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POPULATION FLUCTUATION OF NATURAL ENEMIES OF STEM BORER, *Chilo partellus* IN MAIZE

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Date of Receipt: 18.12.2017

Date of Acceptance:22.01.2018

ABSTRACT

Experiments were carried out during four seasons viz., *Kharif*, 2014, *Rabi* 2014-15, *Kharif*, 2015 and *Rabi* 2015-16 to evaluate the population fluctuation of stem borer and natural enemies in maize crop. The highest stem borer infestation during *Kharif* season with mean population of 2.86 larvae / plant was recorded during 40th standard week coinciding with grain filling stage of maize. While during *Rabi* season, peak larval population of *C. partellus* (2.42 larvae / plant) was noticed during 4th standard week coinciding with flowering and fertilization (silking) stage of maize. Peak incidence of *Coccinella transversalis* Fab. and *Cheilomenus sexmaculata* Fab. during *Kharif* season was noticed in 41st standard week (0.84 and 0.72 beetles per plant, respectively), while during *Rabi*, peak population of *C. transversalis* in 2nd and 3rd standard weeks (0.34 beetles per plant) and *C. sexmaculata* in 4th standard week (0.78 beetles / plant). Peak activity of spiders was found to follow the same trend during *kharif* with 1.22 per plant in 41st standard week and 0.89 per plant during *rabi* in 4th standard week. Peak parasitism by *Cotesia flavipes* was found during 40th standard week (25.12 %) in *Kharif* and 4th standard week (10.8%) in *Rabi* coinciding with peak larval population of the maize stem borer. *C. flavipes* showed positive and significant correlation with larval population of *C. partellus* on average basis of both study years of *Kharif* ($r = 0.940$) and *Rabi* ($r = 0.868$) seasons.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops next to wheat and rice. The production of maize is constantly increasing because of the rising demand from the industries since maize is used as raw material for extraction of edible oil, as feed for poultry birds and livestock, and also for starch and glucose industry. Globally, India ranks 5th in area, 4th in production and 3rd in productivity (Pal *et al.*, 2009). Today, it is one of the important coarse cereal crops grown in different agro-climatic conditions in India. The multiple-pest complex of maize crop poses serious limitations in the intensification of maize cultivation in different agro-climatic regions of India. Although 139 insect pests cause varying degree of damage to maize crop, only about a dozen of these are serious and require control measures. Amongst maize stem borers, (*Chilo partellus*) (Swinhoe) occurs as serious pest in India.

With the increasing resistance of many insect pest species to chemical insecticides and an increasing organic food market, pest control strategies are slowly shifting towards more sustainable, ecologically sound and economically viable options. Biologically based pest management strategies present such opportunities through predation or parasitism of pests. Inevitably, the efficacy of biological control systems is highly dependent on natural enemy-prey interactions, which will likely be modified by changing climates. Environmental factors (e.g., temperature) directly affect the survival, development, reproduction and dispersal of pest insects and thus their potential biogeography and biotic potential (Southwood and Henderson, 2000). It is well known that temperature fluctuations are the major factors affecting insect biology, activity and distribution of natural enemies in agro-ecosystems (Duale, 2005). Moreover, it is indicated that climate change affects several life

history parameters e.g., generation time, fecundity, sex ratios and lifespan of parasitoids and predators (Kalyebi *et al.*, 2005). Weather factors may also influence parasitoid activity indirectly by inducing diapause in the host larvae. Therefore, knowledge of how insect pests and their natural enemies respond to climate variation is of fundamental importance in understanding biological insect pest management. Keeping these in view, field and laboratory experiments were conducted to address the importance and impact of weather on *C. partellus* incidence and interaction with natural enemies on maize.

MATERIAL AND METHODS

The investigation was undertaken during four seasons *viz.*, *kharif*, 2014, *rabi* 2014-15, *kharif*, 2015 and *rabi* 2015-16. The maize long duration hybrid, 30V92 was sown with the spacing of 60 cm x 20 cm between row to row and plant to plant in the last week of July (30th standard week) during *kharif*, 2014 and *kharif*, 2015 and in last week of November (48th standard week) during *rabi* 2014-15 and 2015-16, respectively covering an area of 0.1 ha. All the agronomical practices were followed as per the recommendations of ANGRAU in raising the crop during the experimental period.

The observations on population dynamics of *C. partellus* larvae were recorded at weekly intervals. At each observation, 10 maize plants from each of the four corners leaving the boarder rows and another 10 plants at the centre were chosen, uprooted and dissected to record the larval incidence of *C. partellus*. Observations were taken from one week after seedling emergence *i.e.*, 32nd standard week during *kharif*, 2014 and *kharif*, 2015 and continued up to first week of November (45th standard week). During *Rabi* 2014-15 and *Rabi* 2015-16 observations started from 50th standard week and was continued till the disappearance of the pest or harvest of the crop in the field *i.e.*, 11th standard week. The observations were also made for seasonal

occurrence of generalist predators in maize ecosystem *viz.*, *Coccinella transversalis* Fabricius, *Chilomenus sexmaculata* Fabricius, and spiders, simultaneously.

The parasitic interactions with larvae of *C. partellus* were also recorded at weekly intervals. To study the population of larval parasitoid, *Cotesia flavipes* (Cameron) from larvae, the stem borer infested maize plants were collected at weekly intervals from the experimental field and then the larvae were carefully isolated by dissecting the stems. The collected larvae were then reared on natural diet in the laboratory till adult emergence. The per cent parasitism was worked out from the observations made on field collected larvae.

Correlation was worked out between larval incidence of *C. partellus* and the parasitism by *C. flavipes* for four seasons of 2014-15 and 2015-16 individually as well as on cumulative basis during the crop growth period from August to March. The effect of parasitism on the incidence of *C. partellus* on 30V92 maize hybrid was determined separately as well as on cumulative basis using multiple linear regression models equation of type 1 *viz.*, $Y_i = a + b_1x_1$ where incidence of *C. partellus* was taken as the responsive variable (Y), 'a' is intercept, 'b' is slope of regression and *C. flavipes* parasitism as predictor variables to represent the equation.

RESULTS AND DISCUSSION

Larval incidence of stem borer, *C. partellus* in maize

The initial occurrence of *C. partellus* larvae during *Kharif* 2014 was noticed during 32nd standard week (1st week of August, 2014) at 14 days after crop emergence (DAE) with 0.13 larvae / plant. Thereafter the larval population gradually increased and reached the peak during 40th standard week (1st week of October, 2014) at 70 DAE with a mean number of 3.07 larvae / plant coinciding with grain filling stag of maize. The prevailing maximum and

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minimum temperatures during the period were 30.7 °C and 22.5 °C, while the average morning and evening relative humidity was 83.3 and 65.1 per cent, respectively. The peak larval incidence of *C. partellus* during *Kharif*, 2015 was observed during 40th standard week (1st week of October, 2015) at 70 DAE with 2.64 larvae / plant (Table 1). During this period the average maximum and minimum temperatures were 32.5 °C and 23.9 °C, while the average morning and evening relative humidity was 80.6 % and 66.9 %, respectively. The pooled data of *Kharif*, 2014 and 2015 revealed that the peak stem borer infestation with mean population of 2.86 larvae/ plant was recorded during 40th standard week (October 1st week). The larval incidence of *C. partellus* during *Rabi* 2014-15 reached to a peak by 5th standard week (1st week of February, 2015) at 63 DAE with a mean number of 2.33 larvae / plant coinciding with flowering and fertilization (silking) stage of maize. During this period the average maximum and minimum temperatures were 29.8 °C and 19.9 °C, while the average morning and evening relative humidity was 74.4 and 43.7 percent, respectively. Thereafter the incidence has declined gradually to a minimum by 11th standard week (2nd week of March, 2015). The larval population of *C. partellus* during *Rabi* 2015-16 increased gradually and the peak incidence was recorded during 3rd standard week (3rd week of January, 2016) with a mean number of 2.73 larvae/ plant coinciding with tasselling stage of maize (Table 2). The prevailing conditions of this highest peak level were 31.8 °C maximum, 18.4 °C minimum temperatures, 76.6 % morning and 45.2 % evening relative humidity and zero mm rainfall. Similar trend also existed in pooled analysis of *Rabi* 2014-15 and 2015-16, wherein peak larval population of *C. partellus* (2.42 larvae/ plant) was noticed during 4th standard week (January 4th week).

Population fluctuation of *C. transversalis*

The population of *C. transversalis* varied between 0.09 and 1.28 per plant with a peak

incidence during 37th standard week (2nd week of September) during *Kharif*, 2014. Further, the population was higher during 38th to 41st and 36th weeks compared to the population during rest of the standard weeks. Densities of *C. transversalis* recorded during *Kharif*, 2015 were relatively low ranged between 0.07 and 0.64 per plant with a peak incidence during 41st standard week (2nd week of October, 2015). It was more during 33rd to 35th and 37th to 40th weeks compared to the population during rest of the standard weeks. The pooled abundance of *C. transversalis* population varied from 0.08 to 0.84 beetles per plant with peak incidence on 41st standard week (Table 1). This can be attributed to the availability of more prey during October. Further, the population was more during 35th to 40th weeks compared to rest of the standard weeks. Birader (2010) reported higher incidence of *Coccinellids* in late sown maize crop and observed the population fluctuation in relation to prey population.

Predatory activity of *C. transversalis* was first found at three weeks after crop emergence (52nd standard week), but number was generally low early in the *Rabi* season of 2014-15. The peak occurrence of beetles was recorded during 3rd standard week and again on 8th standard week with 0.26 beetles / plant. During *Rabi* 2015-16, population of *C. transversalis* was observed in the field from the first sampling date onwards with its population having peaked at 2nd standard week (0.5 beetles/plant). The pooled population of *C. transversalis* during *Rabi* 2014-15 and 2015-16 varied from 0.08 to 0.34 beetles per plant with peak population on 2nd and 3rd standard weeks (Table 2).

Population fluctuation of *C. sexmaculata*

The variation of *C. sexmaculata* during *Kharif* 2014 revealed that the predator beetle first observed in 34th standard week (3rd week of August, 2014) at 28 DAE and was active up to 44th standard week (1st week of November, 2014) with a peak population (0.46 beetles / plant) noticed during 40th standard week

Table 1. Incidence of *C. partellus* and population of predators and parasitoid of *C. partellus* in maize during Kharif 2014 and 2015

Std. Met. Week	Days aftercrop emergence (DAE)	C. partellus larvae (Mean No. / plant)			Coccinella transversalis (Mean No. plant ⁻¹)			Chilomenus sexmaculata (Mean No. plant ⁻¹)			Spiders (Mean No. plant ⁻¹)			% Parasitism by Cotesia flavipes		
		Kharif 2014	Kharif 2015	Pooled	Kharif 2014	Kharif 2015	Pooled	Kharif 2014	Kharif 2015	Pooled	Kharif 2014	Kharif 2015	Pooled	Kharif 2014	Kharif 2015	Pooled
32	14	0.13	0.64	0.39	0.00	0.23	0.12	0.00	0.27	0.14	0.01	0.31	0.16	0.00	0.00	0.00
33	21	0.80	0.76	0.78	0.49	0.34	0.42	0.00	0.41	0.21	0.24	0.41	0.33	0.00	0.00	0.00
34	28	0.70	1.20	0.95	0.51	0.34	0.43	0.34	0.66	0.50	0.45	0.59	0.52	0.00	0.00	4.29
35	35	1.27	1.16	1.22	0.91	0.40	0.66	0.21	0.53	0.37	0.98	0.60	0.79	10.71	10.34	10.53
36	42	1.37	1.36	1.37	1.13	0.29	0.71	0.31	0.60	0.46	0.94	0.83	0.89	17.24	4.08	10.66
37	49	1.13	1.57	1.35	1.28	0.31	0.80	0.34	0.53	0.44	0.85	0.84	0.85	20.59	7.41	14.00
38	56	1.43	1.84	1.64	1.12	0.33	0.73	0.26	0.80	0.53	0.84	0.79	0.82	24.00	7.69	15.85
39	63	2.40	2.36	2.38	1.06	0.40	0.73	0.18	0.81	0.50	0.75	0.71	0.73	26.92	12.77	19.85
40	70	3.07	2.64	2.86	1.16	0.41	0.79	0.46	0.56	0.51	0.99	0.91	0.95	36.67	13.56	25.12
41	77	2.83	2.24	2.54	1.03	0.64	0.84	0.43	1.01	0.72	1.13	1.30	1.22	32.43	11.48	21.96
42	84	2.47	1.68	2.08	0.72	0.16	0.44	0.41	0.41	0.41	0.81	0.61	0.71	28.13	9.52	18.83
43	91	1.67	2.04	1.86	0.55	0.19	0.37	0.29	0.37	0.33	0.64	0.39	0.52	20.00	12.75	16.38
44	98	1.33	1.76	1.55	0.32	0.16	0.24	0.05	0.19	0.12	0.49	0.24	0.37	17.95	14.81	16.38
45	105	0.67	1.70	1.19	0.09	0.07	0.08	0.00	0.07	0.04	0.18	0.16	0.17	15.18	11.11	13.15
	Mean	1.52	1.64	1.58	0.74	0.31	0.53	0.23	0.52	0.38	0.66	0.62	0.65	17.84	8.86	13.36
	SE	0.23	0.16	0.19	0.11	0.04	0.07	0.04	0.07	0.05	0.09	0.08	0.08	3.16	1.25	2.05

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(1st week of October, 2014). However, in *Kharif* 2015 population of *C. sexmaculata* was noticed in the field right from the first observation at 14 DAE and continued throughout the season with a range between 0.07 and 1.01 per plant. The initial peak population was recorded in 39th standard week (4th week of September, 2015) at 63 DAE with 0.81 beetles per plant and the subsequent peak was observed in 41st standard week (2nd week of October, 2015) with 1.01 beetles per plant. Pooled population ranged from 0.04 to 0.72 beetles per plant with peak incidence in 41st standard week (Table 1).

Population of *C. sexmaculata* was found from the first sampling date onwards, but their number was low (less than 0.2 per plant) early in the season during *Rabi* 2014-15. Predator density increased rapidly from 1st standard week (first week of January, 2015) onwards, with a peak population of 0.55 beetles/ plant recorded during 8th standard week (3rd week of February, 2015) *i.e.* 84 DAE. During *Rabi* 2015-16, a gradual increase in population of *C. sexmaculata* was observed from first week of observation *i.e.* 50th standard week (2nd week of December, 2015) to 3rd standard week (3rd week of January, 2016) and reached a peak population of 1.10 per plant during 4th standard week (4th week of January, 2016). Thereafter, the population showed a declining trend and reached to lowest by 11th standard week (2nd week of March, 2016) with 0.06 beetles per plant. The pooled abundance of *C. sexmaculata* population was varied from 0.14 to 0.78 beetles per plant with peak incidence on 4th standard week. Further, the population was highest during 1st to 3rd and 5th to 8th standard weeks compared to the rest of the standard weeks (Table 2).

Population fluctuation of Spiders

Spiders were widespread in maize experimental fields and occurred throughout the season. Identification up to genus level was done and altogether three spider species *viz.*, *Araneus* sp., *Neoscona* sp., and *Argiope* sp. were found in

maize ecosystem at the experimental site, *Araneus* sp. is the species being the most common. Although a large number of spider species were found at the study site, the numbers of each species were very low and hence they were recorded as single group. Average densities seldom surpassed 0.01 to 1.13 spiders per plant during *Kharif*, 2014 and maximum of 1.13 spiders per plant were found during 41st standard week (2nd week of October, 2014). The abundance of spiders increased in time during *Kharif* 2015 and ranged from 0.31 to 0.84 per plant in the vegetative, 0.79 to 1.30 in the reproductive and 0.16 to 0.61 in the mature plant growth stage with a peak activity of 1.30 per plant during 41st standard week (2nd week of October, 2015). Pooled mean population during *Kharif*, 2014 and *Kharif*, 2015 ranged from 0.16 to 1.22 spiders per plant with peak incidence on 41st standard week (Table 1).

Average abundance of spiders varied from 0.07 to 0.75 per plant, with a peak abundance during 7th standard week (2nd week of February, 2015) during *rabi* 2014-15. Spiders' abundance increased with time from 14 to 56 DAE during *rabi* 2015-16 and was highest (1.12 per plant) in the 4th standard week (4th week of January, 2016) during reproductive phase of the growing season when maize plants were at tasselling stage. In pooled analysis of *rabi* 2014-15 and 2015-16, spiders were active throughout the period, but peak activity was between 3rd to 7th standard weeks with a range of 0.71 to 0.89 per plant (Table 2).

Predator communities were characterized by a rich variety of species, but predator numbers were generally low. The impact of predators was difficult to estimate in the study. Only few stem borer eggs, larvae or pupae were visibly preyed upon, but predators may have had an impact by causing disappearance. Disappearance was not estimated in this study, but earlier workers showed that egg disappearance ranged from 5 to 22% (Bonhof, 2000). The disappearance of young larvae can mainly be

Table 2. Incidence of *C. partellus* and population of predators and parasitoid of *C. partellus* in maize during Rabi 2014-15 and 2015-16

Std. Met. Week	Days aftercrop emergence (DAE)	C. partellus larvae (Mean No. / plant)			Coccinella transversalis (Mean No. plant ⁻¹)			Chilomenus sexmaculata (Mean No. plant ⁻¹)			Spiders (Mean No. plant ⁻¹)			% Parasitism by Cotesia flavipes		
		Rabi 2014	Rabi 2015	Pooled	Rabi 2014	Rabi 2015	Pooled	Rabi 2014	Rabi 2015	Pooled	Rabi 2014	Rabi 2015	Pooled	Rabi 2014	Rabi 2015	Pooled
50	14	0.17	0.47	0.32	0.00	0.16	0.08	0.10	0.23	0.16	0.07	0.33	0.20	0.00	0.00	0.00
51	21	0.47	0.57	0.52	0.00	0.41	0.21	0.16	0.51	0.34	0.20	0.63	0.41	0.00	0.00	0.00
52	28	0.83	0.70	0.77	0.02	0.46	0.24	0.16	0.63	0.39	0.28	0.61	0.45	0.00	9.52	4.76
1	35	1.03	1.40	1.22	0.16	0.47	0.32	0.35	0.79	0.57	0.51	0.74	0.63	0.00	7.32	3.66
2	42	1.13	1.83	1.48	0.17	0.50	0.34	0.36	0.84	0.60	0.55	0.81	0.68	3.10	6.98	5.04
3	49	1.87	2.73	2.30	0.26	0.41	0.34	0.46	0.87	0.67	0.72	0.80	0.76	7.94	8.89	8.42
4	56	2.17	2.67	2.42	0.16	0.42	0.29	0.45	1.10	0.78	0.65	1.12	0.89	11.21	10.42	10.82
5	63	2.33	2.30	2.31	0.20	0.31	0.26	0.44	0.84	0.64	0.69	0.95	0.82	11.92	8.93	10.43
6	70	2.10	1.51	1.81	0.16	0.22	0.19	0.50	0.52	0.51	0.72	0.97	0.85	13.45	4.29	8.87
7	77	1.93	1.66	1.79	0.21	0.21	0.21	0.47	0.45	0.46	0.75	0.66	0.71	4.35	4.17	4.26
8	84	1.40	1.26	1.33	0.26	0.12	0.19	0.55	0.31	0.43	0.59	0.33	0.46	4.17	8.13	6.15
9	91	0.87	1.40	1.14	0.19	0.15	0.17	0.31	0.39	0.35	0.52	0.37	0.45	2.63	12.27	7.45
10	98	0.40	1.45	0.93	0.19	0.13	0.16	0.27	0.25	0.26	0.48	0.26	0.37	3.57	6.03	4.80
11	105	1.40	1.34	1.37	0.17	0.05	0.11	0.21	0.06	0.14	0.39	0.10	0.25	5.41	6.25	5.83
	Mean	1.29	1.52	1.41	0.15	0.29	0.22	0.34	0.56	0.45	0.51	0.62	0.57	4.84	6.66	5.75
	SE	0.19	0.19	0.18	0.02	0.04	0.02	0.04	0.08	0.05	0.06	0.08	0.06	1.24	0.96	0.89

Table 3. Correlation between larval population of *C. partellus* and parasitism (%) by *C. flavipes*

Correlation Parameters	Correlation coefficient (r) values					
	Kharif 2014	Kharif 2015	Pooled	Rabi 2014-15	Rabi 2015-16	Pooled
<i>C. partellus</i> larvae vs parasitism (%) by <i>C. flavipes</i>	0.907*	0.818*	0.940*	0.867*	0.568*	0.868*

* Significant at P < 0.05

Table 4. Multiple linear regression equations between larval population of *C. partellus* and parasitism (%) by *C. flavipes*

Year	Regression Equation	Standard Error	Coefficient of Determination (R ²)	t- value	f value
Kharif 2014	$0.338 + 0.065^*X_1$	0.394	0.813	7.182	51.60
Kharif 2015	$0.743 + 0.107^*X_1$	0.350	0.664	4.854	23.55
Pooled	$0.422 + 0.083^*X_1$	0.238	0.891	10.110	102.40
Rabi 2014-15	$0.658 + 0.134^*X_1$	0.378	0.746	5.883	34.63
Rabi 2015-16	$0.787 + 0.118^*X_1$	0.591	0.326	2.392	5.74
Pooled	$0.401 + 0.179^*X_1$	0.341	0.755	6.104	37.30

X₁- Parasitism (%) by *C. flavipes*

* = Significant at 5% level

attributed to dispersal, and subsequent mortality due to desiccation, predation or inability to find a host plant (Litsinger *et al.*, 1991). Disappearance of late instar larvae is largely associated with dispersal and predator activity and that of pupae with predator activity only (Bonhof, 2000).

Anecdotal observations and petri dish studies indicated that coccinellids, earwigs, anthocorids, lacewings and ants were predators of stem borer eggs. Spiders, earwigs, lacewings and ants were also observed preying on small larvae (Dwumfour *et al.*, 1991). Ants, earwigs and spiders have a high predation capacity (Bonhof, 2000) and are most important predator groups due to their abundance in maize fields. Yogeswari (2015) reported the abundance of two species of coccinellids *viz.*, *C.sexmaculata*, *Cycloneda sanguinea* and four species of spiders *viz.*, *Oxyopes* spp., *Argiope anasuja* (Thorell), *Chrysilla* sp., *Oxyopes salticus* in sorghum and maize agroecosystem. Ants and spiders colonize maize fields early in the season, so they may have an impact on stem borer populations when plants are in their most vulnerable stage. Spiders, which feed almost exclusively on insects, would have potential as biological control agents, but little attention has been given to their role as pest regulators. Laboratory studies indicated that many spiders readily prey on small larvae offered in petri dishes (Bonhof, 2000), and *Tibellus* sp. (Araneida: Philodromidae) also consumed eggs. Aphids (*Rhopalosiphum maidis* Fitch (Homoptera: Aphididae)) were common and present at the same time as eggs and small larvae of *C. partellus* in this study. The presence of alternative prey such as aphids may negatively influence predation of stem borers, especially when coccinellid predators prefer the more abundant and more accessible aphids than the more hidden eggs and small larvae of *C. partellus*.

Parasitism by *Cotesia flavipes*

Larval endoparasitoid, *C. flavipes* was more active (36.7% parasitization) during 40th standard

week followed by 41st standard week (32.4%) while no activity was noticed from 32nd to 34th standard weeks during *kharif*, 2014. However, in *kharif*, 2015 the maximum parasitic activity (14.8%) was noticed only in 44th standard week. In pooled analysis of *kharif* 2014 and 2015, *C. flavipes* activity was low in the beginning of crop season at 14 to 28 DAE. Thereafter the parasitism was found to be increased with a peak activity recorded during the first (40th standard week) and second (41st standard week) weeks of October (25.12 and 21.96%), respectively coinciding with peak larval population of the maize stem borer (Table 1).

Highest parasitization (13.5%) was recorded by the *C. flavipes* on *C. partellus* larvae during 6th standard week followed by 5th standard week (11.9%) in *Rabi* 2014-15 on maize crop. However, in *Rabi* 2015-16 season crop, peak parasitism of 10.4 per cent was recorded initially in 4th standard week and a second peak was observed during the third week of February, 2016 (12.3%) in 9th standard week. In the pooled analysis of both *Rabi* season study years, parasitization by *C. flavipes* was observed to be 10.8 and 10.4 per cent during 4th and 5th standard weeks (Table 2).

Stem borer populations are also determined by the mortality that occurs in the different life stages. In the study, parasitoids were also an important mortality factor of stem borer larval stages. The result of present study revealed that *C. partellus* population was relatively high in *Kharif* season than in *Rabi* season crops. Hence, the parasitism was found to be more in *Kharif* crop (25.1%) than *Rabi* season crop (10.8%) and kept the pest infestations under control which corroborates the findings with Jalali and Singh (2002) who reported that larval population and their natural enemies and pupal parasitism were significantly more in *Kharif*. Getu *et al.* (2003) reported high percentage of parasitism of stem borers by *C. flavipes* in eastern Ethiopia than other surveyed regions, and the parasitism was significantly high.

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In India, Marulasiddesha (1999) reported that the per cent parasitism of *C. flavipes* on the larvae of *C. partellus* is more in the month of October. Parasitization of *C. partellus* larvae by *C. flavipes* ranged from 2.0 to 33.2 at Hissar and most active during third week of August to the first week of September (Mohan *et al.*, 1991). Devi and Raj (1996) recorded 35 to 50 per cent parasitisation by *Cotesia* sp. on *C. partellus* larvae in maize ecosystem which emerged up to the second week of October. Duale and Nwanze (1997) also observed 13 per cent parasitism by *C. flavipes* on *C. partellus* larvae. Highest parasitism (33.33%) by *C. flavipes* was observed on *C. partellus* larvae in sweet sorghum (Deepthi, 2007). Divya *et al.* (2009) also recorded mean parasitisation of *C. partellus* larvae (29%) by *C. flavipes* during *Kharif* season sorghum which is in close agreement with present study. Patel and Purohit (2012) reported that in *Rabi* season stem borer was parasitized by *C. flavipes* from third week of November to fourth week of January with parasitism of 4.76 to 12.70 per cent. The larvae collected from infested maize plants when reared in laboratory, resulted in 5.0, 6.0, 23.0, 35.0 and 4.0 per cent parasitization by *C. flavipes* at Ludhiana, Karnal, Hyderabad, Delhi and Kolhapur, respectively. The incidence of *Cotesia* was found to be minimum (3.03%) at 30 Days after germination (DAG) crop while maximum larvae were found parasitized (18.42%) at 50 DAG of maize crop (Yadav, 2015).

Relationship between larval population of *C. partellus* and parasitism by *C. flavipes*

The results regarding correlation coefficients between larval population of *C. partellus* and parasitism by its larval endoparasitoid, *C. flavipes* on maize crop are shown in Table 3. *C. flavipes* showed positive and significant correlation with larval population of *C. partellus* during both study years of *kharif* 2014 ($r = 0.907$); *kharif* 2015 ($r = 0.818$) as well as on cumulative basis ($r = 0.940$) and *rabi* 2014-15 ($r = 0.867$), *rabi* 2015-16 ($r = 0.568$) and on

cumulative basis ($r = 0.868$). Patel *et al.* (2016) also reported that *C. flavipes* showed significant positive correlation with larval population of *C. partellus* in maize during *Kharif* 2007 and 2008 in Gujarat.

The impact of parasitoid, *C. flavipes* on the larvae of *C. partellus* by computing data into multiple linear regression equations is given in Table 4. The multiple linear regression equation for *Kharif* 2014 was $Y = 0.338 + 0.065 * X_1$, indicating every unit increase in *C. partellus* larval population increased *C. flavipes* parasitism by 0.065 per cent with the influence to the extent of 81.3 per cent ($R^2 = 0.813$). The multiple linear regression equation in *Kharif* 2015 was $Y = 0.743 + 0.107 * X_1$, indicating an unit increase in *C. partellus* larval population, *C. flavipes* parasitism increased by 0.107 per cent, with the significant influence to the extent of 66.4 per cent ($R^2 = 0.664$). The multiple linear regression equation for the pooled data (*Kharif* 2014 and 2015) was $Y = 0.422 + 0.083 * X_1$, which indicated an increase in *C. partellus* larval population, increased the *C. flavipes* parasitism by 0.083 per cent and the influence was to an extent of 89.1 per cent ($R^2 = 0.891$). During *Rabi* 2014-15, the impact of parasitoid, *C. flavipes* on the larvae of *C. partellus* could be explained by multiple linear regression equation $Y = 0.658 + 0.134 * X_1$, indicating every unit increase in *C. partellus* larval population increased *C. flavipes* parasitism by 0.134 per cent with the influence to the extent of 74.6 per cent ($R^2 = 0.746$). The variability in *C. partellus* larval population due to parasitoid, *C. flavipes* during *rabi* 2015-16 was best explained by multiple linear regression equation $Y = 0.787 + 0.118 * X_1$, indicating an unit increase in *C. partellus* larval population increased *C. flavipes* parasitism by 0.118 per cent, with the significant influence to the extent of 32.6 per cent ($R^2 = 0.326$). The multiple linear regression equation for the pooled data (*rabi* 2014-15 and 2015-16) was $Y = 0.401 + 0.179 * X_1$, which indicated an increase in *C. partellus* larval population, increased the *C. flavipes* parasitism by 0.179 per cent and the

influence was to an extent of 75.5 per cent ($R^2 = 0.755$).

CONCLUSION

The study revealed the presence of diversified predatory and parasitoid species associated with maize crop. These natural enemies manifested variable seasonality trends which seem to be connected with their preferable life stages of *C. partellus* abundance on the crop. The dominant occurrence of *C. flavipes* all the year round may suggest its potential role in combating *C. partellus*, and invites additional studies on this species to be exploited in proper way.

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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON NITROGEN UPTAKE IN RICE-NO TILL JOWAR CROPPING SEQUENCE

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Date of Receipt: 16.12.2017

Date of Acceptance: 19.01.2018

ABSTRACT

The experiment was conducted during *Rabi* for two consecutive years (2015-2016 and 2016-2017) on sandy clay loam soils. The treatments consisted of different combinations of nitrogen during *kharif* preceding rice crop and three nitrogen levels applied during *rabi* no till jowar crop. The experiment was laid out in a split plot design with thirteen main plots (preceding *kharif* rice) split into three sub plots (*rabi* no till jowar), thus, total 39 treatments and replicated thrice. Results indicated that all the characters studied were significantly higher with application of 100% RDN through inorganic fertilizer (T_1) during *kharif* and 100% N level applied during *rabi* however it was on a par with that of application of 50% RDN+ 50 % Green manure (T_{12}), 50% RDN + 50% Poultry manure (T_6) and 100 % N level during *rabi* in both the years of study.

INTRODUCTION

Jowar (*Sorghum bicolor* L. Moench) is traditionally grown as food crop in semi-arid tropics of India which occupies an area of 6.07 M ha with a productivity of 697 kg ha⁻¹ and a total production of 4.23 Mt (CMIE, 2016). In Andhra Pradesh, jowar is grown in an area of 1.74 M ha with annual production of 3.57 M t and productivity of 2051 kg ha⁻¹ (CMIE, 2016). In Krishna agroclimatic zone of Andhra Pradesh, it is emerging as a potential alternate feed, fodder and bio-energy crop. Further, its tolerance to high temperature and drought makes it suitable for dry climatic condition. Previously, rice is succeeded by blackgram which is slowly replaced by either jowar or maize due to severe Yellow Mosaic Virus infestation to blackgram. Hence, farmers of this region are showing interest in jowar in view of its low water requirement and withstands to harsh climatic conditions. It is grown under rice-fallows covering an area of 21,000 ha and yields 6.8 t ha⁻¹ under zero till conditions (Mishra *et al.*, 2011). Zero tillage or reduced tillage is being followed widely for many crops around the world and this technology has potential to allow saving time, energy, water and labour in crop establishment (Piggin *et al.*, 2002). A no-till system is a soil management technique that reduces soil

disturbance, increases soil organic matter accumulation and can also increase crop yield (Bayer *et al.*, 2000).

MATERIAL AND METHODS

The experiment was conducted at Agricultural College Farm, Bapatla which is situated at 15° 54' N latitude and 80° 25' E longitude, at an altitude of 5.49 m above the MSL and is about 8 km away from the Bay of Bengal. The chemical analysis of soil showed that the soil is sandy clay loam in texture and is low in available N, medium in P and high in Organic Carbon and K. Average maximum and minimum temperatures were 33.0°C and 22.1°C during 2015-16 and 33.2°C and 22.8°C during 2016-17, respectively. The weekly mean relative humidity ranged from 71.1% to 82.9% during 2015-16 and 69.5% to 79.3% during 2016-17, while the average relative humidity was 75.9% and 74.6% during 2015-16 and 2016-17, respectively. The crop was irrigated as and when required. Overall, the weather conditions prevailed during the growth period was normal and congenial for optimum performance of sorghum crop.

The experiment was laid out during *Rabi* 2015-16 and 2016-17 in split plot design with 13 main treatments of different combinations of nitrogen during

kharif in a randomized block design and replicated thrice (T_1 : 100% RDN; T_2 : 75% RDN + 25% Farmyard manure; T_3 : 50% RDN + 50% Farmyard manure; T_4 : 25% RDN + 75% Farmyard manure; T_5 : 75% RDN + 25% Poultry manure; T_6 : 50% RDN + 50% Poultry manure; T_7 : 25% RDN + 75% Poultry manure; T_8 : 75% RDN + 25% Vermicompost; T_9 : 50% RDN + 50% Vermicompost; T_{10} : 25% RDN + 75% Vermicompost; T_{11} : 75% RDN + 25% Green manure; T_{12} : 50% RDN + 50% Green manure and T_{13} : 25% RDN + 75% Green manure) and three nitrogen levels applied during *rabi* no till jowar crop (0% N, 50% N and 100% N). Recommended dose of Nitrogen (RDN) i.e. the inorganic nitrogen 120 kg N ha⁻¹ was applied through urea, one-third as basal at the time of sowing, remaining N is applied in two equal splits at active tillering and panicle initiation stages. The experiment was repeated during 2nd year (2016-17) in another field.

After harvesting the rice crop, next day bunds formation was done according to the *rabi* layout plan. Sowing of jowar was done manually by using a seed rate of 10 kg ha⁻¹ and adopting a spacing of 45 cm x 15 cm. Good and healthy seeds were hand dibbled into the soil at a depth of 2 cm- 3 cm to obtain optimum planting density. Nitrogen (100 kg ha⁻¹) was applied in the form of urea (46% N) in two equal splits i.e., ½ at 10 DAS and remaining ½ at 30 days after first application as per the treatments. Entire dose of phosphorus (60 kg ha⁻¹) was applied in form of Single Super Phosphate (16% P₂O₅) and 40 kg K₂O ha⁻¹ was applied in the form of Murate of Potash (60% K₂O), at the time of 1st split application of urea. To maintain optimum plant population, gap filling was done at 10 days after sowing (DAS) and thinning was done at 15 DAS. Timely weed control, irrigation and plant protection measures were taken up. The data on growth and yield attributes, grain and stover yield and nutrient uptake was analysed by adopting standard procedures.

RESULT AND DISCUSSION

Grain yield and Straw yield

Progressive and significant increase in grain yield (Table 1) was observed with each successive increment in nitrogen levels. Application of 100% N level significantly enhanced the grain yield (3082 kg ha⁻¹, 3251 kg ha⁻¹) over rest of the nitrogen levels (0% and 50%) in two successive years of study and pooled data analysis, as it might have promoted the growth of roots as well as functional activity resulting in higher extraction of nutrients from soil environment to aerial plant parts. The improvement in yield attributes with N consequently resulted in higher grain yield. The yield could be as a result of good dry matter production for grain filling as a result of greater number of leaves. These results are in agreement with the findings of and Sareen and Sharma (2010) who also reported similar increase in growth and yield of sorghum with increased nitrogen level. Increased stover yield was observed with increasing levels of N, in both the years of experiment. Application of 100% N level (Table 2) significantly enhanced the stover yield (7293 kg ha⁻¹, 7645 kg ha⁻¹) over rest of the nitrogen levels (0% and 50%). This could be ascribed to its positive influence on both vegetative and reproductive growth of the crop which lead to increase in stover yield. Similar findings of response in rice fallow sorghum to higher nitrogen levels were reported by Sareen and Sharma (2010).

Nitrogen Uptake

During both the years of study and pooled analysis, nitrogen (Table 3 and Table 4) uptake by no- till jowar followed the same trend as that of grain yield and significantly influenced by nitrogen sources and nitrogen levels during both the years of study, but there is a non- significant interaction.

Total nitrogen uptake by the crop recorded the maximum content under 100% RDN (T_1), which was statistically on a par with 50% RDN+50% GM

Table 2. Stover yield (kg ha⁻¹) of no till jowar as influenced by residual effect of nitrogen sources imposed to kharif rice in combination with nitrogen levels applied to rabi jowar

Nitrogen sources	2015-16			Mean	2016-17			Mean	Pooled data			Pooled Mean
	Nitrogen level (kg N ha ⁻¹)				Nitrogen level (kg N ha ⁻¹)				Pooled data			
	0%	50%	100%		0%	50%	100%		0%	50%	100%	
T₁:100% RDN	6337	7353	8189	7293	6804	7668	8464	7645	6571	7511	8327	7469
T₂:75% RDN+25% FYM	6077	6968	7942	6996	6310	7161	8148	7206	6194	7065	8045	7101
T₃:50% RDN+50% FYM	6118	7133	7901	7051	6351	7215	8121	7229	6235	7174	8011	7140
T₄:25% RDN+75% FYM	5926	7023	7984	6978	6173	7023	8038	7078	6050	7023	8011	7028
T₅:75% RDN+25% PM	6296	6941	7846	7028	6255	7394	8189	7279	6276	7168	8018	7154
T₆:50% RDN+50% PM	6228	7188	8052	7156	6667	7517	8313	7499	6448	7353	8183	7328
T₇:25% RDN+75% PM	6228	7147	7942	7106	6365	7353	8189	7302	6297	7250	8066	7204
T₈:75% RDN+25% VC	6214	7257	7984	7151	6283	7449	8272	7334	6249	7353	8128	7243
T₉:50% RDN+50% VC	6091	7078	7956	7042	6365	7435	8134	7311	6228	7257	8045	7177
T₁₀:25% RDN+75% VC	6159	6831	7929	6973	6241	7119	8066	7142	6200	6975	7998	7058
T₁₁:75% RDN+25% GM	6145	6914	7956	7005	6324	7366	8231	7307	6235	7140	8094	7156
T₁₂:50% RDN+50% GM	6228	7421	8011	7220	6667	7613	8368	7549	6448	7517	8190	7385
T₁₃:25% RDN+75% GM	6063	6872	7970	6968	6447	7380	8148	7325	6255	7126	8059	7147
Mean	6162	7087	7974		6404	7361	8206		6283	7224	8090	
		CD				CD				CD		
		(P_≤0.05)	CV (%)			(P_≤0.05)	CV (%)			(P_≤0.05)	CV (%)	
Treatments (T)		139	10.6		154	2.7			146.5	6.65		
N levels (N)		158	5.3		57	3.9			107.5	4.6		

RDN: Recommended dose of Nitrogen; **FYM**: Farmyard Manure; **PM**: Poultry manure **VC**: Vermicompost; **GM**: Green manure

Table 3. Nitrogen uptake (kg ha⁻¹) by grain of no till jowar at harvest as influenced by residual effect of nitrogen sources imposed to *khari* rice in combination with nitrogen levels applied to *rabi* jowar

Nitrogen sources	2015-16			2016-17			Mean	Pooled data			Pooled Mean	
	Nitrogen level (kg N ha ⁻¹)			Nitrogen level (kg N ha ⁻¹)				Mean	Pooled data			
	0%	50%	100%	0%	50%	100%			0%	50%		100%
T ₁ :100% RDN	32.3	41.9	53.2	33.1	44.7	60.4	46.1	32.7	43.3	56.8	44.3	
T ₂ :75% RDN+25% FYM	29.6	36.5	42.7	28.7	37.0	49.4	38.4	29.2	36.8	46.1	37.4	
T ₃ :50% RDN+50% FYM	29.0	36.3	45.0	29.3	37.3	47.4	38.0	29.2	36.8	46.2	37.4	
T ₄ :25% RDN+75% FYM	28.5	32.4	41.0	27.8	35.2	44.5	35.9	28.2	33.8	42.8	35.0	
T ₅ :75% RDN+25% PM	27.0	34.7	44.0	27.5	37.3	47.6	37.5	27.3	36.0	45.8	36.4	
T ₆ :50% RDN+50% PM	31.1	40.7	52.2	32.9	43.3	59.4	45.2	32.0	42.0	55.8	43.3	
T ₇ :25% RDN+75% PM	27.8	35.4	43.4	29.5	38.9	49.0	39.1	28.7	37.2	46.2	37.4	
T ₈ :75% RDN+25% VC	27.3	34.3	43.7	28.9	39.6	47.9	38.8	28.1	37.0	45.8	37.0	
T ₉ :50% RDN+50% VC	27.9	35.2	45.3	29.7	37.5	50.3	39.2	28.8	36.4	47.8	37.7	
T ₁₀ :25% RDN+75% VC	28.9	30.9	42.7	29.4	35.1	44.6	36.4	29.2	33.0	43.7	35.3	
T ₁₁ :75% RDN+25% GM	28.8	32.2	45.7	30.8	38.6	50.8	40.0	29.8	35.4	48.3	37.8	
T ₁₂ :50% RDN+50% GM	32.0	39.9	51.4	33.4	42.9	59.0	45.1	32.7	41.4	55.2	43.1	
T ₁₃ :25% RDN+75% GM	29.0	33.9	46.0	28.5	38.4	51.3	39.4	28.8	36.2	48.7	37.9	
Mean	29.2	35.7	45.9	30.0	38.9	50.9		29.6	37.3	48.4		
Treatments (T)	CD (P≤0.05)			CD (P≤0.05)			CD (P≤0.05)			CD (P≤0.05)		
N levels (N)	3.2			2.2			2.2			2.7		
	6.3			7.3			7.3			6.8		
N levels (N)	8.5			10.2			10.2			9.35		
	9.8			5.3			5.3			7.55		

RDN: Recommended dose of Nitrogen; FYM: Farmyard Manure; PM: Poultry manure VC: Vermicompost; GM: Green manure

Table 4. Nitrogen uptake (kg ha⁻¹) by stover of no till jowar at harvest as influenced by residual effect of nitrogen sources imposed to *kharif* rice in combination with nitrogen levels applied to *rabi* jowar

Nitrogen sources	2015-16			2016-17			Mean	Pooled data			Pooled Mean	
	Nitrogen level (kg N ha ⁻¹)			Nitrogen level (kg N ha ⁻¹)				Mean	Pooled data			
	0%	50%	100%	0%	50%	100%			0%	50%		100%
T ₁ :100% RDN	19.0	26.4	35.4	22.0	30.8	38.5	30.4	20.5	28.6	37.0	28.7	
T ₂ :75% RDN+25% FYM	14.2	22.2	32.6	15.8	24.2	35.4	25.1	15.0	23.2	34.0	24.1	
T ₃ :50% RDN+50% FYM	14.9	21.3	32.0	16.2	23.1	34.8	24.7	15.6	22.2	33.4	23.7	
T ₄ :25% RDN+75% FYM	12.7	18.8	29.0	14.7	20.1	31.1	22.0	13.7	19.5	30.1	21.1	
T ₅ :75% RDN+25% PM	15.8	21.7	29.0	16.1	24.3	32.7	24.4	16.0	23.0	30.9	23.3	
T ₆ :50% RDN+50% PM	18.1	25.0	34.0	20.0	27.1	36.9	28.0	19.1	26.1	35.5	26.9	
T ₇ :25% RDN+75% PM	16.5	22.8	27.1	18.2	24.8	33.2	25.4	17.4	23.8	30.2	23.8	
T ₈ :75% RDN+25% VC	17.2	21.3	27.3	17.7	24.3	33.0	25.0	17.5	22.8	30.2	23.5	
T ₉ :50% RDN+50% VC	15.7	22.0	30.2	17.3	24.7	32.7	24.9	16.5	23.4	31.5	23.8	
T ₁₀ :25% RDN+75% VC	13.5	19.8	29.6	14.9	21.7	31.9	22.8	14.2	20.8	30.8	21.9	
T ₁₁ :75% RDN+25% GM	15.4	22.9	29.5	17.3	25.7	33.5	25.5	16.4	24.3	31.5	24.1	
T ₁₂ :50% RDN+50% GM	18.3	26.9	34.9	19.5	28.9	38.4	28.9	18.9	27.9	36.7	27.8	
T ₁₃ :25% RDN+75% GM	14.4	21.1	29.7	16.8	23.7	32.6	24.4	15.6	22.4	31.2	23.1	
Mean	15.8	22.5	30.8	17.4	24.9	34.2		16.6	23.7	32.5		
Treatments (T)	CD (P _≤ 0.05)			CD (P _≤ 0.05)			CD (P _≤ 0.05)			CD (P _≤ 0.05)		
	2.9			2.3			2.3			2.65		
	4.6			8.3			8.3			6.45		
N levels (N)	6.1			6.9			6.7			6.50		
	12.1			6.7			6.7			9.40		

RDN: Recommended dose of Nitrogen; FYM: Farmyard Manure; PM: Poultry manure VC: Vermicompost; GM: Green manure

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(T₁₂) and 50% RDN+50% PM (T₆), which might be due to production of higher stover yield and higher nutrient availability, residual effect of green manure and poultry manure during the next season. The lowest N uptake was noticed in treatments 25% RDN+75% FYM (T₄) and 25% RDN+75% VC (T₁₀). Nitrogen uptake of a crop is the total of nitrogen absorbed by grain and stover, which has increased with the age of the crop. The higher uptake at harvest even with lower concentration of nitrogen in plants was due to the substantial increase in biomass production. Adeniyane *et al.* (2011) reported that addition of manures reduced the loss of nitrates through leaching from the soil by providing a significant amount of plant nutrients which created a balancing effect on the supply of nitrogen.

Higher biomass production might be the most pertinent reason for the higher uptake of nutrients in the treatments which received higher levels of nitrogen. From 30 DAS, 60 DAS, 90 DAS and at harvest (grain + straw), the highest nitrogen uptake was recorded with the application of highest level 100% N, which was significantly higher than that of 0% N and 50 % N level. These results are in close conformity with the findings of Balasubramanian and Ramamoorthy (1996) who noticed in sweet sorghum that with increase in nitrogen level from 0 kg N ha⁻¹ to 120 kg N ha⁻¹, grain yield and nitrogen uptake had increased and the highest grain yield (3441 kg ha⁻¹) was recorded at 120 kg N ha⁻¹ and Pushpendra Singh *et al.* (2012) observed that the Maximum grain yield (3915 kg ha⁻¹), straw yield (12,922 kg ha⁻¹), biological yield (16,837 kg ha⁻¹) and nitrogen uptake(89.3 kg ha⁻¹) of sorghum were recorded with the application of 120 kg N ha⁻¹ compared to lower levels (40 kg N ha⁻¹ and 80 kg N ha⁻¹). Increased availability of nutrients along with drymatter might be the most pertinent reason for the increased uptake of nutrients in the treatments with high levels of nitrogen. The inorganic nitrogen not only provides an immediate source of N

for plant growth but also enhances the mineralization of applied as well as native organic matter by meeting the N requirement of the decomposers. The results of the experiment support the findings of Jat *et al.* (2013) who reported that highest grain yield (4.18 t ha⁻¹) and stover yield (14.74 t ha⁻¹) and nitrogen uptake (73.3 kg ha⁻¹) was recorded by the treatment that received, 100% NPK.

CONCLUSION

Overall, the field studies conducted for two consecutive years clearly indicated that the application of 100% RDN through inorganic fertilizer was remained on par with combined application of inorganic and organic sources *i.e.* green manure and poultry manure (@ 50% each) and these treatments had a significant influence in increasing productivity, profitability and high nutrient uptake in rice - no till jowar sequence.

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CHARACTER ASSOCIATION AND PATH ANALYSIS FOR YIELD ATTRIBUTES IN PIGEONPEA (*Cajanus cajan* (L.) Millsp.)

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Date of Receipt: 03.01.2018

Date of Acceptance:02.02.2018

ABSTRACT

Character associations and path coefficients among 47 pigeonpea genotypes were studied during *kharif*, 2013 for seed yield and yield components. The results revealed that phenotypic and genotypic correlations are in similar direction and significant. Seed yield plant⁻¹ was observed to be significantly and positively associated with days to maturity, plant height, no. of primary branches plant⁻¹, no. of secondary branches plant⁻¹ and no. of pods plant⁻¹. The studies on path coefficients revealed high and positive direct effects of no. of pods plant⁻¹, no. of secondary branches plant⁻¹ and no. of primary branches plant⁻¹ at both phenotypic and genotypic levels on seed yield, indicating the importance of direct selection for these traits in pigeonpea yield improvement programmes.

INTRODUCTION

Pigeonpea [*Cajanus cajan* (L.) Millsp.] is an important protein (20% - 22%) food legume of rainfed tropics and sub-tropics. In India, pigeonpea is second most important pulse crop. Pigeonpea has recorded a considerable increase in area and production, however, the crop productivity (average crop productivity of 780 kg ha⁻¹) needs further improvement (Varshney *et al.*, 2010). Improvement over existing varieties is a continuous process and the increase in yield potential is the basic criteria in any crop improvement programme. Generally, direct selection for yield is not aimed at, as it is a complex and quantitatively inherited character, highly influenced by environment. As such, high genotypic and environmental interactions are likely to restrict the improvement, if selection is based on yield as a simple trait. Therefore, correlation between seed yield and yield components are of considerable importance in selection programmes (Gangadhar, 2013). Path coefficient analysis provides an effective means of partitioning the correlation into direct and indirect effects (Renukadevi and Subbalakshmi, 2006). Correlation and path analysis thus help in identifying suitable selection criteria for improving the yield. The study was undertaken in this context to elucidate

information on character association and path coefficient for seed yield and yield components in pigeonpea.

MATERIAL AND METHODS

The study was conducted during *kharif*, 2013 at Agricultural College Farm, Mahanandi which falls under the Scarce Rainfall Agro-Climatic Zone of Andhra Pradesh situated at 15° 51' N latitude, 78° 61' E longitude and altitude of 233.48m above MSL. Experimental material for present investigation was comprised of 47 pigeonpea genotypes involving 22 B-lines and 25 R-lines obtained from International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru. The genotypes were evaluated in a randomized complete block design with two replications. Each genotype was raised in four-row plots of three m length with a spacing of 120 cm x 30 cm. Border rows were also planted around the entries to increase the precision of study and reduce border effect. All recommended package of practices were followed for raising a healthy crop (ANGRAU, 2012). Observations were recorded on five randomly selected plants in each replication for seed yield and yield components *viz.*, plant height, no. of primary branches plant⁻¹, no. of secondary

branches plant⁻¹, no. of pods plant⁻¹, no. of seeds pod⁻¹. Days to 50% flowering, days to maturity and 100-seed weight were recorded on plot basis. The mean values were subjected to correlation analysis and path analysis (Dewey and Lu, 1959).

RESULTS AND DISCUSSION

Correlations and path co-efficient analysis provide a realistic basis for allocation of weightage to each of the contributing characters in deciding upon a suitable selection criterion for genetic improvement of complex characters like yield. Hence, these parameters were studied in the investigation to assess the relationships among seed yield and its components for enhancing the usefulness of selection. The results obtained on character associations for yield and yield components are presented in Table 1. A perusal of the results revealed phenotypic and genotypic correlations to be in similar direction and significant in general. Further, the genotypic correlations were noticed to be in general higher than phenotypic correlation values for almost all the characters, indicating the strong association at genetic level and less influence by environment.

Seed yield plant⁻¹ was observed to be significantly and positively associated with days to maturity ($r_p=0.2353^*$ and $r_g=0.2827$), plant height ($r_p=0.5069^{**}$ and $r_g=0.5646$), number of primary branches plant⁻¹ ($r_p=0.5366^{**}$ and $r_g=0.5795$), number of secondary branches plant⁻¹ ($r_p=0.6238^{**}$ and $r_g=0.6627$) and number of pods plant⁻¹ ($r_p=0.7032^{**}$ and $r_g=0.7097$) indicating their importance as selection criteria in pigeonpea yield improvement programmes. The findings are in conformity with the reports of Techale *et al.* (2013) for seed yield plant⁻¹ with days to 50 per cent flowering, days to maturity, pods plant⁻¹, plant height; and Bhadru (2010) for seed yield plant⁻¹ with no. of primary branches plant⁻¹ and number of secondary branches plant⁻¹. Association of seed yield per plant with other characters, namely, days to 50 per cent flowering ($r_p=-0.0300$ and $r_g=-0.0282$), number of seeds per pod ($r_p=0.1144$ and

$r_g=0.1015$) and 100-seed weight ($r_p=-0.1210$ and $r_g=-0.1504$) was non-significant in the present study. These findings are in conformity with the reports of Sidhu *et al.* (1985) for days to 50 per cent flowering; Balyan and Sudhakar (1985) for number of seeds pod⁻¹; and Srinivas *et al.* (1999) for 100 seed weight. Studies on character associations among the yield components revealed significant and positive association of days to 50 per cent flowering with days to maturity ($r_p=0.5999^{**}$ and $r_g=0.6354$), plant height ($r_p=0.3367^{**}$ and $r_g=0.3891$), number of primary branches plant⁻¹ ($r_p=0.2931^{**}$ and $r_g=0.3099$) and number of secondary branches plant⁻¹ ($r_p=0.2477^{**}$ and $r_g=0.2784$); days to maturity with plant height ($r_p=0.4235^{**}$ and $r_g=0.4413$), number of primary branches plant⁻¹ ($r_p=0.5248^{**}$ and $r_g=0.5559$), number of secondary branches per plant ($r_p=0.5019^{**}$; $r_g=0.5442$) and number of pods plant⁻¹ ($r_p=0.3316^{**}$ and $r_g=0.3588$); plant height with number of primary branches plant⁻¹ ($r_p=0.5766^{**}$ and $r_g=0.5852$), number of secondary branches plant⁻¹ ($r_p=0.5732^{**}$ and $r_g=0.6076$) and number of pods plant⁻¹ ($r_p=0.6536^{**}$ and $r_g=0.6778$); number of primary branches plant⁻¹ with number of secondary branches plant⁻¹ ($r_p=0.7859^{**}$ and $r_g=0.8062$) and number of pods plant⁻¹ ($r_p=0.6097^{**}$ and $r_g=0.6362$); number of secondary branches plant⁻¹ with no. of pods plant⁻¹ ($r_p=0.6832^{**}$ and $r_g=0.7085$); and number of seeds pod⁻¹ with 100 seed weight ($r_p=0.5467^{**}$ and $r_g=0.5854$) indicating the possibility of simultaneous improvement of these characters through selection. However, negative inter-character associations was observed for number of primary branches with 100 seed weight ($r_p=-0.2082^*$ and $r_g=-0.2170$); and number of pods plant⁻¹ with 100 seed weight ($r_p=-0.3727^{**}$ and $r_g=-0.3979$), indicating competition for a common possibility, such as nutrient supply and the need for balanced selection, while attempting for improvement of these traits. These results are also in conformity with the findings of Salunke *et al.* (1995) for days to 50 per cent flowering with number of secondary branches plant⁻¹; Rama Devi (2012) for

Table 1 . Phenotypic and genotypic correlations for yield and yield components in pigeonpea

Character	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches plant ⁻¹	No. of secondary branches plant ⁻¹	No. of pods plant ⁻¹	No. of seeds pod ⁻¹	100 seed weight (g)
Days to 50 % flowering	0.5999** (0.6354)	0.3367** (0.3891)	0.2931** (0.3099)	0.2477* (0.2784)	0.0342 (0.0574)	0.1864 (0.2180)	0.1525 (0.1338)	-0.0300 (-0.0282)
Days to maturity		0.4235** (0.4413)	0.5248** (0.5559)	0.5019** (0.5442)	0.3316** (0.3588)	-0.1225 (-0.1280)	0.0111 (0.0103)	0.2353* (0.2827)
Plant height (cm)			0.5766** (0.5852)	0.5732** (0.6076)	0.6536** (0.6772)	0.1878 (0.1834)	-0.0622 (-0.0627)	0.5069** (0.5646)
No. of primary branches plant ⁻¹				0.7859** (0.8062)	0.6097** (0.6362)	-0.1817 (-0.2171)	-0.2082* (-0.2170)	0.5366** (0.5795)
No. of secondary branches plant ⁻¹					0.6832** (0.7085)	-0.1706 (-0.2030)	-0.1798 (-0.2073)	0.6238** (0.6627)
No. of pods plant ⁻¹						-0.1297 (-0.1508)	-0.3727** (-0.3979)	0.7032** (0.7097)
No. of seeds pod ⁻¹							0.5467** (0.5854)	0.1144 (0.1015)
100 seed weight (g)								-0.1210 (-0.1504)

* and ** Significant at 0.05 and 0.01 levels, respectively; Values in parentheses are genotypic correlations

days to 50 per cent flowering with plant height; Mahajan *et al.* (2007) for days to 50 per cent flowering with primary branches plant⁻¹; and Techale *et al.* (2013) for days to 50 per cent flowering with days to maturity; and days to maturity with plant height, number of primary branches plant⁻¹, number of secondary branches plant⁻¹ and no. of pods plant⁻¹; in addition to plant height with primary branches plant⁻¹, number of secondary branches plant⁻¹ and number of pods plant⁻¹; Salunke *et al.* (1995) for number of primary branches plant⁻¹ with number of secondary branches plant⁻¹, and number of pods plant⁻¹; Bhadru (2010) for number of secondary branches plant⁻¹ with number of pods plant⁻¹; and Sodavadiya *et al.* (2009) for number of seeds per pod⁻¹ with 100 seed weight.

The Association of a character with yield or any other dependent variable may be found through the study of genetic correlations. Path coefficient partitions the correlation into direct and indirect effects. Hence, phenotypic and genotypic direct and indirect effects of yield components on seed yield plant⁻¹ for 47 pigeonpea genotypes in the investigation are arrived (Table 2). A perusal of the results revealed genotypic and phenotypic path coefficients are in similar direction and magnitude in general. Further, the genotypic path co-efficients were observed to be of higher magnitude, compared to phenotypic path co-efficients. The results also revealed high residual effect for both phenotypic (0.6097) and genotypic (0.5499) path co-efficients respectively indicating that variables studied in the present investigation explained only about 40 (phenotypic) and 45 (genotypic) per cent of the variability in yield and therefore, other attributes besides the characters studied are contributing for seed yield plant⁻¹. A detailed analysis of the direct and indirect effects also revealed high positive direct effect of number of pods plant⁻¹ ($P_p = 0.4875$ and $P_g = 0.2846$) followed by number of secondary branches

plant⁻¹ ($P_p = 0.3115$ and $P_g = 0.3938$) and number of primary branches plant⁻¹ ($P_p = 0.1324$ and $P_g = 0.152$). These traits, with the exception of number of seeds per pod had also exhibited highly significant and positive associations (0.7032^{**} and $r_g = 0.7097$; $r_p = 0.6238^{**}$ and $rg = 0.6627$; and $rp = 0.5366^{**}$ and $rg = 0.5795$, respectively) with seed yield plant⁻¹. These results are in conformity with the findings of Sreelakshmi *et al.* (2011) for no. of pods plant⁻¹ and no. of secondary branches plant⁻¹ and Techale *et al.* (2013) for number of seeds pod⁻¹. High direct effects of these traits therefore appeared to be the main factor for their strong association with seed yield per plant. Hence, these traits should be considered as important selection criteria in all improvement programmes and direct selection for these traits is recommended for yield improvement in pigeonpea.

High positive direct effect for number of seeds pod⁻¹ ($P_p = 0.3182$ and $P_g = 0.4367$) was also recorded in the investigation. However, its association with seed yield plant⁻¹ was noticed to be non-significant (0.1144 and $r_g = 0.1015$), indicating the need for adoption of restricted simultaneous selection model to nullify the undesirable indirect effects and make use of the direct effect. Negligible direct effects on seed yield plant⁻¹ were recorded by days to maturity ($P_p = 0.0562$ and $P_g = 0.1835$) and plant height ($P_p = -0.0722$ and $P_g = 0.0328$). However, their association with seed yield plant⁻¹ was observed to be significant and positive ($r_p = 0.2353^*$ and $r_g = 0.2827$; $r_p = 0.5069^{**}$ and $r_g = 0.5646$, respectively) indicating a major role of indirect effects. In addition, days to 50 per cent flowering ($P_p = -0.2314$ and $P_g = -0.4104$) had recorded more negative direct effects on seed yield plant⁻¹. Association of this trait with seed yield plant⁻¹ was however, non-significant indicating the influence of indirect effects of this trait, mostly through days to maturity on seed yield plant⁻¹. These results are in broad agreement with the findings of Bhadru (2010)

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Table 2. Phenotypic and genotypic path coefficients for yield and yield components in pigeonpea

Character	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of primary branches plant ⁻¹	No. of secondary branches plant ⁻¹	No. of pods plant ⁻¹	No. of seeds pod ⁻¹	100 seed weight (g)	Seed yield plant ⁻¹ (g)
Days to 50% flowering	-0.2314 (-0.4104)	-0.1388 (-0.2608)	-0.0779 (-0.1597)	-0.0678 (-0.1272)	-0.0573 (-0.1143)	-0.0079 (-0.0235)	-0.0431 (-0.0895)	-0.0353 (-0.0549)	-0.0300 (-0.0282)
Days to maturity	0.0337 (0.1166)	0.0562 (0.1835)	0.0238 (0.0810)	0.0295 (0.1020)	0.0282 (0.0998)	0.0186 (0.0658)	-0.0069 (-0.0235)	0.0006 (0.0019)	0.2353* (0.2827*)
Plant height (cm)	-0.0243 (0.0128)	-0.0306 (0.0145)	-0.0722 (0.0328)	-0.0416 (0.0192)	-0.0414 (0.0199)	-0.0472 (0.0222)	-0.0136 (0.0060)	0.0045 (-0.0021)	0.5069** (0.5646**)
No. of primary branches plant ⁻¹	0.0388 (0.0481)	0.0695 (0.0863)	0.0764 (0.0908)	0.1324 (0.1552)	0.1041 (0.1251)	0.0807 (0.0987)	-0.0241 (-0.0337)	-0.0276 (-0.0337)	0.5366** (0.5795**)
No. of secondary branches plant ⁻¹	0.0772 (0.1096)	0.1563 (0.2143)	0.1786 (0.2392)	0.2448 (0.3175)	0.3115 (0.3938)	0.2128 (0.2790)	-0.0531 (-0.0799)	-0.0560 (-0.0816)	0.6238** (0.6627**)
No. of pods plant ⁻¹	0.0167 (0.0163)	0.1617 (0.1021)	0.3186 (0.1928)	0.2972 (0.1811)	0.3331 (0.2017)	0.4875 (0.2846)	-0.0632 (-0.0429)	-0.1817 (-0.1133)	0.7032** (0.7097**)
No. of seeds pod ⁻¹	0.0593 (0.0952)	-0.0390 (-0.0559)	0.0597 (0.0801)	-0.0578 (-0.0948)	-0.0543 (-0.0887)	-0.0413 (-0.0659)	0.3182 (0.4367)	0.1739 (0.2556)	0.1144 (0.1015)
100 seed weight (g)	0.0001 (-0.0164)	0.0000 (-0.0013)	0.0000 (0.0077)	-0.0001 (0.0266)	-0.0001 (0.0254)	-0.0002 (0.0487)	0.0003 (-0.0717)	0.0005 (-0.1224)	-0.1210 (-0.1504)

* and ** Significant at 0.05 and 0.01 levels, respectively; Residual effect= 0.6097 (Phenotypic) and 0.5499 (Genotypic); Diagonal values= direct effects; Off-diagonal values= indirect effects; Values in parantheses are genotypic effects

and Sreelakshmi *et al.* (2011) who reported that maximum direct effects on seed yield was exhibited by no. of primary branches plant⁻¹, days to 50% flowering and no. of pods plant⁻¹.

CONCLUSION

The study revealed that direct selection for no. of pods plant⁻¹ and number of branches plant⁻¹ is effective for yield improvement in pigeonpea.

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NUTRIENT UPTAKE AND ECONOMICS OF COTTON IN HIGH DENSITY PLANTING SYSTEM UNDER VARIED PLANT SPACING AND NITROGEN LEVELS

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Date of Receipt: 03.01.2018

Date of Acceptance: 05.02.2018

ABSTRACT

The experiment was conducted during *Kharif*, 2016 - 2017 to determine the optimum spacing and nitrogen in cotton under high density planting system. A closer spacing of 60 cm × 10 cm gave significantly higher seed cotton yield (1666 kg ha⁻¹) and maximum uptake of NPK and higher gross returns, net returns and benefit cost ratio (BCR) than the other spacings tested and it was on par with 75 cm × 10 cm. The highest seed cotton yield and maximum uptake of NPK and higher gross returns, net returns and benefit- cost ratio was recorded with a nitrogen level of 150 kg N ha⁻¹ (1620 kg ha⁻¹) than other nitrogen levels tested.

INTRODUCTION

Cotton crop is an important commercial crop grown in vertisols under rainfed conditions of coastal Andhra Pradesh. It occupies an area of about 4.41 lakh ha with an annual production of 13.1 lakh bales and productivity of 719 kg lint ha⁻¹ (AICCIP, 2017). Cotton production is labour intensive in almost all the developing countries. A novel way to avoid labour problem is to go for mechanical harvesting. Cotton being indeterminate in growth habit, it is difficult to harvest the seed cotton in one time. However, research results suggest that by manipulating the crop geometry especially by providing closer spacing one time harvest is possible and the yield reduction may be compensated by increasing the plant population by way of High Density Planting System (HDPS). The HDPS is now being conceived as an alternate production system having a potential for improving the productivity and profitability, enhancing input use efficiency, reducing input costs and minimizing the risks associated with the current cotton production system in India. Fertilizer, particularly nitrogen requirement is most likely to be higher under HDPS (Jost and Cothren, 2000).

Nitrogen is required for all stages of plant growth and development because it is the essential

element of both structural and non structural components of the plant (Majid *et al.*, 2011). The investigation was therefore undertaken to study the nutrient uptake and economics of cotton under HDPS with different spacing and nitrogen levels.

MATERIAL AND METHODS

The experiment was conducted at Agricultural College, Bapatla, during *Kharif* 2016 – 17. The soil of experimental field was black clay in texture, slightly alkaline in reaction (7.62), low in organic carbon (0.4 %), low in available nitrogen (200.3 kg ha⁻¹), medium in available phosphorus (25 kg ha⁻¹), medium in available potassium (250 kg ha⁻¹). The experiment was laid out in split plot design and replicated thrice with sixteen treatments comprising of four spacings 60 cm × 10 cm (S₁), 75 cm × 10 cm (S₂), 90 cm × 10 cm (S₃), 90 cm × 45 cm (S₄) as main plot treatments and four nitrogen levels 60 kg N ha⁻¹ (N₁), 90 kg N ha⁻¹ (N₂), 120 kg N ha⁻¹ (N₃), 150 kg N ha⁻¹ (N₄) as sub plot treatments. Cotton variety Suraj was sown on 07.8.2016. Nitrogen was applied (in the form of urea) as per the treatments in three equal splits at 30 DAS, 60 DAS and 90 DAS along with recommended dose of potassium and entire quantity of phosphorus was applied basally. Recommended cultural practices and plant protection

Table 1. Nutrient content, nutrient uptake and economics of cotton under high density planting system as influenced by varied spacing and levels of nitrogen

Treatments	Seed cotton yield (kg ha ⁻¹)	Stalk yield (kg ha ⁻¹)	Nutrient content (%)			Nutrient uptake (kg ha ⁻¹)			Gross returns (Rs ha ⁻¹)	Net returns (Rs ha ⁻¹)	B:C Ratio
			N	P	K	N	P	K			
Spacing (cm)											
S ₁ - 60 cm x 10 cm	1666	7118	0.72	0.22	0.62	65.8	20.0	56.6	83306	49751	1.48
S ₂ - 75 cm x 10 cm	1550	6551	0.71	0.2	0.6	60.9	17.9	52.1	77522	44099	1.31
S ₃ - 90 cm x 10 cm	1356	5914	0.7	0.19	0.59	52.9	15.0	44.6	67817	34486	1.03
S ₄ - 90 cm x 45 cm	1173	5454	0.69	0.18	0.57	49.0	13.0	40.9	58665	25678	0.77
CD @ 5%	174.0	420.6	NS	NS	NS	3.5	1.9	2.6			
Nitrogen levels (kg ha⁻¹)											
N ₁ - 60 kg N ha ⁻¹	1253	5107	0.68	0.17	0.58	45.7	11.6	38.9	62670	29894	0.91
N ₂ - 90 kg N ha ⁻¹	1372	5674	0.7	0.19	0.59	52.8	14.7	44.7	68625	35484	1.07
N ₃ - 120 kg N ha ⁻¹	1500	6632	0.7	0.21	0.6	59.6	17.9	50.8	75016	41510	1.23
N ₄ - 150 kg N ha ⁻¹	1620	7632	0.73	0.22	0.62	70.4	21.7	59.7	81000	47128	1.39
CD @5%	111.5	310.7	NS	NS	NS	2.7	2	2.6			

NS : Non-significant

measures were followed throughout the crop growing season. Seed cotton yield and stalk yield and nutrient content in the plants, nutrient uptake by the plants and gross returns, net returns and benefit-cost ratio (BCR) were recorded.

RESULTS AND DISCUSSION

The plant height, dry matter accumulation and number of bolls per square meter were maximum at closer spacing of 60 cm X 10 cm. Similarly, superior growth and yield attributes were recorded at 150 kg N ha⁻¹. The seed cotton yield was significantly higher with closer spacing of 60 cm × 10 cm than other spacings tested due to more number of bolls per unit area and the stalk yield also significantly higher with 60 cm × 10 cm due to more dry matter accumulation. Similarly, Venugopalan *et al.* (2014) reported that genotypes suraj, PKV 081, ADB 39 and ADB 281 were promising in terms of yield morphological features, earliness and nutrient use efficiency under HDPS (45 cm x 15 cm) under verticceptisols of Nagpur. Regarding nitrogen, significantly superior seed cotton yield was recorded at 150 kg N ha⁻¹ than other levels of nitrogen tested due to its favourable effect on plant growth and development, which resulted in increased dry matter accumulation and associated betterment in yield attributing characters. Highest stalk yield was recorded at 150 kg N ha⁻¹ (Table 1).

The nitrogen, phosphorus and potassium (N, P and K) content in the plants were not significantly affected by plant spacing and levels of nitrogen. Similar results were reported by Babaria *et al.* (2010) in Bt cotton with different fertilizer levels in south Saurashtra region. However, uptake of nutrients by the plants at harvest was influenced by varied spacing and levels of nitrogen tested, but their interactions were non-significant. The maximum N, P and K uptake by plants at harvest was recorded with closer spacing of 60 cm × 10 cm than other spacings tested. This might be due to higher dry matter accumulation per unit area which is a result of more number of

plants accommodated per unit area. Similarly, Devaraj *et al.* (2011) reported that maximum dry matter accumulation was recorded at closer spacing of 67.5 cm x 60 cm than wider spacing of 100 cm x 45 cm and 100 cm x 60 cm at both the locations (Sirsar and Hisar). The N, P and K uptake by the plants was significantly higher with application of 150 kg N ha⁻¹, may be due to favourable effect of nitrogen on the growth and development of the plants (Table 1). Similar results of higher nutrient uptake under narrow geometry than wide geometry was observed by Dhillon *et al.* (2006) and Jithendra Singh *et al.* (2016). Higher gross returns, net returns and benefit cost ratio (BCR) (1.48) was recorded at closer spacing of 60 cm × 10 cm, regarding nitrogen levels the gross returns, net returns and benefit-cost ratio (BCR) was significantly higher with application of 150 kg N ha⁻¹, similar results were observed by Divya *et al.* (2016).

CONCLUSION

Seed cotton yield, stalk yield and nutrient uptake, gross returns, net returns and benefit-cost ratio was significantly higher at closer spacing of 60 cm × 10 cm with application of 150 kg N ha⁻¹.

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IMPACT OF MIDSEASON DROUGHT ON PHYSIOLOGICAL AND BIOCHEMICAL PARAMETERS IN GROUNDNUT

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Date of Receipt: 04.01.2018

Date of Acceptance: 05.02.2018

ABSTRACT

Drought is one of the important abiotic stresses restricting the productivity of groundnut in rainfed situation by altering physiological and biochemical parameters. The effect of transient water deficit stress on physiological and biochemical parameters like SPAD Chlorophyll Meter Reading (SCMR), the Specific Leaf Area (SLA), proline content, catalase and peroxidase enzymes was analysed during Kharif, 2016 at pegging and pod filling stages in four groundnut genotypes with different levels of drought tolerance under two water regimes viz., field capacity and mid-season drought. The results indicated that SCMR, proline content, catalase and peroxidase levels were increased and SLA decreased significantly in all genotypes at different levels of moisture stress condition when compared to control. Under prolonged drought stress, the increase in proline content is more predominant in drought sensitive genotypes like Kadirib6 and Narayani and is twice as that of drought tolerant genotypes TCGS 1157 and MLTG 4. In contrast, catalase and peroxidase enzymes activity was found to be significantly high in drought tolerant genotypes than in drought sensitive genotypes. The genotypes with high SCMR, peroxidase and catalase activity and low SLA and proline content can tolerate moisture stress and can be used as a basis in development of groundnut genotypes for rainfed condition.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oilseed legume in the world. The leading groundnut producing countries are China, India, Nigeria, USA and Myanmar. India has been contributing a significant share occupying first place with a cultivated area of 5.8 million hectares and production of 6.8 million tonnes in India (FAO, 2016) and second place next to China in production (Janila *et al.*, 2016). Drought is one of the major abiotic stress and groundnut yields suffers due to low, erratic and unassured rainfall. Yield losses due to moisture stress depend on crop growth stage, drought intensity and duration (Nigam *et al.*, 2005). In the changing global climatic scenario, the yield losses can be more noticeable in future due to vagaries of monsoons and frequent occurrence of dry spells in crop growth period. Prolonged dry spell at critical crop growth stages such as flowering, peg formation/penetration and pod filling stage commences in the mid-season from 50 to 80 DAS. Terminal drought occurred during seed filling and maturity that affect seed quality, 100

seed weight, and increased levels of aflatoxin contamination (Girdthai *et al.*, 2010).

To attain sustainable groundnut yields, development of genotypes with high water use efficiency and drought tolerance are highly essential. The genotypes with the ability to increase their root length and volume significantly contribute to drought stress alleviation (Songsri *et al.*, 2009). In addition to high level of drought tolerance, the genotypes should maintain sustainable pod yield under moisture stress. SLA and SCMR have been used as surrogate traits for water use efficiency (Sheshshayee *et al.*, 2005) and are relatively stable across environments. Nigam *et al.* (2005) suggested that rapid progress in drought tolerance breeding can be achieved by using physiological traits such as SCMR and SLA.

At cellular level, a series of enzymatic and non-enzymatic antioxidant systems get activated to cope with drought stress. Moisture stress induces changes in osmolytes viz., proline accumulation and increased expression of specific enzymes such as catalase and peroxidase to avoid oxidative stress.

Proline accumulation is a common metabolic response of higher plants under water deficits (Leigh *et al.*, 1981). Tardieu (2014) reported that under moisture stress situation, groundnut induces stomatal closure as mechanism to reduce water loss. Stomatal closure decreases CO₂ assimilation results in increased rate of photorespiration which in turn loss of chlorophyll and thereby resulted in decreased photosynthetic activity, which results in increased rate of photorespiration and reactive oxygen species (ROS) were generated. The ROS were detoxified by increased levels of catalase and peroxidase activity. Therefore, an understanding of traits associated with drought tolerance such as large root system for increased water uptake, maintain high photosynthesis capacity, maintain plant water potential and to protect the cells from oxidative stress greatly contribute to crop yield under water stress. The main objective of the experiment was to assess the physiological and biochemical traits contributing to mid-season drought stress tolerance in groundnut.

MATERIAL AND METHODS

The experiment was conducted using 11 groundnut genotypes namely, TCGS 1073, TCGS 1157, TCGS 1173, TCGS 1398, MLTG 4, TPT 1, Narayani, Kadiri 6, Kadiri 9, ICGV 0707 and ICGV 07132 were screened for moisture stress tolerance under two water regimes viz., field capacity and moisture stress in *Kharif, 2016*. After 50 DAS, water level at field capacity was maintained throughout the experiment for control, whereas, in moisture stress imposition treatment, water was withheld from 50 DAS (Puangbut *et al.*, 2009). Among the eleven genotypes, MLTG 4 and TCGS 1157 were more tolerant to moisture stress and in contrast Narayani and Kadiri 6 were highly sensitive to moisture stress. The field experiments were carried out with those four genotypes at Regional Agricultural Research Station (RARS), Tirupati during *Rabi 2016-17* (DOS: 9.12.16) in randomized block design. There were two main treatments viz., control (well watered) and mid-season moisture stress (50-80 DAS). Under control

condition, the plot was irrigated and in mid-season moisture stress imposed plot, irrigation was withheld from 50 DAS to 80 DAS and irrigation is resumed after 80 DAS till harvest.

Analysis of physiological and biochemical parameters

Root length and root to shoot ratio

The root length and root to shoot ratio were recorded in well watered and respective drought stress imposed genotypes at the time of final harvest according to the method of Bohm (1979). For measurement of total root length, the roots were traced up to the bottom by using a backhoe. Groundnut plants were dug out along with huge mass of soil and washed with tap. The root system was placed on a clear plastic sheet and the total root length was determined. To determine root/ shoot ratio, root dry matter obtained were divided by the above ground dry matter.

Specific Leaf Area (SLA)

Specific leaf area was calculated by dividing total leaf area by total leaf weight according to the procedure of Kalariya *et al.* 2015. Three tetra foliate leaves (3rd fully expanded leaf from the top on the main axis for uniformity) were collected for calculating the SLA for each replication in the morning hours (9:00 to 9:30 am) at 60, 70 and 80 DAS in both stressed and respective controls. These leaves were cleaned and their leaf area was estimated using a leaf area meter (LI 3100C Area meter, LI COR., USA). The samples were dried in a hot air oven at 80°C until constant weight was achieved and leaf dry weight was determined by using electronically operated analytical weighing balance (Shimadzu, Japan) with accuracy of 0.01 mg.

SPAD Chlorophyll Meter Reading (SCMR)

The SCMR was measured according to the procedure of Kalariya *et al.* (2015). From each genotype, third leaf from the terminal bud of main axis (with four leaflets) was used for the measurement

of SCMR in three replications by handheld portable Minolta SCMR meter (SPAD-502 Minolta, Tokyo, Japan).

Estimation of Leaf Proline Content

Proline content of the leaf was estimated by modified method of Bates *et al.* (1973) at 10, 20 and 30 days after stress imposition. Proline content was estimated by OD value at 520 nm using UV 2450 visible spectrophotometer. The standard graph was prepared by using different concentrations of proline. The Leaf proline content was calculated using the following formula and expressed as $\mu\text{g g}^{-1}$ of leaf sample.

Estimation of Peroxidase activity

Peroxidase activity was estimated by following the procedure of Angelini *et al.* (1990) with slight modifications. Sample absorbances were recorded at 436 nm in a time difference of one minute

$$\mu \text{ moles of proline/g tissue} = \frac{\mu\text{g proline}}{115.5} \times \frac{\text{ml x ml toluene}}{\text{g sample}} \times \frac{5}{\text{g sample}}$$

Where, 115.5 is the molecular weight of proline

using UV 2450 visible spectrophotometer. The Peroxidase activity was calculated in $\text{min}^{-1} \text{g}^{-1}$ using the following formula

Peroxidase activity = change in OD value/minute/gram of leaf sample

Estimation of Catalase activity

Catalase activity was assayed by following the procedure of Aebi (1974) with slight modifications at 10, 20 and 30 days after stress imposition. Sample absorbances were recorded at 240 nm using UV 2450 visible spectrophotometer. The Catalase activity was calculated in units $\text{min}^{-1} \text{g}^{-1}$ using the following formula
Catalase activity = change in OD value/minute/gram of leaf sample

Statistical analyses

All the mean values of the physiological parameters and biochemical parameters were analysed using SPSS trial version 2.0.

RESULTS AND DISCUSSION

Root length varied among the genotypes and increased under various moisture regimes (Table 1). The drought sensitive genotypes (Kadiri 6 and Narayani) have short root length than the drought tolerant genotypes (MMLTG 4 and TCGS 1157). The average root length and root: shoot ratio of groundnut genotypes were increased after 30 days of water stress (50-80 DAS) in all the genotypes when compared to control. Drought tolerant genotypes like TCGS1157 (16.0 cm), MLTG4 (16.0 cm), displayed better ability to expand their roots than drought susceptible genotypes Kadiri6 (14.8cm) and Narayani (15.2cm) (Table 1). These genotypes also showed increase in total root length in drought regime

as compared to non-stressed control, however, this increase in root length was non-significant. The extent and the pattern of root development were closely related to the ability of the plants to absorb water, enhancement of root growth under drought conditions allows the plant to extract more water from deeper zones may contribute to the drought tolerance in groundnut (Madhusudhan and Sudhakar, 2014). Higher root/shoot ratios were obtained in moisture stress regime and increased with the increase in the intensity of drought stress when compared to control. Among genotypes, TCGS 1157 showed highest root/shoot ratio followed by MLTG 4 (Table 2). Paramasivam *et al.* (2014) stated that the imposition of drought stress in sunflower genotypes inhibited the shoot growth significantly but the root length increased to a larger extent.

Table 1. Root length of groundnut genotypes estimated in well watered (Control) and respective moisture stress imposed condition at the time of harvest

S.No	Genotypes	Root length			
		Control (cm)		Moisture Stress (cm)	
		Mean	CV	Mean	CV
1	MLTG 4	13.5±1.1	8.1	16.0±1.5	9.3
2	TCGS 1157	13.4±1.2	8.9	16.0±2.5	15.6
3	Narayani	12.0±0.8	6.9	15.2±1.1	7.2
4	Kadiri 6	12.6±1.1	8.7	14.8±1.3	8.7

Table 2. Root shoot ratio of groundnut genotypes estimated in well watered (Control) and respective, moisture stress imposed condition at the time of harvest

S.No	Genotypes	Root shoot ratio	
		Control	Stressed
1	MLTG 4	0.34	0.61
2	TCGS 1157	0.33	0.67
3	Narayani	0.36	0.55
4	Kadiri 6	0.38	0.50

Table 3. SPAD chlorophyll meter reading of groundnut genotypes estimated in well watered (Control) and respective moisture stress imposed condition at 60 DAS, 70 DAS and 80 DAS

S.No	Genotypes	SPAD at 50 DAS (before imposition of moisture stress)	SPAD at 60 DAS		SPAD at 70 DAS		SPAD at 80 DAS	
			Control	Stressed	Control	Stressed	Control	Stressed
1	MLTG 4	41.2±0.4	46.5±1.1	48.2±1.6	47.7±0.5	49.1±1.5	49.2±0.1	50.1±1.4
2	TCGS 1157	44.0±2.3	44.6±0.7	41.8±1.9	45.3±1.4	41.8±0.9	47.1±0.8	45.9±1.5
3	Narayani	28.5±1.8	38.0±3.0	40.8±0.5	40.9±0.6	40.8±0.5	40.4±1.3	42.2±0.1
4	Kadiri 6	33.1±0.7	38.2±1.9	41.8±1.0	37.6±0.8	38.4±0.7	39.8±0.9	39.2±0.6
	Mean	36.7	41.79	43.13**	42.89	42.52**	44.125*	45.35**
	C.V			2.54		9.457		14.04

** Significant at 1% level of significance

IMPACT OF MIDSEASON DROUGHT IN GROUNDNUT

The groundnut genotypes displayed significant differences in SCMR over different periods of moisture stress. Before moisture stress imposition the SCMR values were regarded in drought tolerant genotypes like MLTG4 (41.2) and TCGS1157 (44.0) and in drought susceptible genotypes Kadiri 6 (28.5) and Narayani (43.3) (Table 3). The SCMR values have continuously increased upto 80 DAS after stress imposition regarded 50.1 and 45.9 (MLTG4 and TCGS1157) in drought tolerant genotypes and 39.2 and 42.2 in drought susceptible genotypes (Kadiri 6 and Narayani). Similar to these results, results, Jongrunklang *et al.* (2008) found that drought significantly increased SCMR value. Leaf photosynthesis is generally correlated with chlorophyll content per unit leaf area and hence the SPAD chlorophyll meter can provide a useful tool to screen for genotypic variation in potential photosynthetic capacity under drought conditions (Nageswara Rao *et al.*, 2001; Songsri *et al.*, 2009). At cellular level, the increase in SCMR might be due to reduction SLA and RWC and thereby the chloroplast density per unit leaf area may be increased under moisture stress conditions. At physiological level, high SCMR under stress is due to less reduction in leaf water potential (Talwar *et al.*, 2004).

Low SLA is preferable as it indicates higher drought resistance (Chakraborty *et al.*, 2015). Drought stress significantly reduced specific leaf area (SLA) in all the groundnut genotypes under moisture stress at different time intervals ranging from 60 DAS to 80 DAS, whereas, a continuous increase in SLA under control condition. At 30 days after stress imposition 19% reduction in SLA values were regarded in drought stress imposed genotypes. In case of TCGS 1157 and MLTG 4 genotypes recorded 23% decreased in SLA at 30 days after stress imposition when compared with respective control. Drought stress significantly reduced specific leaf area (SLA) in all the groundnut genotypes under moisture stress at different time intervals ranging from 60 DAS

to 80 DAS, whereas, a continuous increase in SLA under controlled condition (Table 4). Based on the SLA values of the study, drought tolerant groundnut genotypes (TCGS 1157 and MLTG 4) can be clearly distinguished from the drought susceptible genotypes (Kadiri 6 and Narayani). Low SLA indicated thicker leaves and could be used as an economically surrogate trait for drought resistance. Similar results were reported by Chakraborty *et al.* (2015) who observed that the imposition of water stress decreased SLA significantly at both pegging and pod development stages and also the drought tolerant genotypes displayed more reduction in SLA than drought susceptible genotypes. Under rainfed situation, genotypes with low SLA and high SCMR values can be suggested without much reduction in yield even though the crop experienced dry spells during crop growth period. In addition, SCMR can be used as non-destructive measure to estimate chlorophyll density while screening groundnut genotypes for drought tolerance (Arunyanark *et al.*, 2009). However, Nageswara Rao *et al.* (2001) suggested that if SLA is to be used as a screening tool, then sampling should be performed on clear (full sunlight) days. Under high-radiation condition, variation in SLA should be largely driven by photosynthetic capacity. Thus, genotypic differences in SLA as a consequence of photosynthetic capacity may be better expressed on days with high radiation. It could be hypothesized that peanut genotypes with low SLA have more photosynthetic machinery per unit leaf area and hence potential for greater assimilation under **drought stress** because thicker leaves usually have a greater photosynthetic capacity compared with thinner leaves.

In drought tolerant genotypes viz., MLTG 4 and TCGS 1175, at 10 days after moisture stress imposition the proline content was recorded as 136.3 $\mu\text{g g}^{-1}$ and 168.3 $\mu\text{g g}^{-1}$, respectively. In drought susceptible genotypes viz., Kadiri 6 and Narayani, at 10 days after stress imposition the accumulation of proline content was 134 $\mu\text{g g}^{-1}$ and 211 $\mu\text{g g}^{-1}$,

Table 4. Specific Leaf Area (cm² g⁻¹) of groundnut genotypes estimated in Control and respective moisture stress imposed condition at 60 DAS, 70 DAS and 80 DAS

S.No	Genotypes	SPAD at 50 DAS (before imposition of moisture stress)	SPAD at 60 DAS		SPAD at 70 DAS		SPAD at 80 DAS	
			Control	Stressed	Control	Stressed	Control	Stressed
1	MLTG 4	118.3±4.1	128.3±0.3	113.8±11.8	129.4±0.4	114.7±3.3	151.1±1.7	123.9±2.0
2	TCGS 1157	107.9±1.9	118.3±3.1	117.9±1.4	138.7±3.1	128.6±2.9	161.7±1.4	133.1±2.2
3	Narayani	138.4±4.4	120.0±4.0	120.0±1.1	135.7±4.2	128.2±0.4	144.8±3.3	136.5±0.4
4	Kadiri 6	139.4±9.4	130.3±2.0	125.0±0.2	140.7±1.9	137.6±5.4	146.6±0.3	133.2±1.5
	Mean	126.62	124.17	119.17**	136.24	127.25**	151.05	131.67**
	C.V			3.36		3.02		3.17

** Significant at 1% level of significance

Table 5. Proline content (µg g⁻¹) of groundnut genotypes estimated in Control and respective moisture stress imposed condition at 60 DAS, 70 DAS and 80 DAS

S.No	Genotypes	50 DAS (before imposition of moisture stress)	Proline content at 60 DAS		Proline content at 70 DAS		Proline content at 80 DAS	
			Control	Stressed	Control	Stressed	Control	Stressed
1	MLTG 4	10±1.6	8.5±0.6	136.6±1.6	25.5±2.5	179.0±2.5	37.3±1.5	262.7±1.8
2	TCGS 1157	7.1±1.1	16.1±1.9	168.3±1.6	26.1±2.5	241.1±12.0	39.9±1.8	247.2±5.3
3	Narayani	1.7±0.2	3.8±1.0	211.0±2.0	18.0±3.3	322.8±2.0	69.0±1.7	432.7±10.8
4	Kadiri 6	3.4±0.9	5.5±0.9	134.9±3.4	15.7±0.4	288.3±5.3	32.0±0.2	409.6±3.2
	Mean	5.41	8.27	162.45**	21.24	257.63**	44.40**	337.85**
	C.V			38.72		32.54		22.6

** Significant at 1% level of significance

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respectively. The accumulation of proline has increased significantly in MLTG 4 and TCGS 1175 genotypes at 20 days (176 and 241 $\mu\text{g g}^{-1}$) and 30 days (247 and 262 $\mu\text{g g}^{-1}$) after moisture stress imposition. The proline content has increased even more in Kadiri 6 and Narayani than drought tolerant genotypes at 20 days (288 and 322 $\mu\text{g g}^{-1}$) and 30 days (409 and 432 $\mu\text{g g}^{-1}$) after stress imposition. The proline accumulation in drought susceptible genotypes *viz.*, Kadiri 6 and Narayani has increased two folds than the drought tolerant genotypes *viz.*, TCGS 1157 and MLTG 4 at prolonged moisture stress of 20-30 days (Table 5). In response to drought stress, proline accumulation normally occurs in the cytosol where it contributes substantially to the cytoplasmic osmotic adjustment (Leigh *et al.*, 1981). In addition to proline, accumulation of soluble sugars and aminoacids such as glutamate, glutamine and asparagin were found in tissues as a general response to drought stress. The accumulated proline may facilitate the survival of cells under severe moisture stress by stabilization of macromolecules, a sink for excess reductant, ROS and a store of carbon and nitrogen for use after relief of water deficit (Maiti *et al.*, 2000). Naidu *et al.* (2001) reported that the accumulation of leaf proline content in green gram has increased due to drought stress in all the green gram genotypes, among the ten genotypes studied K 851 and LGG 407 accumulated more proline under drought stress. This accumulated proline possibly contributed towards osmotic adjustment which plays a major role in maintaining turgor over fluctuating soil water potential.

Under prolonged moisture stress condition the catalase activity increased continuously in all groundnut genotypes. Catalase activity at 30 days after stress imposition has recorded two fold increase in drought tolerant genotypes *viz.*, MLTG4 (5.8 Ug^{-1}) and TCGS 1157 (4.7 Ug^{-1}) under stress condition when compared with control. Lowest catalase was noticed in drought susceptible genotypes *viz.*, Narayani (3.3 unit enzyme g^{-1} fresh weight) and Kadiri 6 (2.6 unit

enzyme g^{-1} fresh weight) at 80 DAS (Table 6). The peroxidase activity was recorded as 0.39 Ug^{-1} , 3.71 Ug^{-1} , 0.39 Ug^{-1} and 0.79 Ug^{-1} in MLTG 4, TCGS 1157, Kadiri 6 and Narayani at 50 days after sowing. Highest peroxidase activity recorded in TCGS 1157 and Narayani groundnut genotypes (30.0 Ug^{-1} and 32.4 Ug^{-1} , respectively) than Kadiri 6 and MLTG 4 (13.9 Ug^{-1} and 18 U g^{-1}) at 30 days after moisture stress. Similar results were reported by Chakrabarthy *et al.* (2015) who found that the total chlorophyll content of the leaf increased in most of the cultivars when drought was imposed at the initial stage. Prolonged drought stress of 35 days (45 DAS to 80 DAS) induces stomatal closure and thereby decreases CO_2 assimilation. It resulted in increased rate of photorespiration which inturn destroy the chlorophyll and induces senescence. Moisture stress increases production of ROS that inactivate enzymes, damage cellular components and diminish the defense capacity of plants. Plants possess antioxidant defense system against ROS, operative through the changes in activities of catalase and peroxidase (Chakraborty *et al.*, 2015). In this study, oxidative stress (H_2O_2 production) varied in the groundnut cultivars facing water deücit stress at 10, 20 and 30 days of moisture stress; however, the extent varied with the cultivars. Activity of catalase and peroxidase was noticed in tolerant genotypes was relatively higher than in the susceptible ones due to better balance maintained between ROS production and the capacity of the defense mechanisms to protect the plant under severe stress. Tardieu (2012) also reported similar kind of results in groundnut that moisture stress situation induces stomatal closure as mechanism to reduce water loss and thereby resulted in decreased photosynthetic activity.

CONCLUSION

Under moisture stress condition, drought tolerant genotypes MLTG4 and TCGS1157 showed highest SCMR at different moisture stress levels than drought susceptible genotypes Kadiri 6 and Narayani

Table 6. Catalase activity (units min⁻¹ g⁻¹) of groundnut genotypes estimated in Control and respective moisture stress imposed condition at 60 DAS, 70 and 80 DAS

S.No	Genotypes	50 DAS (before imposition of moisture stress)	Catalase activity at 60 DAS		Catalase activity at 70 DAS		Catalase activity at 80 DAS	
			Control	Stressed	Control	Stressed	Control	Stressed
1	MLTG 4	0.5±0.1	0.9±0.1	1.8±0.2	0.9±0.1	2.9±0.7	1.9±0.6	5.8±1.7
2	TCGS 1157	0.6±0.4	1.3±0.1	2.1±0.1	1.4±0.2	2.5±1.0	1.7±0.4	4.7±0.1
3	Narayani	0.2±0.0	0.5±0.2	0.6±0.0	0.4±0.2	2.3±1.4	0.3±0.1	3.3±0.6
4	Kadiri 6	0.3±0.1	0.3±0.9	0.7±0.1	0.4±0.1	1.7±1.0	0.5±0.3	2.6±0.5
	Mean	0.4	0.75	1.1	0.77	2.35	1.1	4.1
	C.V			54.32		49.76		33.18

** Significant at 1% level of significance

Table 7. Peroxidase activity (units min⁻¹ g⁻¹) of groundnut genotypes estimated in control and respective moisture stress imposed condition at 60 DAS, 70 and 80 DAS

S.No	Genotypes	50 DAS (before imposition of moisture stress)	Peroxidase activity at 60 DAS		Peroxidase activity at 70 DAS		Peroxidase activity at 80 DAS	
			Control	Stressed	Control	Stressed	Control	Stressed
1	MLTG 4	0.39±0.3	0.59±0.6	2.00±1.2	1.19±0.1	5.80±1.2	7.20±0.2	18.00±1.1
2	TCGS 1157	0.71±0.6	1.19±0.7	1.90±0.8	3.00±0.3	6.50±0.5	6.50±0.5	30.00±0.5
3	Narayani	0.39±1.2	0.39±0.5	1.20±0.5	2.00±0.5	2.90±0.1	3.70±1.2	32.40±2.0
4	Kadiri 6	0.79±0.5	0.79±1.2	2.00±1.0	0.87±0.1	2.00±0.1	4.30±0.9	13.90±2.3
	Mean	0.56	0.73	1.84	1.76	4.45	5.42	17.10
	C.V			101.75		115.93		39.18

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and SCMR can be used as non-destructive measure to estimate chlorophyll density while screening groundnut genotypes for drought tolerance. SLA decreased significantly in drought tolerant genotypes than in drought susceptible genotypes. The increased levels proline under drought stress can be better considered as drought stress indicator in groundnut. The accumulation of proline was more in drought susceptible (Kadiri 6 and Narayani) genotypes than drought tolerant (TCGS 1157 and MLTG 4) genotypes, both catalase and peroxidase activities have increased in all the genotypes submitted to prolonged moisture stress to protect the cell from ROS generated in photorespiration. Under prolonged drought stress, the increase in proline content is predominant in drought sensitive genotypes viz., Kadiri 6 and Narayani and is twice as that of drought tolerant genotypes TCGS 1157 and MLTG 4. In contrast, catalase and peroxidase enzymes activity was found to be significantly high in drought tolerant genotypes than in drought sensitive genotypes. The genotypes with high SCMR, peroxidase and catalase activity and low SLA and proline content that tolerate moisture stress can be used as a basis for development of groundnut genotypes for rainfed condition.

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PERFORMANCE OF SORGHUM HYBRIDS UNDER DIFFERENT NITROGEN LEVELS IN RICE-FALLOW CONDITIONS OF NORTH COASTAL ANDHRA PRADESH

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Date of Receipt:15.12.2017

Date of Acceptance:31.01.2018

ABSTRACT

The field experiment was conducted on sandy loam soil during *Rabi* 2016-17. The treatments comprised combination of four sorghum hybrids and four nitrogen levels laid out in split plot design with three replications. Among the hybrids, CSH 25 was recorded with highest yield (6841 kg ha⁻¹) and panicle length (28.25 cm). With the different nitrogen levels tested, application of 120 kg N ha⁻¹ (7491 kg ha⁻¹) was recorded with highest yield, panicle length (29.90 cm) and test weight (3.97). However, stover yield was highest with hybrid CSH 15R and with 120 kg N ha⁻¹. Gross returns, net return and B:C ratio were also highest with CSH 25 and with highest N level (120 kg ha⁻¹). Hence, the study revealed that for rice fallow situation sorghum can be successfully grown with hybrid CSH-25 and application of 120 kg N ha⁻¹ which were found promising for North Coastal Zone of Andhra Pradesh.

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench) is an important crop for millions of farmers in the semi-arid tropics in India. It is re-emerging as a potential alternative food, feed, fodder and bioenergy crop. However, part of the sorghum crop area has now been replaced by soybean, cotton and maize and is shifted to marginal lands. In rice-fallows of Coastal Andhra Pradesh, sorghum cultivation is gaining popularity among farmers due to its high productivity and low water requirement (Mishra *et al.*, 2011). It is now grown in more than 24,000 ha area in rice-fallows with an average productivity of 6.5 t ha⁻¹ in A.P., which is the highest in the country.

Usually, farmers grow pulses (greengram and blackgram) in rice-fallows in the Krishna-Godavari zone of Andhra Pradesh as *utera* cropping (broadcasting of seeds in standing crop of rice). However, in the recent times, the area under pulses has declined due to late planting of rice and severe attack of viral diseases and parasitic weed *Cuscuta*. Farmers of the region are now growing maize (in assured irrigated areas) and sorghum (in less irrigated

areas) in rice-fallows as alternate crops to pulses. It results in many economic and environmental benefits over conventional tillage, such as lower labour and fuel needs, reduced soil erosion, reduced runoff, increased soil organic Carbon content, and increased soil biological activity (West and Post, 2002). Schlegele *et al.* (2007) recorded 25% higher grain yield in no tillage than reduced tillage and 98% greater than conventional tillage.

Farmers of the area are using the fertilizers and pesticides indiscriminately (Chapke *et al.*, 2011). The input use by sorghum may vary with different cultivars depending upon their growth behaviour and rooting pattern. Nitrogen (N) fertilization is becoming increasingly important in gauging the economic and environmental viability of agroecosystems and exploiting genotypic differences in N demand and efficiency have been proposed as possible alternatives for reducing the cost and reliance upon fertilizer N (Gardner *et al.*, 1994). Many promising sorghum hybrids have been evolved for traditional sorghum growing areas, making it essential to investigate the differential response of promising

hybrids to nitrogen in non-traditional areas such as rice-fallows. The investigation was therefore undertaken to find out the relative response of sorghum hybrids to different nitrogen levels in rice-fallows of North Coastal Zone of Andhra Pradesh.

MATERIAL AND METHODS

The field experiment was conducted during *Rabi*, 2016-17 at the Agricultural College, Naira. The experiment soil was sandy loam in texture with a pH of 7.42 and EC of 0.064 dSm⁻¹, medium in organic carbon (0.56%), low in available nitrogen (96 kg ha⁻¹), low in available phosphorus (12.4 kg ha⁻¹) and medium in available potassium (151 kg ha⁻¹). The experiment was laid out in split plot design with three replications. The treatments comprised combination of four sorghum hybrids *viz.*, V₁- CSH 15R, V₂- CSH 16, V₃- CSH 25 and V₄- MLSH 296 and four nitrogen levels N₁: 0 kg N ha⁻¹, N₂: 80 kg N ha⁻¹, N₃: 100 kg N ha⁻¹ and N₄: 120 kg N ha⁻¹. The total rainfall of 8.0 mm was received in two rainy days during the growth period of rice fallow sorghum. A recommended dose of 80 kg P₂O₅ and 80 kg K₂O ha⁻¹ was applied as basal and nitrogen was applied in the form of urea in three splits at 15 DAS, 60 DAS and at flowering. Data on growth parameters *viz.*, days to 50% panicle emergence, days to maturity, yield attributes *viz.*, panicle length and test weight, yield parameters such as grain yield and stover yield was recorded. Gross returns, net returns and B:C ratio was calculated. Statistical analysis of the data collected was carried out following the analysis of variance technique for split plot design.

RESULTS AND DISCUSSION

Growth parameters

The results showed that 50 percent panicles emerged significantly early with the application of 120 kg N ha⁻¹ (N₄) gradually followed by the 100 kg N ha⁻¹ (N₃), 80 kg N ha⁻¹ (N₂) and no application of nitrogen (0 kg N ha⁻¹) with clear statistical disparity between each of them (Table 1). Non application of

nitrogen (N₁) resulted in a delay by about 12 days in the emergence of 50 per cent panicles compared to N₄. Similarly, N₄ recorded significantly early maturity gradually followed by the other N levels with clear disparity between each of them. Control treatment (N₁) recorded late maturity by nearly three days compared to N₄. Higher concentration and uptake of nitrogen by plants with sufficient fertilization might have resulted into greater synthesis of protein and earlier flower primordial development which ultimately resulted into earlier flowering and maturity. Similarly, Patidar and Mali (2004) reported that there was significant difference in number of days taken for 50 per cent flowering with increasing levels of nitrogen from 0 to 120 kg N ha⁻¹ and control (75) took maximum number days for 50 per cent flowering. Mishra *et al.* (2014) also similarly reported that number of days taken for 50 per cent flowering decreased with 80 kg N ha⁻¹ and control took maximum number of days to 50 per cent flowering in *kharif* grain sorghum.

Application of nitrogen at higher levels might have helped in enhanced reproductive growth and development resulting in early appearance of reproductive structures. On an average, fertilized plants were found to flower five days earlier than those that were not fertilized. These results are similar to that of Buah and Mwinkaara (2009) who reported that the application of N significantly affected days to flowering, plant height and leaf area index in sorghum crop in Guinea Savanna Zone of Africa.

Yield attributing characters

Panicle length in CSH 16(V₂) was significantly superior among the hybrids. CSH 25 (V₃) (29.82 Cm) was superior to MLSH 296 (V₄) and CSH 15R(V₁) and was inferior to CSH 16 (V₂). CSH 15R (V₁) (21.90 Cm) was significantly inferior to all the sorghum hybrids taken for trial (Table 2). Panicle length at the highest nitrogen level (N₄) (29.90 Cm) was significantly superior as compared to all the other the levels of nitrogen tried. Regarding, interaction,

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Table 1. Effect of different hybrids and nitrogen levels on growth parameters of rice fallow sorghum

Treatments	Plant Population per m ²		Days to 50% panicle emergence	Days to maturity
	Initial	Final		
Hybrids				
CSH 15R	12.7	11.9	70	105
CSH 16	12.9	12.5	70	107
CSH 25	12.9	12.5	70	106
MLSH 296	12.9	12.7	70	106
CD @ 5%	NS	NS	NS	NS
CV%	2.75	1.03	1.87	1.89
N-levels (kg ha⁻¹)				
0	12.5	12.0	77	107
80	12.9	12.0	71	107
100	13.0	12.4	67	106
120	13.0	13.2	65	104
CD @ 5%	NS	NS	1.0	1.0
CV%	2.67	3.12	2.27	2.29
H at N				
CD @ 5%	NS	NS	NS	NS
N at H				
CD @ 5%	NS	NS	NS	NS

panicle length was the highest with the hybrid CSH 25 at 120 kg N ha⁻¹ (V₃N₄) and the lowest panicle length was recorded by CSH 15R at 0 kg N ha⁻¹ (V₁N₁). The differentiation in the panicle length can be attributed to the variation in the genetic constitution of different hybrids. These results are in conformity with Mishra *et al.* (2011) who reported that sorghum hybrid CSH 16 recorded significantly highest panicle length (41.4cm) over the other hybrids and varieties under rice fallow conditions of Guntur district. Chapke *et al.* (2014) recorded significantly

highest panicle length with hybrid 3660A x CB35 (35 cm) under rice-fallow conditions of Guntur district. Marked differences on panicle length were recorded with each increment in nitrogen levels. Greater panicle length due to 120 kg N ha⁻¹ could be attributed to its favourable effect on cell enlargement, production of larger leaves and improves photosynthetic efficiency of plants. The lowest panicle length was observed in 0 kg N ha⁻¹. Similarly, Mishra *et al.* (2013) reported that the hybrids CSH

16 recorded highest panicle length (28.19 cm) significantly at the level of 125 kg N ha⁻¹ of sorghum under rice fallow conditions. Besides, Patil (2013) reported that panicle length of sorghum was higher with application of 80 kg N ha⁻¹ (16.6cm) as compared with absolute control (14.4cm) in deep black soils of Bellary. Goutami *et al.* (2015) reported that highest panicle length was obtained with application of 150 kg N ha⁻¹ (22.8) but was on a par

with 90 kg N ha⁻¹ (22.1cm) and superior over absolute control (20.9 cm) in rice fallow conditions sorghum.

Test weight of rice fallow sorghum hybrids did not differ with each other. Results showed that test weight at highest nitrogen level (N₄) (3.97), was significantly superior as compared to all other levels of nitrogen tried. Test weight obtained with the application of 100 kg ha⁻¹ (N₃) was the next best treatment, but was, however, significant with the

Table 2. Effect of different hybrids and nitrogen levels on yield attributes and yield of rice fallow sorghum

Treatments	Panicle length (cm)	Test weight (100- seed weight)	Grain yield (kg ha ⁻¹)	Stover yield (kg ha ⁻¹)
Hybrids				
CSH 15R	21.90	3.35	5023	15477
CSH 16	29.82	3.50	6068	12873
CSH 25	28.25	3.35	6841	13536
MLSH 296	27.72	3.46	6044	9222
CD @ 5%	0.88	NS	1037	598
CV%	3.22	4.9	14	4.7
N-levels (kg ha⁻¹)				
0	22.80	2.93	3436	8872
80	26.61	3.19	6296	11992
100	28.39	3.57	6751	14043
120	29.90	3.97	7491	16201
CD @ 5%	0.48	0.11	593	407
CV%	2.12	3.9	13	8.2
H at N				
CD @ 5%	1.2	0.26	NS	920
N at H				
CD @ 5%	1.0	0.24	NS	868

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application of 80 kg ha⁻¹ (N₂). Test weight with the combination of CSH 15R at 120 kg N ha⁻¹(V₁N₄) (4.13) was the highest which and on a par with MLSH 296 at 120 kg N ha⁻¹ (V₄N₄) (3.96) while the lowest test weight was recorded by CSH 15R at 0 kg N ha⁻¹(V₁N₁) (2.70). Increase in test weight at higher level of nitrogen might be due to greater assimilating surface at reproductive development resulted in better grain formation because adequate production of metabolites and their translocation towards grain which shows improvement in nutrient concentration and up take. This might have resulted in increased weight of individual grain expressed in terms of test weight. Similar findings were reported by Pushpendra Singh *et al.* (2012) who observed that highest thousand seed weight (27.39) in sorghum (CSV 15) with the application of 120 kg N ha⁻¹ as compared with other levels of nitrogen during *kharif* season at Udaipur, Rajasthan.

Grain and Stover yield

Grain yield of sorghum indicated that yield obtained with CSH 25 (V₃) (6841 kg ha⁻¹) was significantly higher than all the other hybrids except CSH 16 (V₂) (6068 kg ha⁻¹) with which it was statistically comparable (Table 2). Grain yield recorded with MLSH 296 (V₄) (6044 kg ha⁻¹) was on a par with all the hybrids except CSH 25 (V₃). The lowest grain yield was recorded with CSH 15R (V₁) (5023 kg ha⁻¹) among all hybrids taken for study. Grain yield obtained at highest nitrogen level (N₄) (7491 kg ha⁻¹) was significantly superior as compared to all the nitrogen levels tried. Yield obtained with the application of 100 kg ha⁻¹ (N₃) was next best treatment but was, however, comparable with the application of 80 kg ha⁻¹ (N₂). Both these nitrogen levels were significantly superior to N₄ and significantly superior to no application of nitrogen (N₁) (3436 kg ha⁻¹), which recorded the significantly lowest grain yield among all the four levels of nitrogen tested in this experiment.

The superiority of hybrid CSH 25 (V₃) in terms of yield under rice fallow conditions can be attributed to its higher number of grains per panicle, dry matter accumulation at harvest as compared to other three hybrids. It has also the ability to put up the growth under low temperature conditions at early stages. Similar observations were reported by Chapke *et al.* (2014) who recorded highest grain yield with hybrid 456A x CB134 (9.05t ha⁻¹) which was comparable with hybrid CSH 16 (8.62 t ha⁻¹) under rice fallow conditions of Guntur district. The increase in the grain yields with enhanced N application could be ascribed to better plant growth and dry matter production due to higher photosynthetic area. This was further supported by the fact that soil of the experimental field was low in nitrogen (96 kg ha⁻¹). These results are in corroboration with Mishra *et al.* (2014) who reported higher grain yield and it was on par with 60 kg N ha⁻¹ (31.4 q ha⁻¹) and this was significantly higher than control and Similarly, Vara Prasad *et al.* (2014) reported that grain yield of sorghum increased linearly with increasing nitrogen fertilizer regimes. Maximum grain yield was obtained at 90 kg N ha⁻¹ (46.4 q ha⁻¹) followed by 45 kg N ha⁻¹ (35.4 q ha⁻¹) and the lowest yield was obtained with 0 kg N ha⁻¹ (31.4 q ha⁻¹).

Stover yield obtained with CSH 15R (V₁) (15477 kg ha⁻¹) was significantly superior to all the hybrids. Yield of stover with CSH 25 (V₃) was found to be superior to all other hybrids except V₁, while yield with CSH 16 (V₂) was significantly superior to MLSH 296 (V₄) (9222 kg ha⁻¹). Stover yield at the highest nitrogen level (N₄) (16201 kg ha⁻¹) was significantly superior as compared to all the other the levels of nitrogen levels tried. Stover yield obtained with the application of 100 kg ha⁻¹ (N₃) was the next best treatment but was, however, significantly superior to 80 kg ha⁻¹ (N₂). No application of nitrogen (N₁) (8872 kg ha⁻¹) recorded the significantly the lowest yield among all the four levels of nitro gen

Table 3. Effect of different hybrids and nitrogen levels on economics of rice fallow sorghum

Treatments	Gross return (Rs. ha ⁻¹)	Net return(Rs. ha ⁻¹)	B:C ratio
Hybrids			
CSH 15R	97053	55456	1.33
CSH 16	110159	68520	1.64
CSH 25	124696	83057	2.00
MLSH 296	114781	73141	1.75
CD @ 5%	13882	13866	0.34
CV%	12	10	4
N-levels (kg ha⁻¹)			
0	64684	23044	0.55
80	114305	72666	1.73
100	122868	81270	1.95
120	144833	103194	2.47
CD @ 5%	13512	13511	0.32
CV%	13	11	5
H at N			
CD @ 5%	NS	NS	NS
N at H			
CD @ 5%	NS	NS	NS

tested in this experiment. Stover yield was the highest with the hybrid CSH 15R at 120 kg ha⁻¹ (V_1N_4) (18900 kg ha⁻¹) which was superior over other interaction combinations. The lowest stover yield was recorded by MLSH 296 at 0 kg N ha⁻¹ (V_4N_1) (5522 kg ha⁻¹). Higher stover yield with CSH 15R (V_1) might be owing to its tall growing nature as reflected by its highest plant height and also dry matter production. Similar observations were noticed by Patil (2007) who reported that Maximum stover yield was recorded in sorghum hybrid CSH 15R (2.20 t ha⁻¹) as compared

with other sorghum hybrids during *rabi* in vertisols of Bellary. Highest stover yield recorded with the application of 120 kg N ha⁻¹ might be due to the fact that nitrogen application increases the activity of cytokinin in plant which leads to the increased cell division and elongation. Madhukumar *et al.* (2013) also reported that significantly higher stover yield (89.6 q ha⁻¹) was recorded with the application of 180 kg N ha⁻¹ and application of 90 kg N ha⁻¹

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produced significantly lower yield ($79. \text{ q ha}^{-1}$) during post rainy season.

Economics

Economics (Gross returns and net returns) registered with CSH 25 (V_3) was significantly higher than all the other hybrids except MLSH 296 (V_4) with which it was statistically comparable. Economics recorded with CSH 16 (V_2) was on par with all the hybrids except CSH 25 (V_3) (Table 3). The lowest returns were recorded with CSH 15R (V_1). B:C ratio of CSH 25 (V_3) (2.00) was significantly superior to all the hybrids. B:C ratio with MLSH 296 (V_4) was found to be superior to all other hybrids except V_3 , while B:C ratio with CSH 16 (V_2) was significantly superior to CSH 15R (V_1) (1.33). Significantly lowest B:C ratio was recorded with CSH 15R (V_1) and was thus inferior to all the sorghum hybrids under trial.

Higher gross, net returns and B:C ratio were obtained at the highest nitrogen level (N_4) (2.47) and was superior to all the nitrogen levels tried (Table 3). Benefit-cost ratio obtained with the application of 100 kg ha^{-1} (N_3) was comparable with the application of 80 kg ha^{-1} (N_2). Both these nitrogen levels were inferior to N_4 and significantly superior to no application of nitrogen (N_1) (0.55), which recorded the significantly lowest of these parameters. Interactions of hybrids and N levels for gross, net returns and benefit cost ratio were found to be non-significant. Nitrogen fertilization markedly influenced the B:C ratio. The ratio increased with increased levels of nitrogen. Higher B: C ratio was recorded with the application of 120 kg ha^{-1} (N_4). This higher B:C ratio might be due to more economic yield obtained at higher levels of nitrogen than lower level of nitrogen. Mishra *et al.* (2015) also reported similar findings and observed that the highest net returns ($\text{Rs.}25,970 \text{ ha}^{-1}$) and benefit - cost ratio (1.79) were obtained with application of 150% RDF (120 kg N ha^{-1}) which were on par with 100 % RDF, but significantly superior over control .

CONCLUSION

Sorghum can be successfully grown by choosing hybrid CSH 25 (V_3) and with application of 120 kg N ha^{-1} (N_4) for obtaining the highest yield making it technically feasible and economically profitable proposition under the resource constrained rice fallow conditions of North Coastal Zone of Andhra Pradesh.

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EFFECT OF SPACING AND NITROGEN LEVELS ON PRODUCTIVITY OF PEARLMILLET IN DRYLAND REGIONS

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Date of Receipt: 01.01.2018

Date of Acceptance:03.02.2018

ABSTRACT

Studies on response of pearl millet (ABH-1) to spacing and nitrogen levels in alfisols of scarce rainfall zone under rainfed conditions revealed that plant height, DMP, number of panicles plant⁻¹, panicle length, threshing percentage, grain yield, net returns and B:C ratio did not differ significantly due to spacing, however, pearl millet sown at 60 cm x 15 cm produced higher growth, yield attributes, yield and economics. Application of 80 kg N ha⁻¹ resulted in tallest plants and 60 kg N ha⁻¹ produced higher drymatter 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 and straw yield was higher with application of 80 kg N ha⁻¹. Nitrogen levels did not influence panicle length and threshing percentage.

INTRODUCTION

Pearlmillet, the world's hardiest warm season cereal crop (Reddy *et al.*, 2013), is an indispensable arid and semiarid crop of India (Ramesh *et al.*, 2006) cultivated as dual purpose (food and feed) crop in over 8.3 mha ranking fourth among total cereals. Further, the nutritional value of pearl millet offers much scope to development of value added products in new health conscious consumer segments (Yadav *et al.*, 2011) 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 (Parthasarathy *et al.*, 2006). 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 increases the potential and improving the quality of grains.

Pearlmillet 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 pearl millet and has shown variable growth and yield response to N application (Gascho *et al.*, 1995). Generally, pearl millet is known for growing under low N management and several studies showed that N application can increase pearl millet production efficiency (Singh *et al.*, 2010). Nitrogen use efficiency (NUE) of pearl millet is higher than many other crops, increasing the rate of N fertilization does not always accompany a corresponding increase in grain yield (Muchow, 1988).

Ananthapuram district is the second most drought - affected district of India. It receives around 500 mm rainfall annually. In this region pearl millet is an important crop 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. Agronomic variations among pearl millet genotypes have been reported earlier by Khairwal *et al.* (2007). Hence, there is a need to improve yields of pearl millet by refining the existing agronomic practices. Pertinent information regarding optimum nitrogen dose and spacing for pearl millet during *kharif* season is meagre. Keeping these in view, the experiment was conducted to study the response of pearl millet to spacing and nitrogen levels under rainfed condition.

MATERIAL AND METHODS

The field experiment was conducted in alfisols of scarce rainfall zone under rainfed conditions during *kharif*, 2015-16 at Agricultural Research Station, Ananthapuramu of Andhra Pradesh. The soil 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 (S₁: 30 cm x 15 cm; S₂: 45 cm x 15 cm and S₃: 60 cm x 15 cm) and five nitrogen level treatments *viz.*, N₁: Control (No N); N₂: 40 kg ha⁻¹; N₃: 60 kg ha⁻¹; N₄: 80 kg ha⁻¹ and N₅: 100 kg ha⁻¹. and was laid out in 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. The seeds of ABH – 1 were sown by dibbling method in furrows at a depth of 5 cm. As per the treatments half of the N, entire P₂O₅ and K₂O kg ha⁻¹ were applied at the time of sowing in the form of urea, single super phosphate and muriate of potash, 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 at critical stages of crop weed competition. Standard cultural practices were followed and is uniform for all treatments (ANGRAU, 2014). 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. Cost of cultivation was worked out based on labour charges an input costs. Gross returns were calculated based on local market price of pearl millet and net returns by subtracting the total cost of cultivation from gross returns.

RESULTS AND DISCUSSION

Rainfall and Crop performance

It is observed that the rainfall during the year of experiment is within the limits of normal and the crop has also received normal rainfall of 248 mm in 21 rainy days during its growth period of 83 days. The details of temperature and rainfall distribution

Table 1. Rainfall and rainy days during crop growth period

Date of sowing	16.7.2015
Date of harvesting	6.10.2015
Crop duration (days)	83
Normal annual rainfall (mm)	590.6
Actual annual rainfall (mm)	641
Rainfall during crop period (mm)	248
Number of rainy days during the year	44
Number of rainy days during crop period	21

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Table 2. Weather during different phenophases of pearl millet

Phenophases	Days taken	Maximum Temperature (° C)	Minimum Temperature (° C)	Rainfall (mm)	Rainy days
Sowing to Emergence	7	33.9	25.2	10.6	1
Emergence to panicle emergence	42	35.1	24.6	67.0	8
Panicle emergence to flowering	51	34.7	24.8	0.0	0
Flowering to grain formation	61	33.7	24.2	116.0	6
grain formation to maturity	83	33.2	24.1	54.4	6
Total/Mean	83	34.1	24.6	248	21

revealed that the temperatures (maximum and minimum) were within the normal range during all the growth stages (Table 2). The distribution of rainfall was optimum during different phenophases except during the period from panicle emergence to flowering. There was a well distribution of rainfall of 170.4 mm during the critical periods from flowering to maturity, which helped the crop to give better yields.

Response of pearl millet to adopted spacing and applied nitrogen level

Growth

Drymatter production of pearl millet at harvest did not differ significantly due to spacing (Table 3). However, larger drymatter production was recorded with 60 cm x 15 cm spacing. Drymatter production measured at harvest was significantly influenced by nitrogen levels. Highest drymatter 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). Interaction effect of spacing and nitrogen levels on drymatter production was found non-significant.

Leaf area index was significantly influenced by spacing at 60 DAS (Table 3). The crop spaced at 30 cm x 15 cm recorded significantly highest leaf area index compared to the crop spaced at 45 cm x

15 cm and 60 cm x 15 cm. Leaf area index was significantly influenced by nitrogen levels. 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 non-significant. Higher stature of growth attributes *viz.*, dry matter production 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 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 higher drymatter accumulation.

Yield attributes

Varied spacings had not exerted any significant influence on yield attributes of pearl millet (Table 3). However, highest number of panicles per plant and panicle length recorded with 60 cm x 15 cm and the lowest was recorded with 30 cm x 15 cm spacing. Varied spacings had not shown significant influence on threshing percentage. However, highest threshing percentage was recorded

Table 3. Effect of spacing and nitrogen levels on productivity of pearl millet in dryland regions

Treatments	Plant height at harvest (cm)	DMPat harvest (g/plant)	LAI at 60 DAS	Number of panicles plant ⁻¹	Panicle length (cm)	Threshing Percentage	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Net Returns (Rs. ha ⁻¹)	B: C ratio
Spacing										
S ₁ : 30 x 15 cm	98.2	53.2	1.04	1.56	18.8	68.1	2720	3078	28573	2.34
S ₂ : 45 x 15 cm	97.9	56.7	0.79	1.56	18.7	65.1	2828	3019	30203	2.46
S ₃ : 60 x 15 cm	98.5	60.1	0.73	1.75	19.4	65.4	2988	3344	32595	2.67
CD at 5%	NS	NS	0.12	NS	NS	NS	NS	243	NS	NS
Nitrogen levels										
N ₁ : Control (No N)	90.3	53.9	0.62	1.42	18.9	62.9	2431	3034	24968	2.17
N ₂ : 40 kg/ha	101.5	53.4	0.78	1.58	18.7	65.4	2790	3142	34233	2.85
N ₃ : 60 kg/ha	94.8	60.2	0.87	1.62	19.2	67.1	3083	3048	29581	2.41
N ₄ : 80 kg/ha	102.8	59.3	0.93	1.69	19.2	66.2	2964	3354	31924	2.54
N ₅ : 100 kg/ha	101.7	57.4	1.06	1.87	18.9	69.5	2958	3157	31578	2.47
CD at 5%	6.1	3.1	0.15	0.35	NS	NS	366	268	5494	NS
Interaction (S X N)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

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Table 4. Correlation coefficient between yield attributes and yield of pearl millet as influenced by spacing

Parameter	Number of tillers plant ⁻¹	Number of panicles plant ⁻¹	Panicle length (cm)	Single panicle weight (g)	Grain weight panicle ⁻¹ (g)	Threshing Percentage (%)	Test weight (g)	Harvest Index	Grain Yield (kg ha ⁻¹)	Straw yield
Number of tillers plant ⁻¹	1									
Number of panicles plant ⁻¹	0.999**	1								
Panicle length (cm)	0.983**	0.991**	1							
Single panicle weight (g)	0.996**	0.999**	0.995**	1						
Grain weight per panicle (g)	0.868**	0.893**	0.945**	0.908**	1					
Threshing Percentage (%)	-0.468	-0.419	-0.296	-0.388	0.033	1				
Test weight (g)	0.962**	0.975**	0.996**	0.982**	0.971**	-0.208	1			
Harvest Index	0.731**	0.693*	0.592	0.669*	0.296	-0.945	0.517	1		
Grain Yield (kg ha ⁻¹)	0.937**	0.916**	0.855**	0.902**	0.639*	-0.748	0.805**	0.924*	1	
Straw yield (kg ha ⁻¹)	0.975**	0.985**	0.999**	0.991**	0.957**	-0.259	0.999**	0.560	0.835**	1

* = Significant at 5 % level ; ** = Significant at 1 % level

with 30 cm x 15 cm and the lowest was recorded with 45 cm x 15 cm.

Number of panicles plant⁻¹ was higher with application of 100 kg N ha⁻¹ which was comparable with 80 kg ha⁻¹, 60 kg ha⁻¹ and 40 kg ha⁻¹ with significant parity between treatments 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 kg N ha⁻¹, 80 kg N ha⁻¹ 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. However, maximum panicle length was recorded with 60 kg N ha⁻¹ and 80 kg N ha⁻¹. The least panicle length was observed with application of 40 kg N ha⁻¹. These findings are in contrast to the studies of Maas and Hanna (2006) who reported that an increase in rate of nitrogen up to 112 kg ha⁻¹ led to a boost in head length. Ahmed *et al.* (2015) observed that from 0 – 80 kg N ha⁻¹ panicle length increases with increase in N application but further increase of N from 80-120 kg N ha⁻¹ has not resulted in further increase in panicle length. These results are in conformity with the findings of Pandey and Sinha (2010).

Threshing percentage was not significantly influenced by nitrogen level. However, maximum threshing percent was recorded with application of 100 kg N ha⁻¹ compared to other levels of Nitrogen. The control treatment has registered least value. Test weight was also not significantly influenced by different nitrogen levels. However, application of 80 kg N ha⁻¹ recorded highest test weight. The lowest test weight was recorded with control treatment. These results are in accordance with findings of Mustapha *et al.* (1997) who reported that N application to the crop produced heavier seeds than the control.

Grain and straw yield

Grain yield was not significantly influenced by variable spacing (Table 3). However, 60 cm x 15 cm spacing recorded maximum grain yield compared to 45 cm x 15 cm and 30 cm x 15 cm. Variation in grain yield was remarkable due to applied level of nitrogen. Maximum grain yield was recorded with 60 kg N ha⁻¹ compared to lower level of 40 kg N ha⁻¹ and higher level of 80 kg N ha⁻¹ and 100 kg N ha⁻¹ with significant parity between treatments. 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), Jat *et al.* (1994) and Sharma *et al.* (1999) who observed that grain yield of pearl millet had increased with increased levels of nitrogen. The interaction effect due to adopted spacing and applied levels of nitrogen on grain yield was found non-significant.

Straw yield was significantly influenced by the adopted spacing (Table 3). The crop spaced at the spacing of 60 cm x 15 cm registered highest straw yield compared to 30 cm x 15 cm and 45 cm x 15 cm. Among different levels of nitrogen applied, highest straw yield was recorded with 80 kg N ha⁻¹ compared to 40 and 100 kg N ha⁻¹ with significant parity. The lowest straw yield was recorded with control. Among different levels of nitrogen, 80 kg ha⁻¹ was optimum as it gave significantly higher grain and straw yield compared to 40 kg N ha⁻¹, 60 kg N ha⁻¹ and on par yield at 100 kg N ha⁻¹. The increased yield response upto a dose of 80 kg N ha⁻¹ compared to a higher dose of 100 kg N ha⁻¹ can be attributed to increased uptake of nitrogen. As the soil was deficient in available nitrogen, the crop absorbed this nutrient efficiently and thereby enhanced the dry matter production. This might have resulted in more number of panicles per sq m that supported higher grain and straw yield (Yakadri and Pratap Kumar

Table 5. Correlation coefficient between yield attributes and yield of pearl millet as influenced by nitrogen levels

Parameter	Number of tillers plant ⁻¹	Number of panicles plant ⁻¹	Panicle length (cm)	Single panicle weight (g)	Grain weight per panicle (g)	Threshing Percentage (%)	Test weight (g)	Harvest Index	Grain Yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)
Number of tillers plant ⁻¹	1									
Number of panicles plant ⁻¹	0.960**	1								
Panicle length (cm)	0.310	0.159	1							
Single panicle weight (g)	0.988**	0.971**	0.217	1						
Grain weight per panicle (g)	0.857**	0.872**	0.130	0.921**	1					
Threshing Percentage %	0.992**	0.958**	0.202	0.987**	0.850**	1				
Test weight (g)	0.851**	0.854**	0.608*	0.827**	0.745**	0.786**	1			
Harvest Index	0.561	0.540	-0.198	0.502	0.177	0.627*	0.216	1		
Grain Yield (kg ha ⁻¹)	0.839**	0.729**	0.536	0.745**	0.449	0.816**	0.745**	0.694*	1	
Straw yield (kg ha ⁻¹)	0.316	0.474	0.301	0.280	0.155	0.260	0.646*	0.164	0.379	1

* = Significant at 5 % level ; ** = Significant at 1 % level

Table 6. Correlation coefficient between yield attributes and yield of pearl millet as influenced by interaction between spacing and nitrogen levels

Parameter	Number of tillers plant ⁻¹	Number of panicles plant ⁻¹	Panicle length (cm)	Single panicle weight (g)	Grain weight per panicle (g)	Threshing Percentage (%)	1000 seed weight (g)	Harvest Index	Grain Yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)
No. of tillers plant ⁻¹	1									
No. of panicles plant ⁻¹	0.850**	1								
Panicle length (cm)	0.195	0.333	1							
Single panicle weight (g)	0.364	0.116	0.455	1						
Grain weight per panicle (g)	0.292	0.045	0.335	0.889**	1					
Threshing %	0.000	-0.076	-0.095	0.163	0.586*	1				
1000 seed weight (g)	0.064	-0.194	-0.073	0.306	0.319	0.154	1			
Harvest Index	0.444	0.286	-0.236	0.015	0.119	0.200	0.337	1		
Grain yield (kg ha ⁻¹)	0.326	0.217	-0.213	0.118	0.260	0.373	0.600*	0.781**	1	
Straw yield (kg ha ⁻¹)	-0.208	-0.109	0.061	0.141	0.226	0.322	0.355	-0.355	0.303	1

* = Significant at 5 % level ; ** = Significant at 1 % level

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Reddy, 2009). The interaction effect was found to be non-significant with varied spacing and levels of nitrogen.

Economics

Net returns and B:C ratio were not significantly influenced by varied spacings and nitrogen levels (Table 3). However, highest net returns and B:C ratio was recorded with 60 cm x 15 cm and the lowest net returns and B:C ratio was recorded with 30 cm x 15 cm. Among nitrogen levels, higher net returns and B:C ratio was recorded with application of 40 kg N ha⁻¹ compared to 60 kg N ha⁻¹, 80 kg N ha⁻¹ and 100 kg N ha⁻¹ which in turn are comparable to each other. The higher economic returns might be due to higher grain and straw yields registered under higher nitrogen levels. The lowest net returns and B:C ratio was recorded with control. The interaction effect was found to be non-significant with different levels of nitrogen and spacing.

Correlation between yield attributes and yield as influenced by spacing

There was positive and significant correlation between number of tillers and panicles plant⁻¹ (Table 4). Panicle length was positively and significantly correlated with number of tillers and panicles plant⁻¹. Single panicle weight, grain weight panicle⁻¹, test weight, harvest index, grain yield, straw yield were positively and significantly correlated with number of tillers and panicles plant⁻¹. Panicle length was positively and significantly correlated with single panicle weight. Panicle length and single panicle weight were positively and significantly correlated with grain weight panicle⁻¹, test weight, grain and straw yield. There was positive and significant correlation between single panicle weight and harvest index. Grain weight panicle⁻¹ was positively and significantly correlated with test weight, grain and straw yield. Test weight was positively and significantly correlated with grain and straw yield. There was positive and significant correlation between

grain yield and harvest index, grain yield and straw yield.

Correlation between yield attributes and yield as influenced by nitrogen levels

Single panicle weight, grain weight panicle⁻¹, threshing percentage, test weight, grain yield was positively and significantly correlated with number of tillers and panicles plant⁻¹ (Table 5). There was positive and significant correlation between number of tillers plant⁻¹ and number of panicles plant⁻¹, panicle length and test weight, harvest index and grain yield. Single panicle weight was positively and significantly correlated with grain weight panicle⁻¹, threshing percentage, test weight and grain yield. Grain weight panicle⁻¹ was positively and significantly correlated with threshing percentage and test weight. Threshing percentage was positively and significantly correlated with test weight, harvest index and grain yield. Test weight was positively and significantly correlated with grain and straw yield.

Correlation between yield attributes and yield of pearl millet as influenced by interaction between spacing and nitrogen levels

Number of panicles plant⁻¹ was positively and significantly correlated with number of tillers (Table 6). There was positive and significant correlation between grain weight panicle⁻¹ and single panicle weight. Threshing percentage was positive and significantly correlated with grain weight panicle⁻¹. Grain yield was positive and significantly correlated with test weight and harvest index.

CONCLUSION

ABH-1 can be grown at inter row spacing of 45 cm or 60 cm to get higher grain yield and net returns under rainfed conditions. Though, application of 60 kg N ha⁻¹ and 80 kg N ha⁻¹ resulted in higher grain and straw yield, application of 40 kg N ha⁻¹ is optimum because of higher net returns and B:C ratio.

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PERFORMANCE OF MAIZE-CHICKPEA SEQUENCE AT DIFFERENT SOWING DATES AND NITROGEN MANAGEMENT PRACTICES

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Date of Receipt: 02.01.2018

Date of Acceptance:06.02.2018

ABSTRACT

Studies were conducted on clay soils for two years to find out the influence of sowing time and nitrogen levels on the yield performance and yield attributing characters in maize-chickpea sequence. Sowing dates followed and nitrogen levels applied to maize and chickpea significantly influenced the yield attributes, yield and monetary returns of both the crops during both the years of the experiment. Highest grain and straw yield, higher amount of N uptake by kernel and stover and higher B:C Ratio were recorded by both the crops when maize was sown on the 1st FN of July with 200% RDN and 100% RDN applied to succeeding chickpea during *Kharif* and *Rabi* of 2013-14 and 2014-15.

INTRODUCTION

Improving and maintaining soil health for enhancing and sustaining agricultural production is of utmost importance for India's food and nutritional security. Though India is a food surplus nation with about 231.5 million tonnes food grain production per annum, it will require about 4-5 million tonnes additional food grain each year if the present trend in rising population persists (CMIE, 2010). Due to increase in population pressure, the demand for food, feed, fodder, fiber, fuel, pulses and oil seed production is rapidly increasing. To meet the future demand, we would need better planning and management and as well as intensification of crop production. It is anticipated in India by 2025, total food grain demand will reach 291 million tonnes comprising 109 mt of rice, 91 mt of wheat, 73 mt of coarse grains and 25 mt of pulses in spite of the limitation for the expansion of cultivable land area (Kumar and Shiva, 2010). One of the alternatives to achieve this goal is to raise the crop productivity through improved varieties and the matching production technologies to sustain soil fertility, cropping systems and crop productivity in future. Intensive cultivation through the multiple cropping with proper planning in a sustainable way will help in increasing the food grain

production for meeting the future demand and requirement.

Maize in *kharif* and chickpea in *rabi* is one of the crop sequence in India in both irrigated and rainfed areas. This sequence occupies 5.4 lakh hectraes and contributes 0.65 % of total food grain production of the country (Anonymous, 1996). In the Malaprabha Command area of Karnataka, maize in *kharif* and chickpea in *rabi* is the most profitable cropping system occupying nearly one lakh ha (Anonymous, 2006). Of these two crops, maize removes lot of nutrients (148 kg N, 62 kg P₂O₅ and 133 kg K₂O ha⁻¹) and addition of nutrients to soil is often less than the removal (Anonymous, 2004). The succeeding chickpea builds up the soil nitrogen symbiotically and its leaf senescence character also improves the soil organic matter. The yield of maize and chickpea mainly depends on the major agronomic practices *i.e.*, time of sowing and nitrogen supply to these crops (Jaliya *et al.*, 2008 and Gaur *et al.*, 1992). The productivity of chickpea was also significantly influenced by different dates of sowings (Harpreet *et al.*, 2005) and nitrogen levels from 0 to 45 kg ha⁻¹ (Shrikrishna *et al.*, 2004). Maize has wide adaptability and compatibility under various soil and climatic conditions; hence it is cultivated in sequence

with different crops under various agro ecological conditions of the country (Vidyavathi *et al.*, 2011). Hence, the maize-chickpea sequence was studied with an objective to examine the agro-economic feasibility of maize-chickpea sequence for rainfed areas of Krishna agro climatic zone of Andhra Pradesh.

MATERIAL AND METHODS

The field experiment was conducted at Regional Agricultural Research Station, Lam located at Guntur (Latitude: 16°18', Longitude: 80°29', Altitude: 33 above MSL). The climate is sub-tropical with average annual rainfall of 950 mm. The soil of experimental field was clay loam in texture, neutral to slightly alkaline in reaction (pH 7.8 to 8.2), low in available N (204 kg ha⁻¹), high in P₂O₅ (96.5 kg ha⁻¹) and K₂O (886.5 kg ha⁻¹) and medium in organic carbon (0.51%), respectively. The experiment was conducted for two successive *kharif* and *rabi* seasons of 2013-14 and 2014-15 in Krishna agro-climatic zone of Andhra Pradesh. The experiment consisting of three sowing dates as main plots treatments *viz.*, 2nd FN of June, 1st FN of July and 2nd FN of July, three nitrogen levels as sub-plot treatments *viz.*, 100 %, 150 % and 200 % RDN (RDN=200 kg N ha⁻¹) applied to preceding maize and four N levels as sub-sub plot treatments *viz.*, 0, 50 %, 75 % and 100 % RDN (RDN=20 kg N ha⁻¹) to succeeding chickpea. All treatments were randomly allocated and replicated thrice in a split plot design for *kharif* crop and split-split designs for *rabi* crop during 2013-14 and 2014-15 of the experimentation. Each main plot was divided into required size of three sub plots and each sub-plot is again divided into four sub-sub plots of required size. Recommended dose of N for maize was applied in three splits (1/2 at sowing, 1/4 at knee high stage and 1/4 at tasselling stage, respectively) to preceding maize and entire dose of N was applied at the time of sowing to succeeding chickpea. A popular and non-lodging medium duration maize variety P-3396 and popular *desi* chickpea JG-11 were used in both

the years of study. The data pertaining to soil, weather and yield attributes and yield was collected during crop growth period. Statistical analysis pertaining to yield and yield attributes was done following the analysis of variance technique for split and split-split design. Statistical significance was tested by applying F-test at 0.05 level of probability and critical difference (CD) were calculated for those parameters.

RESULTS AND DISCUSSION

Weather prevailing during crop growth

On season basis, *kharif* maize crop received mean maximum and minimum temperatures of 32.2°C and 22.2 °C, sunshine hours 4.6 hrs day⁻¹ and total rainfall of 799 mm in 49 rainy days. *Rabi* chickpea received mean maximum and minimum temperature of 31.0 °C and 19.4 °C, sunshine hours 5.7 hrs day⁻¹ and total rainfall of 276 mm in 11 rainy days, respectively. The above weather data was the average of both the years of the experiment.

Response of maize to different sowing dates and nitrogen levels under maize-chickpea sequence

The rate of increase in plant height of maize was faster up to 60 days and thereafter it slowed down. Among the three sowing dates; taller plants, more drymatter accumulation, cob length, number of kernel rows cob⁻¹, cob diameter, cob weight and number of kernels cob⁻¹ were recorded with the sowing on 2nd FN of June and was on a par with 1st FN of July. Sowing either during 1st FN or 2nd FN of July gave statistically comparable plant height during both years of the study. The nitrogen levels tried were found to be significant w.r.t plant height, drymatter accumulation and above yield attributes. Among the three nitrogen levels, nitrogen applied at 200 % RDN recorded significantly taller plant, more drymatter and higher yield attributes over 100 % RDN but it was on a par with 150 % RDN during both the years of study. The interaction between sowing dates and nitrogen levels was found to be non-significant. This increase in growth and yield attribute at higher levels of

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Table 1. Growth response of maize at different sowing dates and N levels under maize-chickpea sequence (mean of two years)

Treatments	Plant height (cm)				Dry matter accumulation (gm ⁻²)			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
Main plots : Sowing dates								
2 nd FN of June	86.83	237.39	241.43	107.6	67.0	1001.7	1994.1	21.9
1 st FN of July	86.32	217.58	222.09	100.6	32.6	793.8	1820.9	21.1
2 nd FN of July	82.37	201.95	209.71	91.6	30.8	510.7	1537.7	19.4
CD (P_≤0.05)	NS	28.57	30.03	8.7	7.0	85.4	207.3	2.1
CV (%)	12.61	9.89	10.04	8.5	12.4	8.5	8.9	6.3
Sub plots: N Levels								
100 % RDN	79.48	204.49	203.22	97.5	34.7	575.6	1506.8	19.2
150 % RDN	86.48	218.81	222.40	103.5	44.2	756.7	1836.1	20.8
200 % RDN	89.57	233.61	247.61	109.1	51.5	974.0	2009.8	22.5
CD (P_≤0.05)	NS	25.93	31.36	7.3	5.7	76.4	209.7	1.9
CV (%)	10.96	11.41	13.53	6.8	12.8	9.7	11.5	8.2
Interaction	NS	NS	NS	NS	NS	NS	NS	NS

nitrogen might be due to better availability and utilization of nitrogen resulting in improved assimilation of nitrogen at increasing levels of nitrogen resulting in increased plant height and cell division and cell elongation as promoted by nitrogen (Table 1 and Table 2).

Kernel and stover yield of maize was significantly affected by sowing dates and nitrogen levels during the both the years of experiment. However, the interaction of these factors was found to be non-significant. Among the different sowing dates, the higher kernel and stover yield was recorded with 2nd FN of June and was significantly superior over 2nd FN of July sowing and on a par with the 1st FN of July sowing during the first and second years of the study. The increased kernel and stover yield in first sowing window might be due to the cumulative

effect of substantial improvement in growth characters like plant height, drymatter accumulation and higher yield attributes viz., increased size of cob, more number of filled kernels. Increase in the kernel yield with increase in the nitrogen level was observed. A significantly increased kernel yield was registered by the application of the 200 % RDN which was followed by 150 % RDN. Applying 200 % RDN and 150 % RDN were statistically comparable with each other. Improvement in kernel and stover yield of maize with increase in the level of nitrogen might be due to the manifestation of elevated level of nitrogen on growth and yield parameters resulting in the superior performance of maize over the lower levels. Similar results were also reported by Maryam *et al.* (2013) who recorded that if consumption of nitrogen increases, the plant will have more use possibility

Table 2. Yield and yield attributes of maize as influenced by sowing dates and N levels under maize-chickpea sequence (mean of two years)

Treatments	cob length (cm)	No. of kernel rows cob ⁻¹	cob diameter (cm)	cob weight (g)	No. of kernels cob ⁻¹	100 kernel wt (g)	N up take (kg ha ⁻¹)		Kernel yield (q ha ⁻¹)	stover yield (q ha ⁻¹)	Available soil N
							Kernel	stover			
Main plots : Sowing dates											
2 nd FN of June	21.9	15.0	2.4	263.6	535.2	25.7	111.9	107.6	95.2	12.3	107.5
1 st FN of July	21.1	14.5	2.3	229.9	522.5	25.1	102.4	100.6	93.2	11.1	98.3
2 nd FN of July	19.4	13.7	2.3	209.3	462.2	24.5	95.8	91.6	77.4	10.5	85.9
CD (P_≤0.05)	2.1	1.3	NS	33.5	56.0	0.0	11.5	14.0	12.5	1.7	16.3
CV (%)	6.3	6.6	10.3	11.1	8.4	8.6	8.5	9.9	10.8	11.3	9.0
Sub plots: N Levels											
2 nd FN of June	19.2	13.6	2.3	212.2	481.6	24.4	97.5	94.9	81.1	12.3	92.5
1 st FN of July	20.8	14.7	2.3	234.7	509.0	25.1	103.5	100.0	91.0	11.1	98.4
2 nd FN of July	22.5	15.8	2.3	255.9	529.3	25.7	109.1	104.9	93.6	10.5	104.3
CD (P_≤0.05)	1.9	0.8	NS	29.6	33.2	0.0	7.3	10.2	8.1	1.2	10.4
CV %	8.2	5.7	10.4	12.1	6.4	7.3	6.8	8.7	8.9	10.0	7.3

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Table 3. Growth response of chickpea at different sowing dates and N levels under maize-chickpea sequence (mean of two years)

Treatments	Plant height at harvest (cm)			DM accumulation at harvest (g m ⁻²)			Nitrogen uptake (kg ha ⁻¹)		Available soil N (kg ha ⁻¹) after harvest
	30 DAS	60 DAS	HARVEST	30 DAS	60 DAS	HARVEST	by seed	by stover	
Main plots : Maize sowing dates									
2 nd FN of June	14.11	28.28	39.90	8.07	116.11	188.72	60.14	51.22	141.06
1 st FN of July	17.66	41.98	47.28	9.61	125.11	291.28	60.08	51.59	142.54
2 nd FN of July	15.95	33.54	45.16	8.53	121.91	268.60	59.45	51.45	140.52
CD (P<0.05)	0.97	1.99	1.24	0.70	5.01	36.35	NS	NS	NS
CV (%)	9.08	8.79	4.31	12.22	6.38	12.87	5.50	5.50	7.47
Sub-plot : N applied to Maize									
100% RDN	15.63	33.12	43.27	8.46	114.92	196.89	59.08	50.76	140.40
150% RDN	15.86	34.84	43.79	8.72	118.20	227.45	59.81	51.16	140.85
200% RDN	16.23	35.83	45.27	9.01	129.39	324.25	60.77	52.34	142.86
CD (P<0.05)	0.47	0.81	1.18	0.46	3.29	42.89	1.28	1.46	NS
CV (%)	5.71	4.58	5.22	10.34	5.29	10.37	5.63	5.63	7.89
Sub-sub plot : N applied chickpea									
0 % RDN	15.67	16.33	41.65	16.33	16.33	220.24	59.11	50.77	138.25
50 % RDN	15.72	16.81	43.15	16.81	16.81	245.22	59.72	51.24	139.73
75 % RDN	15.92	17.27	45.07	17.27	17.27	261.85	60.12	51.29	142.28
100 % RDN	16.33	17.90	46.59	17.90	17.90	270.82	60.59	52.39	145.23
CD (P<0.05)	0.56	0.82	1.70	0.59	2.88	43.06	1.24	1.50	4.05
CV (%)	6.42	4.37	7.07	12.50	4.38	6.83	5.43	5.43	4.49
Interaction	AxB	NS	NS	NS	NS	NS	NS	NS	NS

Table 4. Yield and yield attributes of chickpea as influenced by sowing dates and N levels under maize-chickpea sequence (mean of two years)

Treatments	No. of branches plant ⁻¹	No. of pods plant ⁻¹	No. of seeds pod ⁻¹	1000 grain weight (g)	Harvest index (%)	Seed yield (q ha ⁻¹)	Stover yield (t ha ⁻¹)	Available soil N (kg ha ⁻¹) after harvest
Main Plots: Maize sowing dates								
2 nd FN of June	3.21	78.30	1.19	237.02	38.27	13.32	1.63	141.06
1 st FN of July	5.30	110.39	1.20	247.19	38.71	17.43	2.93	142.54
2 nd FN of July	5.06	96.25	1.20	243.20	37.47	15.45	2.69	140.52
CD (P_≤0.05)	0.49	6.36	NS	NS	NS	0.31	0.17	NS
CV (%)	11.82	14.02	17.42	3.21	14.94	3.03	10.30	7.47
Sub-plot : N applied to Maize								
100% RDN	4.30	82.98	1.19	238.45	37.43	14.02	1.94	140.40
150% RDN	4.48	94.05	1.20	242.72	38.05	14.75	2.37	140.85
200% RDN	4.79	107.91	1.20	246.35	39.03	17.42	3.23	142.86
CD (P_≤0.05)	0.20	6.78	NS	NS	NS	0.57	0.11	NS
CV (%)	8.15	14.69	13.46	6.99	11.67	7.25	8.50	7.89
Sub-sub plot : N applied to chickpea								
0 % RDN	4.02	79.05	1.19	236.79	37.02	618.10	2.21	138.25
50 % RDN	4.33	90.88	1.19	242.33	37.82	738.24	2.47	139.73
75 % RDN	4.63	98.06	1.20	244.77	38.39	826.65	2.66	142.28
100 % RDN	5.12	111.92	1.20	246.13	39.42	935.23	2.72	145.23
CD (P_≤0.05)	0.34	7.14	NS	NS	NS	0.66	0.13	4.05
CV (%)	16.96	15.24	15.92	7.77	14.13	7.86	12.40	4.49
Interaction	NS	NS	NS	NS	NS	NS	NS	NS

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and by more nitrogen absorbing by the roots and transferring to reproductive organs, harvest index will increase.

Response of chickpea to sowing dates and nitrogen levels under maize-chickpea sequence

Plant height, drymatter accumulation, yield attributes and yield of *rabi* chickpea was significantly influenced by maize sowing dates and N levels and N application to succeeding *rabi* chickpea. Maximum plant height, drymatter accumulation, number of branches, number of pods plant⁻¹ in chickpea was recorded when the preceding maize was sown on 1st FN of July at 200 % RDN and 100 % RDN applied to succeeding chickpea. Early sowing, adequate nitrogen and soil moisture that makes higher availability of nutrients in the soil, longer sunshine hours per day resulting in more photosynthetic activity, efficient translocation of photosynthates to sink might have resulted in increased drymatter production might be due to the fact that nitrogen fertilization made the plants more efficient in photosynthetic activity, enhancing the carbohydrate metabolism and ultimately increasing in drymatter accumulation finally resulted in higher yield.

All the sowing dates and nitrogen levels tried in preceding maize and also N levels tried in succeeding chickpea differed significantly on grain yield and stover yield of chickpea with one another during both the years of the study. Significantly higher grain yield and stover yield of chickpea was recorded when the preceding maize was sown on 1st FN of July and applying 200 % RDN and giving 100 % RDN to succeeding chickpea in both the years of the study gave higher yields. Nitrogen levels tried in preceding maize and N levels tried in succeeding chickpea only differed significantly with N up take during both the years of the study. Significantly higher N uptake of succeeding chickpea was recorded when the preceding maize was applied with 200 % RDN and 100 % RDN applied to succeeding chickpea in both the years of the study. Similar results were

reported by Sreerekha *et al.* (2015). From the maize- chickpea sequence, high gross returns (Rs. 2,18,429/-), net returns (Rs. 1,38,555/-) and B:C Ratio (3.8) were registered when maize was sown on 1st FN July applied with 200 % RDN and when chickpea was applied with 100 % RDN. These results are in accordance with the findings of Lingaraju *et al.* (2010); Jnanesha and Alagundagi (2012); Vidyavathi *et al.* (2012) and Mohankumar and Hiremath (2015) who reported significantly higher net returns and benefit- cost ratio in maize- chick pea sequence.

CONCLUSION

There is scope to adopt maize-chickpea cropping sequence in rainfed areas of Krishna zone as evident from the better yield levels of both the crops in both the years of study. Sowing maize during 1st FN of July, applying 200 % RDN to maize and applying 100 % RDN to succeeding chickpea were found to be the best agronomic management practices for maize-chickpea sequence in rainfed areas of Krishna zone.

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EFFECT OF DIFFERENT SHADING INTENSITIES AND GENOTYPES ON PRODUCTION OF LEAFY CORIANDER IN OFF SEASON

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Date of Receipt: 18.12.2017

Date of Acceptance:19.01.2018

ABSTRACT

The investigation was under taken to study the effect of different intensities of shade as one factor and promising genotypes as another factor in Factorial Randomized Block Design with three replications during the years 2009-10 and 2010-11. Among the treatments, days taken for germination was observed significantly less under 50% shade (9.88 days) followed by 75% shade (11.04 days). With regard to genotypes, Sadhana germinated earlier (11.20 days) being on par with other genotypes. Number of leaves was recorded significantly more under 50% and 75% shade (6.11) than control (4.41). Among the genotypes significantly more number of leaves were recorded in LCC- 244 (6.43) being on par with LCC- 234 (6.12) than Sadhana (4.81) *i.e.* check. Significantly maximum yield was recorded with 50% shade (3.59 t ha⁻¹) followed by 35% shade (3.01 t ha⁻¹) than control (0.51 t ha⁻¹). Among the genotypes, significantly maximum yield was recorded in LCC- 244 (3.18 t ha⁻¹) being on par with LCC-234 (2.89 t ha⁻¹) than check (1.87 t ha⁻¹).

INTRODUCTION

Coriander (*Coriandrum sativum*) leaf is rich in Vitamin A and has lot of medicinal values. (Balakrishna and Pushpa Kumari, 2001; Murthy and Sridhar, 2001). There is a lot of demand for coriander leaf throughout the world for its fragrance and medicinal values. Coriander under irrigated conditions is grown through out the year for leaf purpose. However, cultivation of this crop is restricted to only cooler parts of the regions in summer season as the crop can't withstand high temperatures. This offers the growers high remunerative price (Rs.100/- to 150/-per kg) for the crop. There is a great demand for leaf during summer months from March to June, as production is limited to only a few areas of the country, where summer temperatures are low. Isbell (2009) reported that coriander can be grown as short duration crop and has potential to rotate as a second crop following winter crop and can get remunerative income in a short span of time. However, high temperature is considered as the major limiting factor for germination and growth of coriander during summer. Bomme *et al.* (2007) studied the spring cultivation of coriander for leaf and suggested that the coriander variety 'Santos' can be grown for

highest leaf yield. There is lack of information regarding the technology for summer production of leafy coriander and suitability of genotypes for leaf. Protected cultivation provides the best way to increase the productivity and quality of vegetables as well as to tolerate biotic and abiotic stresses compared to open field condition (Singh *et al.*, 2007). Greenhouse cultivation showed superior yield and yield attributing characters as compared to open field condition of cucurbits (Dixit *et al.*, 2005). To make the conditions congenial, some low cost structures (50% agro shadenet as roofing material) may be used especially during off-season. However, information is not available on the technology for cultivation of coriander in off season and the potential genotypes for leafy coriander. Hence, the investigation was under taken with an objective to study the effect of different shade intensities and genotypes suitable for leaf purpose in coriander during summer season.

MATERIAL AND METHODS

The investigation was carried out for a period of two years during 2009-10 and 2010-11 at Horticultural Research Station, Lam, Guntur. The

experiment was conducted in Factorial Randomised Block Design (RBD) with three replications consisting of different intensities of shade as one factor and genotypes as second factor. Six promising genotypes viz., LCC- 231, LCC- 234, LCC- 242, LCC- 244 and Sadhana (check) were evaluated under open, 35%, 50% and 75% shade intensities during summer season in Factorial RBD with three replications. The experimental soil was slightly alkaline (pH 7.7), low in organic carbon (0.43%), medium in available nitrogen (168 kg ha⁻¹), low in available phosphorus (17.4 kg ha⁻¹) and high in exchangeable potassium (954 kg ha⁻¹). At the time of sowing, organic manure in the form of FYM was added as basal dose in addition to 100 gm of urea/ 30 m²/ plot. Sowing was done at 2cm - 5 cm depth and paddy straw was used as mulch upto germination. Necessary cultural operations were taken up periodically for the experimental field. The crop was sown during second fortnight of May in both the seasons. As the crop was sown for leaf purpose harvesting was done at 45 days after sowing. Data on days to germination, number of leaves, yield and essential oil content was recorded during the crop growth period. Pooled analysis was done as per the method suggested by Jawahar (2006).

RESULTS AND DISCUSSION

The pooled analysis of the data indicated that the genotypes and different intensities of shade under evaluation exhibited significant differences for all the characters under study.

Number of days to germination

Results of the investigation revealed that number of days to germination was significantly influenced by the varieties and intensities of shade. (Table 1). Number of days taken for germination was more under open conditions (14.2 days) than under shade net. Among the treatments, days taken for germination was significantly less under 50% shade (9.88 days) followed by 75% shade (11.04 days). Early germination in shade net may be due to micro

climatic conditions resulting in low temperature and high humidity under shade net. Better germination and growth under shading as compared to control was observed by Guha *et al.* (2013) in coriander. The optimum temperature range for coriander seed germination is 24°C-25°C (Allahmoradi *et al.*, 2013). The low percentage of germination as well as delayed germination in open (control) plot may be attributed to higher air temperatures. In case of 50% shading and 75% shading plots, the air temperatures (at 2.30 pm) were 3°C to 5 °C less than that of control plot. Shading might have created the optimum micro-climatic condition by reducing the soil temperature and increasing the available soil moisture (Sarada *et al.*, 2011). The reduced soil temperature along with enhanced humidity might have activated the embryos and thereby reflecting earlier and higher percentage of germination under shade net condition. With regard to genotypes, Sadhana germinated earlier (11.20 days) being on a par with other genotypes. The variability observed with regard to germination among cultivars may be due to variability in genotypes.

Number of leaves

Number of leaves was significantly influenced by the varieties and shade intensity (Table 1). Number of leaves was significantly higher under 50% shade and 75% shade (6.11) than open conditions (4.41). Among the genotypes, significantly more number of leaves were recorded in LCC- 244 (6.43) being on a par with LCC – 234 (6.12) than check (4.81). Similar results of variation in performance of genotypes were reported by Uliana and Timoth (2007) in summer coriander. This might be due to variability in performance of genotypes under beneficial micro-climate in the shade net house. Similar results of better leaf growth was observed in protected cultivation in coriander by Guha *et al.* (2016); vegetables by Rajasekhar *et al.* (2013) and Singh *et al.* (2007) which may be due to less biotic and abiotic stress conditions compared to open field. The reduction in the average maximum air temperature

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Table 1. Effect of shade intensities and genotypes on no. of days to germination and no. of leaves in coriander

Entry Shade intensity	No. of days to germination					Number of leaves				
	Open	35%	50%	75%	Mean	Open	35%	50%	75%	Mean
LCC-231	14.8	13.3	10.0	9.7	11.9	3.5	5.0	5.9	5.7	5.1
LCC-233	15.3	12.7	10.1	10.9	12.3	3.8	5.2	6.4	6.0	5.4
LCC-234	14.0	13.1	10.8	11.9	12.4	5.3	6.2	6.7	6.3	6.1
LCC-242	13.3	12.8	9.5	12.0	11.9	4.8	5.4	5.7	6.1	5.5
LCC-244	13.4	12.1	9.8	12.3	11.9	5.3	6.7	6.7	7.0	6.4
Sadhana	14.3	11.9	9.1	9.5	11.2	3.7	4.8	5.3	5.5	4.8
Mean	14.2	12.7	9.9	11.0	12.0	4.4	5.6	6.1	6.1	
	CD (P≤0.05)	CV (%)				CD (P≤0.05)	CV (%)			
Treatments	1.83	23.1				0.40	11.0			
Cultivars	2.25					0.5				
VxT	4.5					0.99				

Table 2. Effect of shade intensities and genotypes on leaf yield and essential oil % in coriander

Entry Shade intensity	Leaf Yield (t ha ⁻¹)					Essential Oil (%)				
	Open	35%	50%	75%	Mean	Open	35%	50%	75%	Mean
LCC-231	0.23	2.45	2.46	2.67	1.95	0.10	0.15	0.22	0.15	0.16
LCC-233	0.23	2.7	3.57	2.63	2.28	0.12	0.24	0.20	0.19	0.19
LCC-234	0.29	3.55	4.54	3.18	2.89	0.10	0.19	0.21	0.23	0.18
LCC-242	0.24	3.09	4.13	3.06	2.63	0.10	0.13	0.20	0.20	0.16
LCC-244	0.32	3.86	5.03	3.52	3.18	0.19	0.33	0.25	0.22	0.25
Sadhana	0.19	2.39	1.81	1.57	1.49	0.12	0.15	0.20	0.17	0.16
Mean	0.25	3.01	3.59	2.77		0.12	0.20	0.21	0.19	
	CD (P≤0.05)	CV (%)				CD (P≤0.05)	CV (%)			
Treatments	1.18	22.5				NS	23.5			
Cultivars	1.45					0.07				
VxT	2.9					NS				

and light intensity by shading might have created an environment congenial for growth of plant thereby reflecting in higher foliage growth, while the consistently higher temperature in the open plot might have resulted in poor growth of coriander during summer season. The early germination under shade net might have also resulted in more vegetative growth of plant. The seeds germinated earlier had more number of leaves and resulted in vigorous growth during the later period also.

Yield

Results of the investigation revealed that leaf yield ($t\ ha^{-1}$) was significantly influenced by the varieties and shade intensities (Table 2). Among the genotypes maximum yield was recorded in LCC- 244 ($3.18\ t\ ha^{-1}$) being on par with LCC-234 ($2.89\ t\ ha^{-1}$) than check ($1.87\ t\ ha^{-1}$). Similar results of variation in performance of coriander genotypes in shadenets during off season was reported by Bomme *et al.* (2007), Tehlan and Malik (2010). Among the shade intensities, maximum yield was recorded with 50% shade ($3.59\ t\ ha^{-1}$) followed by 35% shade ($3.01\ t\ ha^{-1}$) than open conditions ($0.51\ t\ ha^{-1}$). This indicated that the yield of leafy coriander during the summer season was significantly influenced by different shading treatments. The various shading treatments significantly increased the yield to an extent of about 6-7 times as compared to the control. Similar results of increase in yield of leafy coriander due to different intensities of shade were reported by Dixit (2007); shade intensities and variety was reported by Tehlan and Malik (2010). In case of coriander, as entire plant is used as a vegetable, increase in the growth characters, early germination, more number of leaves, etc. might have directly resulted in increased yield. Therefore, better yields in shading treatments might be attributed to better growth of plants due to favourable range of temperatures and light intensity that prevailed in shading treatments which in turn enhanced the rate of photosynthesis and thereby more carbohydrate accumulation. (Kotadia *et al.*,

2012). Higher germination percentage in shaded treatments might have resulted in increased plant population and subsequently increased yield.

Essential Oil (%)

The data pertaining to essential oil percentage revealed that there was significant difference with respect to genotypes and shade intensities (Table 2). Among the genotypes, essential oil percentage was significantly maximum in LCC-244 (0.25%) being on a par with LCC-233 (0.19%). The variability observed in essential oil content might be due to variability in performance of genotypes. However, the essential oil percentage among the different shade intensities was not significant.

CONCLUSION

Among the different shaded treatments, 50% shade was ideal for coriander cultivation as it recorded early germination, more number of leaves and higher yield. With regard to genotypes, LCC-244 and LCC-234 gave more number of leaves and yield than Sadhana (check). Hence, the study indicated that during off season (summer) coriander can be cultivated under 50% shade net conditions with LCC -244 and LCC- 234 genotypes.

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ADOPTION BEHAVIOUR OF GROUNDNUT FARMERS IN CHITTOOR DISTRICT OF ANDHRA PRADESH

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Date of Receipt: 06.01.2018

Date of Acceptance: 12.02.2018

ABSTRACT

Adoption behaviour of 180 farmer beneficiaries from eight adopted villages of *RAAS Krishi Vigyan Kendra* (KVK), Chittoor with respect to the recommended Groundnut production technologies was studied during the year 2012. Four types of behaviour viz., full adoption, partial adoption, discontinuation and non-adoption for fourteen recommended package of practices in Groundnut was analysed. The results revealed that overall there was a positive trend (greater than 50% full adoption for ten recommended practices) in the adoption behaviour of the beneficiaries of KVK. However, KVKs need to put efforts to influence the farmers (through different interventions) for complete adoption of the recommended technologies for improving the productivity and profits of the farmers.

INTRODUCTION

The Indian Council of Agricultural Research (ICAR) has a network of 681 *Krishi Vigyan Kendras* (KVKs) in India (ICAR, 2017). Ever since their establishment, KVKs have played effective role of technology backstopping to extension personnel and subsequently to farmers so as to enable them to augment their productivity and profitability (Kokate, 2010). The KVKs are playing the role of intermediary institutions to fine tune the research conducted, often under controlled conditions, before its adoption in farmer's field. An investigation was conducted to study the adoption behaviour of respondents from adopted villages of the KVK with respect to the recommended Groundnut production technologies in Chittoor district of Andhra Pradesh. Wilkening (1950) stated that the farmer's decision for adoption of improved farm practices may be considered as a process in which he/she (a) hears about the practice, (b) discusses its advantages and disadvantages with other farmers or with experts, (c) makes the decision to adopt the practice and obtains the specific information necessary to carry out the practice. This process may occur over a period of time.

Degree of adoption of any item of package of practice may be of complete or full, partial, non-adoption and discontinuation. A proper feedback from the farmers will certainly provide an insight to the scientists for further research or modification of the new farm technology. In the study, adoption behaviour of farmers from adopted villages of KVK with respect to recommended production technologies of Groundnut crop was examined.

MATERIAL AND METHODS

RAAS Krishi Vigyan Kendra of Chittoor District, Andhra Pradesh was purposively selected for the study (2012-13). Out of the 20 mandals adopted by the KVK, five Mandals viz., Yerpedu, Chandragiri, Ramachandrapuram, Narayanavanam and Karvetinagaram were selected randomly for the study. Of the 23 villages adopted by the KVK in these five mandals, eight villages were selected randomly. About 180 KVK beneficiaries (farmers) who are involved in KVK programmes such as Trainings, OFTs, FLDs, Field days, etc., were selected from these five villages proportionately for the study. The adoption behaviour of the farmers was studied using an interview schedule with respect

to recommended package of practices of Groundnut (ANGRAU,2012) in terms of four types of adoption behaviour *viz.*, full adoption, partial adoption, discontinuation and non adoption with the scores 3, 2, 1 and 0, respectively. The reasons associated with each type of behaviour were extracted from the respondents and presented as frequencies and percentages.

RESULTS AND DISCUSSION

The adoption behaviour of the respondents towards recommended package of practices is presented in Table 1.

About 39.03 per cent of the respondents have not adopted the recommended groundnut varieties while 29.31 per cent of respondents have fully adopted, 25.70 per cent have partially adopted and 5.97 per cent have discontinued the practices. The extent of adoption of the respondents with respect to Farmer's seed multiplication was 31.11 per cent full adoption, 38.89 per cent partial adoption, 11.11 per cent discontinued and 18.89 per cent non-adoption. Respondents, by and large, had fully adopted (97.22%) recommended land preparation practices for Groundnut cultivation. With respect to recommended sowing season, the extent of adoption was 71.67 per cent full adoption, 17.78 per cent partial adoption, 2.05 per cent discontinuation and 8.06 per cent non-adoption. From Table 1 it is observed that 65 per cent of the respondents fully adopted the recommended seed rate, 25.56 per cent partially adopted, 2.22 per cent discontinued and 7.22 per cent had not adopted at all. Regarding recommended seed treatment, the adoption behaviour was 44.33 per cent full adoption, 15.56 per cent partial adoption, 7.56 per cent discontinuation and 32.55 per cent non-adoption.

Full adoption of the recommended sowing method was only 28.33 per cent, while 42.22 per cent have not adopted this practice. 20.56 per cent partially

adopted and 8.89 per cent discontinued this practice. With respect to recommended spacing, 77.22 per cent of the respondents fully adopted this practice, 16.11 per cent partially adopted, and 6.67 per cent had not adopted. None of the farmers had discontinued this practice. The adoption behaviour of the respondents with respect to water management practices was 56.11 per cent full adoption, 16.11 per cent partial adoption, 0.85 per cent discontinuation and 26.95 per cent non-adoption. The distribution of respondents with respect to the adoption of fertilizer management practices was 71.25 per cent full adoption, 15.14 per cent partial adoption, 2.50 per cent discontinuation and 11.11 per cent non-adoption.

More than half of the respondents (68.70%) fully adopted recommended weed management practices followed by 16.48 per cent partial adoption, 13.70 per cent non-adoption and 1.11 per cent discontinuation. With regard to recommended cultural practices such as trap crops, border crops, bird perches, etc., the adoption behaviour as noticed from the Table 1 was 63.62 per cent full adoption, 24.17 per cent partial adoption, 1.39 per cent discontinuation and 10.84 per cent non-adoption. About 56.11 per cent of respondents fully adopted pest management practices as per recommendations, 13 per cent partially adopted, 7.22 per cent discontinued and 23.67 per cent had not followed pest management practices as per recommendations suitable for the area. The adoption behaviour with respect to recommended harvesting practices of Groundnut revealed 83.33 per cent full adoption followed by 7.22 per cent of partial adoption, 5 per cent of non-adoption and 4.45 per cent of discontinuation (Table 1).

Reasons for different adoption behaviour as expressed by the respondents

Various reasons expressed for different types of adoption behaviour of the respondents is presented in Table 2.

Table 1. Adoption behaviour of farmers towards recommended package of practices in Groundnut

n=180

S.No	Recommended package of practices	Adoption behaviour											
		Full adoption		Partial adoption		Discontinued		Non-adoption					
		Frequency (N)	%	Frequency (N)	%	Frequency (N)	%	Frequency (N)	%				
1	Recommended improved varieties	53	29.31	46	25.70	11	5.97	70	39.03				
2	Farmer's seed multiplication	56	31.11	70	38.89	20	11.11	34	18.89				
3	Land preparation	175	97.22	3	1.67	1	0.56	1	0.56				
4	Sowing season recommended for the area	129	71.67	32	17.78	5	2.50	14	8.06				
5	Recommended Seed rate	117	65	46	25.56	4	2.22	13	7.22				
6	Seed treatment	80	44.33	28	15.56	14	7.56	58	32.88				
7	Method of sowing	51	28.33	37	20.56	16	8.89	76	42.22				
8	Recommended spacing	139	77.22	29	16.11	0	0	12	6.67				
9	Water management	101	56.11	29	16.11	2	0.83	48	26.95				
10	Fertilizer management	128	71.25	27	15.14	5	2.50	20	11.11				
11	Weed management	124	68.70	29	16.48	2	1.11	25	13.70				
12	Recommended Cultural practices	113	63.62	44	24.17	3	1.39	20	10.84				
13	Pest management	101	56.11	23	13.00	13	7.22	43	23.67				
14	Recommended harvesting practices	150	83.33	13	7.22	8	4.45	9	5.00				

Table 2. Reasons expressed by the farmers for different adoption behaviour of the technologies

S.No	Recommended package of practices	Reasons (in order of farmers response)			n=180
		Full adoption	Partial adoption	Discontinued	
1	Recommended improved varieties	<p>^a High yielding than any other varieties (43.4%).</p> <p>^a Short duration variety and hence suitable for our farming situation (28.3%).</p> <p>^a Uniform pegging and maturity (20.75%).</p> <p>^a Suitable to rabi season (7.55%)</p>	<p>^a Recommended seed ratespecified for the variety is not followed (63.04%).</p> <p>^a Sowing is not done in the specified season (36.96%)</p>	<p>^a Low shelling percentage (72.73%).</p> <p>^a Yields not satisfactory (27.27%)</p>	<p>^a Unaware of the new varieties (65.71%).</p> <p>^a Non availability of quality seed of latest varieties (34.29%)</p>
2	Farmer's seed multiplication	<p>^a Risk of purchase of seed at higher cost is avoided (37.5%).</p> <p>^a Seed purity is maintained (28.57%).</p> <p>^a Timely sowing is possible (19.64%).</p> <p>^a Quality of seed & germination is good (8.93%).</p> <p>^a High yield is achievable (5.36%)</p>	<p>^a Own seed is developed only from rabi season's crop (72.86%).</p> <p>^a Recommended moisture for storage is not maintained (27.14%)</p>	<p>^a Labour shortage (40%).</p> <p>^a Quality seed is not produced from my field (35%).</p> <p>^a Hand picking is laborious and costly (15%).</p> <p>^a Coincidence of rains during harvesting (10%)</p>	<p>^a Seed produced in my field will not give high yields if used for next season (44.12%).</p> <p>^a Lack of seed storage facilities (26.47%).</p> <p>^a Groundnut is cultivated only one season in a year (20.59%).</p> <p>^a Forced to sale for immediate requirement of cash (8.89%)</p>

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3	Land preparation	<p>^a Reduced pest incidence (58.86%).</p> <p>^a Weed infestation is reduced (28%).</p> <p>^a Improves the yield (13.14%)</p>	<p>^a Ploughing is done with nine tynes cultivator (100%)</p>	<p>^a Intensive cropping system - three crops a year (100%)</p>	<p>^a No additional benefit from deep ploughing (100%)</p>
4	Sowing season recommended for the area	<p>^a High yields are obtained (59.69%).</p> <p>^a Pest and diseases incidence is not high if sowings are done timely (29.46%).</p> <p>^a North east monsoon helps in getting good crop during rabi season (10.85%)</p>	<p>^a Very early sowings are helping to achieve high yields (59.38%).</p> <p>^a Sowing date is preponed due to climate change in <i>kharrif</i> (40.63%)</p>	<p>^a Harvesting is difficult due to coincidence of rainfall (100%)</p>	<p>^a Delay in rainfall in <i>kharrif</i> season (42.86%).</p> <p>^a Non availability of bullock drawn ploughs (21.43%).</p> <p>^a Seed is not available timely (21.43%).</p> <p>^a Groundnut cultivation is done only in rabi season & no <i>kharrif</i> crop (14.29%)</p>
5	Recommended seed rate	<p>^a Optimum plant population gives high yields (79.49%).</p> <p>^a Field coverage with crop canopy reduces the sucking pest complex on the crop (20.51%)</p>	<p>^a More seed rate is required for high yields (45.65%).</p> <p>^a Cost of seed is high (39.13%).</p> <p>^a Rainfed crop in <i>kharrif</i> season (15.22%)</p>	<p>^a Some plants die in the field and hence more seed rate is used (100%)</p>	<p>^a Not aware of the recommended seed rate (61.54%).</p> <p>^a Not possible due to manual sowing (38.46%)</p>
6	Seed treatment	<p>^a Cheapest and easiest method of pest controlling practice (42.5%).</p>	<p>^a Seed treatment is done with fungicide alone (60.71%).</p> <p>^a Chemical is not applied as per the recommended dose (25%).</p>	<p>^a Laborious process (50%).</p> <p>^a <i>Trichoderma viridi</i> is not available in the open market (35.71%).</p>	<p>^a Unaware of <i>Trichoderma viridi</i> seed treatment (32.76%).</p> <p>^a Not aware of treatment with Imidacloprid (31.03%).</p>

		<p>^a Very effective against soil borne & seed borne pathogens (35%).</p> <p>^a Crop is protected against pests and diseases up to 30 days after sowing (16.25%).</p> <p>^a Prevents root grub damage (6.25%).</p>	<p>^a Seed treatment is done just before sowing (14.29%)</p>	<p>^a Not so beneficial (14.29%)</p>	<p>^a Lack of sufficient time for seed treatment (22.41%).</p> <p>^a Chlorpyrifos seed treatment is not necessary for our area as root grub is not observed (13.79%)</p>
7	Method of sowing	<p>^a Sowing operation is completed quickly than traditional method (37.25%).</p> <p>^a Cost effective compared to traditional sowing (21.57%).</p> <p>^a Seed rate is less than traditional sowing method (17.65%).</p> <p>^a Sowing is done timely (17.65%).</p> <p>^a Traditional bullock drawn implements are not available (5.88%)</p>	<p>^a Seed rate used is not as per recommendation (62.16%).</p> <p>^a Fertilizer is not applied through tractor drawn ferti cum seed drill (38.84%)</p>	<p>^a Germination is affected (43.75%).</p> <p>^a Skill involvement required for sowing with ferti cum seed drill sowing (37.5%).</p> <p>^a Yields were not satisfactory (18.75%)</p>	<p>^a Non-availability of the implement in our village (75%).</p> <p>^a Not aware of ferti - cum - seed drill sowing (25%)</p>
8	Recommended spacing	<p>^a High yielding is achievable (66.91%).</p> <p>^a Coverage of field with crop canopy reduces weed infestation (33.09%)</p>	<p>^a High plant population is maintained (75.86%).</p> <p>^a Due to pest and disease incidence after sowing (24.14%)</p>		<p>^a Not possible with traditional sowing method (75%).</p> <p>^a Not aware of the recommended spacing (25%)</p>

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9	Water management	<p>a Uniform and profuse flowering (40.59%).</p> <p>a High yields are achievable due to low pest incidence (32.67%).</p> <p>a Judicious use of irrigation water through sprinkler system (20.79%).</p> <p>a Weed infestation is reduced (5.94%)</p>	<p>a During <i>kharrif</i>, difficult to withhold irrigation up to 25 days after sowing due to coincidence of rains during sowing time (100%)</p>	<p>a Lack of funds to get new sprinkler set (100%)</p>	<p>a Crop is under rainfed situation (45.83%).</p> <p>a Poor groundwater source (31.25%).</p> <p>a Installation of sprinkler system is costly (22.92%)</p>
10	Fertilizer management	<p>a Oil content and shelling percentage increased due to Gypsum (55.47%).</p> <p>a Pest problem is reduced (27.34%).</p> <p>a Required nutrients can be supplied through soil test results (12.5%).</p> <p>a Management of Iron deficiency increased yields (4.69%)</p>	<p>a Cost of fertilizers is increased (44.44%).</p> <p>a Complex fertilizers are used (33.33).</p> <p>a Availability of SSP is poor (22.22)</p>	<p>a Expected yields are not obtained (100%)</p>	<p>a Unaware of recommended fertilizer doses (40%).</p> <p>a Unaware of iron deficiency (30%).</p> <p>a Gypsum is not timely available (30%)</p>
11	Weed management	<p>a Cost of weed management is reduced (37.1%).</p> <p>a Crop loss is reduced and yields can be improved (33.87%).</p>	<p>a Weedicide doses are not as per recommendation (55.17%).</p> <p>a Application of weedicides is not timely (44.83%)</p>	<p>a Parthenium is not manageable and to be eradicated completely (100%)</p>	<p>a Unaware of weedicides (44%).</p> <p>a Weedicides damage the main crop (36%).</p> <p>a Able to manage weeds through manual weeding (20%)</p>

12	Cultural practices	<p>^a Weeds are better controlled using pre-emergence weedicide (21.77%) .</p> <p>^a Pest and disease problem is reduced (7.26%)</p> <p>^a Incidence of <i>Spodoptera</i> is noticed in the egg stage itself and controlled at that stage before it damages the crop (37.17%) .</p> <p>^a Wind borne pest infestation is reduced (26.55%) .</p> <p>^a Bud necrosis incidence is reduced due to control of thrips (23.89%) .</p> <p>^a Viral diseases are controllable. (12.39%)</p>	<p>^a Trap crops are not sown as per the recommendation (63.64%) . Random sowing of Jowar/Maize along the border (36.36%)</p>	<p>^a Laborious process(100%)</p>	<p>^a Lack of time (45%) .</p> <p>^a Not practicable under rainfed situation (35%) .</p> <p>^a Non availability of Castor / Sunflower seed in time (20%)</p>
13	Pest management	<p>^a Precautionary spray at 15 days reduces sucking pest incidence (32.67%) .</p> <p>^a Destroying pest at egg stage is very economical (26.73%) .</p>	<p>^a Pesticides / fungicides are not applied as per the recommended doses (73.91%) .</p> <p>^a Applying neem oil purchased from market at unspecified doses (26.09%)</p>	<p>^a Non-availability of NPV in time in market (61.54%) .</p> <p>^a Necessity of poison bait for <i>Spodoptera</i> didn't arise as it was managed through chemicals (38.46%)</p>	<p>^a Unaware of the recommended chemicals and doses (27.91%) .</p> <p>^a Unaware of NPV concept (25.58%) .</p>

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14	Recommended harvesting practices	<p>^a Tikka leaf spots are effectively controlled (21.78%).</p> <p>^a Poison bait is cost effective and best method for controlling <i>Spodoptera</i> (10.89%).</p> <p>^a Optimum plant population is maintained (7.92%)</p>	<p>^a Pods are not treated with chemicals before storing (69.23%).</p> <p>^a Recommended moisture percentage is not maintained in the pods (30.77%)</p>	<p>^a Shortage of manual labour (62.5%).</p> <p>^a Quality of seed was damaged during storage in previous season (37.5%)</p>	<p>^a <i>Spodoptera</i> is not a serious pest in rained <i>kharif</i> situation (18.6%).</p> <p>^a Neem seed is not available in our area (16.28%).</p> <p>^a Laborious process to collect virus affected worms and prepare NPV solution (11.63%)</p>
		<p>^a Cost of seed input for next crop is reduced (40.67%).</p> <p>^a Additional price benefit (34.67%).</p> <p>^a Quality of seed is maintained if pods are manually separated from plants (19.33%).</p> <p>^a Seed is not blackened due to handpicking (5.33%)</p>	<p>^a Pods are not treated with chemicals before storing (69.23%).</p> <p>^a Recommended moisture percentage is not maintained in the pods (30.77%)</p>	<p>^a Shortage of manual labour (62.5%).</p> <p>^a Quality of seed was damaged during storage in previous season (37.5%)</p>	<p>^a Costly process to adopt hand picking of seed (66.67%).</p> <p>^a Marketing through middle men and hence care is not taken (33.33%)</p>

Recommended Improved Varieties: The reasons for full adoption were 'High yielding than any other varieties', 'Short duration variety and hence suitable for our farming situation', 'Uniform pegging and maturity' and 'suitable to rabi season'. 'Recommended seed rate specified for the variety is not followed' and 'sowing is not done in the specified season' were the reasons given by farmers for partial adoption behaviour. 'Low shelling percentage' and 'Yields not satisfactory' were the reasons behind discontinuation and 'Unaware of the new varieties' and 'Non availability of quality seed of latest varieties' were the reasons for non-adoption. TAG-24 was the popular variety in the area due to high yielding nature and short duration, hence it was adopted. The new varieties released are to be introduced among the farming community duly emphasizing the advantages over the existing popular varieties.

Farmer's seed multiplication: 'Risk of purchase of seed at higher cost is avoided', 'Seed purity is maintained', 'Timely sowing is possible', 'Quality of seed and germination will be good' and 'High yield is achievable' were the reasons expressed by groundnut farmers for full adoption of this practice. 'Own seed is developed only from rabi season's crop' and 'Recommended moisture for storage is not maintained' were the reasons for partial adoption. Reasons for discontinuation given by the respondents were 'Labour shortage', 'Quality seed is not produced from my field', 'Hand-picking is laborious and costly' and 'Coincidence of rains during harvesting'. 'Seed produced in my field will not give high yields if used for next season', 'Lack of seed storage facilities', 'Groundnut is cultivated only one season' and 'Immediate requirement of cash' were the reasons for non-adoption. Misconception among the farmers regarding own seed usage for next season might be the reason for non-adoption of own seed production. Introduction of machinery especially harvesting and threshing equipment for Groundnut need to be introduced and awareness shall be created among the farmers.

Land preparation: The reasons for full adoption were 'Reduces pest incidence', 'Weed infestation is reduced' and 'improves the yield'. Reason for partial adoption was 'Ploughing is done with nine tyne cultivator'. 'Intensive cropping system - three crops a year' was the reason given for discontinuation of recommended land preparation practice. 'No additional benefit from deep ploughing' was the reason for non-adoption of this practice. The probable reason for discontinuation and non-adoption of recommended practice might be due to land preparation practice using nine tyne cultivator involves less drudgery than MB Plough. Awareness on benefits of recommended land preparation practices needs to be created among the farming community for full adoption of the practice.

Sowing season recommended for the area: The respondents expressed 'High yields are obtained', 'Pest and diseases incidence is not high if sowings are done timely' and 'North- East monsoon helps in getting good crop during rabi season' as the reasons for high adoption of sowing in recommended timeline. 'Very early sowings are helping to achieve high yields' and 'Sowing date is preponed due to climate change in *Kharif* were the reasons for partial adoption. 'Harvesting is difficult due to coincidence of rainfall' was the reason for discontinuation while 'Delay in rainfall in *Kharif* season', 'Non availability of bullock drawn ploughs', 'Seed was not available timely' and 'Groundnut cultivation is done only in rabi season and no *kharif* crop' were the reasons for non-adoption of this practice (Table 2).

Recommended seed rate: 'Optimum plant population gives high yields' and 'Field coverage with crop canopy reduces the sucking pest complex on the crop' were the reasons behind full adoption of recommended seed rate practice by the respondents. 'More seed rate is required for high yields', 'Cost of seed is high' and 'Rainfed crop in *kharif* season' were the reasons given for partial adoption. The reason for discontinuation was 'some plants wither in the field

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and hence more seed rate is used'. 'Not aware of the recommended seed rate' and 'Not possible due to manual sowing' were the reasons for non-adoption. Awareness programmes on optimum seed rate and sowing using tractor drawn seed drill have to be conducted so that farmers adopt recommended seed rate.

Seed treatment: 'Cheapest and easiest method of pest controlling practice', 'Very effective against soil and seed borne pathogens', 'Crop is protected against pests and diseases up to 30 days after sowing' and 'Prevents root grub damage' were the reasons for high adoption. 'Seed treatment is done with fungicide alone', 'Chemical is not applied as per the recommended dose' and 'Seed treatment is done just before sowing' were the reasons for partial adoption. 'Laborious process', '*Trichoderma viridi* is not available in the open market' and 'Not so beneficial' were the reasons for discontinuation. The respondents who had not adopted this practice expressed reasons such as 'Unaware of *Trichoderma viridi* seed treatment', 'Not aware of treatment with Imidacloprid', 'Lack of sufficient time for seed treatment' and 'Chlorpyrifos seed treatment is not necessary for our area as root grub is not observed'. Majority of the farmers were practicing seed treatment using Mancozeb, however, to achieve full benefit of seed treatment farmers need to be sensitized on treatment with insecticide viz., Imidacloprid for management of Collor rot, Peanut Bud necrosis, Peanut Stem necrosis, etc.

Method of sowing: 'Sowing operation is completed quickly than traditional method', 'Cost effective compared to traditional sowing', 'Seed rate is less than traditional sowing method', 'Sowing is done timely' and 'Traditional bullock drawn implements are not available' were the reasons given for full adoption behaviour. 'Seed rate used is not as per recommendation' and 'Fertilizer is not applied through tractor drawn ferti cum seed drill' were the reasons for partial adoption. The reasons for discontinuation

are 'Germination is affected', 'Skill involvement for sowing with ferti cum seed drill sowing' and 'Yields were not satisfactory'. 'Unavailability of the implements in our village' and 'Not aware of ferti - cum - seed drill sowing' were the reasons for non-adoption of this practice. This trend might be due to non-availability of tractor drawn seed drill and skilled labour to operate the implement ensuring good germination, low seed rate, spacing, etc.

Recommended spacing: Respondents expressed that 'High yielding is achievable' and 'Coverage of field with crop canopy reduces weed infestation' were the reasons for full adoption. The reason for partial adoption was 'High plant population is maintained'. Reasons for non-adoption were 'Not possible with traditional sowing method' and 'Not aware of the recommended spacing'. This trend is noticed due to non-adoption of tractor drawn seed drill and farmers are still sowing behind plough using labour. Availability of tractor drawn seed drills at village level increases adoption of recommended sowing method by the farmers (Table 2).

Water management: 'Uniform and profuse flowering', 'High yields are achievable due to low pest incidence', 'Judicious use of irrigation water through sprinkler system' and 'Weed infestation is reduced' were the reasons stated by the respondents for high adoption behaviour. The reason for partial adoption was 'During *kharif* difficult to withheld irrigation upto 25 DAS due to coincidence of rains during sowing time'. 'Lack of funds to get new sprinkler set' was the reason stated for discontinuation. The reasons for non-adoption were 'Crop is under rainfed situation', 'Poor groundwater source' and 'Installation of sprinkler system is costly'. Majority of the farmers are still practicing flood irrigation and they need to be sensitized on the advantages of Sprinkler irrigation on Groundnut growth and yielding. Subsidy component on the micro irrigation system needs to be enhanced for the benefit of all the categories of farmers.

Fertilizer management: 'Oil content and shelling percentage increased due to Gypsum', 'Pest problem is reduced', 'Required nutrients can be supplied through soil test results' and 'Management of Iron deficiency increased yields' were the reasons for full adoption of fertilizer management practices. 'Cost of fertilizers is increased', 'Complex fertilizers are used' and 'Availability of SSP is poor' were the reasons for partial adoption. The main reason for discontinuation was 'Expected yields are not obtained'. Non-adoption behaviour was due to reasons such as 'Unaware of recommended fertilizer doses', 'Unaware of iron deficiency' and 'Gypsum is not timely available'. Timely availability of Gypsum to the farmers and training programmes on management of iron deficiency helps in adoption of recommended fertilizer management practices.

Weed management: 'Cost of weed management is reduced', 'Crop loss is reduced and yields can be improved', 'Weeds are better controlled using pre-emergence weedicide' and 'Pest and disease problem is reduced' were the reasons for full adoption of recommended weed management practices. Reasons for partial adoption behaviour were 'Weedicide doses are not as per recommendation' and 'Application of weedicides is not timely'. Reason for discontinuation was 'Parthenium is not manageable and to be eradicated completely'. 'Unaware of weedicides', 'Weedicides damage the main crop' and 'Able to manage weeds through manual weeding' were the reasons for non-adoption. Awareness on pre and post emergence herbicides, their mode of application, cost effectiveness over manual weeding need to be created among farmers for adoption of effective weed management practices.

Cultural practices: The respondents stated that 'Incidence of *Spodoptera* is noticed in the egg stage itself and controlled at that stage before it damages the crop', 'Wind borne pest infestation is reduced', 'Bud necrosis incidence is reduced due to control of thrips' and 'Viral diseases are controllable' as the reasons for

full adoption of the cultural practices. 'Trap crops are not sown as per the recommendation' and 'Random sowing of Jowar/Maize along the border' were the reasons for partial adoption. 'Laborious process' was the reason for discontinuation of cultural practices. The reasons for non-adoption behaviour were 'Lack of time', 'Not practicable under rainfed situation' and 'Non availability of Castor / Sunflower seed in time'. The trend observed emphasizes the need of imparting knowledge to the farmers about border cropping, trap cropping, arrangement of bird perches, physical collection of caterpillars, etc., for effective management of pests and diseases in groundnut crop (Table 2).

Pest management: 'Precautionary spray at 15 days reduces sucking pest incidence', 'Destroying pest at egg stage is very economical', 'Tikka leaf spot disease is effectively controlled', 'Poison bait is cost effective and best method for controlling *Spodoptera*' and 'Optimum plant population is maintained' were the reasons for full adoption of recommended pest management practices. 'Pesticides / fungicides are not applied as per the recommended doses' and 'Applying neem oil purchased from market at unspecified doses' were the reasons for partial adoption behaviour. The reasons for discontinuation were 'Non-availability of NPV in market' and 'Necessity of poison bait for *Spodoptera* didn't arise as it was managed through chemicals'. 'Unaware of the recommended chemicals and doses', 'Unaware of NPV concept', '*Spodoptera* is not a serious pest in rainfed *Kharif* situation', 'Neem seed is not available in our area' and 'Laborious process to collect virus affected worms and prepare NPV solution' were the reasons expressed by the respondents. This trend of non-adoption of recommended pest management practices especially Integrated Pest Management practices indicates the necessity of arranging training programmes to the farmers on advantages of IPM measures and market availability of Neem Oil, NPV, etc.

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Recommended Harvesting Practices: The respondents expressed that 'Cost of seed for next crop is reduced', 'Additional price benefit', 'Quality of seed is maintained if pods are manually separated from plants' and 'Seed is not blackened due to handpicking' as the reasons for full adoption behaviour. 'Pods are not treated with chemicals before storing' and 'Recommended moisture percentage is not maintained in the pods' were the reasons for partial adoption behaviour. The reasons for discontinuation were 'Shortage of manual labour' and 'Quality of seed was damaged during storage'. 'Costly process to adopt hand picking of seed' and 'Marketing through middle men' were the reasons for non-adoption behaviour of the respondents. The above trend indicated that still there is a section of farming community who were not adopting recommended harvesting practices for production of good quality seed such as hand picking, shade drying, etc. Farmers were also not aware that seed production has high market price than selling entire produce (Table 2).

CONCLUSION

The investigation revealed that majority of the farmers (78%) are adopting (full adoption and partial adoption) one or the other recommended package of practices in Groundnut crop in adopted villages of KVK, while 22% of the farmers fell under

non adoption category (discontinuation or non-adoption). Timely dissemination of the technology through various extension methods resulted in improved adoption of recommended technologies by Groundnut farmers. However, KVKs need to put efforts to influence the farmers (through different interventions) for complete adoption of the recommended technologies for improving the productivity and profits of the farmers.

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IMPACT OF MGNREGA IN TERMS OF DIRECT CHANGES- A STUDY IN SRIKAKULAM DISTRICT OF ANDHRA PRADESH

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Date of Receipt:09.01.2018

Date of Acceptance:12.02.2018

ABSTRACT

The study examined the impact of MGNREGA in terms of direct changes experienced by the beneficiaries during the year 2015. One hundred and twenty(120) respondents were selected randomly for the study. The results revealed that majority of the MGNREGA beneficiaries' experienced medium direct changes followed by high and low direct changes. Direct changes observed due to implementation of MGNREGA were increased employment generation (286 days/ year), increased number of employed persons in the family (3 or more), increased daily working hours (> 7 hours), increased daily wage rates (360/- Rs.), increased income generation, increased community and individual assets creation and reduced migration (47 days/ year).

INTRODUCTION

The Government of India launched the National Rural Employment Guarantee Scheme, one of the largest rural development programmes, in February, 2006 and it was renamed as Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) on 2nd October, 2009. MGNREGA includes activities under nine different heads. MGNREGA aims at enhancing livelihood security of households in rural areas by providing 100 days of wage employment to every household whose adult members volunteer to do manual work, which is primarily for natural resource management offering gender neutral wages. The fact that it is not simply a work creation programme but derives its legitimacy from being an asset creation programme is often overlooked. When it is not, there is a widespread belief that assets created under MGNREGA are of dubious usefulness. Recently a few researchers have begun to assess the impact of MGNREGA especially focusing on migration,gender issues, agricultural and livelihood vulnerability reduction and environmental implications. Such efforts are still relatively infrequent compared with those that focus on labour and wages,implementation, etc.

Hence, there is a paramount need to find out the impact of MNREGA experienced by the beneficiaries in terms of direct changes. With this back drop, the study was conducted to know the impact occurred due to implementation of MGNREGA in terms of direct changes in srikakulam district of Andhra Pradesh.

MATERIAL AND METHODS

The study was conducted during the year 2015 with ex-post facto research design in Srikakulam district of Andhra Pradesh. MGNREGA is carried in a big way in all the 40 mandals of srikakulam district. Based on the criteria of maximum wage employment generation, out of 40 mandals in the district, three mandals namely Seethampeta, Ranasthalam and Polaki and four villages from each mandal (a total of 12 villages) were selected purposively. From each village, 10 beneficiaries were selected randomly, thus, constituting a total of 120 respondents. The data was collected from the sample of MGNREGA beneficiaries through personal interview method. Statistical tools viz., Frequency, Percentage, Mean and Standard Deviation were applied to analyse the data. Z test was applied to study the significance of difference with respect to

the Direct changes occurred before and after implementation of MGNREGA.

RESULTS AND DISCUSSION

Direct changes occurred experienced by MGNREGA beneficiaries

Direct changes were measured in terms of employment generation, income generation, reduction in migration and community & individual assets creation, which were experienced by the

beneficiaries as a result of implementation of MGNREGA in Srikakulam district. The direct changes before implementation of MGNREGA serves as a bench mark, whereas, the estimate of direct changes after implementation of MGNREGA minus before MGNREGA will be the impact of direct changes through MGNREGA. The beneficiaries were categorised into three groups on the basis of mean and SD.

Table 1. Distribution of the selected MGNREGA beneficiaries according to the direct changes (n=120)

S. No.	Direct changes	MGNREGA Beneficiaries	
		Frequency	Percentage
1	Low direct changes (> 40.38)	15	12.50
2	Medium direct changes (36.72- 40.38)	67	55.83
3	High direct changes (< 36.72)	38	31.67
	Total	120	100.00
	Mean: 38.55 SD: 1.83		

Majority (55.83%) of MGNREGA beneficiaries experienced medium direct changes followed by high (31.67%) and low (12.50%) direct changes (Table 1). The direct changes experienced by the beneficiaries were assessed in the categories of

1. Employment generation

It was evident from Table 2 that before introduction of MGNREGA, majority (68.33%) of MGNREGA beneficiaries had medium employment generation followed by high (19.17%) and low (12.50%) employment generation. After introduction of MGNREGA, majority (75.84%) of MGNREGA beneficiaries had medium employment generation and the rest of all belonged to the category of high (12.55%) followed by low (11.61%) employment generation. In order to find significance of difference in employment generation of beneficiaries before and

after MGNREGA, the data was subjected to 'Z' test and the 'Z' value (10.73**) obtained was found significant at 1 per cent level of significance indicating that there existed a significant difference in employment generation of MGNREGA beneficiaries before and after MGNREGA. The mean employment available for MGNREGA beneficiaries before introduction of MGNREGA was 218.50 days and after introduction it was 286.25 days. This increase in employment days might be due to policy initiative and enhanced fund allocation by the Central Government and the scheme is accessible to everyone at their door step. These findings were in agreement with the findings of Jeyshee *et al.* (2010), Kantharaju (2011), Dadhabahu and Gopikrishna (2013) and Sitarambabu *et al.* (2013) who observed that MGNREGA is providing employment. Employment generation was also assessed in terms of

a. Number of employed persons in the family

The beneficiaries were categorized into three groups based on number of persons employed in the family as one person, 2 persons, 3 and more persons. It is evident from Table 2 that before introduction of MGNREGA, majority (54.17%) of MGNREGA beneficiary families had one employed person followed by two (34.16%) and more than three persons (11.67%) in the family. After introduction of MGNREGA, majority (84.17%) of families had three and more persons employed followed by two (14.16%) persons and one (1.67%) person employed in the family. Calculated 'Z' value (14.09**) of Table 2 was found significant at 1% level of significance indicating that there existed a significant difference in employed persons in MGNREGA beneficiary families before and after MGNREGA implementation. This might be due to 33.00 per cent reservation for women under MGNREGA. As the works undergoing were within 5 KM radius of their residence, every member within the family was willing to participate to gain employment. Similar results were reported by Argade (2010).

b. Daily working hours

The daily working hours of MGNREGA works was categorized into three groups <5 hours, 5-7 hours and >7 hours. Results furnished in Table 2 clearly exhibit that majority (46.67%) of MGNREGA beneficiaries daily working hours were 5-7 hours before MGNREGA introduction. After implementation of the scheme 76.70 per cent of MGNREGA beneficiaries were having more than 7 daily working hours. Calculated 'Z' value (8.06**) of Table 2 was found significant at 1% level of significance indicated that there existed a significant difference in daily working hours of MGNREGA beneficiaries before and after MGNREGA. This might be due to the MGNREGA working hours besides regular and additional working hours for the eligible family members. These findings were in disagreement with the findings of Argade (2010).

c. Daily wage rates

The wage rates for MGNREGA works was categorized into three groups upto Rs.200, Rs.200-Rs.300 and >Rs.300. It is clear from the Table 2 that majority (67.50%) of beneficiaries were having daily wage rates in between Rs.200 to Rs.300 before implementation of the scheme. About 76.66 per cent of beneficiaries were getting more than Rs.300 as daily wage rate after implementation of the scheme. Calculated 'Z' value (19.69**) of Table 2 was found significant at 1 per cent level of significance. It indicated that there existed a significant difference in wage rates of MGNREGA beneficiaries before and after MGNREGA. Overall, the mean daily wage rate increased to Rs.360.50 from Rs.267.08 due to the introduction of MGNREGA. The daily wage rates of the beneficiaries were automatically increased by MGNREGA works besides the regular agricultural wages and other allied activities. These findings were in agreement with the results of Pyditalli (2015) who reported that NREGA is able to provide a higher rate of employment to the rural poor households with a high average wage rate per day per person since its inception in the Srikakulam district of Andhra Pradesh.

2. Income generation

It is evident from Table 2 that before introduction of MGNREGA, majority (47.50%) of the beneficiaries belonged to medium income generation category followed by high (39.17%) and low (13.33%) categories. After introduction of MGNREGA, majority (88.33%) of the beneficiaries belonged to high income generation category followed by medium (8.33%) and low (3.34%) income generation categories. Calculated 'Z' value (12.70**) of Table 2 was found significant at 1% level of significance. It indicated that there existed a significant difference in income generation of beneficiaries before and after MGNREGA. The mean income of MGNREGA beneficiaries before introduction of MGNREGA was Rs.21,284/- and after introduction of MGNREGA the mean income was

Table 2. Comparative distribution of selected beneficiaries and significance of difference in direct changes experienced by beneficiaries before and after MGNREGA

N=120

S. No	Direct changes	Categories	Before MGNREGA			After MGNREGA			T-value		
			F	%	Mean	SD	F	%		Mean	SD
1	Employment Generation	Low	16	12.50			14	11.61		19.73**	
		Medium	62	58.33	218.53 (Days/year)	51.80	91	75.84	286.25 (Days/year)		45.81
		High	23	19.17			15	12.50			
		Total	101	100.00			120	100.00			
	a. Employed persons in a family	1 person	63	54.17	1.84 (no. of persons)	0.66	3	2.50	3.78 (no. of persons)	1.42	14.39**
		2 persons	41	34.16			17	14.16			
		3 and more	14	11.67			101	84.33			
		Total	118	100.00			120	100.00			
	b. Daily working hours	<5 hours	21	17.50	5.78 (no. of hours/day)	1.75	0	0.00	7.36 (no. of hours/day)	1.97	8.36**
		5-7 hours	56	46.67			36	30.00			
>7 hours		43	35.83			56	46.67				
Total		120	100.00			120	100.00				
c. Daily wage rates	Up to Rs.100	36	30.00	267.38 (Rs/day)	40.06	0	0.00	368.58 (Rs/day)	48.78	19.59**	
	Rs.100-200	61	50.83			10	8.33				
	>Rs.200	1	0.83			110	91.66				
	Total	120	100.00			120	100.00				
2	Income Generation	Low	16	13.33			4	3.34		12.77**	
		Medium	57	47.50	21050.84 (Rs/year)	9077.39	10	8.33	43575.17 (Rs/year)		17028.31
		High	47	39.17			106	88.33			
		Total	120	100.00			120	100.00			
3	Migration	Low	23	19.16	87.84 (Days/year)	46.13	37	31.66	47.85 (Days/year)	37.23	14.38**
		Medium	26	21.66			67	55.84			
		High	71	58.84			16	13.50			
		Total	120	100.00			120	100.00			
F-Frequency			N= percentage			SD= Standard Deviation			** Significant at 0.01 level of probability		

Table 3. Percentage increased by in community and individual assets created before and After MGNREGA

S. No	Type of assets	Before MGNREGA	After MGNREGA	Percentage increased by
1.	Community assets			
	a. Number of wells constructed	87	150	72.00
	b. Number of wells recharged	59	137	132.00
	c. Number of farm ponds constructed	52	100	92.00
	d. Number of plantation works taken	190	288	51.00
	e. Rural connectivity (roads laid)	49	95	93.00
	f. Number of watershed works	62	102	64.00
	g. Social forestry	158	282	78.00
	h. Drinking water tanks constructed	68	104	52.00
	i. De-silting of drinking water tanks	52	97	86.00
	Total assets created	777	1355	74.00
2.	Individual assets			
	a. Farm ponds constructed	245	451	84.00
	b. Earthen field bunds, stone, bunding of fields	259	416	60.00
	c. Plantation works	316	499	57.00
	d. Wells recharged	218	420	92.00
	e. Wells constructed	173	307	77.00
	Total assets created	1211	2093	72.00

Rs.42,979/-. It meant that MGNREGA helped the beneficiaries to double their income. This shift from medium income generation to high income generation after introduction of MGNREGA might be due to the increase in number of days of employment, wage rates and also due to the number of persons employed in a family. Similar trend was reported by Ramesh and Krishna Kumar (2009), Dadabahu and Gopikrishna (2013) and Adeppa (2014).

3. Migration

It is evident from Table 2 that before introduction of MGNREGA, majority (60.84%) of MGNREGA beneficiaries had high migration followed by low (22.50%) and medium (16.66%) migration. After introduction of MGNREGA, more than half (55.84%) of beneficiaries were found to be having medium migration followed by low (31.84%) and high (12.32%) migration. Calculated 'Z' value (14.94**) was found significant at 1% level of significance. It indicated that there existed a significant difference in migration of MGNREGA beneficiaries before and after MGNREGA. This shift from high migration to medium migration might be due to additional employment opportunities provided to MGNREGA beneficiaries thereby increasing their man-days of employment. Generally, after *khari* season people used to migrate to urban areas for nearly about 97 days as it is off season for agriculture activities. However, after introduction of MGNREGA, their migration was reduced to upto 47 days due to availability of employment for them in their own villages. These results are in agreement with the findings of Naidu *et al.* (2010), Dadhabahu and Gopikrishna (2013), Sitarambabu *et al.* (2013) and Adeppa (2014). These results are in contradiction with the findings of Ahuja *et al.* (2011) who inferred that in agriculturally developed area of Haryana MGNREGA did not check the migration as the people were earning more income from migration.

4. Community and Individual assets creation

Overall there was an increase to the extent of 74.00 per cent in community assets created as a result of MGNREGA (Table 3). An orderly arrangement has shown that percentage increase in wells recharged (132.00%) and rural connectivity (93.00%) was more followed by farm ponds constructed (92.00%), de-silting of drinking water tanks (86.00%), social forestry (78.00%), wells constructed (72.00%), watershed works (64.00%), drinking water tanks constructed (52.00%) and plantation works taken up (51.00%).

Table 3 clearly indicates that the overall increase to extent of 72.00 per cent in individual assets created as a result of MGNREGA was observed. About 92.00 percentage of increase in recharge of wells was identified followed by construction of farm ponds (84.00%), construction of wells (77.00%), earthen and stone field bunding (60.00%) and plantation works (57.00%). This trend might be due to the policy initiative of MGNREGA to take up labour intensive activities which may provide steady employment in agricultural slack season, facilitate in engaging more labour as well as in creation of community and individual assets. These findings were in agreement with the findings of Deepak and Mohanty (2009), Chhabra and Sharma (2010), Kantharaju (2011) and Dadhabahu and Gopikrishna (2013) who studied implementation of NREGA with emphasis on coverage of households, employment guaranteed, works undertaken, strengths, bottlenecks and strategies for further strengthening the programme.

CONCLUSION

MGNREGA is a labour intensive programme, which is providing employment to the rural people and improves their livelihood. Overall, majority of the beneficiaries experienced medium direct changes (55.83%) due to the implementation of MGNREGA. The direct changes observed were

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increased employment generation (286 days per year) as the scheme provides opportunities for every rural household. Subsequently, income generation was also prominent. It is also successful in terms of assets creation and reduction in migration

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POST GRADUATE RESEARCH *VIS-À-VIS* FARMERS' NEEDS – A STUDY IN THE FARM UNIVERSITY OF ANDHRA PRADESH

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Date of Receipt: 30.12.2017

Date of Acceptance:31.01.2018

ABSTRACT

The study conducted on the relevance of Post Graduate research in Acharya N.G. Ranga Agricultural University and Farmers Preference in Andhra Pradesh revealed that the PG Research is relevant to the farmers needs. However, the relevance was more in research pertaining to crop improvement and less in crop protection. In Crop Production, priority of the farmers was high on nutrient management (19.22 %), weed management (16.99 %) and soil biology & fertility management (12.26 %) and accordingly research was conducted. Research in organic agriculture, cropping & farming systems, soil and water pollution was not conducted as preferred by farmers. Research on interaction between biotic organisms, compatibility among the pesticide, fertilizers, herbicides need to be focused in view of farmers' demand. Eventhough close relevance was observed between farmers needs and PG research in crop improvement, enough research in molecular biology & biotechnology was not conducted. The demand for research on training needs (19.67%) was more by the farmers while research is being conducted on production economics and farm management (25.00%).

INTRODUCTION

To improve the agricultural production in the farm, an appropriate technology is necessary. Appropriate technology is defined as the latest scientific and technological development that have been adjusted to suit the local conditions to the highest possible degree (FAO, 1996). It is known that State Agricultural Universities (SAUs) are involved in developing many technologies through research and Post Graduate (PG) Research is one which is noticeable. In all the SAUs in the country, the existing Post Graduate system is course work for two semesters followed by research work for two semesters and at Doctoral level course work for two semesters followed by research work for four semesters. Accordingly, a lot of data is being generated at SAUs from the research work conducted by the students. Studies should be conducted to find out whether the outcome generated through PG research is meeting the needs of farmers directly or indirectly, so that the efforts are meaningful. Sandra *et al.* (1989) noted that the goal of agricultural research is the development of stable technologies, the production system changes, a new constraint

becomes the most limiting and new technology must be developed or adjusted to suit farmers needs. Keeping these in view, a study was conducted with an objective to know the relevance of Post Graduate research conducted in ANGRAU and preference of farmers of Andhra Pradesh.

MATERIAL AND METHODS

The study was conducted in the Acharya N.G. Ranga Agricultural University (ANGRAU), Andhra Pradesh, covering the two colleges offering Post Graduate courses *i.e.*, Agricultural College, Bapatla and S.V. Agricultural College, Tirupati. Post Graduate research work conducted during 2011-2016 was collected department-wise from the selected colleges. The data was tabulated, research area wise and compared with the preferred areas of research by the farmers. The data collected was categorized duly identifying the major areas of research (Table 1-4) to compare the farmers' preference and PG research conducted in the state of Andhra Pradesh. The data pertaining to the PG Research was collected with a total sample of 194 in crop production, 129 in crop protection, 116 in crop improvement and 108 in social sciences.

The technological, socio-economic and other research areas preferred by the farmers was collected from the Zonal Research and Extension Advisory Council (ZREAC) reports, District Level Coordination Committee (DLCC) reports of District Agricultural Advisory and Transfer of Technology Centres (DAATTCs) and Scientific Advisory Committee (SAC) meeting reports of *KrishiVigyanKendras* etc., and also through the questionnaire developed in telugu language. A total of 1950 questionnaires were sent to 13 districts of Andhra Pradesh *i.e.* 150 questionnaires to each district (75 for DAATTCs and 75 for KVKs) for data collection. The data was collected pertaining to the research areas preferred by the farmers with a total sample of 359 in crop production, 313 in crop protection, 225 in crop improvement and 183 in social sciences. Comparison was made between the research areas preferred by the farmers and also PG research work conducted in the departments to find out the relevance of the post graduate research to the needs of the farmers. The data was computed using rank order correlation method.

RESULTS AND DISCUSSION

The analysed data related to category wise areas of PG Research conducted in ANGRAU and Farmers Preference for research areas in the state of Andhra Pradesh are presented hereunder.

Crop Production

Nutrient management (19.22 %), weed management (16.99 %), integrated crop management (13.93 %), soil biology and fertility management (12.26 %) and cropping and farming systems (10.03 %) were the most preferred researchable areas as perceived by the farmers, whereas, the PG research was concentrating on nutrient management (23.20 %), followed by weed management (15.46 %) and soil fertility and fertility management (10.82%). This clearly showed that relevance of research was observed in the areas of

soil fertility and fertility management, nutrient and weed management. Studies were also conducted on soil health management (7.73%), even though farmers' preference is very low (1.11%). Priority in PG research was given to performance of cultivars (7.22%) and soil survey and classification (8.76%) even though farmers are preferring organic agriculture (Table 1). Alex *et al.* (2010) also observed that the University Research Policy, Strategy and Organization should research the clients through publication of research results.

It could be inferred from the results that even though organic agriculture, integrated crop management and cropping and farming systems were recognised as the preferred areas of research by the farmers, much importance was not given in PG research. Water management, which is of topical importance in the present context of climate variability, was equally recognised by farmers and post graduate researchers. Research was also conducted on importance of resource management even though farmers have not recognised (Table 1).

Moreover, studies on climate resilient agriculture was not perceived as significant researchable area by the both categories of respondents. Hence, awareness on the climate variability and impact on the crops has to be created among the farmers and the research focus also need to be shifted to this area. In the context of environmental pollution and stagnation of the productivity in crops, soil health management and resource management plays a vital role to sustain agriculture. Hence, awareness has to be created among the farmers and also research has to be concentrated in these areas.

Crop Protection

Management studies of insect pests and diseases were given top priority in farmers' preference as well as PG research (41.53% and 39.53%, respectively) followed by studies on insect pests and

Table 1. Comparison of farmer's preferences and PG research conducted in Crop Production

S.No	Research areas	Farmers preference (n=359)		PG research conducted (n=194)	
		F	(%)	F	(%)
1	Integrated crop management	50	13.93	9	4.64
2	Nutrient management	69	19.22	45	23.20
3	Weed management	61	16.99	30	15.46
4	Water management	21	5.85	10	5.15
5	Organic agriculture	32	8.91	8	4.12
6	Cropping and farming systems	36	10.03	11	5.67
7	Performance of cultivars	13	3.62	14	7.22
8	Studies on climate resilient agriculture	1	0.28	2	1.03
9	Soil survey and classification	16	4.46	17	8.76
10	Soil health management	4	1.11	15	7.73
11	Soil biology and fertility management	44	12.26	21	10.82
12	Resource management	0	0	10	5.15
13	Remote sensing & GIS	1	0.28	1	0.52
14	Soil & water pollution studies	4	1.11	1	0.52
15	Others (Soil transformation, Soil delineation, etc.)	7	1.95	0	0
	r value	0.628			

diseases(14.73%)and Insecticide Residence (10.85 %) in PG research and Insecticide Resistance (12.46%)and studies on insect pests and diseases(14.73%) in Farmers Preference. This clearly depicts that close relevance was observed in choosing crop protection in post graduate research. It could be illustrated from the above results that management studies and insect pest and disease studies were most preferable areas by the farmers as pest management is the primary concern to nullify the damage caused by insect pests and diseases to crops (Table 2). Studies on insect pest and disease development factors were equally recognised by both farmers and PG researchers.

Studies on compatibility of chemicals and also interaction between biotic organisms is not being conducted by researchers, however farmers have recognised their importance. Even though the farmers have not recognised the importance of studies on insect and disease development factors and biological control, but recognising their importance enough focus is being given by researchers. These findings further indicated that farmers are facing problems in identifying the casual organism of a particular pest and their management. In some cases, they were getting confused in differentiating the pest incidence and deficiency symptoms. The PG research is also being concentrated on these aspects indicating the

importance in having clarity regarding the disease causing organisms and their management. Simultaneously it was indicated that research should also take care of making the farmers to understand and differentiate disease symptoms from deficiency symptoms.

Crop Improvement

It is clearly evident from the results (Table 3) that there was matching in farmer's preference and PG research that is being carried out in crop improvement with respect to research areas *viz.*, genetic divergence (22.22% and 29.32 %), heterosis and combining ability (13.33% and 17.24%), character association and selection indices (11.11%

Table 2. Comparison of farmers' preferences and PG research conducted in Crop Protection

S.No	Research areas	Farmers preference (n=225)		PG research conducted (n = 116)	
		F	(%)	F	(%)
1	Management studies on Insect Pests and Diseases	130	41.53	51	39.53
2	Taxonomic Studies of Insect Pests	8	2.56	2	1.55
3	Insecticide Resistance	39	12.46	14	10.85
4	Isolation/Characterization of insect pests and Diseases	27	8.63	19	14.73
5	Biological control of insect pests	10	3.19	13	10.08
6	Insect and Disease Development factors	31	9.90	12	9.30
7	Grain storage pests and their management	13	4.15	4	3.10
8	Post harvest technologies to minimize the yield losses by insect pests	0	0.00	1	0.78
9	Disease causing organisms	25	7.99	13	10.08
10	Others (Interaction among biotic pathogens, compatability studies, etc.)	30	9.58	0	0.00
	r value	0.533			

and 11.21%) and stress management (14.22% and 11.21%).

The results also indicated that both the farmer and PG researchers were not interested in bio-technology aspects, however, it is need of the hour to address different problems in pest management and increase the yield by using bio-technological tools. In the present scenario of climate resilient agriculture, suitable varieties have to be developed by taking consideration of farmer's preferences using

different molecular breeding techniques and bio-technological tools.

Comparison of farmer's preference with the PG research indicated that majority of the farmers were preferring research on nutritional aspects (15.56%) but slightly less percent (7.76%) of studies had been carried out in this aspect which is to be considered while formulating the PG research. The important area where PG research concentrates more was on characterization of genotypes (11.21%),

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however, farmers were not preferring this aspect (6.67%).

With regard to studies on plant growth regulators, research was taken up to a considerable percentage (4.31%) while farmers have not preferred. In spite of non-preference of farmers studies must be conducted as it is an important area which could give key information to study management aspects. Research on seed physiology was not conducted even though farmers were showing preference to certain extent (3.56%). Crop growth models were not preferred as researchable area by farmers and even by the researchers. However, there is need to carry out research in this aspect and also should

bring awareness among the farmers in this aspect. In terms of determining adoption of new practices by farmers, it clearly goes beyond just agronomic evaluation. Rather, it was essential to not only identify the costs and benefits of each introduced technology, but also conduct impact assessments to determine farmers' actual use and management of current and potential technologies, the perceived benefits of the technologies to farmers, and their ideas and perceptions of the technology (Adesina and Baidu, 1995; Alphonse, 1997; Antle and Diagona, 2003)

Social Sciences

Training needs area was insisted by the farmers (19.67%), whereas, preference was very low by the PG researchers (2.78%) which has to be taken

Table 3. Comparison of farmers' preferences and PG research conducted in Crop improvement

S.No	Research areas	Farmers preference (n = 225)		PG research conducted (n = 116)	
		F	(%)	F	(%)
1	Genetic Divergence	50	22.22	34	29.31
2	Heterosis & Combining Ability	30	13.33	20	17.24
3	Stability Analysis	22	9.78	9	7.76
4	Path Analysis	1	0.44	0	0.00
5	Character association & Selection studies	25	11.11	13	11.21
6	Bio technology/ Genetically modified crops	0	0.00	0	0.00
7	Characterization of genotypes	15	6.67	13	11.21
8	Plant growth regulators	0	0.00	5	4.31
9	Stress management	32	14.22	13	11.21
10	Nutritional studies	35	15.56	9	7.76
11	Seed Physiology	8	3.56	0	0.00
12	Others (genetic variability, detection, mapping and gene pyramiding studies etc)	7	3.11	0	0.00
	r value	0.730			

care. More or less similar preference was observed on diffusion and adoption studies by both the categories of respondents. The strategies suggested in diffusion and adoption studies need to be followed by the extension personnel to transfer the technologies to the farmers' fields.

Studies on entrepreneurship were having close relevance (9.26%) with the farmers' preferences (9.84%). Similar trend was observed in case of information and communication technologies (ICT's), impact studies and indigenous technical knowledge (Table 4). Hence, there is a need to focus on the modern aspects *viz.*, information and communication technologies and developmental programmes so that we can transfer the latest technologies to the farmers

fields easily in an understandable way without any barriers.

Crop insurance and agricultural policy which was an important issue in the present day scenario was paid little attention by the farmers and the Post Graduate researchers. Hence, academic researchers have to recognize the importance of crop insurance and agricultural policies and reach the farmers to minimize the economic losses in cost of production of crops and should also bring awareness with regard to this aspect. Even though farmers have encountered constraints regarding agricultural marketing and finance & credit, research has been given less importance to these aspects. Hence, researchers have to study these aspects and make sure that farmers are not being exploited by middlemen in marketing their produce. There is a need to create

Table 4. Comparison of the farmers' preferences and PG research conducted in Social Sciences

S.No	Research areas	Farmers preference (n = 183)		PG research conducted (n = 108)	
		F	(%)	F	(%)
1	Diffusion & adoption studies	20	10.93	13	12.04
2	Entrepreneurship	18	9.84	10	9.26
3	Developmental programmes	10	5.46	9	8.33
4	Organizational studies (Training Needs)	36	19.67	3	2.78
5	Impact studies	13	7.10	8	7.41
6	Information and Communication Technologies(ICT's)	5	2.73	3	2.78
7	Indigenous Technical Knowledge (ITK's)	2	1.09	1	0.93
8	Agricultural policy	6	3.28	5	4.63
9	Agricultural marketing	15	8.20	6	5.56
10	Crop insurance	4	2.19	2	1.85
11	Agricultural finance & credit	14	7.65	12	11.11
12	Production economics & farm management	20	10.93	27	25.00
13	Impact assessment & evaluation studies	9	4.92	9	8.33
14	Others (Psychological studies, studies on rural development, Economic modeling, etc)	11	6.01	0	0.00
	r value	0.608			

awareness on the market prices, market places to the farmers to fetch remunerative prices to their produce.

As research and extension projects and government intervention often come with limited monetary funds and timelines, integrating farmers' preference into the initial project planning phase using the analytical hierarchy process will be more efficient and beneficial for future outcomes (SMARTS, 2009). The correlation studies have indicated that highest relevance between farmers' preference and PG research was observed in Crop Improvement (0.730) followed by Crop Production (0.628) and Crop Protection (0.533).

CONCLUSIONS

Close relevance was observed in farmers' preferences and PG Research being conducted in the state of Andhra Pradesh in majority of the researchable areas except cropping and farming systems, integrated crop management, organic agriculture, character association and selection studies, genetic divergence, management studies of pests and insects, impact evaluation studies and studies on agricultural finance and credit. Studies on climate resilient agriculture need to be focussed by the researchers and awareness on the climate variability and impact on the crops has to be created among the farmers. Studies on soil health management and resource management should be strengthened as they play a vital role in sustainable agriculture in the context of environmental pollution and stagnation of the productivity in crops. Farmers mainly resort to chemical spraying for the management of pests and diseases and hence, studies should be more concentrated on the compatibility of chemicals used for the management of pests and diseases. Post-harvest pest and disease management and grain storage management studies should also be given priority. In order to make farming profitable and sustainable, crop insurance,

marketing and policies on agricultural credit need to be studied and solutions to the problems need to be identified to implement these components effectively.

Research studies on nutritional management need to be prioritised in addition to studies on stress management and characterization of genotypes. Research studies on rural development and psychology of the farmers need to be initiated and the results need to be utilised in framing suitable policies. Studies on crop growth models, gene mapping and pyramiding are some of the important and novel areas where research studies should be concentrated to solve some of the persistent problems. The study gave a clear picture about the areas where research has to be strengthened. It had also given the relevance of farmers' problems with the research being attempted by the PG researchers and serves as a guide for planning the research areas in future.

Acknowledgement

This article was based on the study funded under ICAR Extramural Research Project entitled "Impact of PG Research in Higher Agricultural Education in Southern India". The authors are highly thankful to the Indian Council of Agricultural Research, New Delhi.

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COMPARATIVE ECONOMIC EFFICIENCY OF SOYBEAN PROCESSING UNITS IN MANDSAUR DISTRICT OF MADHYA PRADESH

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Date of Receipt: 02.01.2018

Date of Acceptance:05.02.2018

In India, Soybean production is mainly confined to Madhya Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Karnataka, Uttar Pradesh and Chhattisgarh. Madhya Pradesh has emerged as the Soy state of the country with a share of over 55.63 per cent in area and 53.17 per cent in production. The area under crop in Madhya Pradesh during 2012-13 was 60.32 lakh hectares and the production was 78 lakh tones (Sen, 2013). It has been estimated that nearly 85 per cent of soybean produced in the country is processed and nearly 40 per cent is processed in Madhya Pradesh state alone (Jaiswal, 2009).

Present utilization pattern of soybean in India is that 80 per cent is used for oil extraction, 10 per cent for seed and only 10 per cent for food and feed but it contributes about 12% to the domestic edible oil pool and country earns substantial foreign exchange through export of soy-meal (Kulkarni, 1999). Soybean processing units has capabilities to process soybean for food, feed, pharmaceutical and industrial applications. Soybean can be processed in a variety of ways. Common forms of processed soybean include soy meal, soy flour, soy milk, tofu, soy lecithin, soybean oil and textured vegetable protein (TVP). Three types *i.e.* large, medium and small scale soybean processing unit have been taken into consideration. It is noticed that most of the large soy processing units are involved in soya oil and soymeal processing and medium scale unit are involved into production of soya nuggets and soy flour

whereas small scale is producing mainly soymilk and soy paneer (Tofu). Therefore, an attempt was made to analyse and understand the economic aspects of soybean processing units in Mandsaur district of Madhya Pradesh as the crop is grown by large number of farmers in an area of 2.7 lakh ha and has scope for soybean processing.

Mandsaur district was purposively selected as it is one of the major producers of soybean in the Madhya Pradesh and many of the soybean processing units are located in this district. The study was conducted during the year 2013- 14 and two large, five medium and eight small scale processing units involved in producing various processed products were purposively selected. Thus, a total sample size of 15 processing units formed the basis of the study. The primary data was collected from the processors of the selected units with the help of a pretested schedule.

Table 1 indicated the total processing costs of soybean with respect to particular category of processing unit. The processing costs of large scale unit were calculated on yearly basis. Out of total processing costs, (Rs. 38,489/- per tonne) the major share was spent on purchase of raw material (Rs. 26,021/- per tonne) which accounted for 67.61 per cent of the total processing cost. Other major cost was interest on working capital (9.84 per cent), salaries to permanent employees (3.72 per cent), depreciation on machinery and vehicles (3.70 per cent), electricity and fuel charges (2.83 percent) and

Table 1. Processing costs of the selected large, medium and small scale soybean processing units

S. No.	PARTICULARS	Large scale unit		Medium scale unit		Small scale unit	
		Amount (Rs./tonne)	%	Amount (Rs./tonne)	%	Amount (Rs./tonne)	%
	VARIABLE COST						
1	Cost of raw materials & chemicals	26021.40	67.61	35409.09	65.42	45133.33	21.77
2	Cost of packing materials	466.93	1.21	772.73	1.43	25666.67	12.38
3	Storage charges	312.26	0.81	506.82	0.94	13226.67	6.38
4	Electricity & fuel charges	1089.49	2.83	1909.09	3.53	22066.67	10.64
5	Transport cost	749.03	1.95	1204.55	2.23	16866.67	8.14
6	Wages for labour	992.22	2.58	1479.55	2.73	11533.33	5.56
7	Repairs and maintenance	208.17	0.54	238.64	0.44	4533.33	2.19
8	Telephone charges	38.35	0.10	60.98	0.11	546.67	0.26
9	Sales tax/market cess/mandi tax	41.93	0.11	67.11	0.12	458.67	0.22
10	Spoilage costs	229.57	0.60	256.82	0.47	2133.33	1.03
12	Others	143.97	0.37	309.09	0.57	8200.00	3.96
13	Interest on working capital @ 12.5%	3786.66	9.84	5276.81	9.75	18795.67	9.07
	TOTAL VARIABLE COSTS	34079.97	88.54	47491.26	87.75	169161.00	81.60
	FIXED COSTS						
1	Depreciation on building	504.98	1.31	698.07	1.29	10589.33	5.11
2	Depreciation on machinery and vehicles	1424.61	3.70	2061.36	3.81	12366.67	5.97
3	Administrative charges	382.00	0.99	572.73	1.06	1686.67	0.81
4	Payment to permanent labour	1432.20	3.72	2222.73	4.11	7200.00	3.47
5	Insurance premium	21.79	0.06	43.70	0.08	323.33	0.16
6	License fee	15.08	0.04	23.86	0.04	333.33	0.16
7	Others	227.63	0.59	406.82	0.75	2180.00	1.05
8	Interest on fixed capital @ 10%	400.83	1.04	602.93	1.11	3467.93	1.67
	TOTAL FIXED COSTS	4409.12	11.46	6632.20	12.25	38147.27	18.40
	TOTAL PROCESSING COSTS	38489.09	100.00	54123.46	100.00	207308.27	100.00
	TOTAL PROCESSED QUANTITY (TONNES)	1028		440		15	

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wages for daily labour (2.58 per cent), etc. The processing costs of medium scale soybean processing units was estimated as Rs. 54,123/- per tonne. The major share was occupied by cost of raw material (Rs.35,410/- per tonne) which accounted for 65.42 percent. Other major costs were interest on working capital (9.75 per cent), wages to permanent employees (4.11 per cent), depreciation on machinery and vehicles (3.81 per cent) and electricity and fuel charges (3.53 per cent), etc. Similarly, for the small scale unit, the total cost of processing was found to be Rs. 2,07,308/- per tonne per year. Out of total processing costs, the major share was towards raw material and chemicals (Rs. 4,51,333/- per tonne) which accounted for 21.77 per cent. The other major components are cost of packing material (12.38 %), electricity and fuel charges (10.64 %), interest on working capital (9.07 per cent), transportation cost (8.14 %), storage charges (6.38 %) and depreciation on machinery and vehicles (5.97 %), etc.

It was noticed that the gross return (Rs. 59,616/- per tonne) was more than two times of net returns (Rs. 21,127/- per tonne) for the large scale unit and returns per rupee of expenditure was estimated as 1.55 for the unit processing about 1028 tonnes per annum soybean to produce soy oil and soy meal (Table 2). Similarly, Table 3 shows the returns of medium scale unit engaged in production of soy nuggets and soy flour from the processing of 440 tonnes per annum. The gross return (Rs. 82,045/- per tonne) was approximately three times of net returns (Rs.27,922/- per tonne) and the estimated returns per rupee of expenditure was 1.52. Whereas, the gross return (Rs.3,64,800/- per tonne) was more than two times of net returns (Rs. 1,57,492/- per tonne) for small scale unit. Returns per rupee of expenditure was 1.76 for processing about 15 tonnes of soybean to produce soy milk and tofu, respectively (Table 4).

Table 2. Returns from processing of soybean into soya oil and soy meal of large scale unit

S.No.	Particulars	Soyoil	Soymeal	Total
1	Quantity processed (Tonne)	195	833	1028
2	Quantity produced (kg)	1,75,000	8,12,000	
3	Price (Rs./kg)	95	55	
4	Total cost (Rs./year)			3,95,66,782
5	Total cost(Rs./tonne)			38,489
6	Gross return (Rs./year)	1,66,25,000	4,46,60,000	6,12,85,000
7	Gross return (Rs./tonne)	85,256.41	53,613.44	59,616
8	Net return (Rs./year)			2,17,18,218
9	Net return (Rs./ tonne)			21126.67
10	Returns per rupee of expenditure (Rs.)	1.55		

Table 3. Returns from processing of soybean into soy nuggets and soy flour of medium scale unit

S.No.	Particulars	Soy nuggets	Soy flour	Total
1	Quantity processed (Tonne)	280	160	440
2	Quantity produced (kg)	2,66,000	1,52,000	
3	Price (Rs./kg)	90	80	
4	Total cost (Rs./year)			2,38,14,323
5	Total cost (Rs./tonne)			54,123
6	Gross return (Rs./year)	2,39,40,000	1,21,60,000	3,61,00,000
7	Gross return (Rs/tonne)	85,500	76,000	82045
8	Net return (Rs./year)			1,22,85,677
9	Net return (Rs./tonne)			27921.99
10	Returns per rupee of expenditure(Rs.)			1.52

Table 4. Returns from processing of soybean into soy milk and tofu of small scale unit

S. No.	Particulars	Soy milk	Unit	Tofu	Total
1	Quantity processed(Tonne)	9	Tonne	6	15
2	Quantity produced (L)	75,600	Kilogram	7800	
3	Price (Rs./litre)	60	Rs./kg	120	
4	Total cost (Rs./year)				31,09,624
5	Total cost (Rs./tonne)				2,07,308
6	Gross return (Rs./year)	45,36,000	Rs./year	9,36,000	54,72,000
7	Gross return (Rs/tonne)	5,04,000	Rs./tonne	1,56,000	3,64,800
8	Net return (Rs./year)				23,62,376
9	Net return (Rs./tonne)				157491.73
10	Returns per rupee of expenditure (Rs.)				1.76

It has been found that there is difference among the processing costs of large (Rs. 38,489/- per tonne), medium (Rs.54,123/- per tonne) and small scale (Rs.2,07,308/- per tonne) of processing units as the capital requirement is different to produce

different products. The cost of raw material has significantly influenced the total costs of all categories of soybean processing units as supported by findings of Banafar *et al.* (2004). The study shows that the annual net return was positive for all the units with

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returns per rupee of expenditure of more than one rupee indicating the profitability by producing various soybean processed products.

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EFFECT OF TRAINING PROGRAMMES ON KNOWLEDGE LEVELS OF REDGRAM AND GROUNDNUT FARMERS IN PRAKASAM DISTRICT OF ANDHRA PRADESH

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Date of Receipt: 29.12.2017

Date of Acceptance: 30.01.2018

Human resource is the most precious resource for any country. It is, however, not the numerical but the qualitative strength of the people which forges a country towards progress and prosperity. It is basically the development of human resources that brings about socio-economic or political-cultural transformation of any society. A variety of extension programmes are implemented for creating awareness, educating and motivating the farmers, farm women and rural youth to adopt and manage the new agricultural technologies in the field. This is one of the major contributing factors for making India a food surplus country (Samanta and Gowda, 2003). Training is an empowerment process of creating awareness, imparting knowledge and capacity building leading

to greater participation for greater decision making (Punia *et al.*, 2007). Training programmes can bring about tremendous desirable change in knowledge, skill, attitudes and behavior of the farmers enabling them not only to become well acquainted with the recent technologies but also enhance their skills, competencies and efficiency in a desired manner. The advantage of assessing a knowledge, attitude and practice after training of farmers on a given agro technology is one of the tools for information on the effectiveness of training (Adhikarya, 1996). With this background the pre- and post-evaluation has been conducted to know the knowledge of the farmers/trainees before and after

the training to understand how the training programmes have changed the knowledge of the farmers/trainees.

The evaluation study was conducted at DAATTC, Ongole, Prakasam district of Andhra Pradesh during the year 2015-16. The major crops of the district include rice, redgram (55,891 ha), bengalgram and groundnut (8,222 ha). Two training programmes (for two batches of 30 redgram farmers and 32 groundnut farmers) were organized by DAATTC, Ongole. To understand the level of knowledge of the participants on different aspects of redgram and groundnut improved agricultural technologies before and after the training programme a pretested questionnaire was used. The scores obtained by the participants in both the tests were recorded and analyzed to evaluate the knowledge gain. Correlation analysis was carried out to assess the relationship between profile characteristics of farmers and their knowledge gain through training.

Knowledge levels of the redgram farmers before and after conducting training programme

The effect of training programme on the knowledge level of respondents about the redgram production technology in pre- test revealed that more than fifty per cent (53.33%) redgram farmers were with medium knowledge followed by low knowledge group (40.00%) and very low per cent (6.67%) of

trainees in high knowledge group. Almost equal per cent (46.67% and 43.33 %) of the trainees had medium and high knowledge levels followed by very meager (3.613%) in low knowledge category in post-test. Regarding knowledge gain, half of the trainees were with medium knowledge gain followed by high knowledge gain category (50.00%). Very negligible (3.33%) per cent of trainees were with low knowledge gain. It is therefore, concluded that redgram farmers had high level of knowledge after getting trained. These findings were in conformity with the results of Akhilesh Kumar and Srivastava (2007) and Rathore and Dhakar (2012). The knowledge gain clearly indicates the contribution of the training programme towards their increased knowledge levels on recent research developments viz., recently developed short duration varieties, seed treatment and pest and disease management in redgram production.

The pre-evaluation test majority of the redgram farmers had correct knowledge levels on sowing time (60.00%) and seed rate (53.33%) but they had incorrect knowledge on short duration varieties (90.00%), seed treatment (83.33%), fertilizer management (76.67%), disease management (73.33%) and pest management (63.33%). After getting trained great majority of the farmers had correct knowledge on sowing time (86.67%), seed treatment (76.67%), seed rate (73.33%), pest management (70.00%), fertilizer management (66.67%), disease management (63.33%) and short duration varieties (56.67%). This might be because of their non-exposure to recent research findings particularly recently developed short duration varieties to mitigate the moisture stress situation at pod development stage, seed treatment with *Trichoderma viridi* for wilt management and integrated pest and disease management.

Knowledge levels of the groundnut farmers before and after conducting training programme

It could be inferred that before training almost fifty (46.87%) per cent of the groundnut farmers had medium knowledge followed in low (40.63%) and high

(12.00%) knowledge groups. After participating in training programme fifty six per cent farmers were in high knowledge group followed by medium (37.50%) and in low (6.25 %) knowledge groups. With respect to knowledge gain fifty per cent were in medium category followed by high (40.625%) and low (9.00%) knowledge gain categories.

Component-wise knowledge analysis revealed that in pre test great majority of the groundnut farmers had incorrect knowledge on gypsum management (81.25%), seed rate (75.00%), weed management (71.87%), seed treatment (68.75%), micro nutrient management (65.62%), fertilizer management and disease management (62.50%) and pest management (56.25%). Whereas in post test majority of them had correct knowledge on weed management (80.00%), seed treatment (75.00%), fertilizer management (71.87%), micronutrient management (68.75%), seed rate and disease management (65.63%), pest management (62.50%) and gypsum management (59.38%). The probable reason for increased knowledge on weed management was previously they don't know the post emergence herbicide and its use. Increased knowledge on seed treatment, seed rate and pest and disease management was due to the awareness created in the training programme on seed treatment to maintain optimum plant stand with recommended seed rate leading to decreased pest and disease incidence as a part of Integrated Crop Management.

Relationship between profile characteristics of redgram farmers and their knowledge gain through training programme

It can be concluded that extension contact had significant positive relation at 5% level, innovativeness, trainings undergone and mass media use were having highly significant relation with knowledge gain at 1% level of significance. This might be because these were the major factors facilitating farmers to gain knowledge on redgram production technology. Age, education, farming experience and

farm size had no significant relation with knowledge gain. Parvinder Sharma *et al.* (2013) reported similar findings in their study.

Relationship between profile characteristics of groundnut farmers and their knowledge gain through training programme

It is evident that education was the variable which had positive relation with knowledge gain at 5% level of significance. The plausible explanation for this result may be that education might have provided a platform to people to learn more and gain more information in a given learning situation and because of the easy understanding of the training content by the farmers with their high education. Innovativeness, trainings undergone and mass media exposure were the variables having highly significant relation at 1% level of significance with knowledge gain of the groundnut farmers. Innovativeness was the major factor motivating farmers to get acquainted with recent technologies. More number of trainings participated leads to higher knowledge levels of the farmers. Mass media use was another factor contributing for update of the farmers' knowledge on production technologies. Age, farming experience, farm size and extension contact were found to have no significant relationship with knowledge gain. Similar results were reported by Sarma *et al.* (2013).

Knowledge levels of the farmers after getting trained in both training programmes indicated their knowledge gain through trainings. Therefore, there is a need to give due importance to organize need based training programmes to farmers on major crop production technologies. To be fruitful, the training programmes should be designed based on actual training needs and socio-economic profile of potential trainees.

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INFORMATION COMMUNICATION TECHNOLOGY (ICT) UTILIZATION PATTERN BY UNIVERSITY TEACHERS

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Date of Receipt: 06.01.2018

Date of Acceptance:08.02.2018

Information and communication technology (ICT) is an inclusive term and has positive impact on the development of a nation. ICT is defined as the combination of hardware and software for efficient management of information, that is storage, retrieval, processing and communication, for social, economic and cultural development. (Bisht *et al.*, 2010). According to Mudrak (2004), common ICTs are: computer, LCD projectors, internet, camera, television and cell phone. ICT tools are necessary to make teaching and learning process more effective. Today ICTs has changed the relationship between teachers and students. Adequate technologies are necessary to enhance effective teaching and learning process. Drucker (2006) reported that the use of adequate and appropriate communication and information tools can lead to effective teaching and learning. Information and communication technology (ICTs) is the modern science of gathering, storing, manipulating, processing and communicating desired type of information in a specific environment. Computer technology and communication technology are the main supporting pillars of ICTs and the impact of these two, in the information storage and dissemination is vital (Mahajan, 2002). G.B. Pant University of Agriculture & Technology, Pantnagar is having fully operational computer labs, smart classrooms in all the colleges. Although scientists of this University are using ICTs, however, researchable questions were [1] What types of ICTs they are using? [2] To what extent they are using Information Communication Technologies for improving their professional

efficiency?. Hence, The study was undertaken among the Agricultural faculty of GBPUA&T, Pantnagar with the objective of studying the utilization pattern of Information Communication Technologies among the agricultural scientists.

A survey was carried out in June, 2017 and July, 2017 on University teachers of GBPUA&T, Pantnagar. Simple random sampling was used for the study. A total of 40 University teachers were selected for the study. A semi-structured interview schedule was developed to study the utilization pattern of ICTs. Data revealed that 42.5 per cent of respondents were Professors followed by Associate Professors (30 per cent) and Assistant Professors (27.5 per cent).

Mobile Phone Utilization Pattern:

Mobile Ownership: All scientists owned mobile phone (100%). This is supported by the findings of Singh and Singh (2017) that majority of faculty members owned mobile phone.

Brand of mobile owned: Thirty per cent scientists have owned Sony brand mobile phone followed by Lenovo (27.5 %). Vivo phone is owned by 22.5 % of faculty members. Fifteen per cent scientists have Motorola phone followed by Samsung (12.5 per cent) and Nokia/Micromax (7.5 per cent). Only 5 per cent respondents have Apple and Redmi Mobile phone.

Type of Sim: More than three-fourth (92.5%) of the respondents have double sim followed by single sim (5%).

Mobile services being used: A total of 87.5 per cent respondents were using Idea services followed by Jio (42.5 %). A total of 35 % respondents were using Airtel mobile service followed by Vodafone services (30%).

Approximate monthly expenditure on mobile phone: Nearly 75 per cent respondents were spending less than Rs. 500/- as monthly expenditure on mobile phone followed by 22.5 per cent spending Rs.500/- to Rs.1000/- and only 2.5 % are spending above Rs.1000/-.

Internet Utilization Pattern

Frequency of Use of ICTs: More than half per cent of the respondents (62.5 per cent) were using internet daily followed by weekly(30 per cent) and occasionally (5 per cent). It is fairly clear from the findings that the use of ICT in updating knowledge level and teaching skills by the University teachers was to a great extent. Moreover, ICT is helping teachers in setting innovative projects for students and generating computer online quiz, online test, online discussion forum.

Extent of use of ICT for various purposes:

Total 97.5 per cent respondents were using ICT for data analysis and treatment and communicating with students followed by 92.5 per cent in writing research and conceptual papers. Most of the respondents (95 %) respondents were using Internet for acquiring and updating knowledge in the area of specialization followed by self improvement (90 per cent). More than half of the respondents (87.5 per cent) used Internet for teaching/professional competence followed by participation in seminars, workshop and conferences (72.5 %). Only 30 per cent respondents were using Internet for sharing professional information and findings. A total of 47.5 per cent respondents were using Internet for Research project work. Research findings are supported by Devendra Kumar (2010) who reported that majority of faculty of Sardar Vallabh Bhai University of Agriculture & Technology used internet particularly e–mail and world wide wibe(WWW). Nearly all college faculty members surveyed reported using the Internet to communicate with their students (98%).

Table 1. Purposes for using social media by university teachers (Multi response Table)

S. No.	Statement	SA	A	Neither Agree Nor Disagree	D	SD
1)	I use social media for communicating and interacting with friends.	5 (12.5)	26 (65)	2 (5)	4 (10)	3 (7.5)
2)	I use social media for online learning.	32 (80)	7 (17.5)	1 (2.5)	0	0
3)	I use social media for academic purposes.	23 (57.5)	11 (27.5)	5 (12.5)	0	0
4)	I use social media for official communication, mobilizing and organizing National or International level conferences, Seminars, etc.	5 (12.5)	12 (30)	10 (25)	9 (22.5)	4 (10)
5)	I use social media for updating profile information.	15 (37.5)	14 (35)	7 (17.5)	4 (10)	0

[SA=Strongly agree, A=Agree, D=Disagree SD= Strongly Disagree]; figurs in parnteses include percentges

ICT UTILIZATION PATTERN BY UNIVERSITY TEACHERS

Use of Social Media: Majority of respondents (87.5 per cent) were using Whatsapp

Purpose of using social media: A total of 80 per cent respondents were in strong agreement with the statement that “*I use social media for online learning*”. A total of 65 per cent respondents were in agreement with the statement that “*I use social media for communicating and interacting with friends*” followed by the statement “*I use social media for academic purposes*” (57.5 per cent). A total of 42.5 per cent respondents were in agreement that they use social media for communicating, mobilizing and organizing national or international level conferences, seminars, etc (Table 1).

It can be concluded that all the scientists (100 %) were using ICTs to update academic notes, writing research proposals, conceptual papers, gather and spread information about seminars, workshops and conferences, for acquiring and updating knowledge in the area of their specialization, etc. University teachers were also using social media

such as Whatsapp (87.5%), Facebook (30%) and Linked-in (27.5%), etc.

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Place of Publication : Guntur

Periodicity of publication : Once in three months (Quarterly)

Printer's Name : Ritunestham Press, Guntur

Nationality : INDIAN

Address : Ritunestham Press
D.No. 8-198, Kornepadu, Guntur - 522 017

Publisher's Name : Dr. J. Krishna Prasadji

Address : Dean of Agriculture, Administrative Office,
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