presented in the Table 1.

Table 1. Selection of districts, mandals, villages and respondents

State	Regions & Districts	Mandals	Villages	No. of Respondents
ANDHRA PRADESH	Rayalaseema-Kurnool (D_1)	Rudravaram (M_1)	Erragudidinne (V_1)	10
			Peddakambaluru (V_2)	10
		Pagidyala (M_2)	Muchumarri (V_3)	10
			Lakshmapuram (V_4)	10
		Mahanandi (M_3)	Bollavaram (V_5)	10
			GajulaPalli (V_6)	10
		Gadivemula (M_4)	Koratamaddi (V_7)	10
			Pulimaddi (V_8)	10
	Coastal Andhra-Nellore(D_2)	Dakkili (M_5)	Chapalapalle (V_9)	10
			Nagavollu (V_{10})	10
		Indukurupeta (M_6)	Pamulavaripalem (V_{11})	10
			Kothuru (V_{12})	10
		Atmakuru (M_7)	Bandarupalle (V_{13})	10
			Kanupurupalle (V_{14})	10
		Buchireddypalem (M_8)	Rebala (V_{15})	10
			Nagamambapuram (V_{16})	10
	North Coastal-*Viz*ianagaram (D_3)	*Viz*ianagaram (M_9)	Rakodu (V_{17})	10
			Sarika(V_{18})	10
		Saluru (M_{10})	Mugadavalasa (V_{19})	10
			Saluru (V_{20})	10
		Nellimarla (M_{11})	Pinatharimi (V_{21})	10
			Sathivada (V_{22})	10
		Ramabadhrapuram (M_{12})	Kokkati (V_{23})	10
			Mamidivalasa (V_{24})	10
Total	**3**	**12**	**24**	**240**

Perception of youth towards different farm enterprises was operationalised as the sensory interpretation of different farm enterprises with the help of selected indicators. A total of ten indicators *viz.*, profitability, investment, labour intensity, complexity of management, by-product utilization, available subsidies, input availability, risk involvement, marketing opportunities and compatibility were identified to measure the perception of youth towards different farm enterprises. The farm enterprises were agriculture, vegetable, orchard, plantations, dairy, poultry and sheep. Each indicator was operationalised for better comprehension by the youth in farming.

Profitability - It was operationally defined as the degree of relative generation of net income per unit area of a farm enterprise. **Investment -** Investment was operationally defined as the degree of relative expenditure incurred to produce a unit of farm produce. **Labour intensity -** It was operationally defined as the degree of relative involvement of labour in a farm enterprise. **Complexity of management -** It was operationalised as the degree of relative difficulty in handling the different operations in a farm enterprise. **By-product utilization -** It was operationally defined as the degree of relative utility of by-products obtained from a farm enterprise to another. **Available subsidies -** It was operationalised as the degree of relative availability of subsidies for different inputs of a farm enterprise. **Input availability -** It was operationalised as the degree of relative availability of needed inputs of a farm enterprise. **Risk orientation -** Risk orientation was operationalised as the degree of relative risk involved in terms of investment and returns of a farm enterprise. **Marketing opportunities -** It was operationalised as the degree of relative scope and opportunities for exports and domestic marketing of farm produce. **Compatibility -** Compatibility was operationally defined as the degree of relative sustainability of a farm enterprise with situational and socio-economic variables.

The respondents were asked to rate all the ten indicators of each enterprise followed by them at the time of investigation on a five point continuum *viz.*, very high, high, moderate, low and very low with weightage of 5, 4, 3, 2 and 1 for positive indicators and vice-versa for negative indicators. The scoring of respondents was done by summing up response weightages given for ten indicators of farm enterprises being followed by the youth. Subsequently, the mean score for each indicator of all seven enterprises was obtained. After obtaining the mean scores of all indicators for all enterprises they were ranked based on the mean score. The number of youth practicing different farm enterprises was represented as symbolically by 'N'.

RESULTS AND DISCUSSION

Perception of youth in farming towards different farm enterprises was analysed using ten important indicators as represented in the Table 2 and Fig.1. It could be derived from the Table that majority of youth perceived dairy as more profitable farm enterprise with mean score (3.41), followed by vegetable (mean score =3.27), agriculture (mean score =3.16), sheep (mean score = 3.09), plantation (mean score =3.04) and orchard (mean score =2.30) as least profitable.Majority of the youth in farming perceived that, the investment for poultry was very less with mean score (4.32), followed by orchard (mean score=3.98), sheep (mean score =3.89), plantation (mean score =3.42), agriculture (mean score =3.72), vegetable (mean score =3.46) and highest for dairy (mean score =3.26).

Table 2. Perception of youth in farming towards different farm enterprises

Perception indicators / Farm Enterprise	N	Profit-ability (+) A	Invest -ment (-) B	Labor intensity (-) C	Complexity of management (-) D	By-product utilization (+) E	Available Subsidies (+) F	Input availability (+) G	Risk involvement (-) H	Marketing opportunities (+) I	Compa tability (+) J	Sum of Mean Score	Mean Score of Farm Enterprise	Rank
Agriculture	229	3.16	3.72	3.82	3.36	3.20	3.06	4.15	3.67	3.50	4.50	36.14	3.61	1
Dairy	132	3.41	3.26	3.16	3.51	3.40	3.36	4.09	3.45	4.05	3.93	35.62	3.56	2
Vegetable	35	3.27	3.46	3.03	3.28	3.10	3.02	4.10	3.32	3.93	4.23	34.74	3.47	3
Poultry	42	2.86	4.32	4.19	4.32	2.17	2.62	3.48	3.98	3.26	2.89	34.09	3.41	4
Sheep	21	3.09	3.89	4.24	4.18	2.25	2.89	2.89	3.96	3.72	2.52	33.63	3.36	5
Plantation	4	3.04	3.42	4.02	3.66	2.52	2.86	3.24	4.01	3.37	3.22	33.36	3.34	6
Orchard	22	2.30	3.98	3.29	4.01	2.29	3.01	3.32	3.15	3.11	3.21	31.67	3.17	7
Mean Score of Indicator		**3.02**	**3.72**	**3.68**	**3.76**	**2.70**	**2.97**	**3.61**	**3.65**	**3.56**	**3.50**			

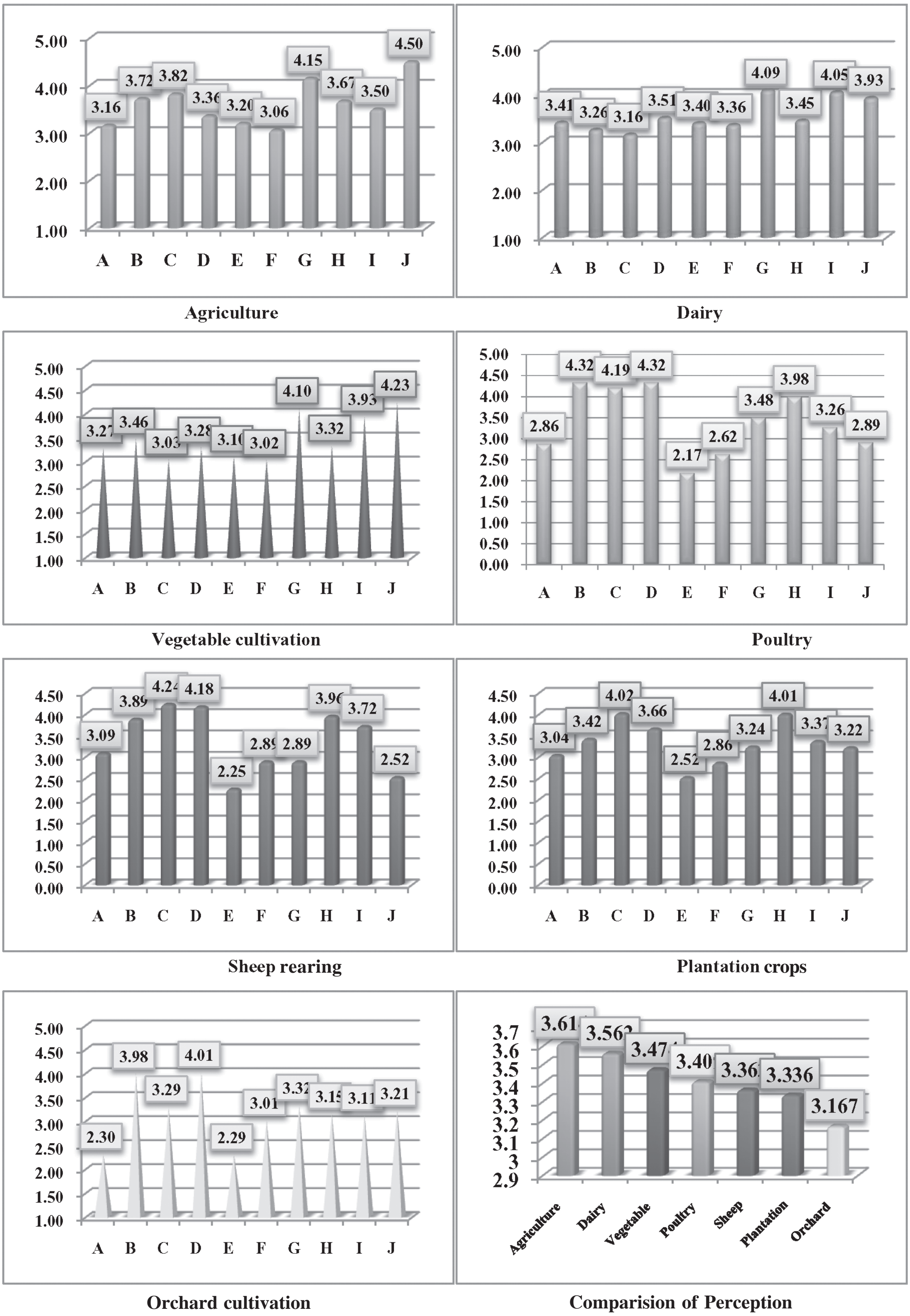

Fig. 1. Perception of youth towards different farm enterprises

The labour intensity for vegetables was perceived as very high (mean score =3.03) by the youth in farming, followed by high for dairy, medium for orchard, slightly medium for agriculture, less for plantation, very less for poultry and just one or two family members were involved for maintaining sheep. This is substantiated by the mean scores 3.16, 3.29, 3.82, 4.02, 4.19 and 4.24, respectively. The majority of youth in farming perceived that the management of poultry (mean score =4.32) was very simple, followed by increasing order of complexity for sheep (mean score =4.18), orchard (mean score =4.01), plantation (mean score =3.66), dairy (mean score =3.51), and finally vegetables (mean score =3.28).The by-products of different farm enterprises were utilized in different ways. By-products of dairy were more efficiently utilized (mean score =3.40), followed by decreasing manner from agriculture (mean score =3.20), vegetables (mean score =3.10), plantation (mean score =2.52), orchard (mean score =2.29), sheep (mean score =2.25) and very less utilization from poultry (mean score =2.17).

The large majority of the youth in farming had perceived that availability of subsidies was maximum for dairy (mean score =3.36), followed by descending sequence for agriculture (mean score =3.06), vegetables (mean score=3.02), orchard (mean score=3.01), plantation (mean score=2.86), sheep (mean score=2.89) and very less for poultry (mean score=2.62).Input availability for different enterprises was perceived as more for agriculture (mean score =4.152), followed by vegetable, dairy, poultry, orchard, plantation and sheep with mean scores (4.10, 4.09, 3.48, 3.32, 3.24 and 2.89).

It was also examined that the risk involved was high in orchards (mean score =3.15) and low in plantations (mean score =4.01) as perceived by the youth in farming. While the risk involved in other enterprises was, vegetable (mean score =3.32), dairy (mean score =3.45), agriculture (mean score =3.67), sheep (mean score =3.96) and less risk was involved in poultry (mean score =3.98). Further, different farm enterprises had different prevailing marketing opportunities. In the perception of youth, the marketing opportunities were vast for dairy enterprise (mean score =4.05), followed by descending order of vegetables (mean score =3.93), sheep (mean score =3.72), agriculture (mean score =3.50), plantations (mean score =3.37), poultry (mean score =3.26) and orchard (mean score =3.11).

Agriculture (mean score =4.50) was perceived as compatible than the other enterprises by the youth in farming. Next to this was vegetable (mean score =4.23), followed by dairy (mean score =3.93), plantations (mean score =3.22), orchard (mean score =3.21), poultry (mean score =2.89) and sheep (mean score =2.52).It is clear from the Table 2 and Fig.1. that the overall perception of youth in farming based on all the indicators was resulted in the ranking of the enterprises. Agriculture was perceived as the most efficient enterprise with average mean score of all the indicators as (3.61). Dairy (mean score =3.56) was perceived as efficient enterprise, followed by vegetable (mean score =3.47) as moderately efficient, poultry (mean score =3.41) as slightly efficient, sheep (mean score =3.36) as less efficient, plantation (mean score =3.34) as very less efficient and at last orchard (mean score =3.17) was perceived as the least efficient enterprise by the youth in farming. The research findings of Anuradha *et al.* (2014) are in line with the present study whereas the results of Arowolo *et al.* (2013) are against the study.

Availability of high yielding breeds and relatively high value for the milk and milk products might have directed the youth in farming towards dairy in terms of its profitability. At the same time, the increased use of multi-varied vegetables, awareness on health and nutritional standards of the people might have resulted in significant demand and reasonably fair prices for vegetables. This situation reproduced a positive perception towards profitability of vegetables. On the other side, poor maintenance of the orchard, lack of irrigation facilities and improper marketing of produce might have developed the perception of relatively lowest profitability in orchards.

Majority of the youth in farming might be taking up poultry as small scale enterprise in their back yards and earning the profits with very limited investment. Simultaneously orchard was also perceived as low investment enterprise because the youth in farming might have acquired the already established orchards as the ancestral property. They might be investing very little amount towards rare farm operations for getting the yield. On the other side, dairy enterprise requires high capital investment towards purchase of quality breeds as well as health and nutritional management of milch animals.

The youth in farming might be in the opinion that rearing of sheep and goat can be taken up with one or two available family labour without the requirement of external labour. They also might have perceived that simultaneously they can attend other farm operations while taking care of their flock. Moreover, they might have viewed that poultry as a household enterprise can be taken up by the female members of the family. On the other extreme, vegetable enterprise was perceived as the relatively labour intensive enterprise due to its high labour involvement at different stages of cultivation to the final harvest and marketing of final products.

Majority of youth in farming are taking up poultry on small scale with locally available backyard poultry breeds which will be acclimatized to local conditions and which require less care towards their management. They might have perceived that poultry can be taken up with very simple production management practices. They also might be thinking that being perennial crop, the majority of orchards are seasonal and requires very limited operations in a year. Further, the operations also can be taken up on a contractual basis without much technological involvement by farmers. Thus, the above reason might have developed such perception in youth. Vegetables being the most sensitive crop both for biotic and abiotic stresses, requires intensive care as well as modern technological interventions. Hence, the youth in farming might be very cautious towards vegetables starting from selection of seeds to the final harvest of the produce.

Dairy and agriculture are the two important mutually supporting enterprises having the effective utility of one by-product to another. Both the enterprises might be serving as the source of sustainability and enhanced profitability. The youth in farming might have perceived that these two enterprises were more effective in their by-product utilization. As poultry been taken on a small scale by majority of the youth in farming, they might not have perceived it as a source of by-products for other farm enterprises.Almost all enterprises were been promoted by the government, non-government and private agencies. Particularly, to see the farming in an integrated form the government is focusing on all the farm enterprises and might be trying to support the farmer by way of reasonable subsidies to different critical inputs and other services. Hence, the youth in farming might have felt that all the enterprises had enough subsidies to motivate the farming community.

Agriculture, dairy and vegetables were the three core areas of farming for which the inputs might be readily available in the market because of its maximum usage by the farmers. On the other side the other farm enterprises might be under limited area on a limited scale and the youth in farming might have faced scarcity or non availability of inputs in time.

Poultry, sheep, plantations and orchards were the four enterprises for which the youth in farming might have experienced a smooth and balanced deal in terms of their handling. No erratic and abrupt changes were observed in these enterprises to struggle for coping mechanism. On the other side the problem of poor quality seeds and other inputs, severe incidence of pests and diseases, high perishability and unpredictable market prices led to perception of maximum risk by the youth in farming.Having multichannel market networking, diversified value addition and unlimited demand, the dairy might have been perceived by the youth in farming as the enterprise with maximum marketing opportunities. The regular and balanced consumption of vegetables also might have shown ample market opportunities for the youth in farming. The prevailing social values, income generation potential of the enterprise, involvement of drudgery and the nature of involvement of family members might have determined the compatibility of an enterprise. The youth in farming might have prioritized agriculture, vegetable, dairy and other enterprises respectively keeping in view of all the above factors.

The overall picture of the perception on different farm enterprises towards the selected ten criteria by the youth in farming inferred that they are comfortable with the management of all the enterprises along with appropriate technical know-how in farming and was cautious about the complexity of management (mean score=3.76) by taking care all aspects of the enterprise development. They had perceived investment (mean score=3.72) as one of the very important indicators and have shown their readiness to invest in different farm enterprises.

Further, they perceived labour intensity (mean score=3.68) for almost all enterprises was not much difficult. The risk involved (mean score=3.65) in all the enterprises was perceived as nominal for almost all enterprises. They also might be willing to take up calculated risks to earn huge profits in farming. Input availability (mean score=3.61) was also perceived as somewhat better for some of the enterprises. On the other side, there was deficiency of inputs in the peak times of requirement. It was also observed that marketing opportunities (mean score=3.56) for the produce of different enterprises was perceived as moderately organized and yet to be improved a lot. Even though the youth in farming were exploring all possible market networks and expressed satisfaction towards the marketing of their produce, still there is ample scope to get better market price through market intelligence, awaiting for high market price, online trading, export orientation, etc. They also perceived compatibility (mean score=3.50) as good for all enterprises to some extent. The average of profitability (mean score=3.02) of all the enterprises also portrayed that the youth in farming have shown a mixed perception towards profitability as some of them might be deriving the income to their level of satisfaction and some may be in the opinion of low to marginal level of income from farming. They were also expecting much more financial support from the government towards critical inputs (mean score=2.97) which are going to contribute significantly towards enhancing quantity and quality of farm produce. The concept of intensification in farming might have led to isolation of different farm enterprises which resulted in poor interdependence in terms of by-product utilization (mean score=2.70).

CONCLUSIONS

Agriculture was perceived as the most efficient enterprise followed by dairy, vegetable, poultry, sheep and plantation. Orchards cultivation was perceived as the least efficient enterprise by the youth in farming.

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A STUDY ON ASSET CREATION UNDER MGNREGA IN PRAKASAM DISTRICT OF ANDHRA PRADESH

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ABSTRACT

A sample of 120 respondents was selected from Janapala Cheruvu Agraharam and Pamidipadu of Bestavaripeta and Korisapadu Mandals respectively. It was observed that availing credit facility from banks has increased from 10.0 to 43.3 percent in Janapala Cheruvu Agraharam and it is still higher in Pamidipadu from 15 to 60.0 percent. Next to this was Self Help Groups (SHGs), which was increased to almost 30 percent in both the villages. MGNREGA is considered as an effective policy in making available the right to employment to every individual. The Act seeks to strengthen the natural resource base of rural livelihood and create durable assets in rural areas. There were four works under MGNREGA, *viz.*, jungle cutting, silting, canal works and farm pond in both villages. These four works exist in the approved list of MGNREGA activities, under watershed related works. Under each of the work, certain interventions were carried out in succeeding years like land levelling, cleaning, silting and jungle cutting. Families who earned from MGNREGS works were able to invest in children's education, health, repayment of old loans, etc.

INTRODUCTION

The Government of India created a historic act, by enacting the Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), the largest employment generating programme in the world, ensuring the right to work in a country with a population of over one billion. The Government of India passed the NREGA, 2005 (Central Act No. 42 of 2005). NREGA was renamed as Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) on October 2nd, 2009. MGNREGA is the first ever law, in the world that guarantees wage employment at an unprecedented scale. This Act gives legal guarantee of at least one hundred days of wage employment in a financial year to a rural household, whose adult members volunteer to do unskilled and manual work. The Act is applicable in the Districts notified by the Government of India, the implementation of the Act calls for the formulation of Rural Employment Guarantee Scheme by the State Governments.

The MGNREGA seeks the creation of durable and sustainable assets that are created by the community and also managed by it (Mehrotra, 2008). For creation of such assets using the guaranteed employment, the act has codified works- water conservation and water harvesting, drought proofing (including afforestation and planting of trees), irrigation canals (including micro and minor irrigation works), provision of irrigation facility to land owned by households of Scheduled castes and Scheduled Tribes (formerly lower castes and indigenous peoples) or to land of beneficiaries of land reforms and *the Indira Awas Yojana* (the house-building programme of the Government of India), renovation of traditional water bodies (including de-silting of tanks), land development, flood control and protection works (including drainage in water-logged areas) and rural connectivity to provide all-weather access. Any other work which may be notified by the central government in consultation with the state government can also be considered.

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MATERIAL AND METHODS

The present study was taken up in Prakasam Dist. of Andhra Pradesh. The research design adopted for this study was *Ex-post-facto* since the phenomenon had already occurred. Accordingly, the sample was selected in Janapala Cheruvu Agraharam (JCA) and Pamidipadu (PMD) of Bestavaripeta and Korisapadu Mandals, respectively. Out of this 60 respondents from each village were selected randomly thus a total of 120 respondents were selected. Stratified random sampling procedure was adopted in the selection of the respondents at two villages.

Table.1 Liabilities of respondents before and after participation in MGNREGA in two villages

n_1= 60, n_2= 60

Category	% Respondents before and after participation in MGNREGA			
	Janapala Cheruvu Agraharam		Pamidipadu	
	Before	After	Before	After
Bank loan	10.0	43.3	15.0	60.0
Cooperative loan	0	0	3.3	3.3
SHG loan	8.3	41.7	43.3	71.7
Local money lender	6.7	30.0	1.7	11.7

n_1 = Janapala Cheruvu Agraharam, n_2 = Pamidipadu

RESULTS AND DISCUSSION

A claim against the asset or legal obligations of a person arising out of past or current transactions or actions was the operational definition of liabilities. Accordingly data was collected with regard to the number of respondents availed the facility of credit and tabulated.

It was observed that the respondents had four major liabilities, *viz*., loans from nationalized banks, cooperative banks, Self Help Groups (SHGs) and also from local money lenders, which means that both institutional and non-institutional lending had increased after participation in MGNREGA. Liabilities, in general has enhanced after participation in MGNREGA. Availing credit facility from banks has increased from 10.0 to 43.3 % in JCA and it is still higher in PMD from 15 to 60.0 %. Next to this was SHG, which was increased to almost 30% in both the villages. Inspite these institutional facilities, lending from local money lender had also increased. This is an alarming situation as usually the rate of interest would be very high in local lending. One of the agenda of all poverty alleviation programmes is safe guarding rural poor from the clutches of local money lenders. This issue needs some attention by the Governance.

Nature and Type of Interventions

This variable was operationalized as the succeeding and supporting activities under taken by the respondents on their own, whether farm or nonfarm, after participation in MGNREGA activity. As MGNREGA was in operation from 2008 onwards

Table 2. Intervention of work

n_1= 60, n_2= 60

Work	Type of intervention	Janapala Cheruvu Agraharam		Pamidipadu	
		Frequency	%	Frequency	%
Jungle cutting	Land levelling	14	23.23	13	21.67
	Cleaning	7	11.67	4	6.67
	Silting and cleaning	2	3.23	2	3.23
	Machinery	8	13.23	5	8.23
	Jungle cutting	4	6.67	8	13.23
Silting	Land levelling	6	10.00	6	10.00
	Cleaning	3	5.00	0	0.00
	Silting and cleaning	2	3.23	0	0.00
	Machinery	1	0.00	2	3.23
	Jungle cutting	1	1.67	5	8.23
Canal work	Land levelling	4	6.67	0	0.00
	Cleaning	4	6.67	2	3.23
	Silting and cleaning	2	3.23	0	0.00
	Machinery	0	0.00	6	10.00
	Jungle cutting	2	3.23	4	6.67
Farm pond	Land levelling	0	0.00	0	0.00
	Cleaning	0	0.00	1	1.67
	Silting and cleaning	0	0.00	0	0.00
	Machinery	0	0.00	2	3.23
	Jungle cutting	0	0.00	0	0.00

n_{1} = Janapala Cheruvu Agraharam
n_{2} = Pamidipadu

in both the villages, the data was reviewed since then and presented below in terms of the number of respondents undertaken the works and interventions.

There were four works under MGNREGA, *viz.*, jungle cutting, silting, canal works and farm pond in both villages. These four exiting in the approved list of MGNREGA activities, under watershed related works. Under each of the work, certain interventions were carried out in succeeding years like land levelling, cleaning, silting and jungle cutting. The data also revealed use of mechanical labour for certain operations. The respondents reported that they utilized it when it was impossible for human labour. The intervention occurred whenever and wherever necessary. Mechanical interventions were also observed in both villages.

As a part of the MGNREGA works the village Gram Sabha's have taken up development of such lands, thereby ensuring that such land owners would be able to cultivate hitherto barren and uncultivable lands. This particular work is more popular in the villages of Andhra Pradesh (such works accounted for over 20 per cent of total works in the state in 2009) as that enabled small and marginal cultivators to engage in crop cultivation, in several cases for the first time in their life. Families who earned from MGNREGA works were able to invest in children's education, health, repayment of old debt, and for other such useful purposes.

Field study of IHD (2009) points out that the maximum works undertaken in Andhra Pradesh were land development works (45 percent), followed by conservation of water bodies and related works (28.9 percent).Ferraro (2002) identified that the more popular initiatives in conservation of ecosystem is the use of development interventions in the peripheral areas of endangered ecosystems. Dumanski and Pieri (2000) noted that the impact(s) of human interventions on the landscape for the major agro ecological zones of tropical, sub-tropical and temperate environments.

Inadequate technical support for planning physical works (especially activities such as de-silting tanks, bundling of agriculture fields, etc.) appears to be a major reason for poor quality of works completed. As a part of the MGNREGA works the village Gram Sabha's have taken up development of such lands, thereby ensuring that such land owners would be able to cultivate hitherto barren and uncultivable lands. This particular work is more popular in the villages of Andhra Pradesh (such works accounted for over 20 per cent of total works in the state in 2009) as that enabled small and marginal cultivators to engage in crop cultivation, in several cases for the first time in their life. Families who earned from MGNREGA works were able to invest in children's education, health, repayment of old debt, and for other such useful purposes.

CONCLUSIONS

The MGNREGA is considered as an effective policy in making available the right to employment to every individual as big asset. Ever since its implementation, several debates have arose regarding the effectiveness of the scheme in achieving the desired objective. It was observed that the respondents had four major liabilities, *viz.*, loans from nationalized banks, cooperative banks, SHG and also from local money lenders, which means that both institutional and non-institutional lending had increased after participation in the MGNREGA. There were four works under MGNREGA, *viz.*, jungle cutting, silting, canal works and farm pond in both villages. Under each of the work, certain interventions were carried out in succeeding years *viz.,* land levelling, cleaning, silting and jungle cutting. As part of MGNREGS works the village Gram Sabha's have taken up development of such lands, thereby ensuring that such land owners would be able to cultivate hitherto barren and uncultivable lands. Families who earned from MGNREGS works were able to invest in children's education, health, repayment of old debt, and for other such useful purposes.

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KNOWLEDGE OF FARMERS ABOUT SOIL HEALTH CARD (SHC) RECOMMENDATIONS IN KURNOOL DISTRICT OF ANDHRA PRADESH

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Soil health plays a vital role to ensure sustainable agricultural production. However, deteriorating soil health has been a cause of concern, which has led to sub-optimal utilization of farm resources. The assessment of knowledge on soil fertility management will help us to understand the knowledge gap existing among farmers, which can be used for devising appropriate extension strategies. According to Yadav *et al.*(2006) "knowledge level and adoption of Soil Fertility Management (SFM) practices are relatively less *i.e.,* 65 per cent of them have no knowledge about SFM practices and just 8 per cent of them have adopted SFM practices".Judicious application of chemical fertilizers by farmers in crops is very much essential to achieve maximum production and to earn maximum profit. Nandini (1995) observed that educational status had positive and significant relationship with knowledge level in both adopter and non-adopter categories of Soil Conservation Programme. However, in the past two decades, the fertility status of soils has decreased drastically due to indiscriminate use of fertilizers *i.e.* the Soil Nutrient Response Ratio has decreased from 14.06 in 1990-91 to 8.59 in 2010-11 (Mission Project to Boost Productivity in rainfed areas of Andhra Pradesh – 2011). Therefore, the Government of Andhra Pradesh initiated the Bhuchetana Project in the year 2010-11 for distributing Soil Health Cards (SHCs) to farmers in order to encourage judicious application of fertilizers, to increase productivity of crops, and to maintain soil fertility. The project is going for the last six years since its inception. Soil samples are collected @ 10 samples per village from the farmers under this project, which are tested in the soil testing labs, based on which SHCs are distributed to the farmers.

In light of the above, the present study was conducted to evaluate the respondent's knowledge about SHC recommendations. The study was conducted in the Kurnool district of Andhra Pradesh state during the year 2014-2015 and *ex-post facto* research design was employed. 100 beneficiary farmers of the Bhuchetana project were selected as the respondents through proportionate random sampling technique 50 respondents were selected from each block of Orvakal and Banaganapalli.

Knowledge level on SHM denoted the extent of knowledge possessed by a farmer respondent on SHM at the time of inquiry. The knowledge level on SHM was measured by means of a 'Teacher Made Test' developed for the study, based on the SHM technologies recommended by ANGRAU and the State Department of Agriculture to the farmers. The test consisted of 12 questions with multiple choice answers. Two score was given for correct answer and one for incorrect answer. The item-wise scores were summed up to arrive at the knowledge score of a respondent, with scores ranging from a maximum

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of 24 to a minimum of 12. Higher score indicated 'more knowledge' and lower score denoted 'less knowledge' of a respondent. Based on the total scores, the respondents were classified into low, medium and high categories using frequency distribution method.

The extent of knowledge was assessed in terms of overall knowledge and technology-wise knowledge. It is seen that majority (83.00%) of the respondents had reported medium level of overall knowledge gain on SHM, followed by 17.00% of the respondents had reported very high overall knowledge gain on SHM.It is seen that all the respondents had knowledge on the items *viz*., use of soil testing, primary nutrients, N fertilizer, P fertilizer, and K fertilizer. This was followed by secondary nutrients (90.0%), micronutrients (85.0%), reclaiming problem soil with lime (69.0%), natural amendment (56.0%), and green manure crop (48.0%). Knowledge on tool for N recommendation in rice, and bio fertilizer was less among the respondents with 14.0 percent and 12.0 percent, respectively. It was found that 100 percent of the respondents had knowledge on use of soil testing. This may be as a result of the wide publicity given by the Department of Agriculture (DoA) on soil testing through the Bhuchetana project. All the respondents had knowledge on the primary nutrients *viz*., N, P and K. This may be due to the experience of farmers in using these fertilizers for a long period of time. Application of secondary and micronutrients have been given an impetus through the Bhuchetana project, which may have caused majority of the respondents to gain knowledge on these practices. Knowledge on natural amendment was less, since prevalence of problematic soils was less in that area. Nearly half the respondents had no knowledge on green manure crops, which may be due to the reason that farmers in general do not grow green manure crops for incorporating into their fields. Most of the respondents had given incorrect response to tool meant for N recommendation in rice. The LCC (Leaf Colour Chart) tool meant for N application in rice is crop specific and therefore it may not be a common practice in that area. The less knowledge on biofertilizers may have occurred due to chance causes.

The Bhutchetana Project is a novel project implemented by the Govt. of Andhra Pradesh in order to encourage farmers to adopt soil test based application of nutrients to soils. It is found through this study that vast majority of the respondents had medium level of overall knowledge on SHM. Cent percent of the respondents had knowledge on the items *viz*., use of soil testing, primary nutrients, N fertilizer, P fertilizer, and K fertilizer. This may be as a result of the wide publicity given by the State Department of Agriculture(DoA) on soil testing through the Bhuchetana project.

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Research Note
J. Res. ANGRAU 43(3&4) 93-95, 2015

EVALUATION OF PIGEONPEA GENOTYPES FOR THEIR GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE

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Redgram [*Cajanus cajan* (L.) Millsp.] is the most important pulse crop of India after chickpea. India occupies an important place with 90% of total global area and production of redgram. It is consumed mostly as split dhal in India. It has a wide range of uses as fresh or canned green peas in parts of India, Africa, Central America and the Caribbeans. Pigeonpea is rich in starch, protein, calcium, manganese, crude fibre, fat, trace elements and minerals. Pigeonpea (2n=22) plays important role in soil fertility by harbouring nitrogen fixing nitrogen in root nodules and fallen leaves with less consumption from external fertilizer application. The crop possesses vast genetic resources but experiencing low productivity due to abiotic and biotic stresses. Proper exploitation of genetic variability was also could not be done to develop genotypes with high yield potential. Yield is a complex character which is governed by poly genes with cumulative effect. Knowledge on genetic parameters *viz.*, genetic

Table 1. ANOVA for different characters in pigeonpea

Character	Source of variance	DF	Sum of Squares	Mean Sum of squares
Height (cm)	Replications	2	176.48	88.24*
	Treatments	21	9827.53	467.97*
	Error	42	7593.51	180.79
Days to 50% flowering	Replications	2	0.12	0.06
	Treatments	21	2389.45	113.78*
	Error	42	32.54	0.77
No. of primary branches	Replications	2	0.12	0.06
	Treatments	21	2389.45	113.78*
	Error	42	32.54	0.77
No. of secondary branches	Replications	2	0.12	0.06
	Treatments	21	2389.45	113.78*
	Error	42	32.54	0.77
No. of pods plant^{-1}	Replications	2	0.12	0.06
	Treatments	21	2389.45	113.78*
	Error	42	32.54	0.77
Test weight (g)	Replications	2	0.82	0.41
	Treatments	21	73.83	3.51*
	Error	42	11.37	0.27
Yield (kg ha^{-1})	Replications	2	0.82	0.41
	Treatments	21	73.83	3.51*
	Error	42	11.37	0.27

* Significant @ 5%

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variability, heritability and genetic advance are essential to organize breeding programme for development of superior genotypes. Keeping these things in view, a study was conducted to estimate genetic parametres for selection in development of elite breeding lines.

Field experiment was conducted at RARS, Lam, Guntur during *kharif,* 2014 that was located at 16^0 22^1 N with 82.16^0 E and located 33m above MSL. Twenty- two pigeonpea genotypes were raised in RBD in three replications with four rows of four metres length. Spacing of $180cm^2$ x $20cm^2$ was followed and data was recorded on five competitive plants for seven characters *viz*., plant height(cm), days to 50% flowering, number of primary branches $plant^{-1}$, number of secondary branches $plant^{-1}$, number of pods $plant^{-1}$, test weight (g) and yield(kg ha^{-1}), on five competitive plants in each replication and subjected to analysis for estimation of coefficient of variation (Burton, 1952), heritability and genetic advance as per Johanson *et al.*(1955).

Presence of genetic variability is prerequisite for improvement of any trait in any crop and success of any breeding programme depends upon extent of variability present in the breeding material used for investigation. In the present study analysis of variance shown highly significant differences among the genotypes for all the characters studied (Table 2). The variability present in the genotypes can be utilized to develop high yielding genotypes by crossing to produce F1 hybrids and study of their segregating generations with selection. The components of genetic variability revealed that the PCV is higher than GCV for all the characters studied indicating that influence of environment, playing major roll in expression of the character. The magnitude of PCV and GCV were moderate to high for all the characters *viz*., yield, number of pods per plant and number of primary branches $plant^{-1}$. These results are in confirmity with findings of Satish Kumar *et al*., (2006), Feroz mahamad *et al.,*(2006), Badru (2011) and Jaganmohan Rao and Tirumala Rao (2015). GCV is the one of the important parameter to be considered in respect of genotypic variation of the trait studied and the amount of heritable portion would be determined with the help of heritability and genetic advance. Heritability in broadscence was high for the characters *viz*., days to 50% flowering, test weight, yield, number of primary branches $plant^{-1}$ and number of secondary branches $plant^{-1}$. Similar results were reported by earlier workers Bhaskaran and Muthaiah (2006) and Sreelakshmi *et al*., (2010). Consideration

Table 2. Estimation of variability, heritability and genetic advance in pigeonpea

Character	Range	CD at 5 %	General Mean	GCV %	PCV %	Heritability in Broad sense (H^2)	Genetic Advance	GA as percent of mean
Plant height	163-228	22.16	202.28	4.83	8.22	0.34	11.85	5.86
Days to 50% flowering	91-119	1.45	112.24	5.46	5.54	0.98	12.51	11.15
No. of primary branches	2.07-3.20	0.41	2.47	10.67	14.62	0.53	0.39	16.05
No. of secondary branches	15.4-20.5	1.66	18.10	6.81	8.80	0.50	1.96	10.86
No. of pods plant-1	287-588	121.28	423.78	12.72	21.52	0.34	65.62	19.84
Test weight	9.6-13.4	0.86	12.07	8.61	9.63	0.80	1.91	15.86
Yield(kg ha^{-1})	1161-2634	530.49	1825.59	22.76	28.74	0.62	676.69	47.50

of genetic advance is highly essential in breeding programmes in addition to heritability alone. Hence, characters with moderate to high heritability and high genetic advance as percent mean would be considered for selection for improvement of particular trait. In the present study characters *viz.*,yield, number of pods plant^{-1}, days to 50% flowering and plant height were considered for improvement as per the suggestions of Johnson *et al.*, (1955)adopting simple selections procedures *viz.,* progeny row method as the characters were governed by additive gene action.Therefore, the present study indicated that there is sufficient genetic variability in pigeonpea that could be used as a base for improvement of the yield and other important attributes of this crop through direct selection and hybridization.

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TENANCY FORMS IN GUNTUR DISTRICT OF ANDHRA PRADESH

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Dr. M .S. Swaminathan, eminent Agricultural Scientist and the Chairman of National Commission of farmers has indicated in the Report of National Commission on Farmers (2011) that 45.00 per cent of the farmers cultivating their own lands want to quit agriculture. In the present agricultural scenario, especially in commercial crops *viz*., chilli and cotton the tenant farmers are increasing. At the same time, since the cultivation of chilli is highly profitable, it is unlikely that the farmers will become insolvent unless poor yields continue years. The credit contracts between the middlemen and the tenant farmers are made orally. No written contract is prepared, though the middlemen record their transactions in their notebooks and give the farmers memos bearing the amounts of credit. Thus, the middlemen in the village provide the farmers with the cultivation techniques, capital, and marketing channels through contract farming tied to credit. By so doing, they have contributed greatly to the establishment of the commercial production of chillies in the study village. It also should be noted that the heavy risk involved in chilli production has been borne by the wholesalers who have abundant funds, a factor which has played an important role in the diffusion of commercial chilli farming.

Guntur district of Andhra Pradesh was purposively selected, as the district stands first in area of the chilli crop among all the districts in Andhra Pradesh state during the year 2011-2012 (National Horticulture Board, 2012). Three mandals *viz*., Veldurthy, Sattenapalli and Pedakurapadu were purposively selected. Two villages were selected randomly from each of the selected mandal. Ten tenant farmers in each of the six villages were again selected randomly for the study. Thus, the total sample constituted 60 tenant farmers. The data was collected with the help of structured interview schedule through personal interview method.Tenancy form was operationalised as the type of lease made by the tenant farmers with the land owner.

For the purpose of study, the tenancy forms were classified into three types namely; formal, semi-formal and informal. Formal type of tenancy form was operationally defined as the lease contract made between the land owner and tenant farmer involving legal procedures. Semi-formal type of tenancy form was operationally defined as the lease contract made between the land owner and tenant farmer involving partial legal procedures. Informal type of tenancy form was operationally defined as the lease contract made between the land owner and tenant farmer involving no legal procedures. Based on the way of expression of tenure of the land, tenancy forms were classified into two types namely; verbal and written. Verbal type of tenancy form was operationally defined as the lease contract made between the land owner and tenant farmer orally. Written type of tenancy form was operationally defined as the lease contract made between the land owner and tenant farmer involving

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documentation procedures. Based on the period from which the tenant farmers had been cultivating the present piece of leased land, tenancy forms were classified into four types namely; short term, medium term, long term and very long term. Short term type of tenancy form was operationally defined as the lease contract made between the land owner and tenant farmer since less than three years. Medium term type of tenancy form was operationally defined as the lease contract made between the land owner and tenant farmer since three to five years. Long term type of tenancy form was operationally defined as the lease contract made between the land owner and tenant farmer for five to ten years. Very long term type of tenancy form was operationally defined as the lease contract made between the land owner and tenant farmer since more than ten years. Based on the size of the leased land, tenancy forms were classified into three types namely; small scale, medium scale and large scale. Small scale type of tenancy form was operationally defined as the lease contract made between the land owner and tenant farmer for a land less than five acres. Medium scale type of tenancy form was operationally defined as the lease contract made between the land owner and tenant farmer for 5 to 10 acres of land. Large scale type of tenancy form was operationally defined as the lease contract made between the land owner and tenant farmer for a land more than 10 acres.

Based on the mode of rent paid by the tenant farmer for the leased land, tenancy forms were primarily classified into three types namely; cash, kind and cash & kind. Cash type of tenancy form was operationally defined as the rent paid by the tenant farmer for the leased land was in its monetary form. Cash type of tenancy form was further classified into four types as '100 per cent cash paid before the commencement of crop'; '50 per cent cash before the commencement of crop and the remaining 50% cash paid after the harvest and sale of produce'; '75 per cent cash paid before the commencement of crop and the remaining 25 per cent cash paid after the harvest and sale of produce' and '100 per cent cash paid after the harvest and sale of produce'. Kind type of tenancy form was operationally defined as the rent paid by the tenant farmer for the leased land was in the form of produce in its entirety *i.e.* chillies. Cash and kind type of tenancy form was operationally defined as the rent paid by the tenant farmer for the leased land in both money and produce form *i.e.* chillies. Cash and kind type of tenancy form was further classified into three types as '100 per cent cash is paid and some produce after harvest is given as a compliment'; '50 per cent cash and 50 per cent kind is paid' and '75 per cent cash and 25 per cent kind is paid'.

It was evident that based on structure, majority of the tenant farmers were informal (95.00%), followed by semi-formal (5.00%) and none of them belonged to formal category. An attempt was also made to study the different forms of tenancy based on the way of expression of tenure of the land existing in the study area among the selected tenant farmers. It was evident that majority of the tenant farmers entered into the agreement of leasing the land verbally (95.00%), followed by written (5.00%). The trust and belief prevailed between the owner and tenant farmers might have been the probable reason for obtaining this trend. It was also evident that for more than half of the tenant farmers, the period from which they had been cultivating the present piece of leased land was short term (60.00%), followed by medium term (30.00%), very long term (6.67%) and long term (3.33%) cultivation categories. The probable reason for having more of short term tenure of land leasing might be some fear prevailing with the land owners. Different forms of tenancy existing in the study area based on the size of the leased land among the selected tenant farmers were also studied. More than half of the tenant farmers leased land on small scale (65.00%), followed by medium scale (28.33%) and large scale (6.67%).It is also noted that among the different modes of rent paid by the tenant farmer for the leased land, highest per cent was recorded in case of the pooled data of cash & kind (55.00%), followed by cash (41.67%) and kind (3.33%). In case of the land lease rent paid as cash and kind, it was observed that more than half of the tenant farmers paid 100 per cent cash and as a complement gave some produce after harvest (51.67%). In case of the land lease rent paid as cash, it was observed that a little less than one third of the respondents paid '100 per cent cash before the commencement of crop' as land lease rent, followed by '50 per cent cash before the commencement of crop and the remaining 50 per cent cash after the harvest and sale of produce' (10.00%) and '75 per cent cash before the commencement of crop and the remaining 25 per cent cash after the harvest and sale of produce' (8.33%) and '100% cash after the harvest and sale of produce' (5.00%). In case of the land lease rent paid as kind, it was observed that, a little proportion of the respondents paid '100% kind after the harvest of produce' (3.33%).

The respondents who paid entire land lease rent in the form of cash before the commencement of crop and the respondents who gave complementary gifts in addition to the full amount of cash might be the tenant farmers not related to the land owners *i.e.* out of kinship to the land owners. Except these members, rest all could be the near and dear and within the kinship. Hence, believed in them and gave the land on lease and took the rent in instalments or kind form or in the form of cash and kind as per the convenience and requirement of the land owners and tenant farmers.Different tenancy forms exist in Guntur district. Whatever may be the form or criteria, farming would be healthy and sustainable only if the term of tenancy is for a longer duration. In that case only the tenant farmer can concentrate to develop the farm and give healthy and good nutrition to the soil, else nature would be exploited.

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