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COMBINING ABILITY STUDIES IN MAINTAINER LINES OF SUNFLOWER (*Helianthus annuus* L.)

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ABSTRACT

Seven diverse inbred lines (B lines) were crossed in half diallel fashion to estimate general combining ability and specific combining ability effects for days to 50 per cent flowering, plant height, days to maturity, hull content, oil content, 100 seed weight, head diameter, volume weight, seed filling and seed yield plant⁻¹. The results exhibited that GCA variances were higher than SCA variances for all traits studied which indicated the importance of both additive and non-additive gene action. However, the magnitude of ratio of general combining ability variances and specific combining ability variances was lower than unity for all characters indicating predominance of non additive gene action. Among the parents, SCG 107B, SCG 44B and EC 304697B were found to be best general combiners for most of the yield contributing traits, seed yield and oil content. Among the crosses, SCG 44B x SCG 107B, EC 494430B x EC 180882B, SCG 44B x EC 304697B and EC 282345B x EC 304697B were found to be the best specific combiners for majority of the characters studied. The crosses, EC 585833B x EC 180882B and EC 282345B x EC 304697B exhibited significant negative and positive sca effects for hull content and oil content, respectively. These specific crosses could be further utilized for deriving desirable inbreds from advanced generations.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an important annual oil seed crop grown all over the world. The sunflower seed contains 40% - 45% of good quality oil by weight and high amount of quality protein (20%) in cake. In sunflower, the cytoplasmic genetic male sterility (CGMS) system, which involves the use of CMS line (A), maintainer line (B) and fertility restorer line (*Rf*) has allowed breeders to exploit heterosis through the development of three-way and single-cross hybrids (Miller *et al.*, 1980). It is clear that use of good general combining B lines (maintainer lines) for back cross transferring of CMS traits will improve the performance of resulting hybrids. Combining ability analysis provides information on nature and magnitude of gene effects on yield and yield attributing characters. Choosing desirable lines for breeding as a parental component of a hybrid variety is of great importance. Thus, the investigation was undertaken to study the combining ability effects of parents and cross combinations for selecting superior parental lines and hybrids for yield, yield contributing characters and oil content.

MATERIAL AND METHODS

Seven diverse inbred lines (B lines) viz., EC-585833B, EC-494430B, SCG-44B, SCG-107B, EC-180882B, EC-282345B and EC-304697B were crossed by hand emasculation and pollination in half diallel manner to obtain 21 hybrids during the summer, 2016-17 and these 21 F₁ crosses were evaluated along with their parents and checks viz., SS-2038 and Modern during rabi, 2016-17 using Randomized Block Design (RBD) with two replications at Oilseeds Research Station, Latur. The data was collected on yield and yield attributing characters viz., for days to 50 per cent flowering, plant height, days to maturity, hull content, oil content, 100 seed weight, head diameter, volume weight, seed filling and seed yield per plant.

RESULTS AND DISCUSSION

The results of analysis of variance (ANOVA) for combining ability for 10 different characters (Table 1) indicated that variance due to parents was highly significant for all the characters thus justifying the selection of parents for combining ability analysis. The hybrids also showed highly significant variability

Table 1. Analysis of variance for combining ability analysis for 10 characters in sunflower

Source of variation	d.f.	Days to 50% flowering	Plant height (cm)	Days to maturity	Hull content (%)	Oil content (%)	100 seed weight (g)	Head diameter (cm)	Volume weight (g 100ml ⁻¹)	Seed filling (%)	Seed yield plant ⁻¹ (g)
Replications	1	4.01	65.77	2.57	4.03*	0.30	0.23	0.31	0.73	3.48	0.14
Treatments	27	38.53**	1264.49**	78.55**	42.53**	10.02**	1.76**	7.42**	36.42**	58.09**	152.21**
Parents	6	68.81**	903.66**	120.40**	82.81**	10.00**	0.99**	7.56**	30.61**	71.87**	82.07**
Hybrids	20	31.05**	998.57**	67.61**	31.27**	10.48**	2.02**	6.84**	39.79**	51.70**	176.47**
Parents Vs. Crosses	1	6.482	8747.89**	46.09**	26.18**	0.93	1.33**	18.15**	3.98	103.08**	87.89**
Error	27	2.610	22.31	4.71	0.93	0.43	0.09	0.68	1.06	2.29	2.57
GCA	6	58.80**	839.01**	114.85**	51.37**	6.26**	2.15***	9.70**	23.48**	86.91**	221.87**
SCA	21	7.96**	573.17**	17.67**	12.66**	4.64**	0.52***	2.00**	16.70**	12.51**	34.45**
Error	27	1.30	11.15	2.35	0.46	0.21	0.04	0.34	0.53	1.14	1.28
GCA/SCA Ratio		0.95	0.16	0.81	0.46	0.15	0.49	0.62	0.15	0.83	0.73

*, **, Significant at 5% and 1 per cent level, respectively.

Table 2. Estimates of general combining ability effects for 10 different characters in sunflower

S. No.	Parents	Days to 50% flowering	Plant height (cm)	Days to maturity	Hull content (%)	Oil content (%)	100 seed weight (g)	Head diameter (cm)	Volume weight (g 100ml ⁻¹)	Filling	Seed yield plant ⁻¹ (g)
1	EC 585833	0.15	-7.29**	0.04	-2.17**	0.29	-0.64**	-0.33	0.26	-1.07**	-3.40**
2	EC 494430	2.27 **	9.47**	3.26**	-0.77**	0.45**	-0.06	-0.02	-0.49*	1.24**	0.07
3	SCG 44	0.61	14.29**	-2.85**	4.47**	-1.63**	0.85**	1.92**	-1.70**	4.52**	8.40**
4	SCG 107	-4.84**	-10.41**	-5.74**	-0.68**	1.11**	0.18*	-0.097	3.32**	1.32**	1.29**
5	EC 180882	1.04**	-8.57**	0.151	-2.57**	-0.16	-0.33**	-1.41**	-1.15**	-4.46**	-6.51**
6	EC 282345	2.88**	4.96**	4.984**	1.15**	-0.01	-0.28**	-0.61**	0.09	-3.22**	-3.22**
7	EC 304697	-0.89	-2.45**	0.15	0.62**	-0.05	0.28**	0.55**	-0.32	1.67**	3.38**
	SE±(m) (gi)	0.35	1.03	0.47	0.21	0.14	0.06	0.18	0.22	0.33	0.35
	SE±(m) (gigi)	0.53	1.57	0.72	0.32	0.22	0.10	0.27	0.34	0.50	0.53

*, **, Significant at 5 % and 1 per cent level, respectively

Table 3. Estimates of specific combining ability(sca) effects for 10 different characters in sunflower

S. No.	Crosses	Days to 50% flowering	Plant height (cm)	Days to maturity	Hull content (%)	Oil content (%)	100 seed weight (g)	Head diameter (cm)	Volume weight (g/100ml)	Seed filling (%)	Seed yield plant ⁻¹ (g)
1	EC 585833 x EC 494430	-0.62	-29.13**	-3.44*	3.33**	-1.05*	0.46*	-1.03*	-3.07**	-2.36*	-2.71*
2	EC 585833 x SCG 44	0.76	7.21*	3.17*	-0.73	-0.23	-0.54*	-0.54	1.54*	1.71	3.59**
3	EC 585833 x SCG 107	0.98	11.07**	4.56**	2.90**	1.70**	0.018	-0.043	0.66	-0.23	-6.08**
4	EC 585833 x EC 180882	1.09	9.58**	-0.33	-4.54**	2.06**	-0.33	-0.89	3.91**	-4.18**	-4.72**
5	EC 585833 x EC 282345	-3.73**	8.05*	3.83*	-5.60**	-0.85	0.29	0.42	2.006**	-2.25*	-2.09
6	EC 585833 x EC 304697	5.54**	3.63	7.67**	-2.90**	-0.54	-0.84**	2.04**	3.09**	1.05	2.80**
7	EC 494430 x SCG 44	-4.34**	3.88	-1.06	-0.19	-0.43	-0.20	-0.78	-6.99**	-0.04	0.99
8	EC 494430 x SCG 107	3.37**	3.15	4.83**	0.79	1.16*	-0.79**	-0.36	-0.70	-2.36*	-3.37**
9	EC 494430 x EC 180882	0.48	18.99**	0.94	2.68**	-2.41**	0.33	2.47**	0.67	4.54**	4.28**
10	EC 494430 x EC 282345	0.65	14.63**	2.61	2.29**	1.49**	-1.15**	1.74**	0.74	1.22	-4.77**
11	EC 494430 x EC 304697	-3.07**	11.70**	2.57*	-0.34	-1.24**	0.73**	0.80	-1.93**	2.60*	8.54**
12	SCG 44 x SCG 107	-0.23	20.50**	3.44*	3.05**	1.86**	1.07**	2.28**	1.35*	3.50**	6.07**
13	SCG 44 x EC 180882	0.87	25.51**	0.57	2.61**	3.77**	-0.35	0.99	-5.38**	1.14	3.10**
14	SCG 44 x EC 282345	0.04	18.15**	-3.78*	-0.78	0.79	1.19	-0.56	2.92**	3.40**	6.27**
15	SCG 44 x EC 304697	-0.18	34.21**	-3.94**	0.91	-3.50**	0.80**	1.37*	-5.22**	2.68*	3.37**
16	SCG 107 x EC 180882	-4.90**	25.51**	-4.57**	5.42**	-1.96**	0.58**	0.13	3.31**	3.23**	1.29
17	SCG 107 x EC 282345	-0.73	18.14**	-6.39**	-0.13	-4.79**	0.75**	0.50	-0.56	4.47**	10.51**
18	SCG 107 x EC 304697	2.54*	34.21**	1.94	1.90**	2.69**	-0.67**	-1.17*	1.65*	-1.79	-5.03**
19	EC 180882 x EC 282345	3.37**	40.84**	2.72	-0.92	-0.53	-0.07**	0.27	4.09**	0.70	-3.008**
20	EC 180882 x EC 304697	-4.34**	4.91	-3.44*	1.12*	1.29**	0.42*	-2.01**	-5.50**	-5.43**	-6.91**
21	EC 282345 x EC 304697	-1.68	-11.75**	4.22**	-2.60**	2.29**	0.16	1.27*	0.17	2.86**	3.04**
	SE± (m) (Sij)	1.25	1.02	2.99	1.37	0.41	0.19	0.52	0.65	0.96	1.01
	SE± (m) (SijSik)	1.52	1.52	4.45	4.45	0.62	0.29	0.77	0.97	1.42	1.51
	SE±(m) (SijSkI)	1.42	1.42	4.16	4.16	0.59	0.27	0.72	0.90	1.33	1.41

* , ** Significant at 5% and 1 per cent level, respectively

for all the characters. The significant differences were also recorded for parent's Vs crosses except for days to 50% flowering, oil content and volume weight indicating presence of heterosis for these characters. The mean sum of squares due to general and specific combining ability were highly significant for all the characters studied, indicating the importance of both additive and non-additive gene effects in expression of these characters. However, the magnitude of ratio of general combining ability variances and specific combining ability variances was lower than unity for all characters indicating predominance of non additive gene action. Similar findings were earlier reported by Chandra *et al.* (2011), Shinde *et al.* (2016) and Shrishaila *et al.* (2017) for days to 50% flowering, plant height, head diameter, 100 seed weight, seed yield plant⁻¹, volume weight, hull content and oil content.

It was quite evident that none of the parent's recorded significant *gca* effect for all the characters studied (Table 2). Among the parents, SCG 107B had significant positive *gca* effect for seed yield plant⁻¹, 100 seed weight, seed filling and oil content whereas significant negative *gca* effects for days to 50% flowering plant height, days to maturity and hull content in desirable direction. The parents, SCG 44B and EC 304697B was also considered as good general combiner for seed yield, seed filling, 100 seed weight and head diameter. Significant positive *gca* effects was earlier reported by Shinde *et al.*, (2016) and Shrishaila *et al.* (2017) for head diameter, 100 seed weight, oil content, volume weight and seed yield plant⁻¹. Deengra *et al.* (2012), Asif *et al.* (2013) and Shinde *et al.* (2016) also reported significant negative *gca* effects for days to 50% flowering, days to maturity and hull content.

Results indicated that none of the cross was good specific combiner for all studied traits (Table 3). In the study, results revealed that crosses SCG 44B x SCG 107B and EC 494430B x EC 180882B were the best specific combiner for majority of the characters studied *viz.*, for plant height, days to maturity, hull content, 100 seed weight, head diameter, volume weight, seed filling and seed yield

plant⁻¹. While the crosses, SCG 44B x EC 304697B and EC 282345B x EC 304697B showed good *sca* effects for seed yield plant⁻¹, head diameter, seed filling and 100 seed weight. Significant positive *sca* effect was earlier reported by Binodh *et al.* (2008), Chavan *et al.* (2009), Shinde *et al.* (2016) and Ingle *et al.* (2017) for seed yield plant⁻¹, 100 seed weight, head diameter, oil content, volume weight, and seed filling. Hull content was negatively correlated with whole seed oil content. The desirable negative significant *sca* effect for hull content, whereas, desirable positive significant *sca* effects for oil content was recorded by the crosses, EC 585833B x EC 180882B and EC 282345B x EC 304697B. However, it was vice versa in the crosses, SCG 107 x EC 180882 and EC 494430 x EC 180882. Ingle *et al.* (2017) also reported similar results for hull content and oil content.

CONCLUSION

It was observed that all the characters studied were governed by non-additive gene action. The best parents for specific combining ability for seed yield and yield contributing characters were SCG107 B and SCG44 B. These inbred B lines could be used for developing CMS lines through backcross breeding. The best crosses for seed yield and yield contributing characters were SCG 44B x SCG 107B and SCG 44B x EC 304697B. These could be further self crossed to produce good inbred lines from advanced generations.

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LIFE HISTORY OF SPOTTED STEM BORER, *Chilo partellus* (SWINHOE) ON DIFFERENT MAIZE CULTIVARS

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ABSTRACT

The spotted stem borer, *Chilo partellus* (Swinhoe) damages several crops and grasses including maize and sorghum in many parts of the world. In this study, the effect of three maize hybrids (DHM 117, DHM 121 and Pioneer 30V92) and three special varieties of corn (Madhuri sweet corn, Priya sweet corn and Amber pop corn) on life history of *C. partellus* was studied under laboratory conditions (25±1°C, 65±5% RH, and 16:8 (L: D) h). The results showed that the larval and pupal period was numerically short on 30V92 hybrid (35.1 and 8.6 days during *kharif* and 38.1 and 9.4 days during *rabi*, respectively). The larval stage passed through six instars on all test maize cultivars. The development time from egg to adult emergence was numerically short on 30V92 (48.6 days in *kharif* and 53.3 days in *rabi*, respectively). The adult longevity was not influenced by the host cultivar but there was a difference between female and male longevity among the host cultivars. There was no distinct difference in the number of eggs laid in two seasons. However, the fecundity was numerically high on 30V92 hybrid during *kharif* (264.9 eggs female⁻¹) and *rabi* (255.6 eggs female⁻¹) compared to all other maize cultivars. This indicated that 30V92 was more suitable for feeding by *C. partellus* than other cultivars as it allowed faster development. Overall, the incubation, larval, pupal, total developmental periods and fecundity of *C. partellus* was not influenced by the host plant cultivars statistically.

INTRODUCTION

Maize or corn (*Zea mays* L.) is one of the important cereal crops of the world, cultivated for food, fodder and for raw material in many industries. In many parts of the world, stem borer, *Chilo partellus* (Swinhoe) is an important pest of maize which possesses serious problem in its successful cultivation. Newly hatched larvae feed on the leaves making pinholes and leaf windowing. They bore down inside the plant whorl and feed. While feeding in the plant whorl, they kill the central shoot, which later on dries up causing dead heart resulting in total loss of the crop.

The quality and quantity of food ingested by an insect can directly affect its survival and reproductive performance. Hence, the fitness of the herbivores depends on the nutrients present in their host plants. Also, the partially resistant cultivars may improve the efficiency of natural enemies and insecticides. Therefore, the use of resistant cultivars can be integrated with biological and chemical control methods as part of an IPM strategy. Understanding

the life history parameters of a pest is necessary to develop an integrated pest management strategy. These parameters provide population growth rate of an insect pest in the present and next generations. Harris (1990) reviewed the literature related to the biology of *C. partellus* in Indian conditions. To date the life history traits of *C. partellus* have been studied on different sorghum and maize cultivars including grasses by several researchers (Marulasiddesha, 1999; Ofomata *et al.*, 2000; Jalali, 2000; Jalali and Singh, 2003; Nagarjuna, 2005; Siddalingappa *et al.*, 2010; Balikai and Sajjanar, 2012). However, in spite of the economic importance of *C. partellus* on maize, there is no published information concerning the life history of this pest on different maize hybrids and special varieties *viz.*, sweet corn and pop corn varieties. Therefore, the present research provides new insight on some aspects of the life history of *C. partellus* on maize hybrids and special varieties. The goal of this research was to evaluate susceptibility or resistance of some commercial maize hybrids and special varieties to *C. partellus* through comparative study on the life history traits of this pest reared on

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these hybrids and special varieties under laboratory conditions.

MATERIAL AND METHODS

Studies on biology of *C. partellus* was made on three popular maize hybrids *viz.*, DHM 117, DHM 121, and Pioneer 30V92 and three special maize varieties *viz.*, Madhuri sweet corn, Priya sweet corn and Amber pop corn in the laboratory for two generations, once in each *kharif* and *rabi* season of 2014-15. The studies were carried out in the laboratory of the Department of Entomology, Agricultural Research Station, Darsi, Prakasam District, Andhra Pradesh.

Life history of *C. partellus* on three hybrids and three varieties of maize was studied from egg to adult in plastic vials (7.5 cm length, 2.5 cm diameter) with the mouth of the vial covered with polythene sheet of 100 gauge using perforated lid. Pure culture of *C. partellus* was initiated by collecting the late instar larvae from adjoining farmer fields and was maintained in the laboratory in plastic tubs of 12 cm high and 30 cm diameter covered with cora cloth using rubber band where they were put on cut maize stem pieces to complete their life cycle. Newly emerged male and female moths obtained from the mass culture were released in a plastic container (30 cm high and 20 cm diameter) containing the seedlings of each cultivar separately for oviposition.

Fresh egg masses of *C. partellus* obtained from pure cultures were maintained in plastic vials separately on each test maize cultivar. On the fourth day after placing the egg mass (the embryo matures to the black-head stage), a fresh soft stem piece having small leaves from 3-4 leaf stage was provided inside each vial for the emerging larva to feed. After emergence, individual larva was transferred to fresh vial containing fresh soft stem with whorl leaf bit. The old stem pieces were replaced by the new ones when rotting started and was checked for exuvium of the caterpillar. The stem pieces used as food for larvae were from the same cultivar of maize which was grown for this purpose. This was maintained till the larva pupated. In each season life history data

on ten larvae were collected separately on each test maize cultivar. Observations were made daily to determine the incubation period of egg, number of larval instars based on moultings, duration of each larval instar, pupal period and total developmental period from egg to adult. Further, morphological characters and behaviour of different stages in the life-cycle of the insect reared on maize were recorded.

For studying the adult longevity and fecundity, 10 pairs of moths (10 males and 10 females) from the emerged adults on each test hybrid were selected. Each pair of moths was transferred to an oviposition cage with maize plants of each test genotype grown in disposable glasses and left for eight days. 10 % honey solution was provided as food. The set was replicated 10 times for each test hybrid and variety. Every day after release of moths the plants are removed from oviposition cage, egg masses were collected from leaf / leaf sheath and counted for the number of egg masses. Later the leaf bits containing egg masses were carefully cut and counted the average number of eggs in each mass with the help of binocular microscope. The maintenance of record was continued till the death of the female. Total number of eggs laid by the mated female and longevity of male and females were recorded. The data resulted from the effects of different maize cultivars on development period, oviposition period, adult longevity and fecundity of *C. partellus* was subjected to the one-way analysis of variance (ANOVA).

RESULTS AND DISCUSSION

The results presented here include the morphological characters, duration of development of all the stages and habits of larvae during *kharif* and *rabi* 2014-15.

Egg

Egg laying was observed on all parts of the plants namely, leaf (both on dorsal and ventral surface), leaf sheath and in the central leaf whorl of maize plant. The eggs were creamy white, flat, oval and scale like in appearance. Eggs became yellowish

after three days and turned to yellowish brown one day prior to hatching revealing the young, coiled larva through the chorion. The incubation period lasted for 4 to 6 days in *kharif* season with an average of 5.4 ± 0.16 , 5.0 ± 0.26 , 5.3 ± 0.26 , 5.0 ± 0.21 , 5.4 ± 0.16 and 4.9 ± 0.28 days on DHM 117, DHM 121, Madhuri, Priya, Amber and 30V92 maize cultivars, respectively. While it was 5 to 7 days in *rabi* season with an average of 6.6 ± 0.16 , 6.2 ± 0.25 , 6.0 ± 0.26 , 6.4 ± 0.22 , 6.1 ± 0.18 and 5.8 ± 0.20 days on DHM 117, DHM 121, Madhuri, Priya, Amber and 30V92, respectively (Table 1). The incubation period was reported to range from 4 to 8 days (Berger, 1989), 5 to 7 days (Nagarjuna, 2005), 3 to 6 days (Jalali and Singh, 2003 and Siddalingappa *et al.*, 2010) and 4 to 6 days (Balikai and Sajjanar, 2012).

Larva

The larva gnawed a circular opening through one end of egg shell and emerged. There were six larval instars and the exuvium was cast off on the maize leaf bit only.

I instar larva

The young larvae eat part or all of the egg shell during hatching. The newly hatched larva was slender, tiny, active and dirty white with a large dark brown head. Body of the larva was covered with number of short hairs. Newly emerged larvae wandered on the leaf bit and then started scraping the leaf tissue through the mesophyll layer. The duration of the first instar lasted for 4 to 6 days on DHM 117, DHM 121, Madhuri, Priya, Amber and 4 to 5 days on 30V92 with an average of 4.8 ± 0.25 , 5.1 ± 0.31 , 4.7 ± 0.15 , 4.8 ± 0.29 , 4.9 ± 0.31 and 4.3 ± 0.15 days in *kharif* season, respectively (Table 1). The average duration of the first instar larva during *rabi* season was 5.4 ± 0.22 , 5.0 ± 0.26 , 4.8 ± 0.33 , 4.8 ± 0.25 , 4.8 ± 0.25 and 4.4 ± 0.16 days when reared on DHM 117, DHM 121, Madhuri, Priya, Amber and 30V92, respectively (Table 2).

II instar larva

Second instar larva was translucent and dirty white. Head and prothorax were dark brown in colour. Second instar was completed in 2 to 7 days on DHM

117, 3 to 7 days on DHM 121, 2 to 6 days on Madhuri, 2 to 7 days on Priya, 3 to 7 days on Amber and 3 to 6 days on 30V92 in *kharif* season with an average of 4.8 ± 0.49 , 5.2 ± 0.51 , 4.2 ± 0.51 , 4.9 ± 0.53 , 5.5 ± 0.50 and 4.4 ± 0.27 days, respectively (Table 1). Whereas, during *rabi* season the second instar period lasted for 3 to 8 days on DHM 117, DHM 121, Madhuri, Priya, Amber and 3 to 7 days on 30V92 with an average duration of 5.8 ± 0.55 , 5.8 ± 0.63 , 5.8 ± 0.70 , 5.3 ± 0.52 , 5.3 ± 0.52 and 4.8 ± 0.44 , respectively (Table 2).

III instar larva

The colour of the third instar larva was dull white. The body was elongated with brown head. The duration of the third instar ranged from 3 to 8 days on DHM 117, DHM 121, Madhuri, Amber and 3 to 7 days on Priya and 30V92 in *kharif* season, with an average of 6.3 ± 0.54 , 6.1 ± 0.62 , 6.0 ± 0.63 , 6.3 ± 0.56 , 5.6 ± 0.43 and 5.2 ± 0.44 days, respectively (Table 1). While the third instar larvae lasted for 3 to 9 days on DHM 117, DHM 121, Priya, Amber and 3 to 8 days on Madhuri and 30V92 in *rabi* season with an average duration of 6.5 ± 0.62 , 6.8 ± 0.70 , 6.5 ± 0.67 , 6.5 ± 0.64 , 6.6 ± 0.65 and 5.7 ± 0.56 days, respectively (Table 2).

IV instar larva

The fourth instar larva was comparatively stout and long with translucent white body. Head and prothoracic shield were brown. The duration of the fourth instar ranged from 3 to 8 days on DHM 117, DHM 121, Madhuri, Priya, 30V92 and 4 to 8 days on Amber in *kharif* season with an average of 6.7 ± 0.54 , 6.4 ± 0.54 , 6.5 ± 0.60 , 5.7 ± 0.56 , 5.9 ± 0.57 and 6.7 ± 0.40 days, respectively (Table 1). Fourth instar larva lasted for 3 to 10 days on DHM 117, 4 to 9 days on DHM 121, 3 to 9 days on Madhuri, 3 to 10 days on Priya, 4 to 10 days on Amber and 3 to 9 days on 30V92 in *rabi* season with an average of 7.1 ± 0.69 , 7.4 ± 0.58 , 6.7 ± 0.65 , 6.8 ± 0.80 , 7.6 ± 0.52 and 6.6 ± 0.56 days, respectively, (Table 2).

V instar larva

Fifth instar larva was almost similar to fourth instar, except for its size. The duration of the fifth

Table 1. Developmental period of different life stages of *C. partellus* on maize cultivars under laboratory conditions (26°C-30°C and 70%-78% RH) during Kharif, 2014 (August-September)

Stage of insect	DHM 117		DHM 121		Madhuri sweet corn		Priya sweet corn		Amber pop corn		30V92		CD @5%
	Range	*Mean ± SE	Range	*Mean ± SE	Range	*Mean ± SE	Range	*Mean ± SE	Range	*Mean ± SE	Range	*Mean ± SE	
Incubation of egg (days)	5-6	5.4±0.16	4-6	5.0±0.26	4-6	5.3±0.26	4-6	5.0±0.21	5-6	5.4±0.16	4-6	4.9±0.28	NS
Larval duration													
I instar	4-6	4.8±0.25	4-6	5.1±0.31	4-5	4.7±0.15	4-6	4.8±0.29	4-6	4.9±0.31	4-5	4.3±0.15	NS
II instar	2-7	4.8±0.49	3-7	5.2±0.51	2-6	4.2±0.51	2-7	4.9±0.53	3-7	5.5±0.50	3-6	4.4±0.27	NS
III instar	3-8	6.3±0.54	3-8	6.1±0.62	3-8	6.0±0.63	3-7	5.6±0.43	3-8	6.3±0.56	3-7	5.2±0.44	NS
IV instar	3-8	6.7±0.54	3-8	6.4±0.54	3-8	6.5±0.60	3-8	5.7±0.56	4-8	6.7±0.40	3-8	5.9±0.57	NS
V instar	3-9	7.4±0.60	3-9	7.2±0.65	3-8	6.6±0.50	3-9	7.0±0.63	4-8	7.0±0.39	3-8	6.4±0.50	NS
VI instar	5-11	9.7±0.60	5-11	9.3±0.65	5-10	8.7±0.54	5-11	9.1±0.62	6-11	9.1±0.57	6-10	8.9±0.43	NS
Total Larval period (days)	20-49	39.7±2.75	21-49	39.3±3.10	20-45	36.7±2.59	20-48	37.1±2.77	24-48	39.5±2.52	22-44	35.1±2.07	NS
Pupal period(days)	8-10	9.4±0.22	7-11	9.7±0.42	8-10	9.5±0.22	7-10	9.3±0.33	7-11	9.5±0.40	7-10	8.6±0.40	NS
Total Developmental Period (days)	33-64	54.5±2.95	36-65	54.0±3.07	35-61	51.5±2.59	31-63	51.4±3.14	40-63	55.0±2.44	36-56	48.6±2.00	NS

*Mean – Mean of ten replications

Table 2. Developmental period of different life stages of *C. partellus* on maize cultivars under laboratory conditions (26°C-30°C and 70%-78% RH) during Rabi, 2014-15 (December-January)

Stage of insect	DHM 117		DHM 121		Madhuri sweet corn		Priya sweet corn		Amber pop corn		30V92		CD @5%
	Range	*Mean ± SE	Range	*Mean ± SE	Range	*Mean ± SE	Range	*Mean ± SE	Range	*Mean ± SE	Range	*Mean ± SE	
Incubation of egg (days)	6-7	6.6 ± 0.16	5-7	6.2 ± 0.25	5-7	6.0 ± 0.26	5-7	6.4 ± 0.22	5-7	6.1 ± 0.18	5-7	5.8 ± 0.20	NS
Larval duration													
I instar	4-6	5.4 ± 0.22	4-6	5.0 ± 0.26	4-6	4.8 ± 0.33	4-6	4.8 ± 0.25	4-6	4.8 ± 0.25	4-5	4.4 ± 0.16	NS
II instar	3-8	5.8 ± 0.55	3-8	5.8 ± 0.63	3-8	5.8 ± 0.70	3-8	5.3 ± 0.52	3-8	5.3 ± 0.52	3-7	4.8 ± 0.44	NS
III instar	3-9	6.5 ± 0.62	3-9	6.8 ± 0.70	3-8	6.6 ± 0.65	3-9	6.5 ± 0.67	3-9	6.5 ± 0.64	3-8	5.7 ± 0.56	NS
IV instar	3-10	7.1 ± 0.69	4-9	7.4 ± 0.58	3-9	6.7 ± 0.65	3-10	6.8 ± 0.80	4-10	7.6 ± 0.52	3-9	6.6 ± 0.56	NS
V instar	4-10	7.6 ± 0.54	5-10	8.2 ± 0.57	4-10	7.7 ± 0.79	4-10	7.6 ± 0.75	4-11	8.9 ± 0.66	3-10	7.6 ± 0.73	NS
VI instar	5-12	10.1 ± 0.72	7-11	9.4 ± 0.52	5-11	9.5 ± 0.62	6-12	9.7 ± 0.63	7-12	10.1 ± 0.57	5-10	9.0 ± 0.49	NS
Total period (days)	22-55	42.5 ± 2.93	26-53	42.6 ± 3.00	22-52	41.1 ± 3.45	23-55	40.7 ± 3.39	25-56	43.2 ± 2.65	21-49	38.1 ± 2.58	Larval NS
Pupal period(days)	7-11	9.7 ± 0.42	8-12	10.7 ± 0.45	7-11	9.7 ± 0.45	9-12	10.4 ± 0.40	7-11	9.5 ± 0.40	8-11	9.4 ± 0.37	NS
Total Developmental Period (days)	35-72	58.7 ± 3.77	43-70	59.5 ± 3.10	37-67	56.8 ± 3.47	40-72	57.5 ± 3.32	39-72	58.8 ± 2.81	36-65	53.3 ± 2.63	NS

*Mean – Mean of ten replications; NS-Non-Significant

instar ranged from 3 to 9 days on DHM 117, DHM 121, Priya; 3 to 8 days on Madhuri, 30V92 and 4 to 8 days on Amber in *kharif* season with an average of 7.4 ± 0.60 , 7.2 ± 0.65 , 7.0 ± 0.63 , 6.6 ± 0.50 , 6.4 ± 0.50 and 7.0 ± 0.39 days, respectively (Table 1). This instar lasted for 4 to 10 days on DHM 117, Madhuri, Priya; 5 to 10 days on DHM 121; 4 to 11 days on Amber and 3 to 10 days on 30V92 in *rabi* season with an average duration of 7.6 ± 0.54 , 7.7 ± 0.79 , 7.6 ± 0.75 , 7.6 ± 0.75 , 8.9 ± 0.66 and 7.6 ± 0.73 days, respectively (Table 2).

VI instar larva

The sixth instar larva was robust and cylindrical. Body was dull white with reddish brown head and rows of black dots on the body. The mature caterpillar stopped feeding and built a loosely spun silk cocoon on the surface of the leaf bit or rearing plastic container. The larva there after shortened its body length and rested inside the cocoon on the side of its body with thoracic legs directed forward. Sixth instar was completed in 5 to 11 days when fed on DHM 117, DHM 121, Priya; 5 to 10 days on Madhuri; 6 to 11 days on Amber and 6 to 10 days on 30V92 with an average of 9.7 ± 0.60 , 9.3 ± 0.65 , 9.1 ± 0.62 , 8.7 ± 0.54 , 9.1 ± 0.57 and 8.9 ± 0.43 days in *kharif* season, respectively (Table 1). Whereas, in *rabi*, it was 5 to 12 days on DHM 117, 7 to 11 days on DHM 121, 5 to 11 days on Madhuri, 6 to 12 days on Priya, 7 to 12 days on Amber and 5 to 10 days on 30V92 with an average of 10.1 ± 0.72 , 9.4 ± 0.52 , 9.5 ± 0.62 , 9.7 ± 0.63 , 10.1 ± 0.57 and 9.0 ± 0.49 days, respectively (Table 2).

There were six larval instars in the life cycle of *C. partellus* which confirm the earlier reports by Nagarjuna (2005) and Siddalingappa *et al.* (2010). During *kharif* season, the total larval period ranged from 20 to 49 days on DHM 117, 21 to 49 days on DHM 121, 20 to 45 days on Madhuri, 20 to 48 days on Priya, 24 to 48 days on Amber and 22 to 44 days on 30V92 with an average of 39.7 ± 2.19 , 39.3 ± 2.12 , 36.8 ± 2.03 , 37.4 ± 2.13 , 39.5 ± 1.92 and 35.1 ± 1.67 days, respectively (Table 1). The total larval duration of the stem borer in *rabi* season varied from 22 to 55 days on DHM 117, 26 to 53 days on DHM

121, 22 to 52 days on Madhuri, 23 to 55 days on Priya, 25 to 56 days on Amber and 21 to 49 days on 30V92 with an average of 42.5 ± 2.93 , 42.8 ± 2.60 , 41.2 ± 3.42 , 40.7 ± 3.21 , 43.2 ± 2.65 and 38.1 ± 2.58 days, on the corresponding maize cultivars, respectively (Table 2). The present findings with respect to larval duration are in agreement with that of Marulasiddesha (1999), Jalali and Singh (2003), Nagarjuna (2005) and Siddalingappa *et al.* (2010). The larvae fed on 30V92 went to pupation in a narrow period compared to those fed on other maize cultivars. This indicated that 30V92 was suitable for feeding by *C. partellus* than other cultivars. This can be an indication that maize hybrid 30V92 has provided more nutritional requirements for larvae of *C. partellus* in order to complete the larval stage in a shorter period of time.

Pupa

Pupa of *C. partellus* was oblong type with broad anterior end which tapered towards posterior end with small spines, black compound eyes. Pupa was brownish and gradually attained dark brown colour by the time of adult emergence. The size of female pupa was slightly larger than of the male pupa. Sex differentiation could be detected in the pupal stage using morphological differentiation at the tip of abdomen especially the space between the genital pores. The pore of the female pupa was wider than that of the male. The pupal period ranged from 8 to 10 days on DHM 117 and Madhuri with an average of 9.4 ± 0.22 and 9.5 ± 0.22 days, 7 to 11 days on DHM 121 and Amber with an average of 9.7 ± 0.42 and 9.5 ± 0.40 and 7 to 10 days on Priya and 30V92 with an average of 9.3 ± 0.33 and 8.6 ± 0.40 , respectively during *kharif* season (Table 1). The pupal period ranged from 7 to 11, 8 to 12, 7 to 11, 9 to 12, 7 to 11 and 8 to 11 days with an average of 9.7 ± 0.42 , 10.7 ± 0.45 , 9.7 ± 0.45 , 10.4 ± 0.40 , 9.5 ± 0.40 and 9.4 ± 0.37 days on DHM 117, DHM 121, Madhuri, Priya, Amber and 30V92, respectively during *rabi* season (Table 2). The present findings are in close agreement with Siddalingappa *et al.* (2010) who reported that pupal period lasted for 6 to 12 days and 7 to 10 days (Jalali and Singh, 2003 and Balikai and Sajjanar, 2012).

Table 3. Adult longevity and fecundity of *C. partellus* under laboratory conditions (26°C-30°C and 70%-78% RH) during 2014-15

Season	Adult longevity (days)						Oviposition period (days)		Fecundity / female	
	Male			Female			Range	*Mean ± SE	Range	*Mean ± SE
	Range	*Mean ± SE	Range	Range	*Mean ± SE	Range				
Kharif 2014 (August-September)										
DHM 117	3-7	4.6 ± 0.45	3-6	3.9 ± 0.31	3-4	3.7 ± 0.15	176-313	228.4 ± 17.17		
DHM 121	3-7	5.1 ± 0.38	3-6	4.4 ± 0.34	3-4	3.9 ± 0.10	181-326	233.7 ± 18.53		
Madhuri sweet corn	4-7	5.4 ± 0.37	3-7	5.1 ± 0.43	4-5	4.2 ± 0.13	173-316	216.3 ± 14.15		
Priya sweet corn	3-6	4.5 ± 0.40	3-6	4.1 ± 0.38	3-4	3.5 ± 0.17	185-335	221.2 ± 16.98		
Amber pop corn	4-7	5.2 ± 0.33	3-6	4.1 ± 0.31	4-5	4.2 ± 0.13	157-286	204.6 ± 13.78		
30V92	3-7	5.2 ± 0.42	3-6	4.6 ± 0.43	3-4	3.4 ± 0.16	213-362	264.9 ± 16.14		
Rabi 2014-15 (December-January)										
DHM 117	4-7	5.1 ± 0.31	3-6	4.1 ± 0.31	3-5	4.1 ± 0.28	157-319	205.1 ± 18.34		
DHM 121	4-7	5.3 ± 0.30	3-6	4.5 ± 0.37	4-5	4.4 ± 0.16	167-309	217.4 ± 15.94		
Madhuri sweet corn	3-7	4.8 ± 0.44	3-6	4.2 ± 0.36	3-5	4.2 ± 0.25	148-311	204.5 ± 13.64		
Priya sweet corn	3-7	5.0 ± 0.47	3-6	4.3 ± 0.37	4-5	4.3 ± 0.15	167-363	223.7 ± 22.36		
Amber pop corn	3-7	5.1 ± 0.38	4-6	4.6 ± 0.22	3-5	4.3 ± 0.26	166-274	195.2 ± 11.74		
30V92	4-7	5.7 ± 0.30	3-6	4.5 ± 0.45	4-5	4.2 ± 0.13	196-347	255.6 ± 16.50		

*Mean – Mean of ten replications

Adult

Adult moths were dirty brown, when at rest the antennae were extended foreword and wings were folded on the abdomen. Emergence of the adults usually occurred during the evening time. Male moths emerged on first day and second day female moths emerged. Males and females could be easily distinguished by the darker and slender body of male and lighter and moderately stout body of the female. Longevity of the adults was studied by providing cotton dipped in 10 per cent honey solution as food. The life span of mated and fed males and females was 3 to 7 days with an average longevity of 4.5 to 5.4 days and 3 to 6 days with an average longevity of 3.9 to 5.1 days, respectively in *kharif* season. Whereas, in *rabi* season the average longevity of males and females was 4.8 to 5.7 and 4.1 to 4.6 days, respectively on different maize cultivars (Table 3). The observations on adult longevity were in confirmation with Jalali and Singh (2003) and Siddalingappa *et al.* (2010).

Oviposition Period

The pre-mating period and mating period of stem borer moths varied from 8 to 11 hours and 4.30 to 6.30 hours, respectively. Newly emerged female moved about for some time and then copulated with the males. While copulating they faced opposite directions and mild disturbance did not deter the process. The female mated only once in her life and mated females rejected the attempts to mate by males. The moth laid eggs during night, but occasionally also observed during the morning hours. The duration of egg laying varied from 3 to 5 days with an average of 3.4 to 4.2 days in *kharif* and 4.1 to 4.4 days in *rabi* season, respectively on different test maize cultivars (Table 3).

Fecundity

Large numbers of eggs were laid on first day after mating. Fecundity ranged from 176 to 313, 181 to 326, 173 to 316, 185 to 335, 157 to 286 and 213 to 362 eggs per female on DHM 117, DHM 121, Madhuri, Priya, Amber and 30V92 with an average of 228.4 ± 17.17 , 233.7 ± 18.53 , 216.3 ± 14.15 , 221.2 ± 16.98 , 204.6 ± 13.78 and 264.9 ± 16.14 eggs,

respectively in *kharif*. There was no distinct difference in the number of eggs laid in two seasons and the number of egg laid by each female varied from 157 to 319, 167 to 309, 148 to 311, 167 to 363, 166 to 274 and 196 to 347 in *rabi* season with an average of 205.1 ± 18.34 , 217.4 ± 15.94 , 204.5 ± 13.64 , 223.7 ± 22.36 , 195.2 ± 11.74 and 255.6 ± 16.50 eggs on DHM 117, DHM 121, Madhuri, Priya, Amber and 30V92, respectively (Table 3). Present observations on fecundity of female stem borer moth, *C. partellus* on different maize cultivars more or less corroborated with the earlier observation reported by Nagarjuna (2005). However, the present findings slightly varied from Siddalingappa *et al.* (2010) who reported number of eggs laid per female ranged from 262 to 657 with an average 412.6 ± 122.17 and 434 eggs per female (Berger, 1989). This variation can be attributed to the variation in climatic factors.

Total life cycle of the maize stem borer, *C. partellus* (egg to adult emergence) was completed in 33 to 64 days on DHM 117, 36 to 65 days on DHM 121, 35 to 61 days on Madhuri, 31 to 63 days on Priya, 40 to 63 days on Amber and 36 to 56 days on 30V92 in *kharif* with an average of 54.5 ± 2.95 , 54.0 ± 3.07 , 51.5 ± 2.59 , 51.4 ± 3.14 , 55.0 ± 2.44 and 48.6 ± 2.00 days, respectively (Table 1). Whereas, total life cycle of the pest was found to range between 35 to 72 days on DHM 117, 43 to 70 days on DHM 121, 37 to 67 days on Madhuri, 40 to 72 days on Priya, 39 to 72 days on Amber and 36 to 65 days on 30V92 during *rabi* with an average of 58.7 ± 3.77 , 59.5 ± 3.10 , 56.8 ± 3.47 , 57.5 ± 3.32 , 58.8 ± 2.81 and 53.3 ± 2.63 days, respectively (Table 2). The present findings are in accordance with that of earlier workers who reported the total lifecycle was completed in 34 to 56 days (Deshpande, 1978); 25 to 50 days (Harris, 1990); 30 to 65 days (Marulasiddesha, 1999); 38 to 64 days (Nagarjuna, 2005) and 30 to 69 days (Siddalingappa *et al.*, 2010) when climate and growing conditions are favourable.

CONCLUSION

The results provided a basis for understanding the relative preference of certain commercial hybrids and special varieties of maize

by spotted stem borer due to physiological and biochemical differences of the host plant cultivars which can be exploited in Integrated Pest Management(IPM).

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NUTRIENT UPTAKE OF RICE AS INFLUENCED BY INTEGRATED NUTRIENT MANAGEMENT PRACTICES

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ABSTRACT

A field experiment was conducted during *khari*f for two consecutive years (2015-2016 and 2016-2017) on sandy clay loam soil of Agricultural College Farm, Bapatla. The treatments consisted of different combinations of nitrogen *i.e.* T₁:100 % RDN, T₂:75% RDN + 25% Farmyard manure, T₃:50% RDN + 50% Farmyard manure, T₄:25% RDN + 75% Farmyard manure, T₅:75% RDN + 25% Poultry manure, T₆:50% RDN + 50% Poultry manure, T₇:25% RDN + 75% Poultry manure, T₈:75% RDN + 25% Vermicompost, T₉:50% RDN + 50% Vermicompost, T₁₀:25% RDN + 75% Vermicompost, T₁₁:75% RDN + 25% Green manure, T₁₂:50% RDN + 50% Green manure and T₁₃:25% RDN + 75% Green manure. The experiment was laid out in a randomized block design with thirteen treatments and replicated thrice. Data collected on growth parameters, yield attributes, grain yield, straw yield, harvest index nutrient uptake (NPK) of rice were subjected to statistical analysis and results indicated that all the characters studied were significantly higher with application of 100% RDN through inorganic fertilizer (T₁), however, it was on a par with that of application of 50% RDN+ 50 % Green manure (T₁₂) and 50% RDN + 50% Poultry manure (T₆) during both the years of study.

INTRODUCTION

Rice (*Oryza sativa* L.) is staple food for more than half of the global population in about 40 countries and more than 65 per cent of the population in India. It is grown in India in an area of 43.49 M ha with a total production of 104.40 M t and a productivity of 2400 kg ha⁻¹ (CMIE, 2016). In Andhra Pradesh, rice is grown in an area of 2.16 M ha with annual production of 7.48 Mt and productivity of 3465 kg ha⁻¹ (CMIE, 2016). In Andhra Pradesh, direct seeded rice is grown in an area of 4.0 lakh ha (Department of Agriculture, 2016), which is gaining momentum among the farmers of Krishna Agro Climatic Zone of A.P. by taking the advantage of early rains received before release of canal water and makes it feasible to rise a second crop early which increases the farmers income. In coastal districts of A.P., due to scarcity of irrigation water and high cost of labour leads to reduced profit for transplanted rice. Hence, direct seeded rice has gained popularity due to its less labour and water needs. Increased use of inorganic fertilizers leads to soil and water pollution. To reduce the pollution, use of organic manures to supplement total recommended levels of nutrients

is an option. Although the use of fertilizers promises to increase the productivity, the indiscriminate and imbalanced uses of fertilizers affect the productivity, soil health and environment. Hence, the focus of agriculture is to evolve ecologically sound nutrient management practices. Integrated nutrient management is the best option to achieve this goal. The farmers use several organic sources with varying levels of nutrients (Khush, 2004). Therefore, it is necessary to evaluate the different sources of organic manures for standardizing the recommendation to rice farmers. Hence, the present study was conducted.

MATERIAL AND METHODS

An 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 (214, 254 kg ha⁻¹), medium in P (39, 34 kg ha⁻¹) and high in OC (0.73, 0.87) and K (472,513 kg ha⁻¹) during both the years, respectively. The

average maximum and minimum temperatures during the rice crop growth period were 32.1 °C and 22.1 °C during 2015-16 and 32.7 °C and 21.9 °C during 2016-17, respectively. The average relative humidity was 77.8% and 72.3% during both the years. A total rainfall of 660.5 mm and 575.2 mm was received during 2015-16 & 2016-17 in 30 and 26 rainy days, respectively. The experiment was laid out during *kharif* (2015-16, 2016-17) in a randomized block design with thirteen treatments and replicated thrice. The treatments consisted of different combinations of nitrogen *i.e.* T₁:100% RDN, T₂:75% RDN + 25% Farmyard manure, T₃:50% RDN + 50% Farmyard manure, T₄:25% RDN + 75% Farmyard manure, T₅:75% RDN + 25% Poultry manure, T₆:50% RDN + 50% Poultry manure, T₇:25% RDN + 75% Poultry manure, T₈:75% RDN + 25% Vermicompost, T₉:50% RDN + 50% Vermicompost, T₁₀:25% RDN + 75% Vermicompost, T₁₁:75% RDN + 25% Green manure, T₁₂:50% RDN + 50% Green manure and T₁₃:25% RDN + 75% Green manure. The experiment was repeated during 2nd year in another field. Recommended dose of Nitrogen - 120 kg N ha⁻¹ was applied through urea, 1/3rd as basal at the time of sowing, remaining N applied in two equal splits at active tillering and panicle initiation stages.

The pre germinated rice seeds were sown @ 80 kg ha⁻¹ in solid rows at 20 cm spacing between two rows in a puddled and levelled moist soil. To maintain uniform plant population, thinning of seedlings and gap filling was done at 10 DAS. Organic manures *viz.*, farmyard manure, poultry manure, vermicompost were applied as per the treatments fifteen days before sowing, green manure was sown 45 days before sowing and incorporated. The inorganic nitrogen (120 kg N ha⁻¹) was applied through urea and uniform application of phosphorous (60 kg P₂O₅ ha⁻¹) and potassium (40 kg K₂O ha⁻¹) were applied through single superphosphate and murate of potash, respectively. Entire quantity of phosphorus and potassium and one-third of the N were applied as basal at the time of sowing. Remaining N was applied in two equal splits at active tillering stage and panicle initiation stage. The data on plant height, total number of tillers m⁻², drymatter

production, yield attributes *viz.*, No. of panicles m⁻², panicle length, No. of grains panicle⁻¹, test weight, grain yield, straw yield and nutrient uptake were analysed by adopting standard procedures.

RESULTS AND DISCUSSION

Grain yield and Straw yield

During both the years significantly higher grain yields were recorded with the recommended dose of inorganic fertilizer 100% RDN (T₁) *i.e.* 5242 kg ha⁻¹ and 5507 kg ha⁻¹ during 1st and 2nd years, respectively, which was statistically on a par with 50% RDN+50% GM (T₁₂) and 50% RDN+50% PM (T₆) *i.e.* 5185 kg ha⁻¹, 5186 kg ha⁻¹ and 5153 kg ha⁻¹, 5281 kg ha⁻¹ during 1st and 2nd years, respectively (Table 1), but proved significantly superior to the rest of the treatments under test. Rice is relatively leafy in its early stages and adequate supply of nitrogen improves the photosynthetic rate and better nutrient uptake and ultimately the grain yield (Padmaja, 2014).

Perusal of the data on straw yield (Table 1) revealed that the straw yield also followed almost similar trend as that of grain yield during both the years of study. Significantly highest straw yield (6496 kg ha⁻¹ and 6749 kg ha⁻¹ during 1st and 2nd year, respectively) was recorded with the treatment that received recommended dose of inorganic fertilizer 100% RDN (T₁), which was statistically on a par with the treatments 50% RDN+50% GM (T₁₂) and 50% RDN+50% PM (T₆) but proved significantly superior to the rest of the treatments. This might be due to stimulated vegetative growth as evidenced through higher plant height, tiller production and drymatter accumulation on account of adequate and prolonged supply of essential nutrients received during each split application, greater availability of nutrients in soil, improved soil environment and higher root penetration leading to better absorption of moisture and nutrients (Ururkar *et al.*, 2010).

Nitrogen Uptake

A perusal of the data (Table 2) showed significant differences in nitrogen uptake in plant at 30, 60, 90 DAS and at maturity (grain and straw)

Table1. Grain yield (kg ha⁻¹) and Straw yield (kg ha⁻¹) of rice during *kharif* as influenced by integrated nutrient management practices

Treatment	2015-16		2016-17	
	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)
T ₁ : 100% RDN	5242	6496	5508	6749
T ₂ : 75% RDN+25% FYM	4113	5495	4067	5274
T ₃ : 50% RDN+50% FYM	4327	5565	4331	5609
T ₄ : 25% RDN+75% FYM	3105	4206	3509	4950
T ₅ : 75% RDN+25% PM	4573	5805	4591	5979
T ₆ : 50% RDN+50% PM	5153	6464	5281	6553
T ₇ : 25% RDN+75% PM	3914	5258	4562	5958
T ₈ : 75% RDN+25% VC	4893	6214	4434	5972
T ₉ : 50% RDN+50% VC	4412	5730	4534	5794
T ₁₀ : 25% RDN+75% VC	3286	4434	3459	4630
T ₁₁ : 75% RDN+25% GM	3814	4850	4907	6264
T ₁₂ : 50% RDN+50% GM	5185	6317	5286	6592
T ₁₃ : 25% RDN+75% GM	4384	5830	4740	5958
SEM±	87.4	254.1	123.1	133.4
CD @ 5 %	289	661	371	400
CV(%)	8.5	7.7	6.4	8.3

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

Table 2. Nitrogen uptake (kg ha^{-1}) of rice during *kharrif* as influenced by integrated nutrient management practices

Treatment	2015-16				2016-17				
	30 DAS	60 DAS	90 DAS	Straw	30 DAS	60 DAS	90 DAS	Grain	Straw
T ₁ : 100% RDN	4.9	26.1	54.6	66.4	54.1	31.4	64.3	66.8	48.8
T ₂ : 75% RDN+25% FYM	3.4	22.1	49.5	52.0	44.5	25.1	58.2	49.7	38.7
T ₃ : 50% RDN+50% FYM	3.6	22.3	44.4	53.3	46.0	25.0	58.3	51.9	43.4
T ₄ : 25% RDN+75% FYM	3.2	19.1	39.5	37.8	33.6	24.4	52.1	42.2	37.8
T ₅ : 75% RDN+25% PM	3.9	21.1	46.5	56.9	48.5	27.0	56.1	57.1	45.4
T ₆ : 50% RDN+50% PM	4.8	25.2	53.5	63.1	52.1	30.5	61.3	66.1	49.4
T ₇ : 25% RDN+75% PM	4.5	23.3	48.2	48.4	42.8	25.9	55.9	55.2	45.9
T ₈ : 75% RDN+25% VC	4.1	21.4	49.1	61.0	49.7	26.4	58.5	54.3	44.9
T ₉ : 50% RDN+50% VC	3.7	22.9	50.3	55.0	47.5	28.4	60.6	56.7	45.0
T ₁₀ : 25% RDN+75% VC	3.4	19.1	41.8	40.3	35.9	25.0	54.6	41.9	36.7
T ₁₁ : 75% RDN+25% GM	4.1	22.2	50.1	47.6	41.2	27.1	56.3	60.7	48.3
T ₁₂ : 50% RDN+50% GM	4.9	24.7	53.9	63.6	52.6	30.9	62.0	65.7	49.2
T ₁₃ : 25% RDN+75% GM	3.8	22.2	48.9	54.5	47.8	26.8	58.3	58.3	47.3
SEm±	0.24	0.89	1.72	2.01	2.22	0.74	1.19	1.66	1.15
CD @ 5 %	0.6	2.8	5.0	6.0	6.5	2.0	3.7	5.0	3.4
CV(%)	14.0	8.9	9.8	8.6	10.3	7.2	7.2	5.9	7.1

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

Table 3. Phosphorus uptake (kg ha^{-1}) of rice during *kharif* as influenced by integrated nutrient management practices

Treatments	2015-16				2016-17				
	30 DAS	60 DAS	90 DAS	Straw	30 DAS	60 DAS	90 DAS	Grain	Straw
T ₁ : 100% RDN	2.0	9.3	19.3	11.9	5.8	11.7	22.9	13.1	6.0
T ₂ : 75% RDN+25% FYM	1.3	8.7	19.1	09.9	4.4	10.7	20.8	10.3	4.2
T ₃ : 50% RDN+50% FYM	1.2	9.3	15.4	11.0	5.2	10.3	22.7	10.3	5.2
T ₄ : 25% RDN+75% FYM	1.1	7.7	15.1	07.6	3.4	9.8	19.3	8.2	4.5
T ₅ : 75% RDN+25% PM	1.4	8.1	15.9	11.0	4.4	10.3	20.9	11.0	5.0
T ₆ : 50% RDN+50% PM	1.9	9.9	19.8	11.7	5.6	11.1	22.5	12.8	5.7
T ₇ : 25% RDN+75% PM	1.8	8.5	16.9	09.1	5.3	11.1	19.6	10.4	5.6
T ₈ : 75% RDN+25% VC	1.3	8.3	17.7	12.0	5.6	11.2	21.7	10.2	5.4
T ₉ : 50% RDN+50% VC	1.6	9.6	17.2	10.4	4.6	11.0	22.0	10.7	4.7
T ₁₀ : 25% RDN+75% VC	1.2	7.7	15.7	07.9	3.4	11.1	21.7	8.6	3.7
T ₁₁ : 75% RDN+25% GM	1.3	8.4	19.3	09.5	4.4	10.5	21.2	11.1	5.5
T ₁₂ : 50% RDN+50% GM	1.9	9.7	19.5	11.7	5.2	11.3	22.8	12.3	5.3
T ₁₃ : 25% RDN+75% GM	1.3	8.9	18.1	11.0	4.3	10.7	21.8	11.8	5.0
SEM±	0.25	0.39	1.12	0.41	0.63	0.64	0.65	0.29	0.57
CD @ 5%	0.5	1.4	3.4	1.3	1.8	1.7	1.9	1.2	1.8
CV(%)	15.3	16.8	19.5	8.6	18.3	13.9	8.8	9.7	14.8

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

Table 4. Potassium uptake (kg ha⁻¹) of rice during *kharif* as influenced by integrated nutrient management practices

Treatments	2015-16				2016-17				
	30 DAS	60 DAS	90 DAS	Straw	30 DAS	60 DAS	90 DAS	Grain	Straw
T ₁ : 100% RDN	18.2	59.0	98.3	14.0	79.9	71.9	109.3	14.7	80.5
T ₂ : 75% RDN+25% FYM	16.2	50.9	93.0	10.8	66.5	61.4	103.5	10.7	63.1
T ₃ : 50% RDN+50% FYM	16.7	49.4	85.8	10.0	68.4	62.9	104.5	10.7	68.4
T ₄ : 25% RDN+75% FYM	15.9	46.9	83.7	06.7	51.3	60.6	102.4	9.4	61.2
T ₅ : 75% RDN+25% PM	16.4	52.1	90.2	11.2	72.9	63.1	102.1	11.9	74.3
T ₆ : 50% RDN+50% PM	18.3	55.1	99.6	11.6	79.3	70.9	108.4	12.7	80.4
T ₇ : 25% RDN+75% PM	17.3	57.5	93.0	09.2	64.8	60.1	103.5	10.9	73.3
T ₈ : 75% RDN+25% VC	16.5	50.1	91.1	12.1	75.8	62.0	107.8	11.1	73.5
T ₉ : 50% RDN+50% VC	16.1	50.6	93.7	10.8	71.6	65.7	102.0	11.1	72.6
T ₁₀ : 25% RDN+75% VC	16.1	45.9	84.2	06.9	53.6	59.6	100.2	9.2	57.3
T ₁₁ : 75% RDN+25% GM	16.9	52.4	94.0	09.5	61.6	64.4	102.4	12.4	77.1
T ₁₂ : 50% RDN+50% GM	18.4	59.0	98.6	11.8	79.9	71.1	108.5	12.0	80.4
T ₁₃ : 25% RDN+75% GM	16.1	50.9	93.0	10.6	72.2	65.2	102.1	11.6	72.9
SEm±	0.59	1.42	2.21	0.61	2.20	1.24	1.43	0.57	1.65
CD @ 5 %	NS	4.4	5.1	1.8	5.6	3.3	3.1	2.6	3.0
CV(%)	9.5	8.4	7.9	7.7	9.8	5.2	4.1	9.7	6.7

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

due to different treatments of sources of organic manures. During both the years of the study, it was observed that significantly higher nitrogen uptake was observed with treatment that received recommended dose of inorganic fertilizer 100% RDN (T_1), which was statistically on par with 50% RDN+50% GM (T_{12}) and 50% RDN+50% PM (T_6) but proved significantly superior to the rest of the treatments. The increased N uptake was due to sufficient and continued availability of N from inorganic and organic source in the soil favouring the efficient use of major and micro nutrients. The uptake being the product of nutrient content and dry matter accumulation, the increase in N uptake by the crop might be due to increased availability of nitrogen and higher grain and straw yields. Similar results were also reported by Pradeep *et al.* (2012). The lowest nitrogen uptake at all the growth stages of rice was recorded with treatment, 25% RDN+75% FYM (T_4) which was on par with treatment, 25% RDN+75% VC (T_{10}) during both years of study. This might be due to unavailability of nutrients at critical stages of crop growth as explained earlier by Choudhary *et al.* (2011).

Phosphorus Uptake

Phosphorus uptake (Table 3) by rice was significantly different at 30, 60, 90 DAS and at maturity (grain and straw) by different treatments of sources of organic manures, while there was no significant variation among the treatments for phosphorus content during both the years of study. Significantly highest phosphorus uptake was noticed with the same treatment that received recommended dose of inorganic fertilizer 100% RDN (T_1), but was statistically on par with 50% RDN+50% GM (T_{12}) and 50% RDN+50% PM (T_6) and proved significantly superior to the rest of the treatments. The increased P uptake was due to higher drymatter accumulation at different stages of crop growth but not by phosphorus content, as uptake being the product of nutrient content and dry matter accumulation. CO_2 produced during mineralization of organic sources play role in solubilization of native P. The present results are in agreement with the findings of Sagarika *et al.* (2012).

Potassium Uptake

The data on potassium followed the similar trend as that was noticed in respect of N and P uptakes at all the stages of crop growth studied *i.e.* 30, 60 90 DAS and at harvest (grain and straw) during both the years of study (Table 4). The same treatment *i.e.* T_1 (100% RDN) proved its superiority by registering the highest potassium uptake but was remained statistically alike with 50% RDN+50% GM (T_{12}) and 50% RDN+50% PM (T_6) and proved significantly superior to the rest of the treatments. Significantly lowest Potassium uptake at all growth stages of rice was recorded significantly with the treatment 25% RDN+75% FYM (T_4) and is on par with treatment 25% RDN+75% VC (T_{10}) at all stages of crop growth *i.e.*, 30, 60, 90 DAS and at maturity (grain and straw) during both years of study.

Higher K uptake recorded by T_1 treatment might be due to better soil condition and reduced K fixation. N, P and K uptake compared to other levels of nitrogen in organic form at all stages could be ascribed to the increase in the available nitrogen due to readily soluble nature, which might have increased the K absorption (Biswas and Narayanasamy, 1998). Increased rice yield could also be ascribed due to significant increase in nutrient uptake of plants in respective treatment involving organic manure *viz.*, poultry manure and green manure. Increase in nutrient availability in poultry manure treated plots was due to higher N content and its gradual mineralization process. This process ensures N availability throughout crop growth period, besides improving crop yield. The added organic manure (poultry manure and green manure) might have enhanced the activity of beneficial soil microflora increasing the availability and uptake of nutrients by the crop. Similar findings were also reported by Meena *et al.* (2010).

CONCLUSION

It can be concluded that the field studies conducted for two consecutive years clearly indicated that the application of 100% RDN through inorganic fertilizer was remained on a 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 nutrient uptake of rice.

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COMBINING ABILITY ANALYSIS FOR GRAIN QUALITY TRAITS IN RICE (*Oryza sativa* L.)

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ABSTRACT

Combining ability analysis for twelve grain quality traits was made among 20 crosses generated in a line x tester (LxT) fashion with five lines and four testers revealed LxT interaction was significant for most of the traits under study (Kharif, 2014). The magnitude of specific combining ability variances was higher than that of general combining ability variances for all the traits under study indicating the major role of non-additive gene action in the inheritance of the traits under study. Among parents, JGL 11118 found to be good for kernel length, kernel breadth, kernel L/B ratio, hulling %, water uptake and volume expansion ratio, NLR 34449 for head rice recovery, IR 64 for kernel length, kernel breadth, hulling % and water uptake and IR 36 for water uptake, volume expansion ratio, kernel elongation ratio, alkali spreading value and gel consistency. The best specific combiners were BPT 5204 x NLR 34449 for kernel length, gel consistency, BPT 5204 x IR 36 for head rice recovery, BPT 5204 x NLR 145 for hulling, MTU 1010 x IR 36 kernel length, JGL 11118 x NLR 145 for water uptake, JGL 11118 x IR 36 for volume expansion, WGL 48684 x IR 36 for head rice recovery and WGL 48684 x NLR 145 for kernel elongation ratio.

INTRODUCTION

Rice (*Oryza sativa* L.) is the world's most important food crop providing more than 20% caloric intake for over 3.5 billion people. The demand for rice continues to rise because of increase in population and improvement in living standards. Change in income level and self sufficiency including rice availability for consumption has brought a shift in the consumer as well as market preferences for better rice grain quality in terms of physical and cooking quality. Reorientation of breeding methodologies is therefore a prerequisite where genetic analysis of quantitative traits on systematic lines can be devised. Choice of suitable parents is of paramount importance since *per se* performance of parents is not always a true indicator of its combining ability in hybrid combination (Sharma and Mani, 2008). The knowledge of combining ability is useful to assess nicking ability among genotypes and at the same time elucidate the nature and magnitude of gene actions involved.

The combining ability analysis gives an indication of the variance due to GCA and SCA which represents a relative measure of additive and non-additive gene actions, respectively. Breeders use these variance components to measure the gene

action and to assess the genetic potentialities of parent in hybrid combinations. Line x tester mating design provide reliable information about the general and specific combining ability (*gca* and *sca*) of parents and their cross combinations and are helpful in estimating various types of gene actions within affordable resources.

MATERIAL AND METHODS

The experimental materials used for the present investigation consisted of F_1 hybrids of 20 crosses developed by crossing 5 lines/genotypes of rice *viz.*, BPT 5204, MTU 1010, WGL 48684, RNR 2465 and JGL 11118 with four testers *viz.*, NLR 34449, NLR 145, IR 36 and IR 64. All the lines used as female parents were crossed to each of the testers by hand pollination during *kharif*, 2014. The F_1 's (20 hybrids along with parental lines (lines (5) + testers (4)) were evaluated in RBD with three replications at Agricultural Research Station, Nellore. In each replication entries (F_1 's and parents) were grown in four rows of 2 m length with spacing of 20 cm X 15 cm transplanted as single seedling/hill. The data was recorded from each cross/genotype in each replication for 12 grain quality traits duly following standard methods on individual plant basis *viz.*, kernel length (mm), kernel breadth (mm), kernel L/B ratio, hulling

(%), milling (%), head rice recovery (%), water uptake (ml), volume expansion ratio, kernel elongation ratio, gel consistency, alkali spreading value and amylose content. All the recommended agronomic and plant protection practices were uniformly applied throughout the crop growth period.

RESULTS AND DISCUSSION

Analysis of variance (ANOVA) revealed that the treatments registered highly significant differences amongst the parents for all the characters except for kernel elongation ratio and alkali spreading value indicating the existence of sufficient variability in the material studied (Table 1). The lines differed significantly for most of the traits except kernel L/B ratio, hulling%, kernel elongation ratio, gel consistency, alkali spreading value and amylose content. Whereas, the testers differed significantly for kernel length, kernel breadth, kernel L/B ratio, water uptake, volume expansion and amylose content. The interaction between lines and testers were significant for the traits *viz.*, kernel length, kernel breadth, hulling%, head rice recovery, water uptake, volume expansion ratio and gel consistency.

Mean squares due to parents vs. crosses were significantly different for all the characters except for kernel L/B ratio and milling % revealing good scope for manifestation of heterosis in most of the characters studied. The effect of crosses was partitioned into lines, testers and their interactions. The mean squares due to lines effect were significant for kernel length, kernel L/B ratio and amylose content suggesting larger contribution of lines towards general combining ability variance components for these traits. The mean squares due to testers effect was non significant for all the characters indicating that there was no significant contribution of testers towards component of *gca* variance in the present material. The mean squares due to Line × Tester interaction effects were significant for most of the characters except for kernel breadth, kernel L/B ratio, milling % and amylose content revealed the significant contribution of crosses for specific combining ability variance components.

The magnitude of *sca* variance was higher than *gca* variance for all the biometrical characters indicating the preponderance of non-additive gene action in the expression of these traits. The ratio of variance due to general and specific combining ability ranged from 0.22 to 2.66 conforming the predominance of the non-additive gene action for all the traits under study except kernel length, L/B ratio, milling % and alkali spreading value which exhibited intermediate values indicating the predominance of both additive and non additive gene actions played an important role. However, for the trait kernel breadth the ratio was near to unity indicating the presence of additive gene action played a prominent role in the inheritance of the trait.

The proportional contribution of lines, testers and line x tester interaction to total variance are presented in Table 1. The per cent contribution towards the total variance was maximum due to the interaction of lines and testers for the traits hulling% (70.72), gel consistency (67.78), head rice recovery (65.09), volume expansion ratio (58.94), kernel elongation ratio (51.31), milling% (48.13), water uptake (44.84) and alkali spreading value (43.62). The maximum contribution of lines alone towards the total variance was observed for number of kernel L/B ratio (61.62), amylose content (49.96), kernel length (47.73) and kernel breadth (38.56).

Among five lines tested for their combining abilities pertaining to different characters under study, the line JGL 11118 recorded significant *gca* effects in desirable direction for majority of the traits *viz.*, kernel length, kernel breadth (negative) kernel L/B ratio, hulling %, water uptake and volume expansion ratio (Table 2). Whereas, the line MTU 1010 for kernel length, kernel L/B ratio, water uptake and volume expansion ratio. Among the testers, NLR 34449 recorded significant *gca* effects for head rice recovery, water uptake and volume expansion ratio. While, the tester IR 64 for kernel length, kernel breadth, hulling% and water uptake and IR 36 for water uptake, volume expansion ratio, kernel elongation ratio, alkali spreading value and gel consistency. Therefore, these lines and testers can be utilized in improvement of the respective traits in breeding programmes.

Table 1. Estimates of genetic components of variance and proportional contribution of lines, testers and line x tester interactions to total variance for grain quality traits in rice

Source of variance	KL (mm)	KB (mm)	KL/B Ratio	H%	M%	HRR%	WU (ml)	VER	KER	GC(mm)	ASV	AC
<i>gca</i>	0.06	0.00	0.02	0.34	0.88	4.15	1166.77	0.52	0.01	15.77	0.49	0.08
<i>sca</i>	0.06	0.00	0.02	2.42	1.34	20.94	2538.21	1.99	0.02	89.27	0.87	-0.10
<i>2gca/2gca+sca</i>	0.68	0.98	0.65	0.22	0.57	0.28	0.48	0.34	0.46	0.26	0.53	2.66
Contribution (%)												
Lines	47.73	38.56	61.62	16.33	31.63	22.50	36.63	26.60	21.76	15.52	21.22	49.96
Testers	21.99	23.98	0.98	12.95	20.24	12.42	18.53	14.47	26.93	16.70	35.15	4.21
Line x Tester	30.28	37.46	37.40	70.72	48.13	65.09	44.84	58.94	51.31	67.78	43.62	45.83

Table 2. Estimates of general combining ability (gca) effects of parents for quality traits in rice

Parents	KL (mm)	KB (mm)	KL/B Ratio	H%	M%	HRR%	WU (ml)	VER	KER	GC(mm)	ASV	AC
BPT 5204	-0.26**	-0.05	-0.06	0.27	0.91	-0.51	11.82**	-0.75**	0.02	-2.10	-0.32	0.59
MTU 1010	0.43**	0.04	0.16*	0.28	1.32	-1.36*	27.95**	0.25*	0.07	-1.10	-0.45*	-0.57
JGL 11118	0.20**	-0.08*	0.25**	0.88*	0.36	1.00	24.70**	0.50**	-0.07	2.15	-0.08	0.20
RNR 2465	-0.24**	0.08*	-0.27**	-0.41	-0.99	3.58**	4.57	0.96**	0.09*	6.28*	1.05**	0.66
WGL 48684	-0.14	0.01	-0.09	-1.03*	-1.61*	-2.72**	-69.05**	-0.96**	-0.11*	-5.22*	-0.20	-0.87*
NLR 34449	-0.22**	-0.05	-0.02	-0.07	0.64	1.96**	12.63**	0.35**	-0.05	-2.03	-0.95**	0.08
NLR 145	-0.02	0.01	-0.02	-0.85*	1.12	-2.48**	-42.47**	-0.43**	-0.09*	-4.63*	-0.25	0.23
IR 36	-0.04	-0.02	0.01	0.13	-0.76	0.57	23.52**	0.71**	0.14**	6.38*	0.95**	-0.26
IR 64	0.29**	0.07*	0.03	0.79*	-0.99	-0.06	6.32*	-0.62**	0.00	0.28	0.25	-0.05
CD 95% GCA(Line)	0.14	0.08	0.14	0.87	1.43	1.29	6.64	0.19	0.08	4.98	0.38	0.87
CD 95% GCA(Tester)	0.13	0.07	0.13	0.78	1.28	1.16	5.94	0.17	0.08	4.46	0.34	0.78

** Significant at 1% ; * Significant at 5%

KL: Kernel length (mm), KB: Kernel Breadth (mm), K L/B Ratio: Kernel L/B ratio, H%: Hulling percentage, M%: Milling Percentage, HRR: Head Rice Recovery (%), WU: Water Uptake, VER: Volume Expansion Ratio, KER: Kernel Elongation Ratio, GC: Gel Consistency, ASV: Alkali Spreading Value, AC: Amylose Content.

Table 3. Estimates of specific combining ability (sca) effects of crosses for quality traits in rice

S. No	Cross	KL (mm)	KB (mm)	K L/B Ratio	H%	M%	HRR%	WU (ml)	VER	KER	GC(mm)	ASV	AC
1	BPT 5204 x NLR 34449	0.36 *	0.00	0.20	-2.18*	-2.16	1.04	-28.13**	-0.41*	-0.13	13.40*	0.32	-0.07
2	BPT 5204 x NLR 145	0.06	0.04	-0.05	2.60**	-0.59	-1.42	-38.03**	-0.13	-0.11	-11.50*	-0.38	0.38
3	BPT 5204 x IR 36	-0.42 **	-0.03	-0.18	-1.08	3.04*	5.23**	54.97**	-0.07	0.13	-6.00	-0.57	0.02
4	BPT 5204 x IR 64	0.00	-0.02	0.03	0.66	-0.28	-4.84**	11.18	0.61**	0.11	4.10	0.63	-0.34
5	MTU 1010 x NLR 34449	-0.23	0.06	-0.24	1.11	1.97	4.54**	37.25**	-0.06	-0.03	2.40	0.45	0.09
6	MTU 1010 x NLR 145	0.17	-0.05	0.17	-2.71**	-1.50	2.38	-54.65**	-0.43*	0.01	6.00	0.75	0.84
7	MTU 1010 x IR 36	0.29 *	0.03	0.10	0.16	-2.02	-5.87**	-31.15**	0.88**	0.01	-7.50	-0.45	-0.11
8	MTU 1010 x IR 64	-0.24	-0.03	-0.03	1.45	1.56	-1.04	48.55**	-0.39*	0.01	-0.90	-0.75	-0.83
9	JGL 11118 x NLR 34449	0.00	0.03	-0.05	0.91	0.19	1.00	-26.50**	-1.72**	-0.12	2.65	0.57	0.42
10	JGL 11118 x NLR 145	0.00	-0.03	0.06	0.49	1.56	1.67	90.60**	1.12**	0.13	4.25	-0.13	-0.93
11	JGL 11118 x IR 36	-0.08	0.00	-0.03	0.71	0.59	0.12	6.10	2.17**	-0.07	-0.25	0.68	-0.24
12	JGL 11118 x IR 64	0.09	0.00	0.03	-2.10*	-2.33	-2.80*	-70.20**	-1.58**	0.06	-6.65	-1.13**	0.75
13	RNR 2465 x NLR 34449	0.13	0.07	-0.04	-0.56	-0.21	-0.19	25.13**	2.08**	0.16	-7.97	-1.55**	-0.04
14	RNR 2465 x NLR 145	-0.41 **	0.06	-0.30*	0.48	-0.19	1.74	-32.78**	-0.34	-0.22*	2.63	-0.25	0.71
15	RNR 2465 x IR 36	0.06	-0.06	0.13	-1.11	-0.31	-3.76**	-13.27	-2.28**	0.10	16.63**	1.55**	-0.80
16	RNR 2465 x IR 64	0.22	-0.06	0.20	1.19	0.72	2.22	20.92**	0.54**	-0.04	-11.27*	0.25	0.14
17	WGL 48684 x NLR 34449	-0.26	-0.16	0.13	0.72	0.21	-6.39**	-7.75	0.10	0.13	-10.48*	1.05	-0.41
18	WGL 48684 x NLR 145	0.18	-0.02	0.12	-0.85	0.73	-4.36**	34.85**	-0.22	0.19*	-1.38	0.20	-1.00
19	WGL 48684 x IR 36	0.15	0.06	-0.02	1.32	-1.29	4.29**	-16.65*	-0.71**	-0.16	-2.88	-1.20**	1.14
20	WGL 48684 x IR 64	-0.08	0.11	-0.23	-1.19	0.34	6.47**	-10.45	0.82**	-0.15	14.73**	1.00*	0.28
	CD 95% SCA	0.28	0.16	0.28	1.74	2.85	2.59	13.29	0.38	0.17	9.97	0.76	1.74

** Significant at 1% ; * Significant at 5%

KL: Kernel length (mm), KB: Kernel Breadth (mm), K L/B Ratio: Kernel L/B ratio, H%: Hulling percentage, M%: Milling Percentage, HRR: Head Rice Recovery (%), WU: Water Uptake, VER: Volume Expansion Ratio, KER: Kernel Elongation Ratio, GC: Gel Consistency, ASV: Alkali Spreading Value, AC: Amylose Content.

Among the twenty crosses tested for specific combining ability for twelve different characters, none of the crosses exhibited significant *sca* for all the characters (Table 3). Each cross showed significant effects for one or more characters only. BPT 5204 x NLR 34449 (low x low) found to be the best for kernel length, gel consistency, BPT 5204 x IR 36 (low x low) for head rice recovery, BPT 5204 x NLR 145 (low x high) for hulling, MTU 1010 x IR 36 (high x low) for kernel length, JGL 11118 x NLR 145 (low x high) for water uptake, JGL 11118 x IR 36 (high x high) for volume expansion, WGL 48684 x IR 36 (low x low) for head rice recovery and WGL 48684 x NLR 145 (high x low) for kernel elongation ratio. These results were in agreement with the earlier findings of Sanjeev Kumar *et al.* (2008) for kernel length, kernel breadth and kernel L/B ratio; Jhansi Rani and Satyanarayana (2015) for hulling% and milling%; Adilakshmi and Upendra (2014) for head rice recovery, water uptake, volume expansion ratio, kernel elongation ratio, alkali spreading value and gel consistency; Asfaliza *et al.*, (2012) for amylase content in rice.

In majority of the crosses significant *sca* effects which involved good and poor general combiners, indicating additive x dominance type of gene interaction involved in the expression of characters. Simple pedigree method of breeding would not be effective to improve the characters. Population improvement *i.e.*, mass selection with concurrent random mating in early segregating generation (Redden and Jensen, 1974) could be a perspective breeding procedure for quality improvement in rice.

Some crosses involving low x low general combiners, however, showed high *sca* effects, suggesting that epistatic gene action, may be due to genetic diversity in the form of heterozygous loci and these could be exploited for heterosis breeding programme. Very few crosses having high x high general combiners showed high *sca* effects indicating the predominance of additive x additive type of gene action and these crosses would be utilized for yield

improvement through single plant selection in segregating generations.

CONCLUSION

It is observed that parental lines JGL 11118 and MTU 1010 among female; NLR 34449 and IR 36 among males and among cross combinations, BPT 5204 x IR 36 x BPT 5204 x NLR 145, JGL 11118 x NLR 145, JGL 11118 x IR 36 and WGL 48684 x NLR 145 could be exploited beneficially in future rice breeding programme by adopting appropriate breeding strategy in order to evolve the varieties with acceptable grain quality.

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PERFORMANCE OF COTTON (*Gossypium hirsutum*) VARIETY SCS 1206 UNDER DIFFERENT NUTRIENT LEVELS AND PLANT DENSITIES IN RAINFED VERTISOLS OF SCARCE RAINFALL ZONE OF ANDHRA PRADESH

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ABSTRACT

Cotton variety SCS-1206 was evaluated under high density planting system in a field trial under rainfed conditions at Regional Agricultural Research Station, Nandyal, Andhra Pradesh, during *kharif*, 2016-17 in vertisols. The study included three plant geometries viz., S₁- 45 cm x 10 cm (2,22,222 plants ha⁻¹), S₂- 60 cm x 10 cm (1,66,666 plants ha⁻¹) and S₃-75 cm x 10 cm (1,33,333 plants ha⁻¹) as main treatments and three fertilizer levels F₁- 90-45-45 NPK kg ha⁻¹, F₂-112.5-56.25-56.25 NPK kg ha⁻¹, F₃- 135-67.5-67.5 kg ha⁻¹ as sub treatments in split plot design with three replications. The result of the experiment indicated that lower sympodial length (11.1 cm) was recorded at closer spacing (45 cm x10 cm). The number of bolls per square metre (68.0), boll weight (4.95 g), seed cotton yield (3854 kg ha⁻¹) and lint yield (1422 kg ha⁻¹) were maximum with spacing of 45 cmx 10 cm. The number of bolls per sq m (61.4), boll weight (4.07g) and seed cotton yield (3355 kg ha⁻¹) recorded with spacing of 75 cm x 10 cm was less. The number of bolls per sq m (69.7), boll weight (4.71 g), seed cotton yield (3724 kg ha⁻¹) and lint yield (1370 kg ha⁻¹) were maximum with F₂-112.5-56.25-56.25 NPK kg ha⁻¹ and on a par with F₃- 135-67.5-67.5 kg ha⁻¹ and significantly superior than F₁- 90-45-45 NPK kg ha⁻¹.

INTRODUCTION

Cotton (*Gossypium* spp.) is one of the most important commercial crops of India. It is one of the most important cash crops next to food grains that play a vital role in Indian economy (Patel *et al.*, 2016). In India, cotton occupied 118.7 lakh hectares with production of 338 lakh bales and productivity of 484 kg lint per ha in the year 2015-16 (Cotton Corporation of India, 2017). Vigilant production and economic strategies are important for cotton growing farmers due to expanding cost of cultivation and stagnating productivity. Adoption of High Density Planting System (HDPS) with the new compact plant type offers an alternative to strategy to optimize production and reduce production cost.

Cotton productivity depends on various factors. Among them, selection of potential genotypes and adaptability to high density planting play a vital role in increasing the productivity of cotton. Generally, in cotton varieties, it was observed that lower plant densities produces high values of growth and yield attributes per plant, but yield per unit area was higher

with higher plant densities (Namdeo *et al.*, 1991; Dhoble *et al.*, 1992; Sharma *et al.*, 2001). However, it may happen that moderate increase in plant densities may not increase the yield but decrease due to competition between plants for nutrients, water, space and light (Nehra and Kumawat, 2003). Higher plant density system of cotton is proved to be a viable cotton production system compared with conventionally grown cotton system with wider rows and low plant density in different cotton genotypes (Nicholas *et al.*, 2004; Witten and Cothren, 2000). The variety SCS 1206 (*G. hirsutum*) released from University of Agricultural Sciences, Raichur, which is a short duration and short stature is found suitable for high plant density system. In view of the above, research work was carried out with an objective to find out the effect of planting densities and different nutrient levels on the yield of cotton variety SCS1206.

MATERIAL AND METHODS

A field experiment was conducted at Regional Agricultural Research Station, Nandyal, during *kharif* 2016-2017 to evaluate the

Table 1. Effect of spacing and fertilizer levels on growth parameters of cotton variety under high density planting system

Treatments	Final plant population (No./net plot)	Plant height (cm)	No. of mono-Podia Plant ⁻¹	No of sympodia Plant ⁻¹	Average sympodial length (cm)	Bolls m ⁻²	Boll weight(g)	Kapas yield (kg ha ⁻¹)	Lint yield (kg ha ⁻¹)	Ginning out turn (%)
Spacing										
S ₁ - 45 cm x 10 cm	196	99.6	1.2	16.6	11.1	68.0	4.95	3854	1422	36.9
S ₂ - 60 cm x 10 cm	121	99.1	1.1	16.2	11.5	66.0	4.11	3384	1229	36.3
S ₃ - 75 cm x 10 cm	93	95.7	1.2	15.6	13.2	61.4	4.07	3355	1203	35.9
SEM ±	3.4	2.4	0.05	0.43	0.4	0.9	0.15	45	22	0.4
CD@ 5%	13.5	NS	NS	NS	1.5	3.5	0.6	175	88	NS
Fertilizer levels										
F ₁ - RDF (90-45-45 NPK kg ha ⁻¹)	136	96.3	1.2	15.7	12.1	60.5	3.93	3181	1152	36.1
F ₂ - 125% RDF (112.5-56.25-56.25 NPK kg ha ⁻¹)	138	97.9	1.1	16.3	11.8	69.7	4.71	3724	1370	36.8
F ₃ - 150% RDF (135-67.5-67.5 NPK kg ha ⁻¹)	136	100.1	1.2	16.3	12.0	65.2	4.48	3688	1332	36.2
SEM ±	3.6	2.8	0.04	0.45	0.37	2.3	0.18	153	54	0.2
CD @5%	NS	NS	NS	NS	NS	7.1	0.56	471	167	NS
Interaction	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	8.0	8.6	9.7	8.3	9.4	10.7	12.5	13	13	1.9

performance of SCS-1206 hirsutum variety under different plant densities and different nutrient levels in rainfed vertisols of Scarce Rainfall Zone of Andhra Pradesh. The soil of the experimental field was deep black clay in textural class with low organic carbon (0.39%) and available nitrogen (188.6 kg ha^{-1}), medium in available phosphorus (23.6 kg ha^{-1}), high in available potassium (480.0 kg ha^{-1}) with pH(8.3) and EC (0.09 dS m^{-1}). A total rainfall of 810 mm was received in 40 rainy days during the season.

The study included three plant densities viz., S_1 -45 cm \times 10 cm ($2,22,222 \text{ plants ha}^{-1}$), S_2 -60 cm \times 10 cm ($1,66,666 \text{ plants ha}^{-1}$) and S_3 -75 cm \times 10 cm ($1,33,333 \text{ plants ha}^{-1}$) in the main plots and three nutrient levels F_1 - 90-45-45 NPK kg ha^{-1} , F_2 - 112.5-56.25-56.25 NPK kg ha^{-1} , F_3 - 135-67.5-67.5 NPK kg ha^{-1} in sub plots in split plot design with three replications. The entire dose of phosphorus was applied as basal in the form of single super phosphate. Nitrogen in the form of urea and potassium in the form of muriate of potash was applied in three equal splits at 30, 60 and 90 DAS by pocketing method as per the treatments. The sowing was done by dibbling at each hill as per the treatment. The plant population was maintained by gap filling and subsequent thinning of plants keeping single plant per hill.

RESULTS AND DISCUSSION

The plant population per net plot varied significantly with different spacing with higher population being recorded in 45 cm \times 10 cm (196) and was lower in 75 cm \times 10 cm (93) (Table 1). There was no effect of spacing and nutrient levels with respect to plant height, number of monopodia plant^{-1} and sympodia plant^{-1} . However, the sympodial length varied significantly among different spacings tested. Maximum sympodial length (13.2 cm) was recorded in 75 cm \times 10 cm compared to 45 cm \times 10 cm spacing.

The number of bolls per sq m varied significantly among the different spacings tested. Maximum number of bolls per sq m (68.0) was recorded in 45 cm \times 10 cm and was on par with 60

cm \times 10 cm (66.0). Lower number of bolls per sq m (61.4) was recorded in 75 cm \times 10 cm. The different nutrient levels tested had significant influence on number of bolls per metre. Maximum number of bolls per sq m was recorded with 112.5-56.25-56.25 NPK kg ha^{-1} (69.7) and was on a par with 135-67.5-67.5 NPK kg ha^{-1} (65.2). Lowest number of bolls per sq m (60.5) was recorded in 90-45-45 NPK kg ha^{-1} (Table 1).

Boll weight differs significantly among different spacings. Higher boll weight (4.95) was observed in 45 cm \times 10 cm and lower boll weight (4.07) was observed in 75 cm \times 10 cm. There was significant effect of different fertilizers levels on boll weight. Higher boll weight (4.71 g) was observed with 112.5-56.25-56.25 NPK kg ha^{-1} and was on par with 135-67.5-67.5 NPK kg ha^{-1} (4.48 g) and lower boll weight (3.93 g) was observed with 90-45-45 NPK kg ha^{-1} .

Among the different spacings tested, maximum seed cotton yield (3854 kg ha^{-1}) and lint yield (1422 kg ha^{-1}) was recorded with closer spacing of 45 cm \times 10 cm and lower seed cotton yield (3355 kg ha^{-1}) and lint yield (1203 kg ha^{-1}) were recorded with 75 cm \times 10 cm. With respect to nutrient levels tested, maximum seed cotton yield (3724 kg ha^{-1}) and lint yield (1370 kg ha^{-1}) was recorded with 112.5-56.25-56.25 NPK kg ha^{-1} and was on par with 135-67.5-67.5 NPK kg ha^{-1} (3688 kg ha^{-1} and 1322 kg ha^{-1} , respectively). Increased levels of nutrients increased the number of bolls and boll weight, which ultimately helped in increasing the seed cotton yield. Similar results were reported by Rekha *et al.* (2008), Sunitha *et al.* (2010). The seed cotton yield (3181 kg ha^{-1}) and lint yield (1152 kg ha^{-1}) recorded in nutrient levels of 90-45-45 NPK kg ha^{-1} (Table 1) were inferior to high levels of nutrients tested. Ginning out turn was not affected by spacings and nutrient levels.

CONCLUSION

Based on the study, it could be concluded that SCS 1206 variety performed well with a spacing of 45 cm \times 10 cm and nutrient level of 112.5-56.25-56.25 NPK kg ha^{-1} in realizing economically higher yield and returns in high density planting system.

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COMBINING ABILITY ANALYSIS FOR YIELD AND FIBRE QUALITY TRAITS IN COTTON (*Gossypium hirsutum* L.)

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ABSTRACT

Forty intra- *hirsutum* hybrids obtained from crossing 8 lines with 5 testers in Line x Tester fashion along with their parents were evaluated to estimate combining ability for seed cotton yield and fibre quality traits during *kharif*, 2016-17 at Regional Agricultural Research Station, Guntur. The results indicated that general combining ability (*gca*) variances due to lines and testers and *sca* variances due to lines x testers interaction were significant for all the characters except for plant height and number of sympodia plant⁻¹. The estimates of *gca* effects revealed that the lines LH 2220, L 1384 and L 1060 were found to be best general combiners for yield and fibre quality traits in desired direction. The cross combinations *viz.*, L 1060x GTHV 13/32, L 1384 x HYPS 152 and LH 2220 x GTHV 13/32 registered high *sca* effects along with high *per se* performance for seed cotton yield plant⁻¹ and its component traits. However, the magnitude of *gca* from lines (females) and testers (pollinators) were lesser than the *sca* indicating predominance of non-additive gene action in the expression of all the traits studied except number of sympodia plant⁻¹.

INTRODUCTION

Cotton is one of the most important commercial crops in India and is being cultivated for its fibre and byproducts. It is the back bone of Indian textile industry and is cultivated over 105.0 Lakh ha with a production of 351 lakh bales (1 bale=170 kg) and a productivity of 568 kg lint ha⁻¹ (AICCIP, 2017). It is a prerequisite in any systematic breeding programme to identify the appropriate parents for hybridization and superior hybrid combinations. The Line x Tester design is very useful for evaluation of parents for *gca* and *sca* variances and effects through hybridization programme. The study was carried out to obtain information on combining ability of parents for seed cotton yield and fibre quality traits in upland cotton. Combining ability is useful in selection of desirable parents for exploitation of hybrids and transgressive expressions and also to assess the ability of parents to generate potential hybrids with a reasonable level of stability (Ashok Kumar and Ravi Kesavan, 2008; Mehmet Coban and Aydyn Unay, 2015).

MATERIAL AND METHODS

The investigation was carried out with the eight lines *viz.*, L 1060, L 1231, L 1384, L 1493, LH 2220, NDLH 1938, NDLH 2010 AND SCS 1001 and 5 testers *viz.*, GTHV 13/32, HYPS 152, L 788, MCU 5 and SURAJ and 40 intra specific hybrid combinations were made in Line x Tester fashion. The trial was conducted at RARS, Lam, Guntur during 2016-17 to estimate the *gca* and *sca* of inbred parents through Line x Tester analysis. The experimental material consisted of 40 hybrids and their parents of upland cotton. The seed was sown in a Randomized Complete Block Design (RCBD) with three replications. Observations were recorded on five randomly selected plants from each genotype per replication for the characters *viz.*, plant height (cm), number of monopodia plant⁻¹, number of sympodia plant⁻¹, number of bolls plant⁻¹, boll weight (g), seed index (g), lint index (g) and seed cotton yield plant⁻¹ (g). The data on days to 50 % flowering, ginning out turn (%), 2.5% span length (mm), micronaire value (10⁻⁶g/inch), bundle strength (g/tex), uniformity ratio were recorded on plot basis. The fibre quality parameters were analysed at Central Institute for

Research on Cotton Technology (CIRCOT) Regional Unit, Coimbatore, Tamilnadu by using High Volume Instrument (HVI).

RESULTS AND DISCUSSION

The study was designed to estimate the *gca*, *sca* variances and their effects for different quantitative and qualitative traits in a set of Line x Tester crosses. The analysis of variance for combining ability revealed significant differences among crosses for all the traits studied and line x tester effects for all the characters except for plant height and number of sympodia per plant (Table 1). The analysis of variance also revealed significant differences among the lines for days to 50% flowering, number of sympodia plant⁻¹, boll weight, seed index, lint index, micronaire value and seed cotton yield plant⁻¹ and in testers for number of sympodia plant⁻¹, number of bolls plant⁻¹ and boll weight. This indicated the presence of significant differences among males and females for these traits. The earlier workers Patil *et al.* (2012) and Patel *et al.* (2012) also reported similar results.

The estimates of general combining ability effects of parents and and specific combining ability effects of hybrids are presented in Table 2 and 3, respectively. Among the lines, L 1384 showed significant positive *gca* effects for 6 traits *viz.*, plant height (4.54), boll weight (0.60), seed index (0.94), lint index (0.60) ginning out turn (0.51) and seed cotton yield plant⁻¹ (16.91) and the line L 1060, exhibited significant positive *gca* effects for the characters *viz.*, number of monopodia plant⁻¹ (0.24) number of sympodia plant⁻¹ (1.51), number of bolls plant⁻¹ (5.51), ginning outturn (0.37) and seed cotton yield plant⁻¹ (25.81) and they can be extensively used as parents in the breeding programmes. The line, L 1493 recorded significant positive *gca* effects for the characters *viz.*, ginning outturn (0.29), 2.5% span length (0.82) and micronaire value (0.15) followed by the line LH 2220 which showed positive significant *gca* effects for the traits *viz.*, plant height (6.29), number of bolls plant⁻¹ (5.64), boll weight (0.20), seed index (0.28), lint index (0.22), ginning outturn (0.32), micronaire value (0.18) and seed cotton yield plant⁻¹ (40.77). Among the testers, GTHV 13/32 showed

significant positive *gca* effects for plant height (5.91), number of sympodia plant⁻¹ (1.02), number of bolls plant⁻¹ (5.43), uniformity ratio (0.57) and seed cotton yield plant⁻¹ (17.96) followed by the SURAJ for number of monopodia plant⁻¹ (0.21) and number of bolls plant⁻¹ (2.58) and tester L 788 for boll weight (0.19), seed index (0.36), lint index (0.16), micronaire value (0.18) and bundle strength (0.83). The present findings are in line with the results of Senthil kumar *et al.* (2013), Deosarkar *et al.* (2014), Alkuddsi *et al.* (2013), Rajamani *et al.* (2014) and Vanaja (2014) who also reported different parents with good general combining ability for seed cotton yield and yield component characters.

The cross combinations, L 1384 x MCU 5 (10.50**), LH 2220 x HYP5 152 (15.62**) and NDLH 2010 x SURAJ (11.24**) has showed significant positive *sca* effects in desirable direction for plant height. Two hybrid combinations, SCS 1001 x SURAJ (-3.00) and L 1384 x SURAJ (-1.26) has showed negative and non significant *sca* effects in desirable direction for days to 50% flowering. Out of 40 cross combinations evaluated, none of the hybrids showed significant positive *sca* effects for number of sympodia plant⁻¹. Seven hybrid combinations *viz.*, L 1231 x L 788 (9.52**), LH 2220 x GTHV 13/32 (9.66**), LH 2220 x MCU 5 (8.40**), NDLH 1938 x L 788 (13.02**), NDLH 2010 x HYP5 152 (9.33**), SCS 1001 x SURAJ (7.47**) and NDLH 2010 x SURAJ (11.70**) has exhibited significant positive *sca* effects for number of bolls plant⁻¹. The top six cross combinations based on *sca* effects identified for boll weight were L 1231 x L 788 (0.23**), L 1384 x HYP5 152 (0.27**), L 1384 x L 788 (0.32*), LH 2220 x GTHV 13/32 (0.22*), NDLH 1938 x HYP5 152 (0.30*) and NDLH 2010 x SURAJ (0.44**). For seed index, the hybrid combinations *viz.*, L 1384 x HYP5 152 (0.90**), L 1384 x SURAJ (0.81**), L 1493 x L 788 (0.63**), LH 2220 x GTHV 13/32 (0.80**), NDLH 1938 x L 788 (0.70*), SCS 1001 x HYP5 152 (0.77**) and SCS 1001 x MCU 5 (0.64**) has recorded significant positive *sca* effects. Based on *sca* effects for lint index the superior hybrid combinations were L 1384 x SURAJ (0.49**), L 1493 x L 788 (0.72**), LH 2220 x GTHV 13/32 (0.46**), NDLH 2010 x MCU 5 (0.58**),

Table 1. Analysis of variance for combining ability for yield and its components in intra-specific hybrids of cotton

Source of variation	d.f.	Plant height (cm)	Days to 50% flowering	Number of monopodia plant ⁻¹	Number of sympodia plant ⁻¹	Number of bolls plant ⁻¹	Boll weight (g)	Seed index (g)
Mean sum of squares								
Replicates	2	61.00	7.87	0.23**	4.76	29.51	0.06	0.39
Genotypes	52	208.00**	34.21**	0.32**	4.13**	199.09**	0.52**	1.58**
Parents	12	169.83**	30.94**	0.27**	4.50**	43.49*	0.67**	1.25**
Parents vs crosses	1	789.54**	20.10	1.25**	6.75	1077.81**	2.30**	3.19**
Crosses	39	204.84**	35.58	0.31**	4.51	224.44**	0.42**	1.64**
Line effect	7	326.99	83.28*	0.31	9.46**	325.76	1.34**	3.95**
Tester effect	4	333.55	8.20	0.64	8.07*	471.79*	0.63*	1.03
Line x tester effect	28	155.94	27.57**	0.27**	2.20	163.77**	0.16**	1.15**
Error	104	42.41	10.48	0.11	1.71	22.36	0.03	0.14
Mean sum of squares								
Source of variation	d.f.	Lint index (g)	Ginning outturn (%)	2.5% span length (mm)	Micronaire value (10 ⁻⁵ g/inch)	Bundle strength (g/tex)	Uniformity ratio	Seed Yield cotton plant ⁻¹ (g)
Mean sum of squares								
Replicates	2	0.16	0.29	0.10	0.01	0.58	0.31	177.81
Genotypes	52	0.57**	3.32**	13.36**	0.45**	12.37**	3.39**	3930.24**
Parents	12	0.33**	2.33**	12.67**	0.40**	16.39**	1.91	1223.78**
Parents vs crosses	1	0.53**	1.27*	62.64**	0.05	20.27**	27.54**	20141.08**
Crosses	39	0.64**	3.67**	12.31**	0.47**	10.94**	3.23*	4347.34**
Line effect	7	1.36*	2.87	5.97	0.93*	10.56	3.23	10928.42**
Tester effect	4	0.36	5.14	6.98	0.54	9.34	4.51	6211.32
Line x tester effect	28	0.50**	3.66**	14.66**	0.35**	11.26**	3.05*	2435.78**
Error	104	0.05	0.26	0.59	0.03	0.79	1.89	209.85

* , ** Significant at 5% and 1% level, respectively

Table 2. Estimates of general combining ability (gca) effects of parents for yield and fibre quality traits in cotton

S. No.	Parents	Plant height (cm)	Days to 50% flowering	Number of monopodia plant ⁻¹	Number of Sympodia plant ⁻¹	Number of Bolls plant ⁻¹	Boll weight (g)	Seed index (g)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(7)
Lines								
1	L 1060	0.07	-0.03	0.24**	1.51**	5.51**	0.06	0.01
2	L 1231	-8.37**	3.04**	-0.17*	0.21	-3.58**	-0.17**	-0.13
3	L 1384	4.54**	-2.69**	0.03	-0.77*	1.22	0.60**	0.94**
4	L 1493	-2.00	-0.63	0.00	-0.26	-8.45**	-0.34**	-0.87**
5	LH 2220	6.29**	-2.09*	-0.12	0.61	5.64**	0.20**	0.28**
6	NDLH 1938	-3.50	0.71	0.07	-1.01**	1.32	0.02	-0.27**
7	NDLH 2010	2.43	3.64**	0.11	-0.16	-0.09	-0.13**	-0.11
8	SCS 1001	0.55	-1.96*	-0.17	-0.12	-1.56	-0.24**	0.16
	SE (g)	1.68	0.83	0.08	0.33	1.22	0.04	0.09
Testers								
1	GTHV 13/32	5.91**	0.40	0.09	1.02**	5.43**	0.06	-0.05
2	HYPS 152	-1.70	-0.10	0.01	-0.24	0.85	0.08*	-0.13
3	L 788	-1.97	-0.77	-0.20**	-0.23	-3.31**	0.19**	0.36**
4	MCU 5	-3.50*	0.73	-0.12	-0.41	-5.55**	-0.17**	-0.14
5	SURAJ	1.27	-0.27	0.21**	-0.14	2.58**	-0.16**	-0.04
	SE (g)	1.32	0.66	0.06	0.26	0.96	0.03	0.07

*, ** Significant at 5% and 1% level, respectively

Table 2 Contd.,

Table 2 Contd.,

S. No.	Parents	Lint index (g)	Ginning outturn (%)	2.5% span length (mm)	Micronaire value (10 ⁻⁶ g/inch)	Bundle strength (g/tex)	Uniformity ratio	Seed cotton yield plant ⁻¹ (g)
		(8)	(9)	(10)	(11)	(12)	(13)	(14)
Lines								
1	L 1060	0.08	0.37**	0.29	-0.05	0.18	0.68	25.81**
2	L 1231	-0.11	-0.20	-0.49*	0.04	-0.51*	0.34	-15.59**
3	L 1384	0.60**	0.51**	-0.37	0.08	-0.95**	0.14	16.91**
4	L 1493	-0.39**	0.29*	0.82**	0.15**	0.21	-0.32	-39.50**
5	LH 2220	0.22**	0.32*	-1.05**	0.18**	-1.04**	0.41	40.77**
6	NDLH 1938	-0.17**	-0.11	-0.17	0.28**	-0.09	-0.13	7.05
7	NDLH 2010	-0.18**	-0.56**	0.33	-0.52**	0.80**	-0.52	-19.15**
8	SCS 1001	-0.05	-0.62	0.65**	-0.16**	1.40**	-0.59	-16.31**
	SE (g)	0.05	0.13	0.19	0.04	0.22	0.35	3.74
Testers								
1	GTHV 13/32	-0.07	-0.19	-0.46*	0.01	-0.68**	0.57*	17.96**
2	HYP5 152	-0.11*	-0.15	0.91**	0.06	0.26	-0.47	11.34**
3	L 788	0.16**	-0.17	-0.17	0.18**	0.83**	-0.31	-3.66
4	MCU 5	0.10*	0.82**	0.03	-0.23**	0.15	0.32	-23.82**
5	SURAJ	-0.08	-0.31**	-0.31	-0.03	-0.55**	-0.10	-1.81
	SE (g)	0.04	0.10	0.15	0.03	0.18	0.28	2.95

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

Table 3. Specific combining ability (sca) effects of 40 hybrids of cotton for yield and yield component traits

S. No	Hybrids	Plant height (cm)	Days to 50% flowering	Number of monopodia plant ⁻¹	Number of Sympodia plant ⁻¹	Number of Bolls plant ⁻¹	Boll weight (g)	Seed index (g)
		(1)	(2)	(3)	(4)	(5)	(6)	(7)
1	L 1060 x GTHV 13/32	1.56	3.40	0.06	0.19	7.62**	0.05	-0.28
2	L 1060 x HYPS 152	-1.23	0.57	-0.46*	0.59	-7.04*	0.02	-0.27
3	L 1060 x L 788	1.54	-3.10	0.29	0.13	6.19*	0.07	0.16
4	L 1060 x MCU 5	2.64	-1.60	0.02	-0.02	-0.97	0.04	0.38
5	L 1060 x SURAJ	-4.50	0.73	0.09	-0.88	-5.80*	-0.18	0.01
6	L 1231 x GTHV 13/32	-3.20	-0.33	-0.20	-0.88	-5.99*	0.03	0.05
7	L 1231 x HYPS 152	6.87	-6.17**	0.50**	0.72	0.35	-0.11	0.47*
8	L 1231 x L 788	-4.79	0.83	0.04	1.27	9.52**	0.23*	0.20
9	L 1231 x MCU 5	-0.72	-1.33	-0.29	-2.05**	-2.15	0.05	-0.52*
10	L 1231 x SURAJ	1.84	7.00**	-0.05	0.95	-1.74	-0.19*	-0.20
11	L 1384 x GTHV 13/32	-7.37	0.40	-0.15	-0.77	2.91	-0.21*	-0.30
12	L 1384 x HYPS 152	0.57	-1.10	0.37	0.23	5.92*	0.27**	0.90**
13	L 1384 x L 788	2.51	2.90	-0.48*	0.02	-6.98*	0.32**	-0.48*
14	L 1384 x MCU 5	10.50**	-0.93	0.14	0.53	-0.71	-0.02	-0.93**
15	L 1384 x SURAJ	-6.20	-1.27	0.11	-0.01	-1.14	-0.36**	0.81**
16	L 1493 x GTHV 13/32	5.70	2.00	0.26	0.76	-2.79	0.08	0.10
17	L 1493 x HYPS 152	-0.03	-0.17	-0.09	0.66	0.15	-0.22*	-0.12
18	L 1493 x L 788	-1.35	0.83	-0.25	-0.29	-3.51	0.11	0.63**
19	L 1493 x MCU 5	-0.02	1.57	-0.20	0.12	7.92**	-0.02	-0.17
20	L 1493 x SURAJ	-4.29	-2.67	0.27	-1.25	-1.77	0.05	-0.45*
21	LH 2220 x GTHV 13/32	2.21	-0.87	-0.05	0.52	9.66**	0.22*	0.80**

Table 3 Contd.,

Table 3 Contd.,

S. No	Hybrids	Plant height (cm) (1)	Days to 50% flowering (2)	Number of monopodia plant ⁻¹ (3)	Number of Sympodia plant ⁻¹ (4)	Number of Bolls plant ⁻¹ (5)	Boil weight (g) (6)	Seed index (g) (7)
22	LH 2220 x HYP5 152	15.62**	-0.37	-0.20	-0.61	-3.97	-0.16	-0.81**
23	LH 2220 x L 788	-6.84	-0.70	0.04	-0.35	-10.27**	-0.14	0.14
24	LH 2220 x MCU 5	-9.24*	3.80	0.32	0.25	8.40**	-0.11	0.51*
25	LH 2220 x SURAJ	-1.75	-1.87	-0.11	0.19	-3.82	0.18	-0.64**
26	NDLH 1938 x GTHV 13/32	5.27	-1.00	-0.14	0.98	1.01	-0.32**	-0.01
27	NDLH 1938 x HYP5 152	-5.43	-0.17	0.35	-0.19	-7.65**	0.30**	-0.42
28	NDLH 1938 x L 788	-1.72	-1.17	-0.06	-0.20	13.02**	0.13	0.70**
29	NDLH 1938 x MCU 5	-2.66	3.33	-0.26	-0.56	-1.48	-0.06	-0.45*
30	NDLH 1938 x SURAJ	4.54	-1.00	0.11	-0.03	-4.90	-0.05	0.18
31	NDLH 2010 x GTHV 13/32	-9.05*	-5.60**	0.19	-0.38	-8.55**	0.01	0.52*
32	NDLH 2010 x HYP5 152	-11.59**	3.57	-0.03	-1.01	9.33**	-0.15	-0.53*
33	NDLH 2010 x L 788	13.35**	1.57	-0.09	0.58	-4.87	-0.51**	-0.80**
34	NDLH 2010 x MCU 5	-3.95	-1.60	0.30	0.65	-7.61**	0.21*	0.53*
35	NDLH 2010 x SURAJ	11.24**	2.07	-0.37	0.15	11.70**	0.44**	0.28
36	SCS 1001 x GTHV 13/32	4.89	2.00	0.03	-0.42	-3.85	0.13	-0.89**
37	SCS 1001 x HYP5 152	-4.77	3.83*	-0.45*	-0.38	2.89	0.06	0.77**
38	SCS 1001 x L 788	-2.70	-1.17	0.52**	-1.16	-3.11	-0.20*	-0.54
39	SCS 1001 x MCU 5	3.46	-1.67	-0.04	1.08	-3.41	-0.09	0.64**
40	SCS 1001 x SURAJ	-0.87	-3.00	-0.06	0.88	7.47**	0.11	0.01
	SE (sij)	7.48	3.72	0.38	1.50	5.44	0.19	0.44

Table 3 Contd.,

Table 3 Contd.,

S. No	Hybrids	Lint index (g) (8)	Ginning outturn (%) (9)	2.5% span length (mm) (10)	Micronaire value (10 ⁻⁶ g/inch) (11)	Bundle strength (g/tex) (12)	Uniformity ratio (13)	Seed cotton yield plant ⁻¹ (g) (14)
1	L 1060 x GTHV 13/32	-0.21	-0.28	-1.20**	-0.11	1.56**	0.37	31.90**
2	L 1060 x HYP5 152	0.02	0.72*	-1.20**	-0.02	-1.05*	0.08	-29.94**
3	L 1060 x L 788	-0.05	-0.56	-3.16**	0.25**	-1.95**	1.91*	23.69**
4	L 1060 x MCU 5	0.15	-0.31	2.71**	-0.20*	1.67**	-1.38	-6.05
5	L 1060 x SURAJ	0.08	0.42	2.85**	0.07	-0.23	-0.97	-19.60*
6	L 1231 x GTHV 13/32	0.33*	1.39**	-1.02*	0.03	-1.61**	0.70	-18.33*
7	L 1231 x HYP5 152	0.22	-0.18	-0.12	-0.21*	2.08**	-0.26	-14.78
8	L 1231 x L 788	-0.03	-0.56	-0.31	0.26**	-0.76	0.91	45.02**
9	L 1231 x MCU 5	-0.08	0.95**	3.16**	-0.33**	2.79**	-1.38	-5.39
10	L 1231 x SURAJ	-0.43**	-1.59**	-1.70**	0.24*	-2.51**	0.03	-6.51
11	L 1384 x GTHV 13/32	-0.17	-0.07	-2.45**	-0.10	-1.70**	1.57	9.43
12	L 1384 x HYP5 152	0.12	-1.44**	2.92**	0.29**	1.12*	-0.39	41.08**
13	L 1384 x L 788	0.11	1.52**	3.16**	-0.17	2.25**	-1.23	-25.52**
14	L 1384 x MCU 5	-0.55**	-0.29	-0.94*	0.14	-0.13	-0.18	-22.06
15	L 1384 x SURAJ	0.49**	0.28	-2.69**	-0.16	-1.53**	0.23	-2.94
16	L 1493 x GTHV 13/32	-0.02	-0.32	2.30**	0.36**	-0.06	-0.97	-20.02*
17	L 1493 x HYP5 152	0.16	1.15**	-1.34**	-0.28**	1.10*	-0.26	-10.87
18	L 1493 x L 788	0.72**	1.83**	0.48	0.29**	-0.48	0.24	-11.14
19	L 1493 x MCU 5	-0.37**	-1.30**	-2.42**	-0.33**	-2.09**	0.95	30.49**
20	L 1493 x SURAJ	-0.50**	-1.35	0.98*	-0.03	1.54**	0.03	11.54
21	LH 2220 x GTHV 13/32	0.46**	0.19	-0.70	-0.33**	1.08*	-0.03	36.54**

Table 3 Contd.,

Table 3 Contd.,

S. No	Hybrids	Lint index (g) (8)	Ginning outturn (%) (9)	2.5% span length (mm) (10)	Micronaire value (10 ⁶ g/inch) (11)	Bundle strength (g/tex) (12)	Uniformity ratio (13)	Seed cotton yield plant ⁻¹ (g) (14)
22	LH 2220 x HYPS 152	-0.47	-0.28	-1.64**	0.36**	-1.12*	-0.32	2.31
23	LH 2220 x L 788	0.15	0.38	1.74**	-0.57**	1.83**	-1.16	-50.47**
24	LH 2220 x MCU 5	0.21	-0.32	-1.06*	0.51**	-1.85**	1.55	23.62**
25	LH 2220 x SURAJ	-0.35*	0.03	1.65**	0.04	0.05	-0.03	-12.00
26	NDLH 1938 x GTHV 13/32	0.09	0.45	0.19	-0.01	-0.06	-0.83	-9.13
27	NDLH 1938 x HYPS 152	-0.29*	-0.45	2.52**	-0.52**	1.86**	-0.13	-24.31**
28	NDLH 1938 x L 788	0.34*	-0.06	-2.80**	0.52**	-1.75**	1.04	52.87**
29	NDLH 1938 x MCU 5	-0.15	0.46	-0.20	0.07	-0.86	0.75	-5.22
30	NDLH 1938 x SURAJ	0.00	-0.39	0.28	-0.07	0.81	-0.83	-14.20
31	NDLH 2010 x GTHV 13/32	0.01	-1.11**	2.78**	-0.24*	2.25**	-1.10	-12.44
32	NDLH 2010 x HYPS 152	-0.13	0.67*	-0.98*	0.52**	-4.32**	0.61	37.58**
33	NDLH 2010 x L 788	-0.63**	-1.04**	1.93**	-0.48**	2.20**	-0.56	-25.32**
34	NDLH 2010 x MCU 5	0.58**	1.34**	-2.57**	0.33**	-0.68	-0.18	-4.89
35	NDLH 2010 x SURAJ	0.16	0.14	-1.16*	-0.13	0.55	1.23	5.06
36	SCS 1001 x GTHV 13/32	-0.50**	-0.24	0.10	0.40**	-1.46**	0.30	-17.95*
37	SCS 1001 x HYPS 152	0.36**	-0.18	-0.16	-0.14	0.33	0.68	-1.06
38	SCS 1001 x L 788	-0.61**	-1.51**	-1.05*	-0.10	-1.34*	-1.16	-9.13
39	SCS 1001 x MCU 5	0.21	-0.53	1.32**	-0.19*	1.15*	-0.12	-10.50
40	SCS 1001 x SURAJ	0.54**	2.46**	-0.21	0.04	1.31*	0.30	38.65**
	SE (sij)	0.26	0.58	0.89	0.18	1.02	1.58	16.65

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

SCS 1001 x HYPS 152 (0.36**) and SCS 1001 x SURAJ (0.54*). The best seven cross combinations identified among forty crosses for ginning out turn based on *sca* effects were L 1231 x GTHV 13/32 (1.39**), L 1231 x MCU 5 (0.95**), L 1384 x L 788 (1.52*), L 1493 x HYPS 152 (1.15**), L 1493 x L 788 (1.83**), NDLH 2010 x MCU 5 (1.34**) and SCS 1001 x SURAJ (2.46**).

For 2.5% span length the cross combinations *viz.*, L 1060 x MCU 5 (2.71**), L 1060 x SURAJ (2.85**), L 1231 x MCU 5 (3.16**), L 1384 x HYPS 152 (2.92**), L 1493 x GTHV 13/32 (2.30**), LH 2220 x SURAJ (1.65**), NDLH 1938 x HYPS 152 (2.52**), NDLH 2010 x GTHV 13/32 (2.78**) registered significant positive *sca* effects. The promising eight cross combinations identified based on *sca* effects were L 1060 x L 78(0.25**), L 1231 x L 788 (0.26**), L 1384 x HYPS 152 (0.29**), L 1493 x GTHV 13/32 (0.36**), L 1493 x L 788 (0.29**), LH 2220 x HYPS 152 (0.36**), NDLH 2010 x HYPS 152 (0.52**) and SCS 1001 x GTHV 13/32 (0.40**). The best hybrid combinations for bundle strength were L 1060 x GTHV 13/32 (1.56**), L 1060 x MCU 5 (1.67**), L 1231 x HYPS 152 (2.08**), L 1231 x MCU 5 (2.79**), L 1384 x HYPS 152 (1.12*), LH 2220 x L 788 (1.83**), NDLH 1938 x HYPS 152 (1.86**) and NDLH 2010 x GTHV 13/32 (2.25*). The best cross combinations identified based on *sca* effects for uniformity ratio were L 1060 x L 788 (1.91*) and L 1231 x GTHV 13/32. The superior nine cross combinations for seed cotton yield plant⁻¹ were L 1060 x GTHV 13/32 (31.90**), L 1060 x L 788 (23.69**), L 1231 x L 788 (45.02**), L 1384 x HYPS 152 (41.08**), L 1493 x MCU 5 (30.49**), LH 2220 x GTHV 13/32(36.54**), LH 2220 x MCU 5 (23.62**), NDLH 1938 x L 788(52.84**) and NDLH 2010 x HYPS 152 (37.58**).

From the study, it was observed that the hybrid combinations, LH 2220 x GTHV 13/32, L 1060 x GTHV 13/32 and L 1384 x HYPS 152 recorded high *per se* performance (249.73, 230.13 and 223.80 g, respectively) for seed cotton yield plant⁻¹ and significant positive *sca* effects (36.54, 31.90 and 41.08, respectively). These cross combinations have also recorded high *per se* performance and significant positive *sca* effects for other important yield

contributing characters such as number of bolls plant⁻¹ (LH 2220 x GTHV 13/32, L 1060 x GTHV 13/32 and L 1384 x HYPS 152), boll weight (L 1384 x HYPS 152) and also for 2.5% span length (L 1384 x HYPS 152).

The ratio of general combining ability component of variance to specific combining ability component of variance indicated the preponderance of additive gene action for number of sympodia plant⁻¹ and non-additive gene action for remaining traits studied. The traits governed by additive gene action may be exploited through simple selection procedures in recombination breeding or pedigree method of breeding. Whereas, the traits governed by non-additive gene action could be improved through breeding procedures such as cyclic hybridization, biparental mating and diallel selective mating system.

CONCLUSION

Based on the *per se* performance and *gca* effects the lines *viz.*, LH 2220, L 1384 followed by L 1060 were identified to be the best combiners for further utilization as parents in the crossing programme. Similarly, the hybrid combination LH 2220 x GTHV 13/32 was found to be the best hybrid with high *sca* effects for most of the traits studied followed by L 1060 x GTHV 13/32. Hence, these hybrids could be subjected to multi location testing and superior hybrid combination may be released under upland condition.

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STUDIES ON CONTINGENT CROP PLANNING FOR RAINFED ALFISOLS

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ABSTRACT

Field experiment was conducted during 2014–15 and 2015–16 at Regional Agricultural Research Station, Tirupati to study the performance of various contingent crops under rainfed conditions. The study of investigation revealed that the productivity was higher with August second fortnight sown crops and clusterbean (vegetable) recorded highest pod yield of 16,113 kg ha⁻¹ and net returns of Rs. 2,03,688/- ha⁻¹. This was followed by fieldbean which recorded pod yield of 5,052 kg ha⁻¹ with net returns of Rs.64,158/- ha⁻¹, followed by cowpea (seed) with a net profit of Rs. 55,197 ha⁻¹ followed by groundnut with pod yield of 1,846 kg ha⁻¹ and net returns of Rs.45,523/- ha⁻¹. Next best contingent crop was castor which recorded net returns of Rs. 38, 444/- ha⁻¹. When different contingent crops were sown during September I FN, clusterbean (Vegetable) recorded pod yield of 10,972 kg ha⁻¹ and gave the highest net returns of Rs. 1,33,945/- ha⁻¹ followed by cowpea (seed) with net returns of Rs.79,644/- ha⁻¹, followed by fieldbean with yield of 4,857 kg ha⁻¹ with net returns of Rs.61,271/- ha⁻¹. Next best contingent crop was Bajra with a seed yield of 3018 kg ha⁻¹ gave net profit of Rs. 35,911/- ha⁻¹.

INTRODUCTION

The productivity of crops in rainfed conditions varies to a great deal from year to year in response to the variability of climate particularly the rainfall (Guled *et al.*, 2013). Due to climate change, uncertainties related to monsoon might increase in future and it is important to evolve strategies to cope with these changes. Though the south west monsoon is a regular cyclic process over the Indian sub continent, its behaviour is often erratic and also become extreme in the arid and semi-arid regions. Choice of right crops and right time of sowing to suit the delayed monsoon is one of the most important crop production strategies which results in realizing profitable yields. These results are in general agreement with those of Chandrika *et al.* (2008). It is essential to evolve contingency crop plans under delayed monsoon to get sustainability of agricultural productivity. Hence, the present investigation was taken up to identify suitable remunerative contingent crop and evaluate its performance under delayed monsoon conditions of Southern Agro-Climatic Zone of Andhra Pradesh

MATERIAL AND METHODS

Field experiment was conducted at Regional Agricultural Research Station, Tirupati of Acharya

N.G. Ranga Agricultural University during 2014–15 and 2015–16. The experimental site is geographically situated at 13.5°N latitude and 79.5°E longitude, with an altitude of 182.9 m, which falls under the Southern Agro-Climatic Zone of Andhra Pradesh. According to Troll's classification, it falls under Semi-Arid Tropics (SAT). The type of soil is red loamy. The experiment was laid out in a randomized block design with factorial concept comprising of two treatments was replicated thrice. First treatment comprising of time of sowing viz., August second fortnight and September first fortnight and second treatment with ten different contingent crops viz., Bajra, korra, castor, fieldbean (vegetable), redgram, cowpea, sunflower, clusterbean (vegetable), clusterbean (seed) and groundnut. All the recommended agronomic and plant protection measures were adopted. Yield of various contingent crops were recorded from net plot area and then calculated hectare yield. Economics of different treatments were estimated based on prevailing local market price of commodities during the respective consecutive years (2014-15 and 2015-16). Impact of treatments is analysed using ANOVA technique which is found significant. Further Duncan's Multiple Range Test (DMRT) is employed using SPSS version 20 (trial version) for multiple comparison and findings are

denoted with alphabets a, b, c, d, e, f etc., according to significant difference among treatments.

RESULTS AND DISCUSSION

A total of 439.5 mm of rainfall was received during the crop growth period of all crops which were sown on August second fortnight, where as it was only 348.5 mm for September first fortnight sown crops during 2014-15 (Table 2). The average maximum temperature of 31.3° C and minimum of 19.3° C was recorded for August sown crops, whereas, it was 31.2° and 18.8° C for September sown crops. Similarly, a total of 1445.3 mm of rainfall was received (due to cyclonic rains) during the crop growth period for all crops which were sown on August second fortnight, whereas, it was only 1252.7 mm for September first fortnight sown crops during 2015-16. The average maximum temperature of 31.5° C and minimum of 20.5° C was recorded for August sown crops, whereas, it was 30.9° and 20.1° C for September sown crops (Table.1). The higher rainfall and favourable temperature reflected in better crop growth lead to higher yields of August sown crops during both the years of study.

The pooled data (2014-15 and 2015-16) of yield of different contingent crops sown on August second fortnight revealed that (Table 3), clusterbean (vegetable) recorded pod yield of 16,113 kg ha⁻¹. Similar results reported by Jagtap *et al.*,(2011). This was followed by fieldbean with pod yield of 5,052 kg ha⁻¹. Next best crop was Bajra with seed yield of 2526 kg ha⁻¹ followed by cowpea with seed yield of 2305 kg ha⁻¹, castor with seed yield of 1890 kg ha⁻¹, groundnut with pod yield of 1846 kg ha⁻¹, korra with

seed yield of 1591 kg ha⁻¹, redgram with seed yield of 1366 kg ha⁻¹, sunflower with seed yield of 1059 kg ha⁻¹ and seed guar with 362 kg seed per hectare (Bharud and Patil, 1996). When all these crops were sown during September second fortnight clusterbean (vegetable) had recorded pod yield of 10,972 kg ha⁻¹. The results corroborated with the findings of Deka *et al.* (2015). Clusterbean was followed by fieldbean with pod yield of 4,857 kg ha⁻¹. Next best crop was cowpea with seed yield of 3023 kg ha⁻¹ followed by bajra with seed yield of 3018 kg ha⁻¹, korra with seed yield of 1658 kg ha⁻¹, castor seed yield of 1596 kg ha⁻¹. Similar results were reported by Gowda *et al.* (2011).Sunflower with seed yield of 1468 kg ha⁻¹, groundnut with pod yield of 1405 kg ha⁻¹, redgram with seed yield of 1214 kg ha⁻¹ was also reported by Ram *et al.* (2011) and seed guar with 402 kg seed per hectare (Fig.1).

The economics of different contingent crops sown during August second fortnight revealed that (Table 3) significantly highest gross returns of Rs. 2,41,687 ha⁻¹ was recorded with clusterbean (vegetable). Next best returns of Rs. 93,387 ha⁻¹ were observed with fieldbean and this was followed by groundnut (Rs. 77,532 ha⁻¹), which was comparable with cowpea (Rs. 70696 ha⁻¹), and these in turn significantly superior over castor which recorded Rs. 51,643 ha⁻¹ and redgram (Rs. 49,175 ha⁻¹). Next best gross returns were recorded with bajra (Rs. 43,442 ha⁻¹). Significantly lowest returns of Rs. 19,781 were observed in clusterbean (seed) which was however comparable with sunflower (Rs. 31,757 ha⁻¹) and korra (Rs. 24,949 ha⁻¹). When the crops sown during first fortnight of September,

Table 1. Weather parameters recorded during crop growth period

Sowing window	2014-15					2015-16				
	Mean temperature (°C)		Mean relative humidity (%)		Total rainfall (mm)	Mean temperature (°C)		Mean relative humidity (%)		Total rainfall (mm)
	Max	Min	I	II		Max	Min	I	II	
August II Fortnight	31.3	19.3	83.4	54.2	439.5	31.5	20.5	85.9	58	1445.3
September I Fortnight	31.2	18.8	83.8	53.3	348.5	30.9	20.1	87.3	59.9	1252.7

Table 2. Date of sowing, date of harvest and total rain fall received during experimentation

Name of the crop and variety	2014-15						2015-16					
	August II Fortnight			September I fortnight			August II Fortnight			September I fortnight		
	Date of sowing	Date of harvest	Total rainfall (mm)	Date of sowing	Date of harvest	Total rainfall (mm)	Date of sowing	Date of harvest	Total rainfall (mm)	Date of sowing	Date of harvest	Total rainfall (mm)
Bajra (PHB- 3)	20-08-14	14-11-14	371.5	05-09-14	17-11-14	294.5	18-08-15	06-11-15	610.1	10-09-15	19-11-15	984.7
Korra (SIA- 3085)	20-08-14	04-11-14	313.5	05-09-14	17-11-14	294.5	18-08-15	07-11-15	610.1	10-09-15	08-12-15	1252.7
Castor (Haritha)	20-08-14	18-02-15	439.5	05-09-14	18-02-15	362.5	18-08-15	09-02-15	1408.1	10-09-15	09-02-16	1252.7
Fieldbean (TFB- 2)	20-08-14	06-01-15	439.5	05-09-14	23-01-15	362.5	18-08-15	20-01-16	1408.1	10-09-15	20-01-16	1252.7
Redgram (TRG- 38)	20-08-14	12-02-15	439.5	05-09-14	12-02-15	362.5	18-08-15	23-02-16	1408.1	10-09-15	23-02-16	1252.7
Cow pea (TPTC- 29)	20-08-14	25-10-14	439.5	05-09-14	25-11-14	294.5	18-08-15	13-01-16	1408.1	10-09-15	13-01-16	1252.7
Sunflower (NDSH- 8)	20-08-14	14-11-14	371.5	05-09-14	17-11-14	294.5	18-08-15	06-11-15	610.1	10-09-15	19-11-16	984.7
Clusterbean (veg.)												
Lakshmi	20-08-14	25-11-14	371.5	05-09-14	28-11-14	294.5	18-08-15	12-11-15	843.6	10-09-15	12-11-15	688.2
Clusterbean (seed)-HG563	20-08-14	02-12-14	371.5	05-09-14	27-12-14	362.5	18-08-15	07-12-15	1408.1	10-09-15	07-12-15	1252.7
Groundnut (Dharani)	20-08-14	13-12-14	439.5	05-09-14	03-01-15	362.5	18-08-15	04-12-15	1408.1	10-09-15	06-01-16	1252.7

Table 3. Yield and economics of contingent crops when sown at different sowing windows (Pooled data of 2014-15 & 2015-16)

Contingent crop	Yield (kg ha ⁻¹)		Gross returns (Rs. ha ⁻¹)		Net returns (Rs. ha ⁻¹)		Price (Rs. kg ⁻¹)	
	August II Fortnight	September I Fortnight	August II Fortnight	September I Fortnight	August II Fortnight	September I Fortnight	2014-15	2015-16
Bajra	2526 ^c	3018 ^c	43442 ^e	51411 ^c	28403 ^d	35911 ^d	16	20
Korra	1591 ^d	1658 ^d	24949 ^f	26621 ^d	15855 ^e	17596 ^e	17	15
Castor	1890 ^d	1596 ^d	51643 ^d	42434 ^d	38444 ^d	29924 ^d	26	30
Fieldbean (veg)	5052 ^b	4857 ^b	93387 ^b	90501 ^b	64158 ^b	61271 ^c	16	21
Redgram	1366 ^d	1214 ^d	49175 ^d	43689 ^d	30426 ^d	24989 ^d	36	36
Cowpea (seed)	2305 ^d	3023 ^c	70696 ^c	95144 ^c	55197 ^c	79644 ^b	35	30
Sunflower	1059 ^e	1468 ^d	31757 ^f	44026 ^d	15038 ^e	27326 ^d	30	30
Clusterbean (veg)	16113 ^a	10972 ^a	241687 ^a	164582 ^a	203688 ^a	133945 ^a	15	15
Clusterbean(seed guar)	362 ^e	402 ^e	19781 ^f	21771 ^e	5032 ^e	5571 ^e	55	52
Groundnut	1846 ^d	1405 ^d	77532 ^c	59026 ^d	45523 ^d	27016 ^d	42	42
Year	NS	S	NS	S	NS	S		
Crop	S	S	S	S	S	S		

NS- Non significant ; S- Significant ; a, b, c, d, e, f same letter indicates insignificant difference among treatments (DMRT)

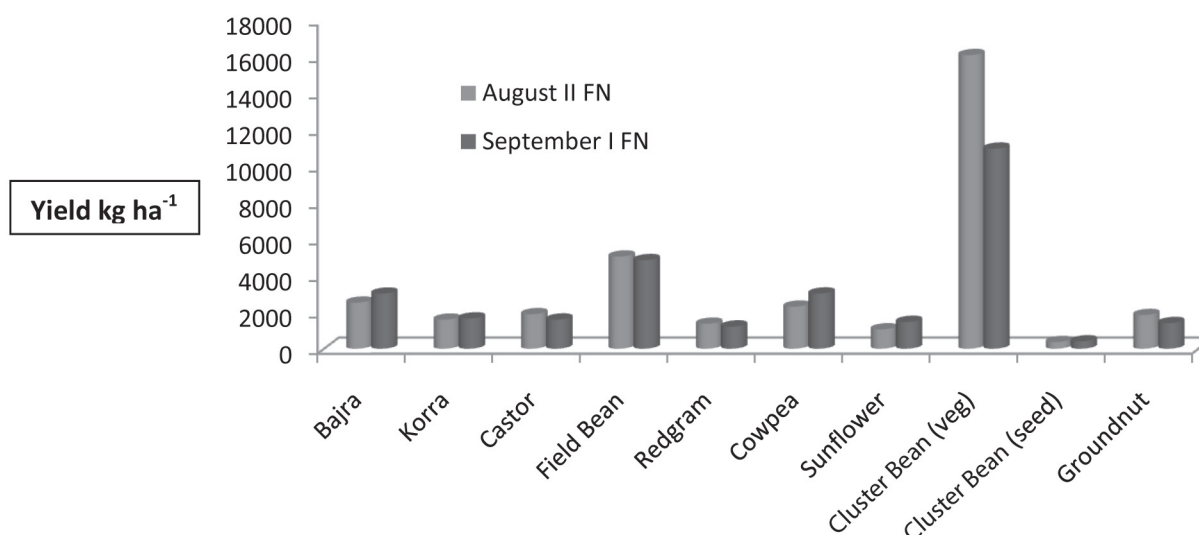


Fig. 1. Yield (kg ha⁻¹) of various contingent crops (Pooled data of 2014-15 and 2015-16)

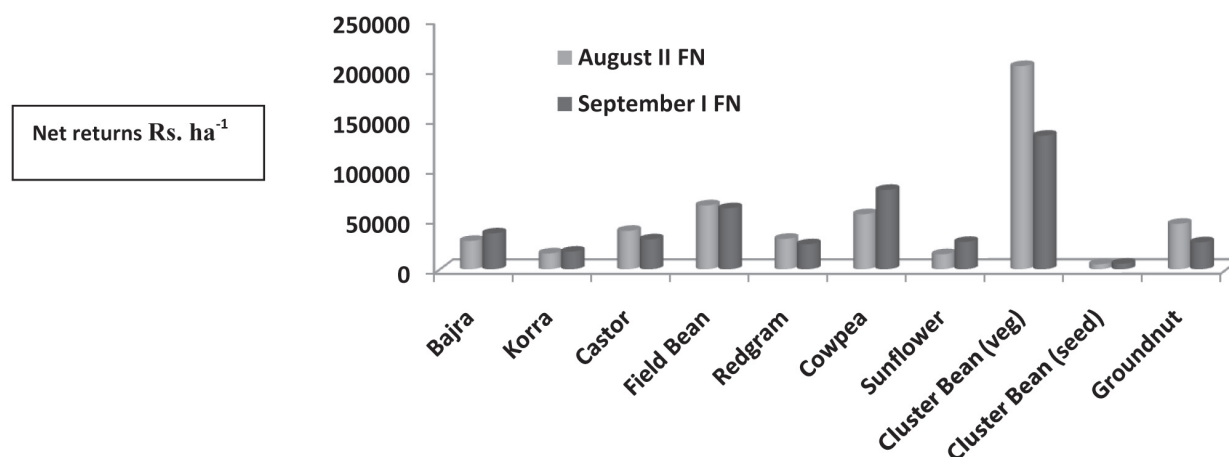


Fig. 2. Net returns (Rs. ha⁻¹) of various contingent crops (Pooled data of 2014-15 and 2015-16)

significantly highest gross returns of Rs. 1,64,582 ha⁻¹ was recorded with clusterbean (vegetable) followed by cowpea with Rs. 95,144 ha⁻¹. Next best returns of Rs. 90,501 ha⁻¹ was recorded with fieldbean (Rs.90,501 ha⁻¹) and Bajra (Rs. 51,411 ha⁻¹). This was followed by groundnut (Rs.59,026 ha⁻¹) which was comparable with sunflower(Rs. 44,026 ha⁻¹), redgram(Rs. 43,689 ha⁻¹), castor (Rs. 42,434 ha⁻¹) and korra (Rs. 26,621 ha⁻¹). Significantly lowest gross returns of Rs. 21,771 ha⁻¹ was recorded with clusterbean (seed).

The net returns of the crops sown during August second fortnight revealed that (Table.3) significantly highest net returns of Rs. 2,03,688 ha⁻¹ was recorded with clusterbean (vegetable). Next best returns of Rs. 64,158 ha⁻¹ were observed with fieldbean and this was followed by cowpea (Rs. 55,197 ha⁻¹) with significant disparity among them. Next best net returns were recorded with groundnut (Rs. 45,523 ha⁻¹), which was comparable with redgram (Rs. 30,426 ha⁻¹), castor (Rs. 38,444 ha⁻¹) and bajra

(Rs. 28,403 ha⁻¹). Korra recorded net returns of Rs. 15,855 ha⁻¹, comparable with sunflower (Rs. 15,038 ha⁻¹) and these in turn significantly superior over clusterbean (seed) which recorded lowest net returns of Rs. 5,032 ha⁻¹. Net returns of the crops sown during first fortnight of September revealed that, significantly highest net returns of Rs. 1,33,945ha⁻¹ was recorded with clusterbean (vegetable) followed by cowpea with Rs. 79,644 ha⁻¹ and fieldbean (Rs. 61,271 ha⁻¹) with significant disparity among them. Next best returns were recorded with bajra (Rs. 35,911 ha⁻¹), castor (Rs. 29,924 ha⁻¹), sunflower (Rs. 27,326 ha⁻¹), groundnut (Rs. 27,016 ha⁻¹) and redgram (Rs. 24,989 ha⁻¹) which were comparable with each other. Significantly lowest gross returns of Rs. 5,571 ha⁻¹ was recorded (Fig.2) with clusterbean (seed).

CONCLUSION

From the experimental results, it can be concluded that clusterbean (vegetable), field bean, cowpea (seed) are found remunerative crops when sown during August second fortnight. If sowings are taken up in the first fortnight of September, clusterbean (vegetable), cowpea (seed), fieldbean and bajra are found to be economical for Southern Agro Climatic Zone of Andhra Pradesh.

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UPTAKE OF MAJOR NUTRIENTS AS INFLUENCED BY IRRIGATIONS AND DIFFERENT LEVELS OF NITROGEN IN WHITE SORGHUM

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ABSTRACT

Field experiment was conducted at Regional Agricultural Research Station, Nandyal during post rainy season (*maghi*), 2015-16 to study the response of white sorghum to levels of irrigations and nitrogen. The results of the experiment revealed that the higher concentration and uptake of major nutrient were obtained at application of 180 kg N ha⁻¹ than 120,150 and 90 kg N ha⁻¹. Further, higher values were recorded with two irrigations which was significantly superior to one irrigation and no irrigation. The interaction between nitrogen levels and irrigations was non significant for concentration and uptake of major nutrients.

INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is the world's fifth major crops in terms of production and acreage. It is a staple food crop for millions of the poorest and food insecure people in the semi-arid tropics of Africa, Asia and Central America. Sorghum is a reliable crop that grows well in hot and dry environments and provides food security and income for millions of poor farmers. The *Rabi* sorghum (post rainy season) has multifaceted problems and irrigation is one of the most important factors that play a vital role in sorghum production. As the crop is raised mostly under rainfed conditions with the help of stored moisture, the moisture deficit, especially during later stages of crop growth poses a serious threat to the crop, resulting in poor yield. In Kurnool district of A.P., sowings are generally taken up during post rainy season called *maghi* (middle of September to middle of October). Two practices are prevailing in Kurnool district *i.e.*, in some areas sorghum is completely grown under rainfed conditions in canal ayacut area, and the second is where one or two irrigations are being given. Further, under KC canal, it is difficult to predict the availability of water for irrigation as the time of irrigation is very important. Therefore, it is very important to find out how much irrigation(water) shall be provided under limited irrigated conditions under KC canal ayacut area for enhancing productivity. Farmers generally go for blanket application of nitrogenous fertilizers

without actually knowing the requirement for the crop particularly if the crop is irrigated. Irrespective of the situation (whether rainfed or irrigated) farmers indiscriminately use nitrogenous fertilizers for sorghum. Further, newly developed varieties with high yield potential require additional doses of nitrogen fertilizers due to their fertilizer responsive nature. Hence, the study was conducted to study the effect of irrigation and nitrogen levels on growth and yield of sorghum during post rainy (*maghi*) season.

MATERIAL AND METHODS

Field experiment was conducted during post rainy season (*maghi*) 2015-16 at Regional Agricultural Research Station, Nandyal. The experimental soil was clayey in texture, strongly alkaline in reaction, non saline with a pH of 8.6, EC of 0.15 dSm⁻¹, medium in organic carbon (0.57 %) and low in available nitrogen (146.2 kg ha⁻¹), medium in available phosphorus (33.2 kg ha⁻¹) and high in potassium (395.6 kg ha⁻¹). The experiment was laid out in split plot design with three replications and treatment combinations of three irrigation levels and four nitrogen levels making twelve treatments. The three irrigation levels *viz.*, no irrigation (rainfed), one irrigation and two irrigations and four nitrogen levels *viz.*, 90, 120, 150 and 180 kg N ha⁻¹. Recommended dose of phosphorus (40 kg ha⁻¹) and potassium (30 kg ha⁻¹) were applied uniformly to all the treatments. Nitrogen was applied in two equal splits. Half of

nitrogen along with full dose of phosphorus and potassium was applied as basal at the time of sowing, while remaining quantity of nitrogen was top dressed

at knee-height stage of crop. Sorghum plants were sampled at monthly interval from the sample rows which were allotted for destructive sampling.

Uptake of nutrients (kg ha^{-1}) = $\frac{\text{Nutrient concentration (pe}}{\text{...}}$

RESULTS AND DISCUSSION

NUTRIENT UPTAKE

Nitrogen uptake (kg ha^{-1})

The data on nitrogen uptake by sorghum as influenced by irrigations and different nitrogen levels are furnished in Table 1. The uptake of nitrogen in the grain was higher with two irrigations (83.4 kg ha^{-1}) which was significantly superior over no irrigation (44.7 kg ha^{-1}) but at par with one irrigation (81.4 kg ha^{-1}). Similarly two irrigations recorded significantly higher uptake of nitrogen (110.7 kg ha^{-1}) in stover than one irrigation (63.4 kg ha^{-1}) and no irrigation (60.5 kg ha^{-1}). However, no irrigation and one irrigation were on a par with each other. Higher concentration of nitrogen in grain was recorded with no irrigation (1.51) which was superior over one (1.33) and two irrigations (1.36) respectively but one and two irrigations were comparable with each other. Nitrogen concentration in stover was significantly higher with two irrigations (1.27) than no and one irrigation. Higher uptake of nitrogen can be correlated with lower availability of nitrogen in the soil. Significant improvement in the uptake of nutrients might be attributed to better availability of nutrients in the soil under non competitive environments with the irrigations (Mathukia *et al.*, 2014).

With each incremental increase in nitrogen levels from 90 to 180 kg N ha^{-1} uptake of nitrogen was increased. Maximum nitrogen uptake of 78.2 kg ha^{-1} was obtained with 180 kg N ha^{-1} in the grain which was on par with 150 kg N ha^{-1} (72.4 kg ha^{-1}) and significantly superior over 90 and 120 kg N ha^{-1} and which were comparable with each other. Higher nitrogen uptake in the stover was recorded with 180 kg N ha^{-1} (86.3 kg ha^{-1}) which was on par with 150 and 120 kg N ha^{-1} and significantly superior over 90 kg N ha^{-1} (65.6 kg ha^{-1}). Higher concentration of nitrogen

in grain and stover was recorded with application of 180 kg N ha^{-1} (1.42 and 1.03) and which was comparable with 150 kg N ha^{-1} . Higher uptake of nutrients might be due to availability of more nutrients at higher fertility level which promoted growth of roots as well as functional activity resulting in higher extraction of nutrients from soil environment to aerial parts (Heeta Sareen and Sharma, 2010). Kumar (2009) revealed that the nutrient accumulation in plants is a function of nutrient concentration and dry matter production. Increased yield levels with higher nitrogen levels and more nitrogen concentration might have resulted in increased nitrogen uptake. The interaction between irrigations and nitrogen levels was found non-significant.

Phosphorus uptake (kg ha^{-1})

The data on phosphorus uptake by sorghum as influenced by irrigations and nitrogen levels are presented in Table 1. Two irrigations (26.8 kg ha^{-1}) significantly increased the uptake of phosphorus in grain than no irrigation (9.7 kg ha^{-1}) but on par with one irrigation (25.5 kg ha^{-1}). With regards to stover, higher uptake of phosphorus was recorded with two irrigations (24.2 kg ha^{-1}) which was significantly superior to no irrigation (16.0 kg ha^{-1}) but on a par with one irrigation (20.8 kg ha^{-1}).72

Higher concentration of phosphorus in grain and stover was recorded with two irrigations (0.44) which was significantly superior over no irrigation (0.32) but on a par with one irrigation (0.41). The higher uptake of phosphorus at more number of irrigations might be due to rate of conversion of phosphorus into soluble form than that of insoluble form under less number of irrigations. This indicated that higher irrigation frequencies might have increased the solubility of phosphorus resulting into higher phosphorus uptake by the crop (Aulakh *et al.*, 2013).

Table 1. Concentration (%) and uptake of major nutrients (kg ha⁻¹) by white sorghum as influenced by irrigations and different nitrogen levels

Treatments	Concentration N%		Uptake N(kg ha ⁻¹)		Concentration N%		Uptake N(kg ha ⁻¹)		Concentration N%		Uptake N(kg ha ⁻¹)		Grain yield(kg ha ⁻¹)	Stover yield (kg ha ⁻¹)
	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover	Grain	Stover		
Irrigations-3														
I ₀ :No irrigation	1.51	0.78	44.7	60.5	0.32	0.20	9.7	16.0	0.31	0.96	9.4	74.1	2956	7665
I ₁ :One irrigation	1.33	0.79	81.4	63.4	0.41	0.26	25.5	20.8	0.40	1.28	24.6	103.3	6092	8033
I ₂ :Two irrigations	1.36	1.27	83.4	110.7	0.44	0.28	26.8	24.2	0.47	1.21	28.7	105.2	6101	8669
SEM ±	0.06	0.07	3.5	3.1	0.02	0.01	4.0	2.5	0.01	0.02	1.7	4.6	63	53
CD (@5 %	0.14	0.19	14.0	12.3	0.04	0.02	1.5	3.8	0.02	0.05	6.8	18.0	247	266
N-levels (kg ha⁻¹) – 4														
N ₁ :90	1.39	0.83	61.2	65.6	0.46	0.23	20.4	18.8	0.37	0.78	16.5	62.1	4392	7878
N ₂ :120	1.40	0.96	67.6	77.4	0.44	0.26	21.5	21.3	0.39	1.15	19.3	92.0	4858	7989
N ₃ :150	1.32	1.00	72.4	83.4	0.45	0.29	25.1	23.9	0.38	1.32	21.1	109.2	5462	8259
N ₄ :180	1.42	1.03	78.2	86.3	0.46	0.30	25.7	25.6	0.49	1.35	27.1	113.5	5486	8364
SEM ±	0.05	0.06	3.4	3.3	0.01	0.02	2.2	2.3	0.01	0.02	2.4	5.8	77	79
CD (@5 %	0.14	0.18	10.2	10.4	0.02	0.04	1.0	1.9	0.03	0.04	7.4	17.4	228	244
Interactions														
I at N														
SEM ±	1.4	1.3	6.2	5.9	1.0	1.1	4.8	5.1	1.1	1.3	4.1	9.2	127	136
CD (@5 %	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	425	442
N at I														
SEM ±	1.6	1.5	7.1	6.3	1.0	1.2	5.0	5.3	1.3	1.4	4.3	9.5	131	140
CD (@5 %	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	420	440

Phosphorus uptake by sorghum increased with increased levels of nitrogen. Nitrogen application at 180 kg ha⁻¹ resulted into higher absorption of phosphorus (25.7 kg ha⁻¹) in grain than at 120 kg N ha⁻¹ (21.5 kg ha⁻¹) and 90 kg N ha⁻¹ (20.4 kg ha⁻¹). In the stover higher uptake of phosphorus was recorded with 180 kg N ha⁻¹ (25.6 kg ha⁻¹) which was significantly superior over 120 kg N ha⁻¹ (21.3 kg ha⁻¹) and 90 kg N ha⁻¹ (18.8 kg ha⁻¹) but was on a par with 150 kg N ha⁻¹ (23.9 kg ha⁻¹). There was no significant difference observed in concentration of phosphorus in grain with increasing nitrogen levels. Higher concentration of phosphorus in stover was recorded with application of 180 kg N ha⁻¹ (0.30) which was significantly superior over 90 kg N ha⁻¹ (0.23). However, 120 kg N ha⁻¹, 150 kg N ha⁻¹ and 180 kg N ha⁻¹ were comparable with each other. Higher levels of nitrogen application might have stimulated more vegetative growth and increased foraging capacity of roots which in turn increased the uptake of phosphorus (Gangadevi *et al.*, 2012). Addition of nitrogen influenced the P uptake by the plant from soil and fertilizer sources. This phenomenon can be explained by the fact that the supply of nitrogen enhances the production of small roots and root hairs, which in turn facilitated the high absorbing capacity per unit of dry weight (Hussaini *et al.*, 2008). The interaction between irrigations and nitrogen levels was found to be non significant.

Potassium uptake (kg ha⁻¹)

The data on uptake of potassium by sorghum as influenced by irrigations and nitrogen levels are presented in Table 1. Persual of data revealed that maximum potassium uptake of 28.7 kg ha⁻¹ was observed at two irrigations which was at par with one irrigation (24.6 kg ha⁻¹) but significantly higher than no irrigation (9.4 kg ha⁻¹). Higher uptake of potassium in stover recorded with two irrigations (105.2 kg ha⁻¹) which was on a par with one irrigation (103.3 kg ha⁻¹) and no irrigation (74.1 kg ha⁻¹) recorded significantly lower uptake compared to one and two irrigations. Potassium concentration in grain was higher with two irrigations (0.47) which was significantly superior over no irrigation (0.31) and one irrigation (0.40). Higher concentration of potassium

in stover was recorded with one irrigation (1.28) which was significantly superior over no irrigation (0.96) and two irrigations (1.21). The increased uptake of nutrients might be due to the supply of irrigation water leading to availability of adequate moisture in the root zone of the soil which played an important role in nutrient uptake involving diffusion, mass flow and interception (Dutta *et al.*, 2015).

Higher doses of nitrogen significantly influenced the potassium uptake. Higher potassium uptake (27.1 and 113.5 kg ha⁻¹ in grain and straw, respectively) was recorded with 180 kg N ha⁻¹ which was on a par with 150 kg N ha⁻¹ which was significantly higher compared to 120 and 90 kg N ha⁻¹. Application of 180 kg N ha⁻¹ recorded higher concentration of potassium in grain (0.49) which was significantly superior over 90 kg N ha⁻¹, 120 kg N ha⁻¹ and 150 kg N ha⁻¹ respectively. Potassium concentration was higher with application of 180 kg N ha⁻¹ (1.35) which was significantly superior over 90 kg N ha⁻¹ and 120 kg N ha⁻¹ but on par with 150 kg N ha⁻¹ (1.32). Higher concentration and availability of nutrients in the rhizosphere might have led to higher uptake by the plant biomass (Mishra *et al.*, 2015). The interaction between irrigations and nitrogen levels was found non- significant.

CONCLUSION

The results indicated that higher concentration and uptake of major nutrients was recorded with two irrigations which were at par with one irrigation and significantly higher than no irrigation. Nutrient concentration and uptake of major nutrients increased with increasing levels of N up to 180 kg N ha⁻¹ but was on par with 150 kg N ha⁻¹. The interaction between nitrogen and irrigation levels was non-significant in respect of concentration and uptake of major nutrients. Hence, by giving one irrigation higher nutrient uptake in sorghum can be obtained and application of 150 kg N ha⁻¹ (as it was comparable with 180 kg N ha⁻¹) in KC ayacut area.

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PRODUCTIVITY AND NUTRIENT UPTAKE OF SEMI DRY RICE (*Oryza sativa* L.) AS INFLUENCED BY DIFFERENT SOURCES OF FERTILIZERS AND ZINC APPLICATION

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ABSTRACT

A field experiment was conducted on direct seeded semi dry rice during *kharif*, 2014 at Agricultural College Farm, Bapatla. The experiment was laid out in Randomized Block Design with nine treatments and three replications. The treatment combinations include FYM and urban compost as organic sources and two methods of zinc application (soil application of $ZnSO_4$ @ 50 kg ha⁻¹ and foliar spray of $ZnSO_4$ @ 0.5 %) with RDF. The results revealed that application of RDF (120: 60: 40 kg NPK ha⁻¹) along with FYM @ 10 t ha⁻¹ and $ZnSO_4$ @ 50 kg ha⁻¹ as basal application recorded significantly higher yield attributes (productive tillers m⁻², total number of grains panicle⁻¹, number of filled grains panicle⁻¹, 1000-grain weight), grain yield (5477 kg ha⁻¹), straw yield (6441 kg ha⁻¹) and nutrient uptake (N, P, K and Zn kg ha⁻¹) of direct seeded semi dry rice and found on a par when zinc was applied as foliar spray @ 0.5% at 20 and 40 DAS with RDF + FYM @ 10 t ha⁻¹. The lowest grain yield (3935 kg ha⁻¹) and straw yield (6441 kg ha⁻¹) was recorded with RDF (T₁) applied alone.

Rice (*Oryza sativa* L.) is the world's second most important cereal crop. In India, rice is grown in an area of 45.5 m. ha with a production of 106.5 m.t. and productivity of 2.4 t ha⁻¹ (Ministry of Agriculture, Gol, 2014). In Andhra Pradesh, rice is grown in an area of 23.88 lakh hectares with a production of 8.12 million tonnes and productivity of 3.4 t ha⁻¹ during the year 2014-15 (Department of Agriculture, 2016). Conventional rice production system requires abundant quantities of water and is labour intensive. Direct seeded rice is a resource conservation technology, economically feasible and technically viable alternative to transplanted rice. Direct seeded semi dry rice needs only 34 per cent of total labour requirement, saves 29 per cent of total cost and 30-50 per cent of water compared to transplanted rice (Nai-Kin and Romli, 2002)

Organic manures when applied in conjunction with inorganic fertilizers would help in enhancing the fertilizer use efficiency, and also in maintaining yield stability through correction of marginal deficiencies of secondary and micronutrients in plants. Zinc deficiency is one of the important factors that is limiting rice productivity worldwide and also a wide spread nutritional disorder affecting human health. Evaluation of environmentally safe nutrient

management practices for increasing productivity and quality of rice is the need of present day agriculture. Hence, the study was undertaken to study the productivity and nutrient uptake of semi- dry rice as influenced by different sources of fertilizers and zinc application.

A field experiment was conducted during *kharif*, 2014 at Agricultural College Farm, Bapatla on sandy clay loam soil with pH 8.3, organic carbon 0.3 per cent, low in available nitrogen (210 kg ha⁻¹), medium in available phosphorus (14 kg ha⁻¹) and available potassium (324 kg ha⁻¹) and low in available zinc (0.4 ppm). The experiment was laid out in a randomized block design with three replications consisting of nine treatments *viz.*, RDF (T₁), RDF + FYM @ 10 t ha⁻¹ (T₂), RDF + Urban compost @ 10 t ha⁻¹ (T₃), RDF + $ZnSO_4$ @ 50 kg ha⁻¹ as basal soil application (T₄), RDF + FYM @ 10 t ha⁻¹ + $ZnSO_4$ @ 50 kg ha⁻¹ as basal soil application (T₅), RDF + Urban compost @ 10 t ha⁻¹ + $ZnSO_4$ @ 50 kg ha⁻¹ as basal soil application (T₆), RDF + FYM @ 10 t ha⁻¹ + Foliar application of $ZnSO_4$ @ 0.5% at 20 and 40 DAS (T₇), RDF + Urban compost @ 10 t ha⁻¹ + Foliar application of $ZnSO_4$ @ 0.5% at 20 and 40 DAS (T₈) and RDF + $ZnSO_4$ @ 0.5% at 20 and 40 DAS (T₉). Recommended dose of fertilizer (120: 60: 40 kg NPK

ha⁻¹) was commonly applied to all treatments. The variety BPT 5204 (Sambamahsuri) was sown on 1st August, 2014. Thinning and gap filling was done within a week days after sowing. A common dose of 60 kg P₂O₅ ha⁻¹ and 40 kg K₂O ha⁻¹ was applied in last ploughing through SSP and MOP, respectively, by taking plot size into consideration. Nitrogen @ 120 kg ha⁻¹ was applied through urea in three equal splits one each at sowing, active tillering and panicle initiation stages. Zinc @ 50 kg ha⁻¹ was applied as basal application in respective treatment plots as zincsulphate hepta hydrate (ZnSO₄.7 H₂O) and the same was applied as foliar spray @ 0.5 % as per the treatments at 20 and 40 days after sowing. The field was irrigated immediately after sowing the dry seeds to achieve good germination. In semi dry system, seeds are sown in ploughed dry soil with monsoon rains. Whenever water is available after onset of monsoon, it is treated as wet paddy. In command area, the crop is converted into the wet condition on receipt of water in canals. The plots were transformed into submerged condition after 40 days of sowing on receipt of canal water. The water was drained out from the field one week before harvest of the crop and field was maintained under saturation. Pre-emergence herbicide, Pretilachlor was applied @ 0.75 kg a.i ha⁻¹ uniformly on second day after sowing. Weeding was done manually at 15 DAS and at 30 DAS to maintain weed free conditions during critical period of crop growth. Need based plant protection measures were taken during crop growth period.

Yield attributes and yield

Among the various treatments, application of RDF (120: 60: 40 kg NPK ha⁻¹) along with FYM @ 10 t ha⁻¹ and ZnSO₄ @ 50 kg ha⁻¹ as basal soil application (T₅) resulted in the highest number of productive tillers m⁻² (363). However, the treatments that received RDF + FYM @ 10 t ha⁻¹ + foliar application of ZnSO₄ @ 0.5 % at 20 and 40 DAS (T₇), RDF + Urban compost @ 10 t ha⁻¹ + ZnSO₄ @ 50 kg ha⁻¹ as basal soil application (T₆) and RDF + Urban compost @ 10 t ha⁻¹ + foliar application of ZnSO₄ @ 0.5 % at 20 and 40 DAS (T₈) remained at par, but

all these treatments proved significantly superior to the rest of the treatments. Remaining treatments i.e. T₄, T₉, T₂, T₃ and T₁ were found statistically at par and the lowest number of productive tillers m⁻² (274) was observed with T₁ which was due to lower uptake of zinc in this treatment, which became a limiting factor and no supplementation of other nutrients either by FYM (or) by Urban Compost. These results are in close conformity with the findings of Kandali *et al.* (2015).

The maximum number of total grains panicle⁻¹ and filled grains panicle⁻¹ was registered with T₅ (174 and 155, respectively) which was on a par with the treatments T₇ (169 and 153, respectively), T₆ (166 and 150, respectively) and T₈ (160 and 147, respectively), but all these treatments proved significantly superior to rest of the treatments (Table 1). Continuous supply of the nutrients due to application of these organics might have supported longer panicles with more spikelets. The contribution of carbohydrates formed from increased photosynthetic activity due to zinc application might have resulted in efficient translocation of food material into the sink (grain) thereby increased the number of filled grains panicle⁻¹. Such an increase in number of filled grains panicle⁻¹ with the application of organics and zinc was also noticed by Esfahani *et al.* (2014). Significantly higher test weight of 17.2 g was observed with T₅ which was on a par with the treatments T₇, T₆ and T₈. Rest of the treatments, T₄, T₉, T₂, T₃ and T₁ were remained at par with each other.

The highest grain yield (5477 kg ha⁻¹) was recorded with RDF + FYM @ 10 t ha⁻¹ + ZnSO₄ @ 50kg ha⁻¹ as basal soil application (T₅) which was on a par with that of RDF + FYM @ 10 t ha⁻¹ + Foliar application of ZnSO₄ @ 0.5 % at 20 and 40 DAS (T₇) but significantly superior to rest of the treatments. The treatments, T₆, T₈, T₄, T₉, T₂ and T₃ were statistically remained on a par but the treatments T₆ and T₈ were found significantly superior to RDF (T₁). The highest grain yield with ZnSO₄ soil application could be attributed to higher number of productive tillers m⁻², number of filled grains panicle⁻¹ and 1000-grain weight. Irrespective of the method of zinc

application, FYM application with RDF significantly increased the grain yield. Superiority of these treatments over rest of treatments might be attributed to FYM in neutralizing the autotoxins released by the roots of rice seedlings and enhancing nutrient supply power and higher zinc concentration maintained by soil application of $ZnSO_4$ in the rhizosphere with constant supply. These results are in agreement with the findings of Sagarika *et al.* (2012) and Esfahani *et al.* (2014). All the treatments resulted in higher grain yield over RDF (T_1).

The lowest grain yield (3935 kg ha^{-1}) was recorded with RDF (T_1) that might be due to significant reduction in yield components as a result of lack of additional nutrient supply by the organic sources (FYM or Urban Compost) and limitation in zinc availability to rice crop. The per cent increase in grain yield due to T_5 over T_7 , T_6 , T_8 , T_4 and T_9 was 5 %, 14 %, 15 %, 19 % and 21 %, respectively.

The highest straw yield (6441 kg ha^{-1}) was recorded with the treatment RDF + FYM @ 10 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1} as basal soil application (T_5) and found on a par with that of RDF + FYM @ 10 t ha^{-1} + Foliar application of $ZnSO_4$ @ 0.5 % at 20 and 40 DAS (T_7) but significantly superior to rest of the treatments. RDF (T_1) was significantly inferior to all other treatments under study. Superiority of these treatments over the other might be due to favourable influence of applied organic sources (FYM and urban compost), which could have provided enough nutrients with better physical conditions of soil and improved soil fertility status and zinc, its catalytic or stimulatory effect in most of the physiological and metabolic process of plants. Significant increase in straw yield with FYM and zinc application was also reported by Sagarika *et al.* (2012). The lowest straw yield (4913 kg ha^{-1}) was recorded with RDF (T_1) applied alone.

Nutrient uptake

At panicle initiation stage, the maximum nitrogen uptake of 85.5 kg ha^{-1} was recorded with T_5 (RDF + FYM @ 10 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1} as basal soil application) which was significantly

superior over other treatments. Total nitrogen uptake by rice crop (rice + straw) at harvest was highest (133 kg ha^{-1}) with T_5 and found on a par with T_7 , T_6 and T_8 . The remaining treatments T_9 , T_4 , T_2 , T_3 and T_1 were at par with each other. However, RDF (T_1) treatment recorded with the lowest nitrogen uptake (63.1 kg ha^{-1}). The higher nitrogen uptake associated with farm yard manure and urban compost incorporation might be ascribed to its beneficial effect in improving the nutrient availability through mineralization and mobilization of native nutrients besides addition of nutrients to soil. Further, the increase in nitrogen uptake with increased supply of nitrogen might be due to increase in growth as reflected in dry matter accumulation, grain and straw yield. Similar results are also reported by Veerangappa *et al.* (2011) and Pradeep *et al.* (2012).

The highest phosphorous uptake (33.1 kg ha^{-1}) at panicle initiation stage was noticed with RDF + FYM @ 10 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1} as basal soil application (T_5) which was on a par with RDF + FYM @ 10 t ha^{-1} + Foliar application of $ZnSO_4$ @ 0.5 % at 20 and 40 DAS (T_7), RDF + Urban compost @ 10 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1} as basal soil application (T_6) and RDF + Urban compost @ 10 t ha^{-1} + Foliar application of $ZnSO_4$ @ 0.5 % at 20 and 40 DAS (T_8) but significantly superior to rest of the treatments. However, the lowest P uptake of 25.8 kg ha^{-1} was recorded with RDF (T_1) that received no organics and zinc.

The trend noticed with total phosphorous uptake (grain + straw) by rice crop at harvest was similar to that at panicle initiation (PI) stage in recording significantly the highest total phosphorous uptake with the treatment that received RDF + FYM @ 10 t ha^{-1} + $ZnSO_4$ @ 50 kg ha^{-1} as basal soil application (T_5) which was significantly superior to rest of the treatments except T_7 , T_6 and T_8 . The increase in available phosphorous with organic sources and fertilizer application might be attributed to phosphorous solubilising capacity of FYM and urban compost. Organic acids and carbon dioxide liberated during the decomposition of organic matter might have formed complex substances with metal

Table1. Yield attributes and yield of semi dry rice as influenced by organics and zinc application

Treatments	Productive tillers m ⁻²	Total no. of grains panicle ⁻¹	No.of filled grains panicle ⁻¹	1000-grain weight (g)	Grain yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)
T ₁ : RDF (120-60-40 kg NPK ha ⁻¹)	274	140	125	15.1	3935	4913
T ₂ : RDF + FYM @ 10 t ha ⁻¹	295	146	135	15.5	4267	5285
T ₃ : RDF + Urban compost @ 10 t ha ⁻¹	283	144	129	15.3	4039	5014
T ₄ : RDF + ZnSO ₄ @ 50 kg ha ⁻¹ as basal soil application (SA)	312	153	141	16.0	4438	5466
T ₅ : T ₂ + ZnSO ₄ @ 50 kg ha ⁻¹ as basal (SA)	363	174	155	17.2	5477	6441
T ₆ : T ₃ + ZnSO ₄ @ 50 kg ha ⁻¹ as basal (SA)	334	166	150	16.4	4709	5665
T ₇ : T ₂ + Foliar application of ZnSO ₄ @ 0.5 % at 20 and 40 DAS	338	169	153	16.7	5203	6209
T ₈ : T ₃ + Foliar application of ZnSO ₄ @ 0.5 % at 20 and 40 DAS	328	160	147	16.2	4635	5508
T ₉ : RDF + Foliar application of ZnSO ₄ @ 0.5 % at 20 and 40 DAS	309	151	131	15.9	4306	5307
SEm ±	14	7	5	0.3	234	231
CD @ 5%	41	20	14	1.0	701	692
CV (%)	7	7	6	3.8	9	7

RDF: Recommended dose of fertilizer, FYM: Farm yard manure, DAS: Days after sowing, SA: Soil application

Table2. Nutrient uptake (N, P, K and Zn) of semi dry rice as influenced by organics and zinc application

Treatments	N uptake(kg ha ⁻¹)		P uptake(kg ha ⁻¹)		K uptake(kg ha ⁻¹)		Zn uptake(g ha ⁻¹)	
	PI stage	Harvest	PI stage	Harvest	PI stage	Harvest	PI stage	Harvest
T ₁ : RDF (120-60-40 kg NPK ha ⁻¹)	63.1	97.9	25.8	29.1	81.8	88.4	106.1	174.7
T ₂ : RDF + FYM @ 10 t ha ⁻¹	68.1	105.6	26.7	32.4	85.1	90.9	128.8	249.4
T ₃ : RDF + Urban compost @ 10 t ha ⁻¹	65.6	101.1	26.4	30.7	82.9	89.6	119.8	191.7
T ₄ : RDF + ZnSO ₄ @ 50 kg ha ⁻¹ as basal soil application (SA)	71.8	109.5	27.8	32.7	90.7	98.9	150.2	293.2
T ₅ : T ₂ + ZnSO ₄ @ 50 kg ha ⁻¹ as basal (SA)	85.5	133.5	33.1	37.8	103.8	114.3	196.8	399.5
T ₆ : T ₃ + ZnSO ₄ @ 50 kg ha ⁻¹ as basal (SA)	78.5	122.7	31.0	35.7	95.7	107.5	183.7	364.8
T ₇ : T ₂ + Foliar application of ZnSO ₄ @ 0.5 % at 20 and 40 DAS	81.1	126.6	32.4	36.7	101.2	112.8	190.8	387.2
T ₈ : T ₃ + Foliar application of ZnSO ₄ @ 0.5 % at 20 and 40 DAS	75.6	121.2	30.3	34.1	93.9	105.2	175.4	353.4
T ₉ : RDF + Foliar application of ZnSO ₄ @ 0.5 % at 20 and 40 DAS	69.5	106.9	27.1	33.5	87.5	94.5	137.8	271.4
SEm ±	3.6	4.3	1.1	1.2	3.3	4.0	7.6	16
CD @ 5%	10.9	13	3.2	3.7	9.9	12.1	22.6	48.1
CV (%)	8.6	6.6	6.4	6.2	6.2	7.0	8.5	9.3

RDF: Recommended dose of fertilizer, FYM: Farm yard manure, DAS: Days after sowing, SA: Soil application

ions and increased the concentration of phosphorous in the soil. The present results are in agreement with the findings of Sagarika *et al.* (2012).

Among the various treatments, RDF + FYM @ 10 t ha⁻¹ + ZnSO₄ @ 50 kg ha⁻¹ as basal soil application (T₅) resulted in the highest potassium uptake (103.8 kg ha⁻¹) by rice crop at PI stage (Table-2). However, the treatments *viz.*, T₇, T₆ and T₈ remained on a par, and proved significantly superior to the rest of treatments. Total potassium uptake by rice crop (grain + straw) at harvest was significantly influenced by organics and zinc treatments and followed the similar trend as was at PI stage. The maximum potassium uptake of 114.3 kg ha⁻¹ was recorded with RDF + FYM @ 10 t ha⁻¹ + ZnSO₄ @ 50 kg ha⁻¹ as basal soil application (T₅) followed by T₇, T₆ and T₈. The lowest uptake of potassium (88.4 kg ha⁻¹) was recorded with the application of RDF (T₁) alone. The increase in potassium uptake with these treatments might be due to release of nutrients from organic amendments and also due to solubilisation of mineral bound potassium or native potassium due to application of organic sources and also increased supply of nutrients in addition to RDF resulting in better growth and yield of rice. The results are in close conformity with those of Veerangappa *et al.* (2011).

The treatments which received RDF + FYM @ 10 t ha⁻¹ + ZnSO₄ @ 50 kg ha⁻¹ as basal application (T₅) which was on a par T₇, T₆ and T₈ were equally effective in increasing the zinc uptake and found superior to rest of the treatments which, in turn, also remained statistically on a par with each other. Next in order, RDF + ZnSO₄ @ 50 kg ha⁻¹ as basal application (T₄), RDF + Foliar application of ZnSO₄ @ 0.5 % at 20 and 40 DAS (T₉) and RDF + FYM @ 10 t ha⁻¹ (T₂) were on a par with each other but significantly superior to T₃ and T₁. However, the lowest zinc uptake (106.1 g ha⁻¹) by rice crop at PI stage was recorded with RDF (T₁).

The trend noticed at harvest was similar as was observed at Panicle Initiation stage in recording significantly highest zinc uptake (grain + straw) of 399.5 g ha⁻¹ with the treatment that received RDF +

FYM @ 10 t ha⁻¹ + ZnSO₄ @ 50 kg ha⁻¹ as basal soil application (T₅) which was significantly superior to rest of the treatments except T₇, T₆ and T₈ and followed by T₄, T₉ and T₂ which were on a par with each other but significantly superior to T₃ and T₁. The lowest zinc uptake (174.7 g ha⁻¹) at harvest was recorded with T₁ (RDF).

The beneficial effect of FYM and urban compost was expected as it contributed directly to the nutrient pool of the soil and increased their availability through chelating or mobilizing some of the active soil zinc and there by increased the zinc availability (Patil and Meisheri, 2003). Secondly, release of organic acids might have reduced the soil pH and thus resulted in increased zinc availability. Maximum zinc uptake when applied as basal soil application might be due to higher zinc concentration at rhizosphere and constant supply to the crop as reported by Kandali *et al.* (2015). Easy availability and rapid rate of absorption caused by greater mobility of zinc when applied as foliar spray resulted in higher zinc uptake. These findings are in conformity with the findings of Shivay and Prasad (2009).

CONCLUSION

From the results of the study it could be concluded that addition of FYM @ 10 t ha⁻¹ to RDF along with basal application of ZnSO₄ @ 50 kg ha⁻¹ was found to be beneficial for increasing productivity (5477 kg ha⁻¹) and nutrient uptake in rice grown under semi dry conditions.

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EFFECT OF HARVEST STAGE, ETHYLENE AND DAYS OF STORAGE ON THE PHYSICO-CHEMICAL CHARACTERS OF MANGO (*Mangifera indica* L.) *var. Banganapalli*

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ABSTRACT

The study presents a comparison of two stages of maturity (commercial maturity: 7 to 9^o brix and physiological maturity: 9 to 11^o brix) of the selected mango cultivar Banganapalli and three different ripening processes (control ripening; 100 ppm ethylene ripening and 150 ppm ethylene ripening) and their effect on the physico-chemical characters. Artificial ripening enhanced the change in L*, a* and b* values compared to natural ripening. Harvesting the mangoes at 9-11^o brix TSS indicated good colour compared to 7-9^o brix TSS. pH and titrable acidity are inversely associated parameters. It was observed that as the ripening progressed, acidity in all treatments decreased. TSS was highest (24.45 ± 0.42 brix) on 12th day in 9-11^o brix harvested mangoes treated with 100 ppm ethylene. Total sugar was highest (23.64 ± 0.06^o brix) on 8th day in 9-11^o brix harvested mangoes treated with 150 ppm ethylene. Reducing sugars were found to be highest on 12th day in 7-9^o brix TSS harvested mangoes treated with 150 ppm ethylene. Sugar-acid ratio was highest (73.65 ± 0.56 brix) on 12th day in 7-9^o brix TSS harvested mangoes treated with 100 ppm ethylene. The results of physico-chemical composition of mangoes indicate that artificial ripening treatment with 150 ppm ethylene, followed by 100 ppm ethylene enhanced the sweetness in mangoes by 12th day compared to control on the same day. Hence, harvesting the mangoes at 9-11^o brix TSS (physiological maturity) indicated good physico-chemical properties such as sugars, TSS, sugar acid ratio rather than 7-9^o brix TSS (commercial maturity).

INTRODUCTION

India is native to mango and is also the largest producer of mangoes with 44.14 per cent of the total world production (Kusuma and Basavaraj, 2014), accounting for 41.5% of the total mango produced worldwide and the annual production is estimated to be nearly 18 million tons (Saxena and Gandhi, 2015). Cultivars, agricultural practices and geographical location influence the quality attributes of mango (Jacob and Elke, 2016). Fruit ripening is a complex process that results in marked changes in colour, flavour, aroma, texture, and nutritional value of the flesh (Giovannoni, 2004). Physical indices of maturity such as size, color, firmness are used as criteria for harvesting mango (Jha *et al.*, 2006).

Chemical standards used in the assessment of maturity at harvest are TSS, total acidity, pH, acid/sugar ratio, reducing sugars, tannins, volatile substances, ascorbic acid, internal color of the flesh and oil content (Abbasi *et al.*, 2011). With the advancement of science and technology, various

artificial methods of fruit ripening have been observed mostly to meet consumers' demand and other economic factors. However, in the recent years, artificial fruit ripening has been considered a matter of concern and the effect of artificial ripening has become questionable because of various health related issues (Jayan, 2011). A small concentration of ethylene in air is sufficient to promote the fruit ripening process. Externally applied ethylene is likely to trigger or initiate the natural ripening process in fruits; hence, they can be marketed before the predicted time. The quality as well as the postharvest life of the fruit is influenced by the stage of maturity at harvest (Jha *et al.*, 2007). The physiological and biochemical activities of over mature fruits differ from that of mature ones in terms of respiration rate, transpiration, conversion of starch to sugars and storage life (Kader *et al.*, 2002). The amount of organic acids produced during development decreases during ripening while the amount of soluble sugars increase resulting in a sweet pulp (Simao *et al.*, 2008).

In India, fruits are picked green and stored in ventilated rooms at 15°C-21°C for a week. There is no precise information on the exact stage of harvest and effect of ripening treatments on the physico-chemical composition of mangoes. In view of these, a study was taken up to investigate effect of harvest stages, artificial ripening treatment and days of storage on the physico-chemical characters of Mango (*Mangifera indica* L.) var. Banganapalli.

MATERIAL AND METHODS

Sixty mature, green, undamaged and healthy fruits of the Banganapalli cultivar were harvested at two maturity stages (7-9° brix TSS and 9-11° brix TSS) at Fruit Research Station, Sangareddy in May, 2016. After harvest, the fruits were allowed for desapping for one hour and then the skin of the fruits was cleaned with the help of a cloth followed by washing the fruits with mild neutral detergent sandovit (0.5 ml litre⁻¹). The fruits were then shade dried and taken for ethylene treatment. Two ethylene ripening treatments (100 ppm and 150 ppm ethylene doses) were carried out at Fruit Research Station, Sangareddy. For control, fruits were stored in ambient temperature (27°C-30°C) in a well-ventilated area with 0.75%-0.78% relative humidity. For accelerated ripening, fruits were stored in a well-ventilated chamber and treated with 100 ppm and 150 ppm of ethylene. The fruits were kept in ethylene chamber for four days and they were withdrawn from the chamber on 4th day for analysis. After removing the fruits from ethylene chamber on 4th day, they were stored at ambient temperature (27°C-30°C) in a well-ventilated area with 0.75%-0.78% relative humidity until further analysis. For analysis of physico-chemical characteristics, fruits were withdrawn on day 4, day 8 and day 12, respectively from each treatment and were analysed. A three factorial randomized block design was planned for carrying out the study with 3 factors, three treatments, two replications with one fruit in each replication.

Parameters measurement

To measure the colour attributes of mango pulp, spectrophotometer (Hunter lab Colorflex,

Firmware versions 1.1, Reston, Virginia) was used with a measuring aperture of 36 mm. The L* value indicated the lightness of colour with value ranging from 0, black to 100, white. Positive a* indicates a hue of red-purple; negative a* of bluish-green; positive b* of yellow and negative b* of blue (AOAC, 1998). Mango pulp pH was determined at room temperature using pH meter after being standardized with pH 4 and pH 7 buffers (Amreen *et al.*, 2013). Titrable acidity was determined by titration method following (IS 13844: 2003) and expressed as g/l acid. Total Soluble solids were measured (AOAC, 1980) using refractometer (Digital Abbe Refractometer, Kruss Optronic). A drop of the homogenised mango pulp was squinted on the prism of refractometer. The results were expressed as brix. For the estimation of soluble sugars the method proposed by (Montgomery, 1957) was adopted. It was expressed as mg g⁻¹. Total reducing sugars were estimated according to the Nelson-Somogyi method. It was expressed as gm 100g⁻¹. The sugar- acid ratio was obtained by dividing the total soluble solids (°brix corrected for acids and temperature) by the total titrable acid (g/l acid) at 20°C (Roberto, 2011). Analysis was performed in triplicate samples and the results are presented as mean ± SD. Differences between variables were tested for significance by two-way analysis of variance (ANOVA) using (SAS version 9.1, Statistical Analysis System Institute, Inc. Cary, NC).

RESULTS AND DISCUSSION

The L*, a* and b* values significantly (P<0.05) increased for each maturity and ripening stages measured from 4th day to 12th day, indicating increase in yellowness as the fruit was ripening. The L*, a* and b* values increased because the yellow colour of the mango peel intensified during the storage period. The highest colour changes were observed in 150 ppm ethylene treated mangoes on 12th day, which could be due to accelerated loss of chlorophyll leading to change from greenness to yellow tones. This could be due to formation of carotenoids and other pigments which are responsible for yellow colour in mangoes. Ethylene treatment at 150 ppm

triggered a faster ripening process leading to yellowness from greenness compared to 100 ppm ethylene treatment and natural ripening (Table 1 and Fig.1). According to Ishtiaq *et al.* (2010), yellowness (b^*) of the fruit is accompanied by a progressive sweetness of the fruit pulp due to the formation of sugars resulting probably from starch hydrolysis.

pH is an internal ripeness indicator and acidity is inversely correlated to pH (Vinson *et al.* 2010). pH significantly ($P < 0.05$) increased in the mangoes harvested at 7-9° brix TSS and 9-11° brix TSS in all the treatments (Control, 100 ppm, 150 ppm) from day 4 to day 12 (Table 2). Ellonget *et al.* (2015) found that fruits pH increased with the advancement of ripening. They further reported that there is an inverse relationship between titrable acidity and pH, which could be due to utilization of acids as respiration substrates. Lee *et al.* (2010) reported that decrease in Titrable acidity and pH during storage might be due to the utilization of citric acid and malic acid as substrates for respiration. There was a significant ($P < 0.05$) decrease in the titrable acidity of the mangoes harvested at 7-9° brix TSS and 9-11° brix TSS in all the treatments (Control, 100 ppm, 150 ppm) from day 4 to day 12 (Table 2). The acidity in the fruits during ripening decreased because they are used as a respiratory substrates and generation of ATP (Lee *et al.*, 2010). The reduction in the acidity of the fruit during maturation has been corroborated by Palafox-Carlos *et al.* (2012) in mango (*Mangifera indica* L.).

TSS content significantly ($P < 0.05$) increased in mangoes harvested at 7-9° brix TSS and 9-11° brix TSS in all the treatments (Control, 100 ppm, 150 ppm) from day 4 to day 12 (Table 2). TSS was highest ($24.45 \pm 0.42^{\circ}$ brix) on 12th day in 9-11° brix harvested mangoes treated with 100 ppm ethylene. This may be due to the degradation of cell walls and hydrolysis of starch to sucrose in the ripening stage (Hossian *et al.*, 2014). These results were consistent with the findings of Palafox-Carlos *et al.* (2012) in mango.

There was a significant ($P < 0.05$) increase in the total sugars content of the mangoes harvested at 7-9° brix TSS in all the treatments (Control, 100

ppm, 150 ppm) from day 4 to day 12 (Table 3). The total sugars content of the mangoes increased with increase in days of storage and ripening, making the fully ripened fruits sweeter (Othman and Mbogo 2009). In 9-11° brix TSS harvested mangoes, total sugars significantly ($P < 0.05$) increased in case of control from day 4 (10.05 ± 0.06 mg/100g) to day 12 (13.15 ± 0.04 mg/100g). Whereas, the total sugar content increased from 4th day to 8th day in 100 ppm treated mangoes and 150 ppm treated mangoes. After 8th day, there was a significant decrease ($P < 0.05$) in total sugar content in both 100 ppm and 150 ppm treated mangoes. Total sugar content was highest ($23.64 \pm 0.06^{\circ}$ brix) on 8th day in 9-11° brix harvested mangoes treated with 150ppm ethylene. Hoda (2001) reported that the initial value of total sugar increased with the advancement of storage period, after attaining the peak it was decreased which might be due to its faster utilization in respiration, when the fruits were over-ripe.

There was a significant ($P < 0.05$) increase in the reducing sugars content of the mangoes harvested at 7-9° brix TSS in all the treatments (Control - 2.41 ± 0.06 to 4.70 ± 0.11 mg/100g, 100 ppm - 2.07 ± 0.08 to 4.66 ± 0.03 mg/100g, 150 ppm - 2.20 ± 0.03 to 4.77 ± 0.03 mg/100g) from 4th day to 12th day (Table 3). Similar results of increase in reducing sugars with days of storage were reported by Othman and Mbogo (2009). There was a significant ($P < 0.05$) increase in reducing sugar content of 9-11° brix TSS harvested mangoes in control from day 4 to day 12, whereas, the reducing sugar content increased significantly ($P < 0.05$) from 4th day to 8th day in 100 ppm treated mangoes and 150 ppm treated mangoes. After 8th day, there was a significant decrease ($P < 0.05$) in reducing sugar content in both 100 ppm and 150 ppm treated mangoes. Reducing sugars were found to be highest on 12th day in 7-9° brix TSS harvested mangoes treated with 150 ppm ethylene. Pawar *et al.* (2011) observed changes in reducing sugar content of sapota during maturation. Increase in sugar during ripening process in fruits may probably be due to accumulation of more sugars in fruits due to hydrolysis of starch and, slight decline at over ripe

Table 1. Effect of maturity stages, ethylene and days of storage on L*, a* and b* values in mangoes var. Banganapalli

Parameter	Maturity stage	7 – 9 ^o brix			9 – 11 ^o brix		
		4 th	8 th	12 th	4 th	8 th	12 th
Colour L*	Days of storage						
	Treatment						
	Control	51.87 ± 0.07 ^a	56.28 ± 0.11 ^c	65.90 ± 0.02 ^h	64.60 ± 0.08 ^g	66.60 ± 0.08 ^f	69.81 ± 0.06 ^f
	100ppm Ethylene	56.11 ± 0.05 ^b	63.57 ± 0.08 ^f	72.37 ± 0.06 ⁿ	67.91 ± 0.09 ^j	69.82 ± 0.08 ^f	72.60 ± 0.08 ^o
	150ppm Ethylene	59.48 ± 0.04 ^d	62.38 ± 0.08 ^e	73.78 ± 0.02 ^q	69.21 ± 0.06 ^k	71.68 ± 0.04 ^m	73.29 ± 0.01 ^p
	Control	-7.77 ± 0.08 ^a	-6.70 ± 0.07 ^c	5.37 ± 0.06 ^g	3.96 ± 0.07 ^e	11.89 ± 0.05 ⁱ	17.87 ± 0.06 ^m
	100ppm Ethylene	-7.46 ± 0.08 ^b	8.97 ± 0.03 ^h	9.71 ± 0.05 ⁱ	4.09 ± 0.01 ^f	12.36 ± 0.07 ^k	18.31 ± 0.06 ⁿ
	150ppm Ethylene	0.69 ± 0.07 ^d	8.87 ± 0.06 ^h	12.46 ± 0.05 ^k	5.40 ± 0.05 ^g	12.90 ± 0.01 ^l	19.27 ± 0.08 ^o
	Control	34.39 ± 0.03 ^a	37.58 ± 0.08 ^c	50.49 ± 0.05 ^f	50.26 ± 0.07 ^e	52.37 ± 0.06 ^h	54.16 ± 0.07 ⁿ
	100ppm Ethylene	34.68 ± 0.08 ^b	52.81 ± 0.05 ^f	59.07 ± 0.03 ^q	50.65 ± 0.06 ^g	53.10 ± 0.06 ⁱ	56.17 ± 0.07 ^h
Colour b*	150ppm Ethylene	48.68 ± 0.08 ^d	57.21 ± 0.05 ^e	60.86 ± 0.05 ^f	53.57 ± 0.10 ^k	55.58 ± 0.09 ^m	57.11 ± 0.05 ^o

Note: All the values are expressed as mean ± SD. Values with similar superscripts within rows and columns are statistically similar at 0.05% level

Table 2. Effect of maturity stages, ethylene and days of storage on pH, titrable acidity (g/l acid) and TSS (brix) in mangoes
Var. Banganapalli

Parameter	Maturity stage	7 – 9 ^o brix			9 – 11 ^o brix		
		4 th	8 th	12 th	4 th	8 th	12 th
pH	Days of storage						
	Treatment						
	Control	3.47 ± 0.01 ^b	4.31 ± 0.05 ^f	4.13 ± 0.01 ^d	4.52 ± 0.01 ^h	5.15 ± 0.00 ⁱ	5.63 ± 0.00 ^r
	100 ppm Ethylene	3.33 ± 0.01 ^a	4.66 ± 0.01 ⁱ	4.67 ± 0.01 ⁱ	4.20 ± 0.01 ^e	4.81 ± 0.00 ⁱ	5.57 ± 0.01 ^m
	150 ppm Ethylene	4.05 ± 0.01 ^c	4.28 ± 0.00 ^f	4.82 ± 0.01 ^j	4.41 ± 0.00 ^g	5.02 ± 0.01 ^k	
Titrable acidity (%)	Control	0.86 ± 0.00 ^j	0.74 ± 0.04 ^h	0.45 ± 0.04 ^d	0.84 ± 0.01 ^{ji}	0.64 ± 0.01 ⁱ	0.29 ± 0.01 ^a
	100 ppm Ethylene	0.64 ± 0.02 ^f	0.41 ± 0.01 ^c	0.37 ± 0.02 ^b	0.64 ± 0.01 ^f	0.49 ± 0.01 ^e	0.36 ± 0.01 ^b
	150 ppm Ethylene	0.72 ± 0.01 ^{gh}	0.52 ± 0.01 ^e	0.32 ± 0.01 ^a	0.63 ± 0.02 ^f	0.39 ± 0.01 ^{bc}	0.32 ± 0.01 ^a
TSS (*brix)	Control	14.08 ± 0.10 ^a	19.01 ± 0.01 ^{de}	20.61 ± 0.06 ^f	19.00 ± 0.01 ^{de}	20.73 ± 0.11 ^f	21.15 ± 0.25 ^g
	100 ppm Ethylene	16.42 ± 0.18 ^b	17.75 ± 0.08 ^c	18.40 ± 0.16 ^{cd}	18.90 ± 0.64 ^{de}	21.31 ± 0.42 ^g	24.45 ± 0.42 ^g
	150 ppm Ethylene	16.25 ± 0.08 ^b	19.31 ± 0.81 ^e	19.23 ± 0.16 ^e	18.43 ± 0.41 ^{cd}	19.47 ± 0.03 ^e	22.32 ± 0.47 ^g

Note: All the values are expressed as mean ± SD. Values with similar superscripts within rows and columns are statistically similar at 0.05% level

Table 3. Effect of maturity stages, ethylene and days of storage on total sugars (mg/100g), reducing sugars (mg/100g) and sugar acid ratio in mangoes var. Banganapalli

Parameter	Maturity stage	7 – 9 ^o brix			9 – 11 ^o brix		
		4 th	8 th	12 th	4 th	8 th	12 th
Total sugars (mg 100g ⁻¹)	Days of storage						
	Treatment						
	Control	9.340 ± 0.04 ^a	10.45 ± 0.29 ^c	11.05 ± 0.06 ^d	10.05 ± 0.06 ^b	10.89 ± 0.03 ^d	13.15 ± 0.04 ^e
	100 ppm Ethylene	13.50 ± 0.27 ^f	14.55 ± 0.05 ^h	15.56 ± 0.06 ⁱ	13.75 ± 0.06 ^g	17.25 ± 0.06 ^k	15.96 ± 0.04 ^j
	150 ppm Ethylene	18.00 ± 0.16 ^l	19.90 ± 0.04 ^h	20.56 ± 0.03 ^p	19.66 ± 0.06 ^m	23.64 ± 0.06 ^q	20.33 ± 0.21 ^o
Reducing sugar (mg 100g ⁻¹)	Control	2.41 ± 0.06 ^c	2.70 ± 0.07 ^d	4.70 ± 0.11 ⁱ	2.88 ± 0.00 ^{ef}	3.21 ± 0.18 ^g	3.38 ± 0.04 ^h
	100 ppm Ethylene	2.07 ± 0.08 ^a	2.77 ± 0.06 ^{de}	4.66 ± 0.03 ^j	2.21 ± 0.06 ^b	3.36 ± 0.13 ^h	2.98 ± 0.04 ⁱ
	150 ppm Ethylene	2.20 ± 0.03 ^b	2.92 ± 0.08 ^f	4.77 ± 0.03 ^k	2.73 ± 0.20 ^d	3.90 ± 0.12 ⁱ	2.41 ± 0.02 ^c
Sugar acid ratio	Control	16.37 ± 0.11 ^a	26.25 ± 0.74 ^c	46.31 ± 0.88 ^h	22.76 ± 0.21 ^b	32.65 ± 0.54 ^e	72.67 ± 0.50 ⁱ
	100 ppm Ethylene	26.50 ± 0.26 ^c	43.84 ± 0.56 ^g	73.65 ± 0.56 ⁱ	30.24 ± 0.66 ^d	43.94 ± 0.23 ^g	68.88 ± 0.18 ^k
	150 ppm Ethylene	22.73 ± 0.34 ^b	37.14 ± 0.52 ^f	61.06 ± 0.88 ^j	29.28 ± 0.90 ^d	50.67 ± 0.88 ^f	68.96 ± 0.34 ^k

Note: All the values are expressed as mean ± SD. Values with similar superscripts within rows and columns are statistically similar at 0.05% level

EFFECT OF HARVEST STAGE, ETHYLENE AND DAYS OF STORAGE ON MANGO

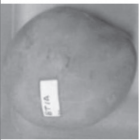
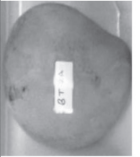

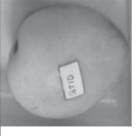


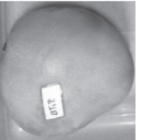








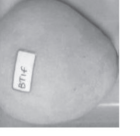
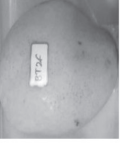

7-9° brix			9-11° brix		
 4 th day Control mango	 4 th day 100 ppm ethylene treated mango	 4 th day 150 ppm ethylene treated mango	 4 th day Control mango	 4 th day 100 ppm ethylene treated mango	 4 th day 150 ppm ethylene treated mango
 8 th day Control mango	 8 th day 100 ppm ethylene treated mango	 8 th day 150 ppm ethylene treated mango	 8 th day Control mango	 8 th day 100 ppm ethylene treated mango	 8 th day 150 ppm ethylene treated mango
 12 th day Control mango	 12 th day 100 ppm ethylene treated mango	 12 th day 150 ppm ethylene treated mango	 12 th day Control mango	 12 th day 100 ppm ethylene treated mango	 12 th day 150 ppm ethylene treated mango

Fig. 1. Maturity and ripening stages of Mango Var. Banganapalli

stage which could be due to utilization of sugars during respiration process.

The results indicated that mangoes harvested at physiological maturity (9-11° brix TSS) turn out to be sweeter and palatable than the ones harvested at commercial maturity (7-9° brix TSS). When ripening takes place, the accumulated starch is degraded and accounts for the synthesis and accumulation of soluble sugars, reaching levels as high as 12% of fresh pulp. The amount of organic acids produced during development decreases during ripening while the amount of soluble sugars increases resulting in a sweet pulp. Hence, permitted levels of artificial ripening can enhance the palatability of the mangoes for consumption than the naturally ripened fruits.

CONCLUSION

Artificial ripening was found to have a positive or enhancing effect on physico-chemical characteristics of the Banganapalli mango. Among the two ethylene treatments (100 ppm and 150 ppm), it was found that 150 ppm ethylene treatment (in ripening the fruit) was effective than 100 ppm ethylene treated mangoes and naturally ripened mangoes in terms of palatability (TSS, sugar content and sugar-acid ratio). However, rapid increase in sugar-acid ratio with 150 ppm ethylene ripening treatment might reduce the keeping quality of the fruits. Hence, for prolonged keeping quality of the mangoes, harvesting them at 9-11° brix TSS and 100 ppm ethylene treatment might lead to longer shelf life. However, harvesting Banganapalli mangoes at 9-11° brix TSS along with 150 ppm ethylene treatment can serve better for eating quality.

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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD AND ECONOMICS OF BROCCOLI

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ABSTRACT

Broccoli is a rich nutritious winter season cole vegetable crop. Integrated nutrient management recorded significant increase in broccoli curd yield in both the years of field trials (2011-12 and 2012-13). Application of poultry manure @ 2.5 t ha⁻¹ + Half RDF of chemical fertilizers (40-30-30 kg N, P₂O₅ and K₂O ha⁻¹) treatment recorded highest average curd weight of 285.17 g with an yield of 104.37 q ha⁻¹ which was 15 % yield increase to the treatment applied with 100% RDF of chemical fertilizers (80-60-60 kg N, P₂O₅ and K₂O ha⁻¹). Treatment T₉ (poultry manure @ 2.5 t ha⁻¹ + Half RDF of chemical fertilizers) recorded highest net returns of Rs.2,22,820/- with benefit - cost ratio of 2.9 and production cost of Rs.76,700/- among all the treatments. The treatments applied with chemical fertilizers or organic manures alone could not increase the yield of broccoli than the treatments integrated with both of organic and inorganic sources. The treatments T₇ (Vermicompost @2.5 t ha⁻¹ + Half RDF of chemical fertilizers) and T₃ (FYM @ 10 t ha⁻¹ + Half RDF of chemical fertilizers) recorded on par curd yields of 98.93 q ha⁻¹ and 95.21 q ha⁻¹, respectively with the treatment T₉ and with benefit - cost ratio of 2.59 and 2.52, respectively. Lowest benefit- cost ratio of 1.59 was recorded in the treatment applied with Vermicompost @ 5 t ha⁻¹.

INTRODUCTION

Broccoli (*Brassica oleracea* var. Italica) is a cole vegetable crop. It is a winter season vegetable crop where curd is the economic part, which can be consumed as salad or in curry preparation. Broccoli is nutritious and rich in availability of vitamins (A, B₁, B₂ and C) and minerals such as calcium, potassium, phytochemicals and fibre. It is also having anti cancerous properties. Nutrient management plays an important role in production of quality vegetables apart from quantity. Integrated nutrient management is one of the options to avoid complete chemical nutrient management, where it leads to deterioration of soil health and produce quality.

Integrated nutrient management improves the soil physical, chemical and biological properties apart from quality yields (Nair and Peter, 1990). Organics improve soil moisture content in the root zone vicinity which in turn increases the availability and uptake of nutrients by plants. Out of total crop nutrient requirement, some portion of recommended nutrients should be supplied through organic manures so as to improve soil productivity and microbial activity, but it is very important to find out their cost effectiveness and availability at farm level. Integrated nutrient management with viable combination of organic

source of nutrients with chemical fertilizers not only limits over vegetative growth but also controls complex pest and disease problems in crop production. A viable combination of organic and chemical sources of nutrients with Integrated Nutrient Management (INM) is an economical option for obtaining qualitative yields. Keeping these in view, different sources of organic manures along with chemical fertilizer combinations were tested to find out suitable and economic combination for broccoli production at Hyderabad condition.

MATERIAL AND METHODS

Field trials were carried out for two consecutive *rabi* seasons (2012-13) in Broccoli at Vegetable Research Station, Rajendranagar, Hyderabad (17° 33' N latitude 78.40° E longitude and 536 m altitude). The soils of the experimental site was clay loam with pH 7.8, E.C 0.34 dSm⁻¹, low in organic carbon 0.3%, low in available nitrogen 256 kg ha⁻¹, high in available phosphorous 34 kg ha⁻¹ and available potassium 520 kg ha⁻¹. The experiment was laid out in randomized block design (RBD) replicated thrice with nine treatments, T₁- Complete Recommended Dose of Chemical Fertilizers (RDF), T₂-FYM @20 t ha⁻¹, T₃- FYM @ 10 t ha⁻¹ + Half RDF of NPK through chemical fertilizers, T₄- Neem cake@

5 q ha⁻¹, T₅- Neem cake@ 2.5 q ha⁻¹+ Half RDF of NPK through chemical fertilizers, T₆-Vermicompost@5 t ha⁻¹, T₇- Vermicompost@ 2.5 t ha⁻¹+Half RDF of NPK through chemical fertilizers, T₈ - Poultry manure@ 5 t ha⁻¹, T₉-Poultry manure@ 2.5 t ha⁻¹+ Half RDF of NPK through chemical fertilizers. Broccoli seedlings of 30 days old are transplanted at 60x45cm spacing in pre-imposed treatment plots. Organic manures were applied at four days before planting along with basal dose of phosphorous. Recommended dose of chemical fertilisers were applied at the rate of 80-60-60 kg N, P₂O₅ and K₂O ha⁻¹, nitrogenous and potash fertilizers were applied in three splits half dose as basal remaining half dose were applied in two splits at 30 and 45 DAT. Crop was irrigated at 7 to 8 day interval based on moisture content in the soil. As plant protection to measure to control sucking pests 3000 ppm neem oil was sprayed @ 2 ml lit⁻¹ water at 30 days after transplanting another spray was given at 15 days after first spray with dimethioate @ 2ml lit⁻¹ water. Diseases were not observed. Harvesting of curds were done at 64 days after transplanting and continued up to 5 to 6 days. Small curds(Side branch curds)were harvested from 15 days after the harvest of main curd and it was continued for 10 days with every alternate day harvest.

RESULTS AND DISCUSSION

Integration of organic manures in combination with half recommended dose of chemical fertilizer management in broccoli showed significant influence on average curd weight and curd yield in two years of experimental results (Table 1). Among all the treatments imposed integration of organic manures with half recommended dose of chemical fertilizer treatments showed significant improvement in yield of Broccoli. Among all the treatments, the maximum highest average curd weight of 273 g and 317.33 g were recorded in both the years 2011-12 and 2012-13 with two years average curd weight of 285.17 g in the treatment T₉ (Poultry manure @ 2.5 t ha⁻¹+Half RDF of chemical fertilizers).The treatment T₇ (Vermicompost @ 2.5 t ha⁻¹+ Half RDF of chemical fertilizers) and T₃ (FYM @10 t ha⁻¹ + Half RDF of

chemical fertilizers) recorded on par average curd weights of 281.83g and 271.17g, respectively to the treatments T₉ (Poultry manure@ 2.5t ha⁻¹+Half RDF of chemical fertilizers) in two years pooled findings, however in the year 2012-13 the treatment T₁ was recorded on par average curd weight with T₉. These findings are in agreement with the findings of Mohapatra *et al.* (2013) and Maurya *et al.* (2008). Application of 100% recommended dose of chemical fertilizer could not influence significantly in increasing the average curd weight as compared to combined application of both organic and inorganic sources, but the treatments applied with only organic source T₈ (Poultry manure @ 5 t ha⁻¹) and T₂ (FYM @ 20 t ha⁻¹) recorded on par average curd weight to the treatment T₁ (100%RDF of chemical fertilizers).The notable increase in average curd weight was observed in the treatments imposed with integration of both organic and inorganic sources of fertilizers might be due to improvement in soil physical conditions and biological activity which lead to continuous supply of nutrients along with micronutrients resulting in good uptake of nutrients and crop vegetative growth (Ranwat *et al.*, 2008; Kumar and Chaudhary, 2002).

Curd yield recorded was significantly higher in the integrated treatments when compared to sole application of organic sources or recommended chemical fertilizers (Table-1).The treatment T₉ (poultry manure @ 2.5 t ha⁻¹ + Half RDF of chemical fertilizers) recorded highest mean curd yield of 104.37 q ha⁻¹. The treatment T₇ (Vermicompost @ 2.5 t ha⁻¹ + Half RDF of chemical fertilizers) and T₃ (FYM @ 10 t ha⁻¹ + Half RDF of chemical fertilizers) recorded 98.93 and 95.21 q ha⁻¹ of curd yield, respectively which were on par with curd yield of treatment T₉. As curd yield directly depends on curd weight, curd yield was also not significantly superior in 100% RDF of chemical fertilizers treatment (T₁) when compared with integrated treatments, but the treatments T₂ (FYM @ 20 t ha⁻¹), T₅ (Neem cake @ 2.5 t ha⁻¹+ Half RDF of chemical fertilizers) and T₈ (poultry manure @ 5 t ha⁻¹) recorded on par curd yield with T₁ (100% RDF through chemical fertilizer) with an yield of 85.08,82.06 and 84.96 q ha⁻¹,

Table1.Effect of integrated nutrient management on yield and yield attributing characters in Broccoli

Treatment	Average Head Weight(g)			Main flower yield(Curd)(q ha ⁻¹)			Branch flower yield(q ha ⁻¹)		
	2011-12	2012-13	Two years pooled	2011-12	2012-13	Two years pooled	2011-12	2012-13	Two years pooled
T ₁ - RDF of NPK through chemical fertilizers	221.67	294.00	257.83	82.40	98.00	90.20	82.85	94.16	88.51
T ₂ - FYM@ 20 t ha ⁻¹	196.33	265.67	231.00	81.60	88.55	85.08	70.31	78.57	74.44
T ₃ - FYM@ 10 t ha ⁻¹ +Half RDF of NPK through chemical fertilizers	239.67	302.67	271.17	89.54	100.88	95.21	67.64	110.31	88.89
T ₄ - Neem cake@ 5 q ha ⁻¹	123.67	270.00	196.83	58.50	90.11	74.30	40.15	79.28	59.72
T ₅ - Neem cake@2.5 q ha ⁻¹ + Half RDF of NPK through chemical fertilizers	166.67	294.33	230.50	66.04	98.01	82.06	47.15	120.75	83.95
T ₆ - Vermi compost@ 5 t ha ⁻¹	132.67	249.00	190.83	60.48	83.00	71.74	60.48	76.11	68.29
T ₇ - Vermi compost@2.5 t ha ⁻¹ +Half RDF of NPK through chemical fertilizers	256.33	298.33	281.83	98.43	99.44	98.93	77.42	95.91	86.67
T ₈ - Poultry manure@ 5 t ha ⁻¹	213.00	272.67	242.85	79.04	90.89	84.96	63.18	89.28	76.23
T ₉ - Poultry manure@ 2.5 t ha ⁻¹ + Half RDF of NPK through chemical fertilizers	273.00	317.33	285.17	102.97	105.77	104.37	80.37	101.19	90.78
C.D @5 %	38.18	61.62	34.83	14.38	20.50	12.05	20.80	24.55	15.46
CV %	10.84	12.50	12.13	10.44	12.47	11.72	18.35	15.09	16.49

Table 2. Economics of integrated nutrient management in Broccoli

* Treatments	Cost of Cultivation (Rs ha ⁻¹)	Gross returns (Rs ha ⁻¹)			Net returns (Rs ha ⁻¹)	B:C Ratio
		Main flower	Branch flower	Total		
T ₁	76,900	1,80,400	88,510	2,68,910	1,92,010	2.49
T ₂	81,500	1,70,160	74,440	2,44,600	1,63,100	2.00
T ₃	79,200	1,90,420	88,980	2,79,400	2,00,200	2.52
T ₄	79,000	1,48,600	59,720	2,08,320	1,29,320	1.63
T ₅	77,950	1,64,120	83,950	2,48,070	1,70,120	2.18
T ₆	81,500	1,43,480	68,290	2,11,770	1,30,720	1.59
T ₇	79,200	1,97,860	86,670	2,84,530	2,05,330	2.59
T ₈	76,500	1,69,920	76,230	2,46,150	1,69,650	2.21
T ₉	76,700	2,08,740	90,780	2,99,520	2,22,820	2.90

* Details of treatments are given in Table 1

respectively. Among all the treatments, T₉ and T₁ treatments recorded four days early curd harvest, this might be due to higher available nitrogen supplied to the crop throughout its crop growth period which leads to increase in leaf area in vegetative stage which in-turn accumulates more dry matter later that can be converted into higher curd weight and curd yield. These findings are in agreement with the finding of Singh and Naik (1993).

Among the integrated treatments, curd circumference was more ranging from 38 to 40cm where the curd was compact and leads to higher average curd weight and increase in the keeping quality. This quality curd yield might be due to balanced supply of all nutrients to the crop during its growth period (Kamala Kanwar *et al.*, 2002). Side branch flowers (small curds) are harvested after 15 days from the period of main curd harvest, which can be used as salad. Side branch curd yield was also recorded almost in the range of 80-90 q ha⁻¹ (Table 1). Among the treatments, T₉ (poultry manure @ 2.5 t ha⁻¹ + half RDF of chemical fertilizers) recorded highest side branch curd yield of 90.78 q ha⁻¹. This treatment T₉ was on par with the treatments T₁, T₃, T₅, T₇ and T₈. Application of organics alone could

not record significantly higher side branch curd yield when compared to integrated treatments and 100% RDF of chemical fertilizers alone treatment. Overall yield improved was 15 % in T₉ (2.5 t ha⁻¹ poultry + half RDF of chemical fertilizers) when compared with T₁ (RDF) while the treatments T₇ (Vermicompost @ 2.5 ha⁻¹+ half RDF of chemical fertilizers) and T₃ (FYM @ 10 t ha⁻¹+ Half RDF of chemical fertilizers) recorded 9% and recorded 3% extra curd yield to T₁ treatment. Combination of organic and inorganic sources of fertilizers supply good amount of nutrients and growth promoting substance apart from improving soil microbial activity which leads to overall improvement in productivity (Singh and Sinsinwar, 2006; Kumar and Chaudhary, 2002).

A perusal pooled data in Table 2 indicated that estimated economic parameter study. During the experiment period (2011-12 and 2012-13) the following are the cost for organic source of fertilizers, FYM @ Rs.500/ tonne, Vermicompost @ Rs.2000/ tonne, Neem cake @ Rs.15000/tonne, Poultry manure @ Rs.1000/ tonne and chemical fertilizer @ Rs.5400 ha⁻¹. Broccoli main curd was sold @ Rs.20/ kg and side branch flower curds @ Rs.10/kg. Among all the treatments, poultry manure is the cheapest source and also recorded highest yield of broccoli,

as poultry feed is rich in proteins, fats, fish meal and minerals so the manure from poultry is rich source of nitrogen and also other nutrients, which leads to higher broccoli curd yield and economic benefits. Higher net returns of Rs.2,22,820/- was recorded in T₉ (poultry manure @ 2.5 t ha⁻¹ + half RDF of chemical fertilizers) with B:C ratio of 2.90. Among all the treatments, T₂ (FYM @ 20 t ha⁻¹ and T₆ (Vermicompost @ 5 t ha⁻¹) treatments registered higher production cost of Rs.81,500 ha⁻¹ due to more bulky quantity of organic source while the lowest production cost was registered in the treatments T₈ (poultry manure @ 5 t ha⁻¹), T₉ (poultry manure @ 2.5 t ha⁻¹ + half RDF of chemical fertilizers) and T₁ (100% RDF of Chemical fertilizers) treatments with an amount of Rs.76,500, Rs. 76,700 and Rs. 76,900/- respectively in the above treatments. As the yield recorded was higher in these treatments, net returns and B:C ratio was also higher in these treatments. These three treatments recorded net returns of Rs.2,22,820/-, Rs.2,05,330/- and Rs.1,92,010/- respectively, with the B:C ratio in the order of 2.90, 2.59, and 2.49 (Meena *et al.*, 2015)

CONCLUSION

The given experimental results reveals that application of poultry manure @ 2.5 t/ha + half recommended chemical fertilizers application treatment recorded highest broccoli main curd yield of 104.37 q/ha and side branch curd yield of 90.78 q/ha. This treatment is recommended as economical because as it recorded highest B:C ratio of 2.9, as poultry manure is having high percent of nitrogen and also with less cost leads to highest economic returns in broccoli. Integration of organics with chemical fertilizers not only beneficial for yield and net returns but also it is beneficial for soil health improvement.

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A STANDARD TEST TO MEASURE THE KNOWLEDGE OF RURAL WOMEN ABOUT HOME SCIENCE TECHNOLOGIES

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ABSTRACT

Knowledge of the rural women plays a vital role in adoption of home science technologies. Having more knowledge develops positive changes in the thinking process of individual. Keeping this in view, a test was developed to measure the knowledge of rural women about selected seven home science technologies viz., Value added products of millets, Nutrition garden, Fruits and vegetables preservation, Tailoring and Embroidery, Vermi composting, Seed bag and Backyard poultry. Data was collected during October to December, 2014 by personal interview method the respondents to construct a knowledge test about home science technologies. A tentative list of 65 items was drafted suited to the area of study. 60 rural women were selected for the study that has undergone training on selected Home Science technologies. Item difficulty index, Discrimination index and Point bi-serial correlation were worked out. Finally, 27 items were selected to measure knowledge of the rural women. The reliability coefficient ($r_{tt}=0.846$) obtained indicated that the internal consistency of the knowledge test developed for the study was very high.

INTRODUCTION

Knowledge plays an important role in rural women life for achieving their aspirations. Bloom *et al.* (1956) considered knowledge as “those behaviour and test situations which emphasizes the remembering, either by recognition or recall of ideas, material or phenomena”. Hence, to participate and adoption of different technologies one should understand the information thoroughly and could able to recollect at the time of implementation. ANGRAU is disseminating many home science technologies through KVKs.

This study was conducted as a part of Ph.D thesis to test the knowledge level of trained rural women in selected Home Science technologies. For the purpose of this study, ‘Knowledge’ was operationalised as “remembering or recalling of information from rural women about the selected technologies of Home science which they have learnt by various extension methods”. For measuring the knowledge level, a knowledge test was constructed and standardized with help of the following techniques with an objective to ascertain knowledge of rural women on selected Home Science technologies.

MATERIAL AND METHODS

A knowledge test was developed to measure knowledge of rural women on Value added products of millets, Nutrition garden, Fruits and vegetables preservation, Tailoring and Embroidery, Vermi composting, Seed bag and Backyard poultry. Data was collected during October to December, 2014 at Gaddimallaiahguda village from Hayathnagarmandal, Rangareddy District and Mukundapuram village from Tripurarammandal of Nalgonda District were selected to conduct study with 30 respondents from each village as a total of 60 rural women who were undergone for training of selected Home Science technologies.

RESULTS AND DISCUSSION

Collection of items

Initially an item pool of Knowledge test was collected focusing on various aspects of selected technologies of Home Science. Expert in the field of Home Science research were consulted to collect the items. Finally, a pool of items for all the seven selected Home science technologies was prepared.

Framing of test items

The knowledge test items part comprised of 65 questions including closed ended questions and open ended questions representing selected Home Science Technologies - Value added products of millets, Nutrition garden, Fruits and vegetables preservation, Tailoring and Embroidery, Vermi composting, Seed bag and Backyard poultry.

Selection of items for item analysis

The criteria followed for selection of items was- they should show the difference between trained or well informed rural women and poorly informed rural women *i.e.* they should have some difficulty to answer; they should cover all the required areas to reach the expectations of the researcher to fulfill all the objectives; items should be more responsive to think and answer rather than memorization of the respondents. Keeping above conditions and criteria, 65 test items selected for knowledge test were pre - tested by administering it to 60 respondents.

Item analysis

The item analysis was carried out in terms of three indices that are item difficulty index, item discrimination index and point bi-serial correlation. The index of item discrimination provides information on how well an item discriminates in agreement that is whether an item really discriminates a well-informed respondent from a poorly informed respondent. Whereas, item difficulty index indicates the extent to which an item was difficult. The point bi-serial correlation provided information on how well item measures or discriminates in agreement with the rest of the test. All the 65 items were administered to all the respondents. The scoring pattern was '1' for each correct answer and '0' for each incorrect answer. After computing the total scores of all 60 respondents on 65 items, and they were arranged in descending order. Then the respondents were divided into six equal groups of 10 members in each group and were labelled as G1, G2, G3, G4, G5 and G6. For the purpose of item analysis, the middle two groups G3 and G4 were eliminated keeping only four extreme groups with high and low scores. (Bloom *et al.*, 1956).

Item difficulty index (P)

The index of difficulty was worked out as the percentage of the respondents answering an item correctly. The assumption of the item statistic of difficulty index was that the difficulty is linearly related to the level of respondent's knowledge about selected Home Science Technologies. The items with 'p' values ranging from 20 to 80 were considered for the final selection of the knowledge test battery.

$$P = \frac{NC}{N} \times 100$$

where, P = difficulty index,

NC = number of respondents answering correctly, and

N = total number of respondents

Item Discrimination Index (E 1/3)

The Item Discrimination Index is indicated by "E 1/3". It indicates the level of discrimination between well informed and poorly informed respondents, was computed using the given formula.

$$E\ 1/3 = \frac{(S1 + S2) - (S5 + S6)}{N/3}$$

Where,

S1, S2, S5 and S6 are the frequencies of correct answers in the groups G1, G2, G5 and G6, respectively.

'N' is the total number of respondents of the sample selected for the item analysis *i.e.* 60.

The discrimination index varies from 0 to 1. The items with discrimination index range from 0.20 to 0.80 were selected for the final test.

Point bi-serial correlation (r_{p bis})

The main aim of calculating point bi-serial correlation was to work out the internal consistency of the item *i.e.* the relationship of the total score to a dichotomized answer to any given item. In a way, the validity power of the item was computed by the

correlation of the individual item of preliminary knowledge test calculated by using the formula suggested by Garret (1966).

$$r_{p\text{ bis}} = \frac{M_p - M_q}{\sigma} \times \sqrt{pq}$$

$r_{p\text{ bis}}$ = Point biserial correlation.

M_p = Means of the total scores of the respondent who answered the item correctly.

$$M_p = \frac{\text{Sum total of } x \text{ y}}{\text{Total number of correct answers}}$$

M_q = Mean of the total scores of the respondents who answered the item incorrectly.

$$\text{or } M_q = \frac{\text{Sum total of } x - \text{Sum total of } y}{\text{Total number of correct answers}}$$

σ = standard deviation of the entire sample (60 respondents)

p = Proportion of the respondents giving correct answer to the item.

$$p = \frac{\text{Total number of correct answers}}{\text{Total number of respondents}}$$

q = Proportion of the respondents giving incorrect answer to the item or

$$q = 1 - p$$

x = Total score of the respondent for all items

y = Response of the individual for the item *i.e.* (Correct -1; Incorrect -0)

Items having significant point bi-serial correlation either at 1 per cent (or) 5 per cent level was selected for the final test of the knowledge.

Representativeness of the test

Care was taken to see that the test items selected finally covered the entire universe or respondent's knowledge on Value added products of millets, Nutrition garden, Fruits and vegetables preservation, Tailoring and Embroidery, Vermi composting, Seed bag and Backyard poultry.

Reliability of the test

Test – Re-test method

The test was administered twice to 60 respondents who were aware of seven Home Science technologies separately with an interval of fifteen days. The two sets of knowledge score obtained by the rural women were correlated. The correlation coefficient (0.846) was highly significant indicating a high degree of dependability of the instrument for measuring knowledge of the rural women.

Validity of the test

The validity of the test items was tested by the method of point bi-serial correlation ($r_{p\text{ bis}}$). The items with highly significant correlation coefficients either at 1 per cent (or) at 5 per cent level indicated the validity of the items of knowledge test designed to measure the knowledge of the rural women on selected seven Home Science Technologies.

Content validity

The content validity of knowledge test was derived from a long list of test items representing the whole universe of latest methods of selected seven home science technologies were collected from various sources as discussed earlier. It was assumed that the score obtained by administering the knowledge test of this study measures what was intended to measure. Thus, the knowledge test developed in the study measures the knowledge of rural women as it showed a greater degree of reliability and validity. Out of 65 items, 27 items were finally selected based on **1.** Items with difficulty level indices ranging from 20 to 80; **2.** Items with discrimination indices ranging from 0.20 to 0.80; **3.** Items having significant point bi-serial correlation either at 1 per cent or 5% level. The items are presented in Table 1.

Table1. Item analysis methodology to measure knowledge of rural women

S. No	Items	Difficulty Index	Discrimination Index	Point biserial correlation
1.	Millets constitute mainly of a) Fibre b) Carbohydrates c) Vitamins d) Proteins	68.33	0.45	.417**
2.	In which form generally children like to take millets? a) Kichidi b) Payasam c) Roti d) Baked products	61.67	0.63	.348**
3.	Foxtail and little millet are so rich of a vitamin a) Beta Carotene (Vit A) b) Vitamin B c) Vitamin C d) Vitamin K	48.33	0.75	.509**
4.	What are the major benefits of nutrition garden? a) Money saving b) Healthy food c) Recreation d) All of these	78.33	0.58	.438**
5.	What is the duration of <i>Bhendi</i> crop?	68.33	0.47	.272*
6.	A nutrition garden needs very little sunlight and lots of shade. True/ False	70.00	0.65	.455**
7.	Cauliflower is more productive and tasty in winter. True/ False	78.33	0.45	.438**
8.	Nutrition garden contains both annuals and perennials. True/ False	78.33	0.35	.356**
9.	In winter season leafy vegetable spoilage is less. True/ False	71.67	0.60	.346**
10.	Grinded spices are used for sauce preparation. Yes / No	78.33	0.35	.356**
11.	Blanching is one of the vegetable preservation treatments. Yes / No	51.67	0.50	.500**
12.	Sodium benzoate is one of the best preservation agents. True/ False	65.00	0.65	.487**
13.	Pickling in vinegar or acetic acid can also preserve food. True/ False	56.67	0.75	.389**
14.	The — colour of carbon that is most commonly used for tracing embroidery design. a) Yellow b) Black c) Red d) Brown	76.67	0.55	.472**
15.	There are two tension points in sewing machine. True/ False	76.67	0.65	.313*

A STANDARD TEST TO MEASURE THE KNOWLEDGE OF RURAL WOMEN

S. No	Items	Difficulty Index	Discrimination Index	Point biserial correlation
16.	Seed bag technology helps in drudgery reduction. Yes / No	60.00	0.70	.453**
17.	How much time can be saved by using seed bag per acre?	35.00	0.50	.289*
18.	___ is used for rearing of earthworms (a) Bamboo tray (b) Apiary (c) Vermibox (d) Poultry farm	66.67	0.50	.309*
19.	Vermicompost is bio-fertilizer which is rich in a) Phosphorus b) Calcium c) Nitrogen d) All of the above	78.33	0.55	.275*
20.	What is the ideal size of the vermin compost pit?	68.33	0.55	.272*
21.	What is the yield of vermicompost that could be obtained from the ideal sized pit?	56.67	0.75	.389**
22.	In how many days vermicompost will be ready to use?	61.67	0.55	.279*
23.	The worms should be introduced in the vermin bed after—days.	75.00	0.55	.427**
24.	Cow dung and agricultural waste should be mixed in the ratio of 1:4.	75.00	0.65	.272*
25.	How many birds can be included in a typical flock size—-?	46.67	0.65	.346**
26.	Willing to rear improved birds. Yes/ No	63.33	0.70	.312*
27.	Delayed maturity and low weight gain is a demerit in local variety poultry birds. Yes/ No	65.00	0.55	.346**

* Significant at 0.05 level of probability; ** Significant at 0.01 level of probability

The final selected 27 items consisted of objective/ close ended and open ended questions. All questions included in the interview schedule are explained to the respondents to get accurate results without any confusion in understanding.

CONCLUSION

A standardized test was developed by appropriate item analysis to measure the knowledge of rural women about the home science technologies. The reliability and validity of the test was also verified

and it was found that the test measures what was intended to measure.

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ECONOMIC ANALYSIS OF RICE PRODUCTION INTERVENTIONS DEMONSTRATED ON TRIBAL FARMERS FIELDS IN KHAMMAM DISTRICT

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The Tribal Sub-Plan (TSP) was initiated during Fifth Five Year Plan(1974-78) by the Government of India for socio-economic amelioration of the tribal communities. The objective of the TSP is to build the capacity of the tribal populations to access education and health services, creation of productive assets and income generating opportunities and protection against exploitation and oppression. The funds provided under the Tribal Sub Plan of the State have to be at least equal in proportion to the ST population of each State or UTs. Similarly Central Ministries/Departments are also required to earmark funds out of their budget for the Tribal Sub-Plan (Ministry of Tribal Affairs). According to the Tribal Welfare Department, Government of Telangana, ST population in the Telangana State accounts for 9.08 per cent of the total population (2011 census) and the dominant groups of tribals in the Telangana State are *Lambadis* (20.46%), *Koyas* (4.86), *Gonds* (2.98%) and *Yerukulas* (1.98%).

The study pertains to a series of training programs organized by ICAR-Indian Institute of Rice Research (ICAR-IIRR) under the TSP project for tribal farmers of Khammam District induring 2014-15. The rice technology package was demonstrated to the selected farmers with Improved *Sambamahsuri* (ISM) - a Bacterial Leaf Blight resistant variety, quality seed production, information on parthenium control measures and skill training on preparation of compost from parthenium. The objectives of the study were to assess the economics of rice production practices and quantify yield gaps and to provide rice intervention package to the selected tribal farmers and to elicit information on constraints in rice production and suggestions from women farmers to improve the effectiveness of training.

To study the existing rice production practices being followed by farmers, a benchmark survey was undertaken and data was collected from 130 farmers of four tandas viz., Basitnagar, Repallyvada, Tekulapalli and Chukka Tanda of Khammam District in Telangana state. The varieties being grown, inputs used and yield obtained were recorded. Out of the 130 sample farmers, based on the financial resources available, the inputs under TSP project were provided to 65 farmers and they were motivated to adopt the selected rice interventions for achieving higher yields. Data was collected using structured interview schedule. Focus Group Discussions (FGDs) preceded data collection. Selection of rice farmers was done by random sampling. Data collected was basically on inputs and outputs. Net returns were calculated.

Any change in the outcome indicators (for instance, yield) between two comparison groups can be attributed largely to a change in variety. In the study, rice interventions with Improved *Sambamahsuri* rice variety in place of Farmer's practice, under similar agro-climatic, biophysical, and socio-economic conditions was studied. After forming two comparable comparison groups, with the rice interventions (RI) and the farmers practice (FP), the survey data was analysed by applying various measures of central tendencies such as mean, ratio, percentage, etc., to measure intended outcome indicators. The difference in the intended outcome indicators is tested for statistical significance by estimating paired-t values. The paired-t test is applied in this case because farmers practice and rice interventions form two comparable groups (a pair) as both were grown by the same sample farmers during the same crop years under similar conditions.

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Information pertaining to the measures as perceived by the women participants was elicited for improving the participation of women farmers in the training program. An Index of Yield Gap was developed which compares actual yield with the best yield achieved in comparable environmental conditions, e.g. between neighbours with similar topography and soils.

$$\text{Index of Yield Gap (I}_g\text{)} = \frac{\text{Best yield realized} - \text{Average yield realized}}{\text{Best yield realized}} \times 100$$

Index of realized potential yield is defined as the percentage of the best yield potential achieved. Thus,

$$\text{Index of realized best potential yield (I}_R\text{)} = \frac{\text{Average yield realized}}{\text{Best yield realized}} \times 100$$

Index of yield gap (I_g) refers to the percentage of yield potential unrealized

$$I_g = 100 - \text{Index of realised best potential yield}$$

The Constraint Index for each variable was calculated by using formula:

$$I \text{ Const.} = \sum \frac{S_i f_i}{N}$$

Where, I_{Const.} Index value for intensity of problem ; \sum Summation; S_i Scale value of ith intensity; f_i Frequency of ith respondent; N =Total number of respondents.

Important socio-economic characteristics of sample households were analysed. The average family size was six members per household. The average number of family labour involved was two per household. The average age of the sample farmers was 41 years indicating that majority of the farmers in the study area were middle aged, agile and were actively taking part in rice cultivation. The average number of years of schooling was 0.85 years. The education level (number of schooling years) was less than one year, as 74% of the respondents were

illiterate. This high rate of illiteracy may be due to the reason that the majority of the sample farmers were middle aged. 21% of the respondents had 1-5 years of schooling and four per cent had 6-10 years of schooling. Only one per cent of the respondents had more than 10 years of schooling. The average size of the farm was 0.69 ha as almost all the farmers were with small and marginal holdings. In order to have efficiency in crop management it is essential that farmers have experience in raising a particular crop (Onumadu and Osahan, 2014). The selected households had fairly long experience in rice cultivation (22 years).

As a part of the rice intervention package, rice variety, improved *Samba mahsuri* was demonstrated on the field of selected farmers. The average yield obtained in farmers practice was 4.9 t ha⁻¹, whereas, the average yield reported from the rice interventions demonstrated on the farmers field was 5.1 t ha⁻¹. A yield gain of four per cent was obtained with the adoption of rice interventions with improved *Samba mahsuri* variety. As $t_{stat} 1.99 > t_{critical} 0.98$, at 5% level of significance, we reject the null hypothesis. The observed difference between the sample means of yields is convincing enough to say that the average yield of demonstrated rice interventions and the average yield of the farmers practice differ significantly.

The data on various inputs used in both the methods was collected. Cost, returns and profits were compared and contrasted for Rice Interventions (RI) and Farmers Practice (FP). In case of Farmers' practice, the cost of cultivation was Rs.50,089/- per ha, whereas, it was Rs.46,987/- per ha for the sample farmers where rice interventions were made. The net returns were Rs.20,013/- and Rs.14,411/- per ha for farmers with rice intervention and farmers practice, respectively. The benefit- cost ratio for Farmers Practice (FP) and Rice Interventions (RI) were 1.29 and 1.43, respectively. The level of yield gains and difference in yield and production cost for improved and Farmers' Practice, as discussed above, are comparable with results reported by Umesh (2015).

Training on seed production of Improved *Samba mahsuri* was imparted to the sample farmers.

Seed production of Improved *Samba mahsuri* yielded 66.3 tonnes of seed and the smallholder farmers' requirements of seed was met through informal farmer-to-farmer exchange of seed. Yield analysis reveals that 30 to 40 per cent of the potential yield is yet to be tapped with available rice production technologies (Swathi *et al.*, 2006). An attempt has been made to quantify the yield gap. The average yield obtained was 4.9 t ha⁻¹ whereas, the best yield realised was 6.75 t ha⁻¹ with a yield gap of 1.85 t ha⁻¹. The index of the yield gap was 27 per cent. The percentage of the best potential yield realized was 73 per cent.

The major constraints as perceived by the sample farmers were high labour cost, pests and disease incidence and lack of remunerative price. The other constraints were lack of adequate storage facilities, high marketing costs, cheating by middlemen, defective and faulty weighing, and high interest rate charged by the private lenders. In Khammam district, the participation of rural women as agricultural labour is substantial (66.2%) as per census 2011 with a fall in percentage of cultivators from 23.4% during 2001 to 12.02% in 2011. The suggestions of women participants for improving the training program indicated that majority of them preferred onsite village based training to institutional training (86 %), transport arrangements to attend the training (73%), monetary compensation for foregoing their wage while attending training program (61%), suitable timing of training (58%), more practical sessions in field (49%) and use of simple language (41%).

It can be concluded that the average yield of Rice Interventions (RI) and the average yield of the Farmers Practice (FP) differ significantly in case of tribal farmers' fields. The Rice Interventions had a

yield advantage of 1.85 t ha⁻¹, which could be attributed to the rice variety, improved *Samba mahsuri*, training on the package of practices and seed production and parthenium composting. There exists a yield gap of 27 per cent which, if shortened, will result in increase in production. Hence, efforts should be made to disseminate the improved rice varieties and information on good management practices.

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ATTITUDE OF FARMING COMMUNITY TOWARDS AGRICULTURE IN UTTARAKHAND

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India faces a huge challenge of feeding 17.5 per cent world's population with just 2.3 per cent of total land area. This makes agriculture sector imperative and vital for Indian economy and fifty per cent population is dependent on agriculture. At present, the agricultural sector in India is facing several challenges ranging from depleting land and water resources to stiff competition in the international market. One of the prime challenges of agriculture is that whether the new age group belonging to farming families would opt for farming as their future occupation or owing to better opportunities in other professions would leave their family occupation (Adah *et al.*, 2016). Attitude plays a very important role in farming. Attitude can be defined as a positive or negative evaluation of people, objects, event, activities, ideas, or just about anything in your environment (Zimbardo *et al.*, 1999). Generally, attitude portrays either positive or negative views toward a person, place, thing or event. People can also be conflicted or ambivalent towards an object, meaning that they simultaneously possess both positive and negative attitudes toward the item in question (Breckler and Wiggins, 1992). The salient factors that go into the building of the overall attitude of the individual towards an object are a) his/her beliefs about the attributes possessed by the object, b) his/her preference or otherwise for those attributes, and c) the relative importance of each attribute to the individual's decision making process. Measurement implies the process of obtaining information which can be subjected to analysis. Attitude measurement relates to the process of measuring an individual's attitude towards an object. It has been stated that attitudes are affected by attributes and beliefs. This study is therefore, an

attempt to examine the attitude of farmers in the Uttarakhand state towards farming. Present investigation was conducted in the year 2016 and aims at finding the attitude of farmers towards agriculture. A total of 200 farmers from Uttarakhand state were selected for the present study. The farmers were randomly selected and interviewed during Farmer's Fair organized by Govind Ballabh Pant University of Agriculture and Technology (GBPUA&T), Pantnagar. For measuring the attitude of farmers towards agriculture, three-point Likert scale was used. It included 12 attitude statements. Response to each statement was recorded as agree or neutral or disagree. For all the statements scores were assigned as 3,2,1 for agree, neutral, disagree responses, respectively.

Age: Majority (82.50 per cent) of the respondents belonged to middle age group (36-55 age) followed by 53.50 per cent of those who belonged to young category (15-35 age). **Education:** It showed that 30 per cent of the respondents were educated up to intermediate level followed by 29.50 per cent respondents who were educated up to high school level. It was found that 22.50 per cent respondents were educated upto middle school level. Total 15 per cent respondents can read and write. Only 2 per cent of the respondents were educated upto UG level and 1 per cent respondents were educated up to post graduation level. Data regarding education indicates that majority of respondents were having education above middle school level. This is similar to findings from other studies where it was found that majority of the farmers were educated up to intermediate level. (Kumar and Mittal, 2006). **Primary occupation:** All the respondents were engaged in

Attitude of farming community towards agriculture

Table 1. Attitude of farming community towards agriculture N=200

S.No	Score	Category	Frequency	Percentage
1	0-12	Negative	35	17.50
2	13-24	Neutral	10	5.0
3	25 and above	Positive	155	77.50
TOTAL			200	100.00

farming as the main occupation. In addition, 48.50 per cent respondents had business as their secondary occupation and 28.50 per cent were also engaged in agriculture and service sector (28.50) for additional income. **Size of the land holding:** Half of the respondents (50 per cent) of the households had land up to 20 acres followed by 19.50 per cent who had land above 20 acres. Eight per cent households had upto 15 acres land. Only 7.5 percent had land upto five acres. **Irrigation facility:** All the farmers have irrigation facility.

Attitude of farming community towards agriculture

Data regarding attitude of farming community towards agriculture has been presented in the Table 1. Attitude of farming community towards agriculture was divided into three categories viz., positive, neutral, negative. Data reveals that majority (77.5 per cent) of the respondents had positive attitude towards agriculture followed by 17.50 per cent of the respondents who had negative attitude towards agriculture and only 5 per cent respondents had neutral attitude towards agriculture. In India, Uttarakhand is considered as one of the

agriculture state and development of the state is primarily linked to the agriculture and its allied sectors and positive attitude of the farmers might be due to regular profits from agriculture.

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EXTENT OF INFORMATION AND COMMUNICATION TECHNOLOGIES (ICTs) UTILIZATION BY THE AGRICULTURAL OFFICERS IN ANDHRA PRADESH

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Information and Communication Technologies (ICTs) are the technologies used for the widespread transfer and sharing of information. Information and Communication Technologies (ICTs) can help in enabling extension workers to gather, store, retrieve, adapt, localize and disseminate a broad range of information needed by farmers, thus transforming them from extension workers to knowledge workers (Meera *et al.*, 2010). ICTs in agriculture promote and distribute new and existing farming information and knowledge which is communicated within the agricultural sector since information is essential for facilitating agricultural and rural development as well as bringing about social and economic changes (Swanson and Rajalahti, 2010). In the changing scenario of Agriculture in A.P., the role of Agricultural Officer is skill oriented and farmers are expecting a diversified performance from an Agricultural Officer. Hence, there is need for the Agricultural Officer to transform their traditional style of functioning to the digital style of functioning which involves more usage of ICTs in their professional activities. Hence, the study was undertaken with an objective to find out the extent of ICT utilization by the Agricultural Officers in Andhra Pradesh.

Ex-post facto research design was followed to study the extent of ICT utilization by the Agricultural Officers in Andhra Pradesh state. The study(2016-17) was carried out in Nellore, Srikakulam and Ananthapur districts. From each of the selected district, forty Agricultural Officers were selected by following simple random sampling procedure constituting a total of 120 respondents. An index was constructed to measure the extent of ICT utilization by the Agricultural Officers.

The multidimensional aspect of extent of ICT utilization by the Agricultural Officers comprises twelve components *viz.*, tools and peripherals, programs, web browsers, search engines, personal e-mails, apps, file sharing, websites related to agricultural extension, social networking sites, conferencing, short messages services(text messages) and online transactions. All these ICTs were measured through five (5) important criteria *viz.*, awareness, accessibility, knowledge, application proficiency and Duration cum frequency of use. The index score of overall extent of each ICT item as well as each component of ICT utilization by the Agricultural Officers was computed by using the formula:

$$= \frac{\text{Awareness} \times \text{Accessibility} \times \text{Knowledge} \times \text{Application proficiency} \times \text{Duration cum frequency of use}}{5}$$

Awareness was measured on a two point continuum namely 'yes' and 'no' with a scores of 1 and 0, respectively. Accessibility was also measured on a two point continuum namely 'yes' and 'no' with a scores of 1 and 0, respectively. Knowledge was measured on a five point continuum *i.e.* very high, high, medium, less and very less with scores of 5, 4, 3, 2 and 1, respectively. 'Application proficiency' was measured on a five point continuum *viz.*, very high, high, medium, less and very less with scores of 5, 4, 3, 2 and 1, respectively. Duration cum frequency of use :A weightage of '1' was given to each completed year to compute ICT utilization by the Agricultural Officers. Frequency of use was

measured on a five point continuum *viz.*, daily, weekly, monthly, half- yearly, yearly with scores of 5, 4, 3, 2 and 1, respectively. The combined score of the two components was computed for arriving final score of duration cum frequency of use.

Distribution of Agricultural Officers by their overall extent of ICT utilization

The results indicated that nearly half (49.16%) of the Agricultural Officers had moderate extent of ICT utilization followed by low (30.84%) and high (20.00%) extent of ICT utilization. The results are in contrary with the Amar *et al.*, (2011), Shirke and Rahool (2013). The above trend might be due to lack of awareness and accessibility of different ICT tools for the Agricultural Officers. Further, Capacity building on ICTs and time management to handle different extension activities might also have contributed for the degree of variation in ICT utilization among the Agricultural Officers.

Extent of awareness, accessibility, knowledge, application proficiency and duration cum frequency of use of different ICTs

The results revealed that about 87.22 per cent awareness was observed regarding 'Websites related to agricultural extension' followed by 'Tools and Peripherals' (66.00%), 'Search Engines' (49.16%), 'Online Transactions' (41.74%), 'Apps' (36.74%), 'Programs' (32.27%), 'Web Browsers' (31.31%), 'Personal Mails' (27.04%), 'Social Networking Sites' (23.28%), 'File Sharing' (12.88%), 'Short Messages Services' (11.25%), 'Conferencing' (09.72%). Accessibility for 'Websites related to agricultural extension' was about 88.05 per cent followed by 'Tools and Peripherals' (67.83%), 'Search Engines' (50.66%), 'Online Transactions' (41.97%), 'Apps' (36.66%), 'Programs' (32.61%), 'Web Browsers' (31.18%), 'Personal Mails' (26.97%), 'Social Networking Sites' (23.64%), 'File Sharing' (12.75%) and both 'Conferencing' and 'Short Message Services' (10.55%).

Knowledge towards 'Websites related to Agricultural Extension' was about 74.11 per cent

followed by 'Tools and Peripherals' (50.95%), 'Search Engines' (38.60%), 'Online Transactions' (32.78%), 'Apps' (26.93%), 'Programs' (24.58%), 'Web Browsers' (24.34%), 'Personal E-Mails' (21.13%), 'Social Networking Sites' (19.41%), 'File sharing'(08.82%), 'Conferencing' (08.28%) and 'Short Messages Services' (07.27%). Application Proficiency towards 'Websites related to agricultural extension' was about 72.16 per cent followed by 'Tools and Peripherals' (51.67%), 'Search engines' (38.93%), 'Online transactions' (30.83%), 'Apps' (26.68%), 'Programs' (24.66%), 'Web Browsers' (23.76%), 'Personal Mails' (20.63%), 'Social Networking Sites' (18.79%), 'File Sharing' (09.32%), 'Conferencing' (08.26%) and 'Short Messages Services' (07.22%). Duration cum frequency of use of 'Websites related to agricultural extension' was about 72.58 per cent followed by 'Tools and Peripherals' (53.05%), 'Search Engines' (39.03%), 'Online Transactions' (31.15%), 'Apps' (27.60%), 'Web Browsers' (25.23%), 'Programs' (24.77%), 'Personal E-Mails' (21.66%), 'Social Networking Sites' (19.55%), 'File Sharing' (10.25%), 'Conferencing' (08.10%) and 'Short Messages Services' (06.86%).

The overall ICT utilization by the Agricultural Officers revealed that 34.16 per cent awareness on all ICTs was noticed followed by 34.62 % accessibility to all ICTs, 26.69 per cent possession of knowledge, 26.45 % application proficiency and 27.09 per cent duration cum frequency of use on all ICTs. The basic limiting factor for poor utilization of ICT by the Agricultural Officers might be lack of awareness on available ICTs. Having awareness on only one-third of the ICTs depicts poor ICT utilization by the Agricultural Officers. Further, accessibility also showed similar observation. Hence, awareness and accessibility were the twin important factors contributing significantly towards poor utilization of ICTs. Further, the knowledge, application proficiency and duration cum frequency of use on ICTs among the Agricultural Officers might be depending on the awareness and accessibility which were found to be only one-third.

Ranking of different components of ICTs based on index score of extent of ICT utilization

The results showed that 'Websites related to agricultural extension' (10.26%) ranked first followed by 'Tools and Peripherals' (8.69%) and 'Search Engines' (5.72%).

The results depicted that under 'Tools and Peripherals' component, both 'Computer' and 'USB drive' followed by 'Android /Apple's iOS/RIM's Blackberry Mobile' were the top three ICT devices used by the respondents. In case of web browsers, 'Google Chrome' was ranked first followed by 'Internet Explorer' and 'Mozilla Firefox', respectively. 'Microsoft Word', 'Microsoft Excel' and 'Microsoft PowerPoint' were ranked successively first, second and third in the 'programs' component. Regarding personal 'E- mails', 'Gmail', 'Yahoo mail' and 'Rediff mail' were in first, second and third rank that are used by the respondents. In case of social networking sites, 'Whatsapp' was ranked first followed by 'Face book' and 'Twitter'. Webistes such as 'Flipkart', 'Amazon' and 'Snapdeal' were ranked first, second and third for 'online transactions'. Regarding Apps, both 'Google Drive' and 'Google Maps' followed by 'Google Sheets' are ranked successively in the order of first, second and third. 'Websites related to Agricultural Extension' that ranked first, second and third are 'www.apcbportal.ap.gov.in', 'www.agrivap.com' and 'www.apagrisnet.gov.in'. In case of search engines, 'Google' was ranked first followed by 'Yahoo' and 'MSN'. 'Share it', 'Wiki classrooms / Wikipedia' and 'We transfer' were ranked in the order from first to third for the component of file sharing in ICT. 'Yahoo messenger', 'Google hangout/ Google talk' and 'Skype' were ranked in order successively in the 'Conferencing' component of ICT. In the component

of 'Short Messages Services', 'Way2sms' and '160by2' items were ranked first and second by the Agricultural Officers.

In conclusion, there was only 34.00 % of awareness on different ICTs, which is directly affecting the extent of ICT utilization by the Agricultural Officers. Hence, all the Agricultural Officers must be exposed to the different ICT tools as well as latest developments in the digital field. The process will lead to create awareness on ICTs and further application in different activities.

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