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HETEROSIS STUDIES FOR SEED YIELD AND ITS COMPONENTS IN EXPERIMENTAL HYBRIDS BASED ON CMS LINES IN SAFFLOWER (*Carthamus tinctorius* L.)

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ABSTRACT

Thirty safflower hybrids resulting from Line x Tester model involving 2 females and15 males were evaluated during *rabi* 2013-14 to estimate the magnitude of heterosis, heterobeltiosis and standard heterosis over two checks *viz*., AKS 207 and PKV Pink for seed yield and its contributing traits. The highest and significant heterosis to the extent of 63.95 per cent over mid parent and 55.20 per cent over the better parent for number of seeds per capsule was recorded in the cross AKS CMS 3A x GMU 2900 and over the best check it was noted for number of primary branches per plant (37.52 %) in cross AKS CMS 3A x GMU 801.For the trait seed yield per plant, number of capsules per plant, 100 seed weight and number of seeds per capsulethe highest and significant heterosis over the best check was recorded by the cross AKS CMS 3A x GMU 2952(23.27%), AKS CMS 3A x GMU 801(32.97 %), AKS CMS 3A x GMU 3420 (29.89 %) and AKS CMS 3A x AKS 207(25.21%), respectively. The cross combination AKS CMS 3A x GMU 2952 was found to record highest useful heterosis for seed yield per plant, seed volume weight and plant height. Further, a cross AKS CMS 2A x GMU 801 was found better than both the checks for earliness. Out of 30 crosses, AKS CMS 3A x GMU 2952, AKS CMS 3A x GMU 801 and AKS CMS 3A x GMU 3420, found to be better on the basis of mean performance and heterosis response. However, these crosses do not have practical value to be exploited at commercial level due to low level of useful heterosis mainly for oil content, seed yield per plant and seed volume weight. Hence, more number of cross combinations should be evaluated using different male parents to enhance the yield ceiling of safflower through hybrid strategy.

INTRODUCTION

In India, mainly nine oilseed crops *viz*., groundnut, rapeseed-mustard, sesame, sunflower, safflower, niger, castor, linseed and soybean are grown. Among them, safflower has high potential value due to nutritional and pharmaceutical properties of seed oil and petals. Safflower oil is rich in PUFA (Linoleic acid 78%), which plays an important role in reducing blood cholesterol level, has good dyeing property and therefore, used in manufacturing of paints, varnishes and linoleum. Safflower oil contains 55-81% linoleic acid, 7.42 % oleic acid, 1-10 % stearic acid and 1-10 % palmitic acid with 90 % unsaturated and 10 % saturated fatty acids (Anonymous, 2002). Latha and Prakash (1984) reported that the seeds of safflower contain almost 27.5 % oil, 15 % protein, 41% crude fibre and 2.3 % ash. More than 60 countries of the world grow safflower, but over half is produced in India mainly for vegetable oil market (Patil *et al*., 1999). Safflower acreage and production around the world has been witnessing wide fluctuations since last two decades. Hence, there is an urgent need not only to stabilize it but also to enhance the productivity of safflower, which can be achieved by developing high yielding hybrids. Heterosis breeding is an important way for improving crop productivity and quality in order to feed the ever-increasing human population, particularly in developing countries. With the availability of male sterile sources in safflower, exploitation of heterosis on commercial scale has become feasible and economical. Further, cytoplasmic male sterile lines have been developed at Dr.Panjabrao Deshmukh *Krishi Vidyapeeth* (Dr. P.D.K.V.), Akola *viz*., AKS CMS 2A and AKS CMS 3A (Deshmukh *et al*., 2014), which increases the ease in hybrid seed production considerably and hence, it is of great importance to plant breeders for exploitation of heterosis by developing high yielding

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hybrids. Hence, the present study was conducted to identify superior cross combinations (involving CMS lines), which will exhibit good amount of heterosis for seed yield and its component traits.

MATERIAL AND METHODS

Genetically diverse parents were deliberately selected on the basis of their distinguishing characters *i.e*. 2 CMS lines *viz*., AKS CMS 2Aand AKS CMS 3A (developed at Oilseeds Research Unit, Dr. P.D.K.V., Akola) as females and 15 males *viz.,* GMU 3420, GMU 5711, GMU 801, GMU 3715, GMU 5609, GMU 2900, GMU 3164, GMU 3923, GMU 2952, GMU 3638 (collected from Indian Institute of Oilseed Research, Hyderabad), AKS S/41, AKS 207, AKS 322, AKS 325 and AKDOR 1 (developed at Oilseeds Research Unit, Dr. P.D.K.V., Akola). The crosses were produced in line x tester scheme for obtaining F_1 seeds of 30 crosses at Oilseeds Research Unit, Dr. P.D.K.V., Akola during *rabi* 2013-14. Utilising CMS system, only hand pollination using pollens from protected flowers of male parents was done in the protected flowers of CMS based females in the morning hours. The parental seeds were multiplied by selfing. A field trial of 48 genotypes [*i.e*. 17 parents, 30 F_1s and two checks *viz*. PKV Pink and AKS 207 (as parent too)] was conducted with three replications in Randomized Complete block Design during *rabi* 2014-15. Each genotype was planted in a single row of 4 m length with 45 cm spacing between rows and 20 cm within rows. All the cultivation practices were followed as per recommendations for safflower cultivation to raise healthy crop (along with protective irrigation). The observations were recorded on randomly selected five competitive plants per plot per replication in parents, F_1s and checks for plant height at harvest, number of primary branches per plant, number of capsules per plant, number of seeds per capsule, 100 seed weight, seed volume weight and seed yield per plant. Whereas, the observations were recorded on plot basis for days to 50 per cent flowering, days to maturity and oil content. The oil content (%) was determined by using Bench top Pulse Nuclear Magnetic Resonance (NMR) Spectrometer (Model MQC OXFORD). The samples of 5-10 grams size were taken for determination of oil content. Data were subjected to analysis of variance for mean performance (Panse and Sukhatme, 1967) and heterosis over mid parent (MP), better parent (BP) and standard check (SC) was calculated as per the standard procedure of Hays *et al.* (1955) and Turner (1953).

RESULTS AND DISCUSSION

Analysis of variance for parents and their hybrids for different traits revealed significant differences for all the traits suggesting the presence of considerable genetic variation in respect of various traits studied (Table 1). Further, partitioning of genotypic (treatments) variance into components *viz*., parents, crosses and parents v/s crosses revealed that the parents differed among themselves significantly for all the characters. Similarly, crosses also showed significant differences for all the traits except plant height. The mean squares due to parents v/s crosses were significant for all the traits except plant height and seed yield indicating the significant differences between parents and crosses for above traits.

Among the 30 crosses, AKS CMS 3A x GMU 2952 exhibited highest and significant mean performance for seed yield per plant *i.e*. 25.04 g/plant along with highest seed volume weight (644.00g/ 1000 ml) and highest plant height at harvest (93.22 cm) over the best check (PKV Pink). Whereas, cross AKS CMS 2A x GMU 801 was found to be earliest for days to 50 per cent flowering (74.67 days) and days to maturity (144.67 days).For oil content the cross AKS CMS 3A x GMU 3420 (33.02 %) was found to

Table 1. Analysis of variance for various characters in safflower

Sources of variation	d.f.	Mean sum of squares									
		Days to 50% flowering	Days to maturity	Plant height at harvest	Number of primary branches per plant	Number of capsules per plant	Number of seeds per capsule	100 seeds weight	Seed volume weight	Seed yield per plant	Oil content
Replications	2	14.688	7.709	133.846	0.215	12.901	0.186	0.288	601.282	6.096	1.164
Treatments	46	82.724**	31.318**	98.829**	4.236**	29.293**	26.928**	1.717**	6922.711**	19.416**	2.971**
Parents	16	70.686**	28.495**	165.843**	4.644**	31.311**	28.058**	2.051**	4401.103**	11.750**	2.729**
Crosses	29	39.672**	19.717**	63.150	3.790**	27.769**	21.731**	1.469**	8063.493**	24.177**	2.615**
Parents v/s Crosses	1	1523.84**	412.90**	61.319	10.633**	41.181**	159.582**	3.558**	14185.78**	4.033	17.140**
Error	92	5.666	7.441	46.684	1.070	4.553	3.781	0.388	893.786	3.370	1.187

(*, ** Significant at P = 0.05 and P = 0.01 probability level, respectively)

Table 2. Range of heterosis for various traits in safflower

S. No.	Trait	Range of heterosis (%) over		
		Mid parent	Better parent	Standard check^
1	Days to 50 % flowering	-14.08 to 2.68	-10.03 to 3.48	-11.18 to 5.91
2	Days to maturity	-4.84 to 2.66	-3.52 to 4.05	-3.13 to 3.35
3	Plant height at harvest (cm)	-13.21 to 11.47	-15.89 to 2.93	-7.97 to 11.42
4	Number of primary branches / plant	-33.33 to 17.86	-34.89 to 12.52	-22.22 to 37.52
5	Number of capsules / plant	-32.69 to 12.36	-43.40 to 3.30	-19.90 to 46.20
6	Number of seeds / capsule	-12.98 to 63.95	-22.69 to 55.20	-33.54 to 25.21
7	100 seed weight (g)	-37.09 to 42.10	-40.20 to 35.22	-27.77 to 29.89
8	Seed volume weight	-18.32 to 27.39	-19.72 to 25.32	-29.79 to 10.21
9	Seed yield / plant (g)	-28.34 to 20.16	-30.02 to 17.44	-33.10 to 23.27
10	Oil content (%)	-7.81 to 1.57	-10.15 to 1.12	-11.85 to 0.54

^ best check among two (PKV Pink & AKS 207) for trait concerned

be the best one. The cross AKS CMS 3A x GMU 801 was found significantly superior for number of primary branches per plant (11.00) and number of capsules per plant (27.77). Whereas, AKS CMS 2A x AKS 207 was found significantly better for number of seeds per capsule (28.26) and 100 seed weight (6.53g). The similar cases were reported in safflower by Shivani *et al.* (2011).

Considerable amount of useful heterosis in desirable direction was observed for all the traits *i.e.* days to 50 per cent flowering, days to maturity, plant height at harvest, number of primary branches per plant, number of capsules per plant, number of seeds per capsule, 100 seed weight, seed volume weight and seed yield per plant except oil content. Among all the traits, the highest range and magnitude of heterosis over mid parent and better parent was recorded for number of seeds per capsule, whereas, over standard check it was recorded for number of capsules per plant (Table 2).

Earliness in flowering is highly desirable trait for a crop like safflower to fit in various cropping sequences. Hence, the crosses exhibiting heterosis in negative direction are of immense value for earliness (Table 3 and 4). In case of days to 50% flowering, the highest, significant and negative heterosis over mid parent was observed in cross AKS CMS 2A x AKS S/41 (-14.08%); over better parent in cross AKS CMS 2A x GMU 5711 (-10.03%) and over best check(AKS 207) in AKS CMS 2A x GMU 801 (-11.18%). In case of days to maturity, the highest, significant and negative heterosis over mid parent was observed in cross AKS CMS 3A x AKS 322 (-4.84%); over better parent in cross AKS CMS 3A x AKS 3638 (-3.07%), however, it was non-significant but highest over best check in the cross AKS CMS 2A x GMU 801 (-3.13%).None of the crosses showed significant and negative useful heterosis over best check *i.e.* AKS 207 for earliness. Similar results were observed by Jhajharia *et al.* (2013) for days to 50 per cent flowering and days to maturity. The highest magnitude of heterosis over mid parent for plant height at harvest was observed in cross AKS CMS 2A x GMU 3164 (11.47%), whereas, cross AKS CMS 3A x GMU 2952 exhibited highest positive and significant useful heterosis (11.42%) over best check *i.e.* PKV Pink. This is in confirmation with the results observed by Fokmare (2001). In case of number of primary branches and number of capsules per plant the cross AKS CMS 3A x GMU 801 showed highest and positive heterosis over mid parent (17.86% and 12.36%, respectively), better parent (12.52% and 3.30%, respectively) and best check *i.e.* AKS 207 (37.52% and 46.20%, respectively). Similar results were also observed by Shivani *et al.* (2011) for number of capitula per plant.

The highest and positively significant heterosis over mid parent and better parent for number of seeds per capsule was observed in the cross *i.e.* AKS CMS 3A x GMU 2900 (63.95% and 55.20%, respectively). Whereas, only one cross *i.e.* AKS CMS 2A x AKS 207 showed highest, positive and significant standard heterosis over the best check PKV Pink (25.21%). Similar results were observed by Shivani *et al.* (2011) and Sarode *et al.* (2008) for number of seeds per capsule. Among all the crosses, AKS CMS 2A x GMU 3923 (42.10%) exhibited highly significant and positive average heterosis for 100 seed weight, whereas, cross AKS CMS 2A x GMU 3420 (29.89%) showed positive and highly significant standard heterosis over the best check (AKS 207). These results are in line with the results obtained byShivani*et al.* (2011).The highest heterosis and heterobeltiosis in desirable direction were recorded for seed volume weight by the cross AKS CMS 2A x GMU 2900 (27.39% and 25.32%, respectively) and highest magnitude of useful heterosis was noticed in cross AKS CMS 3A x GMU 2952 over both the checks *i.e.* PKV Pink (10.21%)

Table 3. Crosses with maximum heterosis in desirable direction for various traits in safflower

Sr. No.	Trait	Maximum beneficial heterosis (%) over mid parent		Maximum beneficial heterosis (%) over better parent		Maximum beneficial heterosis (%) over standard check^	
		Crosses	H_1	Crosses	H_2	Crosses	H_3
1	Days to 50 % flowering	AKS CMS 2A x AKS S/41	-14.08**	AKS CMS 2A x GMU 5711	-10.03**	AKS CMS 2A x GMU 801	-11.18**
2	Days to maturity	AKS CMS 3A x AKS 322	-4.84**	AKS CMS 3A x AKS 3638	-3.07*	AKS CMS 2A x GMU 801	-3.13
3	Plant height at harvest (cm)	AKS CMS 2A x GMU 3164	11.47*	AKS CMS 2A x GMU 3638	2.93	AKS CMS 3A x GMU 2952	11.42*
4	Number of primary branches/ plant	AKS CMS 3A x GMU 801	17.86*	AKS CMS 3A x GMU 801	12.52	AKS CMS 3A x GMU 801	37.52**
5	Number of capsules/ plant	AKS CMS 3A x GMU 801	12.36	AKS CMS 3A x GMU 801	3.30	AKS CMS 3A x GMU 801	46.20**
6	Number of seeds/ capsule	AKS CMS 3A x GMU 2900	63.95**	AKS CMS 3A x GMU 2900	55.20**	AKS CMS 2A x AKS 207	25.21**
7	100 seed weight (g)	AKS CMS 2A x GMU 3923	42.10**	AKS CMS 2A x GMU 3923	35.22**	AKS CMS 2A x GMU 3420	29.89**
8	Seed volume weight	AKS CMS 2A x GMU 2900	27.39**	AKS CMS 2A x GMU 2900	25.32**	AKS CMS 3A x GMU 2952	10.21
9	Seed yield/ plant (g)	AKS CMS 2A x GMU 2952	20.16**	AKS CMS 3A x GMU 3420	17.46*	AKS CMS 3A x GMU 2952	23.27**
10	Oil content (%)	AKS CMS 3A x GMU 3420	1.57	AKS CMS 3A x GMU 3715	1.12	AKS CMS 3A x GMU 3420	0.54

^best check among two (PKV Pink & AKS 207) for trait concerned
(*, ** Significant at P = 0.05 and P = 0.01 probability level, respectively)

and AKS 207 (31.34%). Whereas, for seed yield per plant,highest and significant relative heterosis in desirable direction was recorded bythe cross AKS CMS 2A x GMU 2952 (20.16%) and standard heterosis over both the checks *i.e.* PKV Pink and AKS 207 by the cross AKS CMS 3A x GMU 2952 *i.e.* 23.27 per centand 27.09 per cent, respectively. The heterosis over mid parent, better parent, and standard check for above traits in safflower was also reported by several workers (Sarode *et al.,* 2008; Shivani *et al.,* 2011 and Jhajharia *et al.*, 2013).AKS CMS 3A x GMU 3420 is the only one cross, which showed highest and positively significant standard heterosis over the check AKS 207 *i.e.* 7.42 % for oil content, however, none of the crosses exhibited significant and positive useful heterosis over the best check (PKV Pink) for oil content. On the contrary, significant standard heterosis was revealed by Fokmare (2001) for oil content, which may be due to difference in the parental material used for investigation.

Considerable heterobeltiosis and standard heterosis observed for seed yield and other associated characters suggested the presence of large amount of genetic diversity among the males and the females and also the uni directional distribution of allelic constitution contributing towards desirable heterosis in the present material. Low and non-significant magnitude of heterosis and heterobeltiosis observed for the character oil content

Table 4. Estimates of heterosis (H_1), heterobeltiosis (H_2) and standard heterosis (H_3) in per cent in some crosses for various traits in safflower

S. No.	Genotype			Days to 50% Flowering	Days to maturity	Plant height at harvest	No. of primary branches /plant	No. of capsules per plant	No. of seeds/ capsule	100 seed weight	Seed volume weight	Seed yield/ plant	Oil content
1	AKS CMS 2A x GMU 3420	H_1		2.68	2.66	1.87	-33.33**	-26.38**	8.48	29.67**	0.41	3.20	-0.26
		H_2		3.48	4.05	0.76	-34.89**	-27.70**	0.70	16.67	-4.00	3.09	-1.75
		H_3	A	-0.74	-0.86	4.91	-15.14	-13.84	-25.12**	51.59**	-9.59*	-2.10	0.28
			B	5.51*	3.35*	12.53*	-22.22*	-5.26	-18.00*	29.89**	7.68	0.93	7.15*
2	AKS CMS 2A x GMU 801	H_1		-11.46**	-2.14	-0.61	1.26	-11.94	33.43**	-4.23	2.87	12.76	-4.22
		H_2		-9.19**	-1.81	-2.71	0.04	-16.08*	32.56**	-11.05	2.30	9.04	-5.00
		H_3	A	-17.04**	-7.07**	1.30	24.28*	0.00	-0.13	7.73	-11.13*	7.52	-5.94*
			B	-11.81**	-3.13	8.66	13.92	9.95	9.36	-7.69	5.85	10.84	0.50
3	AKS CMS 2A x GMU 3923	H_1		-7.07 **	-3.10*	-0.65	-24.47**	-24.34**	-12.98	42.10**	6.93	-5.07	-7.81**
		H_2		-6.17**	-1.57	-7.14	-30.66**	-29.92**	-22.69**	35.22**	2.46	-5.56	-8.53**
		H_3	A	-10.00**	-6.21**	-3.32	3.05	-16.49	-26.01**	40.45**	-11.99**	-13.05	-9.43**
			B	-4.33	-2.23	3.71	-5.54	-8.18	-18.97*	20.34	4.83	-10.35	-3.23
4	AKS CMS 2A x AKS S/41	H_1		-14.08**	-2.52	4.26	-9.52	-19.46**	9.05	26.02**	14.87**	11.05	-0.36
		H_2		-9.27**	0.00	-4.72	-11.62	-22.34**	-2.82	20.11	14.75**	0.00	-3.96
		H_3	A	-12.96**	-4.71**	-0.80	15.14	-7.45	-27.74**	37.66**	-1.43	-7.93	-4.90
			B	-7.48**	-0.67	6.41	5.54	1.75	-20.86*	17.96	17.40**	-5.08	1.61
5	AKS CMS 2A x AKS 207	H_1		-6.82**	0.34	-5.12	-11.71	-14.95*	51.15**	-17.32	15.12**	7.86	-2.30
		H_2		-5.91**	0.67	-10.08	-17.09	-25.02 **	37.12**	-21.87*	13.82**	5.13	-4.97
		H_3	A	-11.48**	-4.07*	-6.37	3.00	-10.64	25.21**	-8.82	-2.23	1.97	-5.91*
			B	-5.91*	0	0.43	-5.59	-1.75	37.12**	-21.87*	16.45**	5.13	0.53
6	AKS CMS 3A x GMU 3420	H_1		-3.61	-1.42	1.07	0.03	-7.87	52.65**	-16.51*	8.02	17.83*	1.57
		H_2		-3.42	-1.32	-2.42	-1.09	-12.82	46.52**	-17.5	2.85	17.46*	-1.50
		H_3	A	-5.93**	-3.64*	6.77	31.88**	12.22	-6.69	7.19	-3.14	12.27	0.54
			B	0.00	0.45	14.53*	20.88*	23.39*	2.18	-8.15	15.36**	15.75*	7.42**
7	AKS CMS 3A x GMU 801	H_1		-4.11*	-2.00	-6.92	17.86*	12.36	28.71**	-28.88**	4.18	4.00	-3.23
		H_2		-0.80	-0.45	-11.05*	12.52	3.30	14.39	-30.49**	3.15	2.45	-3.98
		H_3	A	-9.26**	-5.78**	-2.66	50.02**	32.97**	-13.82	-11.83	-10.39*	1.00	-6.49*
			B	-3.54	-1.79	4.41	37.52**	46.20**	-5.63	-24.45*	6.73	4.13	-0.09
8	AKS CMS 3A x GMU 2900	H_1		-1.82	0.65	-11.45*	-11.81	-12.81	63.95**	-37.09**	-8.14	-8.50	-2.89
		H_2		1.90	-1.53	-15.53**	-23.84**	-26.87**	55.20**	-40.27**	-9.25	-15.64	-3.28
		H_3	A	-0.37	-0.86	-7.57	1.55	-5.86	1.77	-15.70	-22.72**	-19.35*	-7.26**
			B	5.91*	3.35*	-0.85	-6.92	3.51	11.45	-27.77**	-7.95	-16.85*	-0.91
9	AKS CMS 3A x GMU 2952	H_1		-7.84**	-3.08*	3.25	3.74	-0.84	32.43**	-9.99	17.98**	18.65**	-2.13
		H_2		-6.44**	-2.65	1.82	-2.03	-1.66	29.27*	-19.08*	8.36	9.89	-2.19
		H_3	A	-8.52**	-5.78**	11.42*	46.98**	26.59**	-24.28**	28.62*	10.27*	23.27**	-6.21*
			B	-2.76	-1.79	19.51**	34.72**	39.18**	-17.08*	10.21	31.34**	27.09**	0.21
10	AKS CMS 3A x AKS 322	H_1		-10.95**	-4.84**	-13.21**	-17.72*	-32.69**	37.89**	-4.45	2.78	-9.09	-1.41
		H_2		-6.06**	-3.07**	-15.90**	-26.13**	-43.40**	27.37*	-12.21	0.51	-10.87	-3.52
		H_3	A	-8.15**	-5.35**	-7.97	-1.50	-27.15**	-11.96	32.95**	-10.45*	-14.79	-7.49**
			B	-2.36	-1.34	-1.28	-9.71	-19.9	-3.59	13.92	6.66	-12.15	-1.16
	SE(d)	H_1		1.71	2.07	3.97	0.70	1.64	1.41	0.45	22.52	1.34	0.74
		H_2,H_3		1.94	2.23	5.58	0.81	1.89	1.63	0.52	26.00	1.49	0.85
	CD at 5 %	H_1		3.42	4.15	7.95	1.41	3.28	2.82	0.90	45.08	2.68	1.48
		H_2,H_3		3.80	4.37	10.93	1.63	3.79	3.25	1.04	52.05	2.93	1.71
	CD at 1 %	H_1		4.55	5.52	10.57	1.88	4.36	3.75	1.20	59.98	3.56	1.97
		H_2,H_3		4.997	5.74	14.37	2.17	5.04	4.33	1.39	69.26	3.86	2.27

H_1=Heterosis; H_2=Heterobeltiosis; H_3=Standard Heterosis; A= Check PKV Pink; B= Check AKS 207
(*, ** Significant at P = 0.05 and P = 0.01 probability level, respectively)

indicated the narrow genetic base among the males and the females for the trait and also the ambi-directional distribution of allelic constitution contributing towards undesirable heterosis. It may also be due to mutual cancellation of effects of dominant alleles present in the material used for study. Though, above cross combinations have significant magnitude of useful heterosis in desirable direction for most of the traits, however, none of the crosses could record considerably high magnitude of standard heterosis for seed yield and its component traits for use in exploiting hybrid vigour at commercial level. Therefore, further investigation to search best combination in this regard is essential.

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EFFICACY AND ECONOMICS OF CERTAIN INSECTICIDAL MODULES AGAINST POD BORERS IN PIGEONPEA (*Cajanus cajan* (L) Millsp.)

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ABSTRACT

Ravages by lepidopteran pod borers during flowering and pod formation stage and podfly during pod formation stage is the major bottleneck in attainment of desired productivity levels of pigeonpea. Present study conducted during *Kharif*, 2011-12 was framed to device cost effective and farmer friendly module for the management of pod borer complex in pigeonpea. Evaluation of eight modules along with a control revealed superiority of the module 5 (Flubendiamide 480 SC 2.0 ml/ 10 L at 50% flowering stage - chlorantraniliprole 20 SC 3.0 ml/ 10L at 20 days after 1st spray), followed by module 7 (Spinosad 3.0 ml/10 L at 50% flowering stage -Flubendiamide 2.0 ml/ 10 L at 20 days after 1st spray) and module 6 (chlorantraniliprole 20 SC 3.0 ml/ 10L at 50% flowering stage – Spinosad @ 3.0 ml/10 L at 20 days after 1st spray), which registered lower pod damage due to different pod borers with highest monetary returns of Rs.9012, 7192 and 7764 /ha, respectively. However, highest incremental cost- benefit ratio of 1: 2.3 was obtained with module 5, followed by module 7 (1:1.8) and module 6 (1:1.7).

INTRODUCTION

One of the major limiting factors in pulses production is the pest complex, which inflicts heavy yield loss (Durairaj *et al.,* 2009). More than 300 insect pests are reported on pigeonpea and extent of damage caused by insect pests varies from 30 to 80 per cent (Sharma *et al.,* 2010). Out of these, *Helicoverpa armigera* (Hubner), *Maruca vitrata* (Geyer) and podfly (*Melanagromyza obtusa* Malloch) are important constraints in attainment of desired production and productivity of pigeonpea (Sharma *et al*., 2008). The pod borer complex comprising of lepidopteran pod borers (*H. armigera* and legume pod borer, *M. vitrata*) and pod fly (*M. obtusa*) targeting reproductive parts are the key pests inflicting damage upto 60 per cent (Patil *et al.,* 1990). Though lot of research has been done on many aspects of pod borer complex including host range, ecology, biology, biological control and chemical control, limited efforts have been made to manage this pest with a well defined integrated approach.Current pest management strategy emphasizes on application of insecticides on the basis of attainment of economic threshold level, which is seldom recorded by farmers. Hence, present study was framed to evaluate the efficacy of insecticide modules to manage the pod borer complex with a calendar based application approach, which will be convenient to resource poor farmers and can go as a widely accepted component of integrated pest management.

MATERIAL AND METHODS

The present study was carried out at Regional Agricultural Research Station, Lam, Guntur during *Kharif* 2011-12. Eight calendar based application of insecticide modules along with an untreated control were evaluated with ICPL 85063 as test variety under rainfed condition (Table 1). Each treatment had a net plot area of 36 m^2 and was replicated thrice in completely randomized block design. Schedule of calendar based application of insecticides was decided considering higher incidence of pod borers during flowering and pod formation stage (Patil *et al.,* 1990; Deshmukh *et al*., 2003). Calendar based application of modules comprised of two to four applications of insecticides at different periods commencing from 50 per cent flowering (Table 1). Twenty- five inflorescences (30 cm length) were selected at random in each plot from the middle two rows for the observations on per cent inflorescence damage due to *M. vitrata*. To assess the degree of infestation, data on five randomly selected plants per replication were recorded for the following parameters.

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Table 1. Efficacy of different insecticidal modules in the management of pod borers in pigeonpea

Module No.	Treatment Details	Per cent inflorescence damage	Reduction over Control (%)	Per cent pod damage due to *M. vitrata*	Reduction over Control (%)	Per cent pod damage due to *H. armigera*	Reduction over Control (%)	Per cent pod damage due to *M. obtusa*	Reduction over control
M1	1. Azadirachtin 10000 ppm 1 ml/L at 50% flowering stage 2. Chlorpyriphos 2.5 ml/L at 10 days after 1st spray 3. Novaluron 1 ml/L at 10 days after 2nd spray 4. Dimethoate 2 ml/L at 10 days after 3rd spray	24.1 (29.4)	34.5	10.2 (18.6)	47.2	11.4 (19.7)	32.1	12.3 (20.5)	39.4
M2	1. Monocrotophos 1.6 ml/L at 50% flowering stage 2. Novaluron 1 ml/L at 10 days after 1st spray 3. Indoxacarb 1 ml/L at 10 days after 2nd spray 4. Profenophos 2 ml/L at 10 days after 3rd spray	16.4 (23.9)	55.4	7.2 (15.5)	62.7	9.5 (18.0)	43.5	14.9 (22.7)	26.6
M3	1. Indoxacarb 1 ml/L + DDVP 1 ml/L at 50%flowering stage 2. Acetamiprid 0.2 g/L at 10 days after 1st spray 3. Spinosad 0.3 ml/L at 10 days after 2nd spray 4. Emamectin benzoate 0.4 g/L at 10 days after 3rd spray	14.1 (22.1)	61.7	3.3 (10.4)	82.9	4.1 (11.7)	75.6	15.4 (23.1)	24.1
M4	1. Spinosad 0.3 ml/L at 50% flowering stage 2. Flubendiamide 0.2 ml/L at 10 days after 1st spray 3. Chlorantraniliprole 0.3 ml/L at 20 days after 2nd spray	3.2 (10.3)	91.3	0.0 (0.0)	100.0	0.0 (0.0)	100.0	10.7 (19.1)	47.3
M5	1. Flubendiamide 0.2 ml/L at 50% flowering stage 2. Chlorantraniliprole 0.3 ml/L at 20 days after 1st spray	5.2 (13.1)	85.9	0.5 (3.9)	97.4	0.3 (3.2)	98.2	13.3 (21.4)	34.5
M6	1. Chlorantraniliprole 0.3 ml/L at 50% flowering stage 2. Spinosad 0.3 ml/L at 20 days after 1st spray	6.3 (14.5)	82.9	0.7 (5.0)	96.4	0.5 (3.9)	97.0	14.7 (22.6)	27.6
M7	1. Spinosad 0.3 ml/L at 50% flowering stage 2. Flubendiamide 0.2 ml/L at 20 days after 1st spray	7.3 (15.7)	80.2	5.1 (13.1)	73.6	5.5 (13.6)	67.3	12.5 (20.7)	38.4
M8	Untreated control	36.8 (37.4)	--	19.3 (26.1)	--	16.8 (24.2)	--	20.3 (26.8)	--
	C.D at 5%	3.7	--	8.6	--	6.5	--	NS	--
	CV (%)	10.1	--	22.6	--	21.7	--	14.0	--

Figures in parentheses are arcsine percentage transformed values.
NS : Non significant

The pods damaged by gram pod borer, spotted pod borer and podfly were detected respectively by the presence of characteristic larger bore holes, irregular holes with webbed excreta and small hole and gnawed or burrowed pod and shriveled seed in the pod. Such infested and healthy pods were counted separately and per cent pod damage due to different insect pests was arrived. Evaluation of bio-efficacy and economics of insecticide module as a whole for the management of pod borer complex of pigeonpea was based on per cent pod damage due to pod borer complex (pods damaged by pod borer complex/total number of pods from five plants taken randomly at maturity) and net plot yield extrapolated to per hectare. The data was subjected to RBD analysis using AGRES package (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Inflorescence damage due to *M. vitrata* The data revealed that per cent inflorescence damage due to *M. vitrata* was low in module 4 (3.2%) and module 5 (5.2%), followed by module 6 (6.3%) and module 7 (7.3%), whereas, untreated control plot had inflorescence damage of 36.8 per cent. Thus, modules 4 and 5, followed by 6 and 7 respectively with 91.3, 85.9, 82.9 and 80.2 per cent reduction of inflorescence damage over control proved better (Table 1).

Pod damage due to *M. vitrata* The per cent pod damage due to *M. vitrata* was almost negligible in module 4 (0.0), module 5 (0.5) and module 6 (0.7), whereas untreated control plot had pod damage of 19.3 per cent. Thus, modules 4, 5 and 6, respectively recorded 100.0, 97.4 and 96.4 per cent reduction of pod damage over control and proved better (Table 1). The results were in agreement with the findings of Shivaraju *et al.* (2011), Dodia *et al.* (2009), Haritha (2008), Rao *et al.* (2007), Chandrayudu *et al.* (2006) and Mittal and Ujagir (2005) against *Maruca* in different pulse crops by application of flubendiamide 24% + thiacloprid 48% SC, spinosad, chlorantraniliprole, spinosad and indoxacarb, novaluron and spinosad in different concentrations, respectively. Studies conducted at Regional Agricultural Research Station, Lam during 2002 revealed that novaluron @ 75 g a.i. ha^{-1} was found to be very effective in reducing the *M. vitrata* pod damage in blackgram.

Pod damage due to *H. armigera* : The data revealed nil and almost negligible pod damage due to *H. armigera* in module 4 (0.0%), module 5 (0.3%) and module 6 (0.5%), whereas, 16.8 per cent pod damage was observed in untreated control. Thus, modules 4, 5 and 6 respectively recorded 100.0, 98.2 and 97.0 per cent reduction of pod damage over control and proved better (Table 1).

The results were in agreement with the findings of Sharma *et al.* (2011), Chowdary *et al.* (2010), Dodia *et al.* (2009), Srinivasan and Durairaj (2007), Meena *et al.* (2006) and Mittal and Ujagir (2005), respectively with emamectin benzoate, chlorantraniliprole 20 SC, flubendiamide 20 WDG @ 50 g a.i. ha^{-1}, spinosad 45 SC (73g a.i. ha^{-1}), flubendiamide 20 WG @ 50g a.i. $ha^{-1}$and spinosad against *H. armigera* in realizing maximum yield with less pod damage.

Pod damage due to *M. obtusa*: The results showed that all the modules were able to reduce the pod damage due to podfly, *M. obtusa*. However, there was no significant difference between the treatmental modules. The pod damage due to podfly was low due to application of module 4 (10.7%), when compared to untreated control which had 20.3% (Table 1).

The effectiveness of spinosad was reported by Halder *et al.* (2006), Singh and Yadav (2006) and Babariya *et al.* (2010), whereas, Giraddi *et al.* (2002), Singh and Yadav (2006) and Babariya *et al.* (2010) reported that indoxacarb was highly effective which corroborates with the present findings. The results were also in agreement with the findings of Meena *et al.* (2006) who reported that spinosad 45 SC @ 56 g a.i. ha^{-1}, emamectin benzoate 5 WSG @ 11 g a.i/ha and flubendiamide 20 WG @ 50 g a.i. ha^{-1}, respectively with pod damage of 9.7, 10.3 and 11.3% and grain damage of 5.8, 6.0 and 6.8 % proved to be the best treatments. Spinosad 45 SC @ 73 g a.i. ha^{-1} proved to be the best treatment in reducing the podfly damage (5.5%) and getting highest grain yield (1730 kg ha^{-1}) at Pantnagar, Varanasi and S.K. Nagar.

Table 2. Economics of different insecticidal modules in the management of pod borers in pigeonpea

Module No.	Treatment Details	Yield (q/ha)	Increase in yield over control (q/ha)	Per cent increase in yield over control	* Cost of Increased yield (Rs.) [A]	** Plant Protection cost (Rs.) [B]	Net Profit (Rs.) (A-B)	ICBR [A-B] / B
M1	1. Azadirachtin 10000 ppm 1 ml/L at 50% flowering stage 2. Chlorpyriphos 2.5 ml/L at 10 days after 1st spray 3. Novaluron 1 ml/L at 10 days after 2nd spray 4. Dimethoate 2 ml/L at 10 days after 3rd spray	5.6	1.9	51.4	6080	3290	2790	1:0.9
M2	1. Monocrotophos 1.6 ml/L at 50% flowering stage 2. Novaluron 1 ml/L at 10 days after 1st spray 3. Indoxacarb 1 ml/L at 10 days after 2nd spray 4. Profenophos 2 ml/L at 10 days after 3rd spray	6.3	2.6	70.3	8160	5097	3063	1:0.6
M3	1. Indoxacarb 1 ml/L + DDVP 1 ml/L at 50%flowering stage 2. Acetamiprid 0.2 g/L at 10 days after 1st spray 3. Spinosad 0.3 ml/L at 10 days after 2nd spray 4. Emamectin benzoate 0.4 g/L at 10 days after 3rd spray	6.8	3.0	83.8	9696	6824	2872	1:0.4
M4	1. Spinosad 0.3 ml/L at 50% flowering stage 2. Flubendiamide 0.2 ml/L at 10 days after 1st spray 3. Chlorantraniliprole 0.3 ml/L at 20 days after 2nd spray	7.9	4.2	113.5	13344	6352	6992	1:1.1
M5	1. Flubendiamide 0.2 ml/L at 50% flowering stage 2. Chlorantraniliprole 0.3 ml/L at 20 days after 1st spray	7.8	4.1	110.8	12960	3948	9012	1:2.3
M6	1. Chlorantraniliprole 0.3 ml/L at 50% flowering stage 2. Spinosad 0.3 ml/L at 20 days after 1st spray	7.6	3.9	105.4	12416	4652	7764	1:1.7
M7	1. Spinosad 0.3 ml/L at 50% flowering stage 2. Flubendiamide 0.2 ml/L at 20 days after 1st spray	7.3	3.5	97.3	11296	4104	7192	1:1.8
M8	Untreated control	3.7	--	--	--	--	--	--
C.D at 5%		0.78	--	--	--	--	--	--
CV (%)		6.7	--	--	--	--	--	--

Standard spray volume: 500 L of water/ha; *Market price of pigeonpea: Rs. 3200 per quintal (2011-12); 1 q= 100 kg;
** Plant protection cost: Cost of the chemical + labour charges for spraying and Knapsack spray rental charges
ICBR : Incremental Cost Benefit Ratio

Seed Yield and Economics: Highest yield was recorded in application of module 4, module 5, module 6 and module 7 with 7.9, 7.8, 7.6 and 7.3 q ha^{-1} respectively. Thus, modules 4, 5, 6 and 7 respectively recorded 113.5, 110.8, 105.4 and 97.3 per cent increase in yield over control and proved better than the rest of the treatments. Amongst the treatments, lowest yield of 5.6 q ha^{-1} was observed due to application of module 1, which was significantly superior over untreated control (3.7 q ha^{-1}) with 51.4 per cent increase in yield. Similar trend of higher seed yield due to application of emamectin benzoate, spinosad and chlorantraniliprole was reported by Dodia *et al.* (2009). Highest monetary returns were observed in application of module 5, module 6, module 7 and module 4 with Rs. 9012, 7764, 7192 and 6992 per ha, respectively. However, higher incremental cost benefit ratio was observed in module 5, module 7, module 6 and module 4 with ICBR of 1: 2.3, 1: 1.8, 1:1.7 and 1: 1.1, respectively (Table 2).

CONCLUSION

Though the present findings could not be compared on calendar based application of insecticides as a module for want of literature, application of module 5, followed by module 7, module 6 and module 4 were found more effective in terms of lower pod damage translating into higher yield and monetary returns.

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EVALUATION OF NEW FUNGICIDE PRODUCT (CARBENDAZIM 12% + MANCOZEB 63% WG) FOR ITS EFFICACY AGAIST GROUNDNUT DISEASES

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ABSTRACT

The field trial conducted with the new fungicide product (Carbendazim 12% + Mancozeb 63% WG) during the season of July to October, 2012 and 2013 at TNAU indicated that this product (Carbendazim 12%+Mancozeb 63% WG)@ 2.5 g kg^{-1} seed dose can effectively control Tikka leaf spot (early), dry root rot and collar rot diseases of groundnut. This dose was at par with higher dose @ 3 g kg^{-1} seed and resulted in better yield. No phytotoxicity was observed up to the dosage of 6.0 g kg^{-1} seed *i.e.* double of the effective dose.

INTRODUCTION

The cultivated peanut (*Arachis hypogaea* L.*),* the member of the family Fabaceae, is one of the largest leguminous oilseed crops grown in India. Crown rot/seedling blight/collar rot (*Aspergillus niger*) is one of the important soil borne diseases of groundnut affecting the crop at three stages of growth *viz.,* germination, emergence and maturity. Pre emergence rotting occurs when seed are affected immediately after sowing. Post- emergence seedling blight occurs when germinated seed are invaded. Sometimes mature plants may also be attacked causing rapid drying of entire plant. The infection when occurs in adult plants show crown rot symptoms. Large lesions develop on the stem below the soil and spread upwards along the branches causing drooping of leaves and wilting of plant.It is one of the important diseases reported from different parts of country being more severe in *kharif* and *rabi.* Stem rot *Sclerotium rolfsii* Sacc. is a well known polyphagous, ubiquitous, omnivorous and most destructive soil borne fungus. The most susceptible growth stage of groundnut to *S.rolfsii* maximum infection, colonization, disease development and mortality was recorded in 15 days old plants and least, mortality in 105 days old plants. Large number of sclerotial initial were noticed on the mycelial mat. Initially sclerotia exhibited white colour later turn to chocolate brown. Sclerotia were superficial on the affected part, spherical or ellipsoidal and measured 0.5 mm to 2.5 mm in diameter.Non-germinated sclerotia become soft and broke easily. Three foliar fungal diseases, early and late leaf spot and rust are widespread and often occur together causing yield loss up to 50-70% (Khedikar, 2010). The two leaf spots are often referred to in India as “tikka” leaf spot disease. The fungi penetrate leaf cells and withdraw their contents causing the cells to collapse and die, forming spots. These foliar diseases lower yields by reducing the green leaf area available for photosynthesis and by stimulating leaf abscission leading to extensive defoliation. There is no resistant or tolerant variety to these diseases which will suit the agro-climatic conditions of India. As a result, use of fungicides is the only alternative for effective management of these diseases (Joshi, 2010).Couch (1995) distinguishes fungicides by their topical or physical mode of action: a. contact fungicides which stay outside of plants, and b. penetrants which penetrate the plant in some manner. Localized penetrants diffuse into leaf surfaces. Acropetal penetrants are transported by xylem towards the leaf tips after they penetrate (upward movement) but do not move in the phloem towards the root tips. Systemic penetrants are fungicides that are

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transported by both xylem and phloem for the management of major diseases of groundnut. The new formulation of SAAF *i.e.* wettable granules in SAAF 75 WG is a mixture of two fungicides (Carbendazim 12%+ Mancozeb 63% WG), is a curative and protective fungicide with broad spectrum systemic and contact activity in the control of diseases in vegetables and fruits. It is having the property of increased percentage of active ingredient. Water-dispersible granules must be mixed with water to be applied. In water, the granules break apart into fine particles similar to wettable powders. The wettable granules have many advantages in controlling the soil and foliar diseases of groundnut. This combination formulation has been found to give good control of major diseases of groundnut.

MATERIAL AND METHODS

The field trial was conducted during July to October, 2012 and 2013 at Tamil Nadu Agricultural University (TNAU) with eight treatments replicated thrice to evaluate the bio-efficacy of Carbendazim 12% + Mancozeb 63 % WG against major diseases of Groundnut.

To treat the seed, slurry with requisite quantity of test fungicide with 10 ml of water per kg of seed was made and swirled in a closed container to make uniform coating on the seeds. Coated seeds were then shade dried and were sown on the next day. All the standard agronomic practices were followed as per the recommendations of the University. The evaluation of the test fungicide was done along with standard checks and untreated control against the incidences of tikka leaf spot (early leaf spot), collar rot and dry root rot diseases of Groundnut. The observations on germination were recorded on 10th day after sowing. In case of tikka leaf spot disease 15-leaves randomly selected on five Groundnut plants/plot were assessed for scoring the incidence

Table 1. Different treatment for the management of major diseases in groundnut

S.No	Treatments	Dosage (g kg $^{-1}$ of seeds)
1.	Carbendazim 12%+Mancozeb 63 % WG	2.0
2.	Carbendazim 12%+Mancozeb 63 % WG	2.5
3.	Carbendazim 12%+Mancozeb 63 % WG	3.0
4.	Mancozeb 75% WP	2.5
5.	Carbendazim 50% WP	2.0
6.	Tebuconazole 2% DS	1.25
7.	Carboxin 37.5% + Thiram 37.5% DS	3.0
8.	Untreated Control	-

Table 2. Effect of Carbendazim 12%+Mancozeb 63 % WG on seed germination of groundnut 10 days after sowing (season I and II)

S.No	Treatments	Product Dose (g kg^{-1} seed)	Season I		Season II	
			Per cent germination	Per cent increase in germination	Per cent germination	Per cent increase in germination
1.	Carbendazim 12%+Mancozeb 63 % WG	2.0	83.00	2.47	82.33	8.80
2.	Carbendazim 12%+Mancozeb 63 % WG	2.5	93.00	14.81	90.00	18.94
3.	Carbendazim 12%+Mancozeb 63 % WG	3.0	93.33	15.22	91.67	21.14
4.	Mancozeb 75% WP	2.5	84.00	3.70	83.33	10.12
5.	Carbendazim 50% WP	2.0	85.67	5.77	84.33	11.44
6.	Tebuconazole 2% DS	1.25	91.33	12.75	89.00	17.62
7.	Carboxin 37.5% + Thiram 37.5% DS	3.0	92.67	14.41	89.67	18.50
8.	Untreated Control	-	81.00	-	75.67	-
	CD @ 5 %		**5.50**		**4.57**	

Table 3. Effect of Carbendazim 12%+Mancozeb 63 % WGon Early Leaf spot of Groundnut – Season I and II

S. No	Treatments	Product Dose (g kg^{-1} of seeds)	PDI days after Sowing (Season I)			% reduction over control	PDI days after Sowing (season II)			% reduction over control
			30 DAS	45 DAS	60 DAS		30 DAS	45 DAS	60 DAS	
1.	Carbendazim 12% + Mancozeb 63 % WG	2.0	4.00 (11.54)[b]	5.10 (13.05)[b]	5.39 (13.31)[b]	57.39	4.92 (12.79)[b]	5.92 (14.06)[b]	6.83 (15.12)[b]	41.47
2.	Carbendazim 12% + Mancozeb 63 % WG	2.5	1.64 (7.27)[a]	1.69 (7.27)[a]	1.74 (7.49)[a]	86.25	1.38 (6.55)[a]	1.53 (7.03)[a]	2.00 (8.10)[a]	82.86
3.	Carbendazim 12% + Mancozeb 63 % WG	3.0	1.61 (7.27)[a]	1.66 (7.27)[a]	1.70 (7.49)[a]	86.56	1.26 (6.29)[a]	1.38 (6.55)[a]	1.96 (7.92)[a]	83.20
4.	Mancozeb 75% WP	2.5	3.56 (10.78)[b]	5.10 (13.05)[b]	5.31 (13.31)[b]	58.02	4.00 (11.54)[b]	4.90 (12.79)[b]	6.82 (15.12)[b]	41.56
5.	Carbendazim 50% WP	2.0	3.12 (10.14)[b]	4.00 (11.54)[b]	5.20 (13.18)[b]	58.89	3.62 (10.94)[b]	4.16 (11.68)[b]	6.00 (14.18)[b]	48.59
6.	Tebuconazole 2% DS	1.25	2.00 (8.10)[a]	2.20 (8.33)[a]	3.05 (9.97)[a]	75.89	2.00 (8.10)[a]	2.32 (8.72)[a]	3.12 (10.14)[a]	73.26
7.	Carboxin 37.5% + Thiram 37.5% DS	3.0	1.80 (7.71)[a]	2.19[a] (8.33)	2.53 (9.10)[a]	80.00	1.96 (7.92)[a]	2.00 (8.10)[a]	2.99 (9.80)[a]	74.38
8.	Untreated Control	-	8.33 (16.74)[c]	10.67 (19.07)[c]	12.65 (20.85)[c]	-	7.00 (15.34)[c]	10.00 (18.43)[c]	11.67 (19.98)[c]	-
	CD Value (p=0.05)		**1.75**	**1.63**	**2.60**		**1.97**	**2.50**	**2.73**	

Values are means of three replications. Figures in the parentheses represent arcsine transformed values PDI; Percent disease index. The common letters show non- significant differences among the treatments based on DMRT.

of diseases. The observations on leaf spot and soil borne diseases were recorded on 30, 45 and 60th days after sowing. The Person Disease Index and per cent rotting data were suitably transformed into arcsine values, analyzed and presented with DMRT symbols. For phytotoxicity evaluations, the leaves of all the treatments including higher dose treatment of Carbendazim 12%+ Mancozeb 63 % WG@ 6.0 g kg^{-1} seed were visually examined and assessed for any sign or symptoms. The weights of harvested Groundnut pods were summed up for calculating plot-wise total yield and converted into q/ha and statistically analysed.

RESULTS AND DISCUSSION

Effect of seed treatment on seed germination

Seed treatment with different chemicals indicated significant improvement in seed germination as compared to untreated plots. Maximum germination (93.33%) was recorded in plots treated with Carbendazim 12%+Mancozeb 63% WG@ 3.0 g kg^{-1} seed which was at par with Carbendazim 12%+Mancozeb 63% WG@ 2.5 g kg^{-1} seed (93.00%), Carboxin 37.5% + Thiram 37.5% DS @ 3.0 g kg^{-1} seed (92.67%) and Tebuconazole 2% DS @ 1.25 g kg^{-1} seed (91.33%). Germination count in these treatments was significantly superior to rest of the treatments indicating 12.75 to 15.22% increase over control. Carbendazim 50% WP @ 2.0 g kg^{-1} seed was the next treatment in order of superiority (85.67%) insignificantly followed by Mancozeb 75% WP @ 2.5g kg^{-1}seed (84.00%) and Carbendazim 12%+Mancozeb 63 % WG@ 2.0 g kg^{-1} seed (83.00%). Untreated plots recorded 81.00 % germination (Table 2).

Effect on early leaf spot of groundnut *(Cercospora arachidicola)*

All the treatments were effective in comparision to untreated control. However, seed treatment of Carbendazim 12%+Mancozeb 63 % WG@ 3.0 g kg^{-1} seed provided the maximum control (PDI 1.66) of the early leaf spot disease at 45 days after sowing (Table 3)which was on par with Carbendazim 12%+Mancozeb 63 % WG at the rate of 2.5 g kg^{-1} of seed (PDI 1.69), Carboxin 37.5% + Thiram 37.5% @3.0 g kg^{-1} seed (PDI 2.19) and Tebuconazole 2% DS @ 1.25 g kg^{-1} seed (PDI 2.20) Carbendazim is suitable for suppression of initial inoculum while Zineb and Chlorothalonil will control latent infections (Noriega-Cantu *et al.*, 2000).

Effect on dry root rot of groundnut *(Scelrotium rolfsii)*

Data obtained from seed treatment of Carbendazim 12%+Mancozeb 63 % WG@ 3.0 g kg^{-1} seed at 45 DAS provided the maximum control (2.67 % rotting) of the dry root rot disease(Table 4) which was on par with Carbendazim 12%+ Mancozeb 63 % WG @ 2.5 g kg^{-1} seed (3.00% rotting), Carboxin 37.5% + Thiram 37.5% @3.0 g kg^{-1} seed (3.67 % rotting) and Tebuconazole 2% DS @ 1.25 g kg^{-1} of seed (3.67% rotting). These treatments were found statistically superior. Carbendazim 12% + mancozeb 63%, mixture of systemic and non systemic fungicide, even, applied once in different treatments and spray timings varied from 30 DAS to 80 DAS at 10 days interval reduced the percent disease index in all treatments.(Chandra, 1992) The diseases, early and late leaf spot are endemic diseases in rainy season causing 90% defoliation. Besides causing quantitative losses, these diseases are responsible for reduction in protein content and oil recovery (Gupta *et al.*, 1987). Few systemic and non systemic fungicides have been recommended to manage these diseases in the Tunga Bhadra and Upper Krishna Project canals in North Eastern Karnataka (Adiver *et al.*, 1995: Jadeja *et al.*, 1999. Gururaj Sunkad *et al.*, 2005). However, the continuous use of same class

Table 4. Effect of Carbendazim 12%+Mancozeb 63 % WG on dry root rot of groundnut season I and II

S.No	Treatments	Product dose g kg^{-1} seed)	Plant rotting (%)-Season I			Percent reduction over control	Plant rotting (%)- Season II			Percent reduction over control
			30 DAS	45 DAS	60 DAS		30 DAS	45 DAS	60 DAS	
1.	Carbendazim 12%+Mancozeb 63 % WG	2.0	5.67 (13.78)[b]	7.00 (15.34)[b]	8.00 (16.43)[b]	42.86	13.67 (21.70)[b]	15.33 (23.05)[b]	16.67 (24.10)[b]	53.69
2	Carbendazim 12%+Mancozeb 63 % WG	2.5	2.33 (8.78)[a]	3.00 (9.97)[a]	3.67 (11.04)[a]	73.79	4.67 (12.60)[a]	5.33 (13.35)[a]	6.67 (14.97)[a]	81.47
3	Carbendazim 12%+Mancozeb 63 % WG	3.0	2.33 (8.78)[a]	2.67 (9.40)[a]	3.33 (10.51)[a]	76.21	4.33 (11.97)[a]	5.00 (12.92)[a]	6.00 (14.18)[a]	83.33
4	Mancozeb 75% WP	2.5	5.33 (13.35)[b]	6.67 (14.97)[b]	7.67 (16.08)[b]	45.21	13.33 (21.41)[b]	14.00 (21.97)[b]	15.33 (23.05)[b]	57.42
5	Carbendazim 50% WP	2.0	5.00 (12.92)[b]	6.00 (14.18)[b]	7.33 (15.71)[b]	47.64	12.67 (20.85)[b]	13.33 (21.41)[b]	14.67 (22.52)[b]	59.25
6	Tebuconazole 2% DS	1.25	3.33 (10.51)[a]	3.67 (11.04)[a]	4.33 (12.01)[a]	69.07	5.67 (13.78)[a]	6.00 (14.18)[a]	7.33 (15.71)[a]	79.64
7	Carboxin 37.5% + Thiram 37.5% DS	3.0	3.00 (9.97)[a]	3.67 (11.04)[a]	4.00 (11.54)[a]	71.43	5.33 (13.35)[a]	5.67 (13.78)[a]	6.67 (14.97)[a]	81.47
	Untreated Control	-	7.00 (15.34)[c]	11.67 (19.98)[c]	14.00 (21.97)[c]	-	21.33 (27.51)[c]	30.00 (33.21)[c]	36.00 (36.87)[c]	-
	CD @ 5 %		**1.81**	**1.75**	**2.01**		**2.45**	**2.80**	**2.98**	

Table 5. Effect of Carbendazim 12%+Mancozeb 63 % WG on collar rot of groundnut – Season I and II

S.No	Treatments	Product Dose (g $kg^{-1}$of seeds)	Plant rotting (%) Season I			Percent reduction over control	Plant rotting (%)- Season II			Percent reduction over control
			30 DAS	45 DAS	60 DAS		30 DAS	45 DAS	60 DAS	
1.	Carbendazim 12%+Mancozeb 63 % WG	2.0	4.33 (12.01)^{b}	6.00 (14.18)^{b}	7.67 (16.08)^{b}	52.06	14.00 (21.97)^{b}	15.33 (23.05)^{b}	18.00 (25.10)^{b}	53.45
2.	Carbendazim 12%+Mancozeb 63 % WG	2.5	1.33 (6.62)^{a}	1.67 (7.43)^{a}	2.00 (8.13)^{a}	87.50	4.67 (12.48)^{a}	5.33 (13.35)^{a}	7.33 (15.71)^{a}	81.04
3.	Carbendazim 12%+Mancozeb 63 % WG	3.0	0.67 (4.70)^{a}	1.33 (6.62)^{a}	1.67 (7.43)^{a}	89.56	4.00 (11.54)^{a}	5.00 (12.92)^{a}	6.67 (14.97)^{a}	82.75
4.	Mancozeb 75% WP	2.5	4.00 (11.54)^{b}	5.67 (13.78)^{b}	7.33 (15.71)^{b}	54.19	12.00 (20.27)^{b}	13.33 (21.41)^{b}	16.00 (23.58)^{b}	58.62
5.	Carbendazim 50% WP	2.0	3.67 (11.04)^{b}	5.33 (13.35)^{b}	6.67 (14.97)^{b}	58.31	11.33 (19.67)^{b}	12.67 (20.25)^{b}	15.33 (23.05)^{b}	60.36
6.	Tebuconazole 2% DS	1.25	1.67 (7.43)^{a}	2.33 (8.78)^{a}	3.00 (9.97)^{a}	81.25	6.00 (14.18)^{a}	6.67 (14.97)^{a}	8.67 (17.12)^{a}	77.58
7.	Carboxin 37.5% + Thiram 37.5% DS	3.0	1.67 (7.43)^{a}	2.00 (8.13)^{a}	2.67 (9.40))^{a}	83.31	5.33 (13.35)^{a}	6.00 (14.18)^{a}	8.00 (16.43)^{a}	79.31
8.	Untreated Control	-	7.33 (15.71)^{c}	12.00 (20.27)^{c}	16.00 (23.58)^{c}	-	24.67 (29.78)^{c}	32.00 (34.45)^{c}	38.67 (38.45)^{c}	-
	CD @ 5 %		**2.85**	**2.30**	**2.70**		**2.81**	**2.95**	**2.87**	

of fungicides for the management of diseases has lead to development of pathogen resistance against the fungicides. Hence, evaluation of new combi-fungicide molecules and other methods should be taken up to check the sudden epidemic of the disease.

Effect on collar rot of groundnut

(Aspergillus niger)

Minimum plant rotting due to collar rot was obtained from seed treatment of Carbendazim 12%+Mancozeb 63% WG@ 3.0 g kg^{-1} seed (1.33% rotting) which was on par with Carbendazim 12% + Mancozeb 63% WG @ 2.5 g kg^{-1} seed (1.67% rotting), Carboxin 37.5% + Thiram 37.5% @ 3.0 g kg^{-1} seed (2.0 % rotting) and Tebuconazole 2% DS @ 1.25 g kg^{-1} seed (2.33% rotting). These seed treatments proved statistically superior over rest of the chemicals (Table 5). Disease management techniques/practices rather than control measures are adopted to address this disease problem properly. Improving levels of host plant resistance along with foliar application of fungicides to manage the disease in locally adapted varieties would substantially increase peanut yields in developing countries (Waliyar *et al*., 1998). At the moment there are only a few varieties possessing tolerance to foliar diseases. However, one to two sprays depending upon the suitable time of application increase the pod yield significantly (Waliyar *et al*., 1998). Fungicide application on different varieties with different levels of resistance improved yield and biomass production about two fold when compared with non-treated plots of same varieties (Pande *et al*., 1998). In long duration varieties such as 28-206 and 47-16, it is better to apply fungicides at later stages of growth. Both of these lines produced 3.16 and 2.94 t ha^{-1} pod yield when fungicide was applied at 70 DAS (Days after sowing) (Waliyar, 1998).The systemic fungicides used to test their efficacy against *A.niger* were carbendazim, propiconazole,tebuconazole and hexaconazole and the non- systemic fungicides used were mancozeb and captan at four concentrations *viz*., 0.10,0.15,0.20 and 0.25 controlled the growth of fungus by recording lower PDI. A single spray of Carbendazim 12 %+ Mancozeb 63% applied once in different treatments and spray timings varied from 30 DAS to 80 DAS at 10 days intervals reduced the percent disease incidence in all treatments. The sprays conducted up to 50 DAS produced significantly more yield than later applications (Chandra *et al*., 1998).

Phytotoxicity

Carbendazim 12% + Mancozeb 63% WG at treatments at 2.0, 2.5, 3.0 and 6.0 g kg^{-1} seed doses were assessed for the phyto-toxicity along with standard checks. The observation on different parameters revealed that all the doses of Carbendazim 12% + Mancozeb 63% WG didn't show any phytotoxicity sign or symptoms in comparision to other treatments. The crop stand and the crop growth were normal at every stage of observation (5, 10, 15, 20, 30 and 45 days after crop germination) (Table 6).

Yield

Carbendazim 12% + Mancozeb 63 % WG at the rate of 3.0 g kg^{-1} seed dose treatment recorded

Table 6. Effect of Carbendazim 12% + Mancozeb 63% WP – phytotoxicity observation on groundnut – Season I & II

S.No.	Treatments	After 5 days of crop germination							
		Product Dose (g/kg^{-1} of seeds)	Leaf tip/surface injury	Wilting	Vein clearing	Necrosis	Epinasty	Hyponasty	Fruit injury
1.	Carbendazim 12% + Mancozeb 63% WG	2.0	1	Nil	Nil	Nil	Nil	Nil	Nil
2.	Carbendazim 12% + Mancozeb 63% WG	2.5	1	Nil	Nil	Nil	Nil	Nil	Nil
3.	Carbendazim 12% + Mancozeb 63% WG	3.0	1	Nil	Nil	Nil	Nil	Nil	Nil
4.	Mancozeb 75% WP	2.5	1	Nil	Nil	Nil	Nil	Nil	Nil
5.	Carbendazim50% WP	2.0	1	Nil	Nil	Nil	Nil	Nil	Nil
6.	Tebuconazole 2% DS	1.25	1	Nil	Nil	Nil	Nil	Nil	Nil
7.	Carboxin 37.5% + Thiram 37.5% DS	3.0	1	Nil	Nil	Nil	Nil	Nil	Nil
8.	Carbendazim 12% + Mancozeb 63% WP	6.0	1	Nil	Nil	Nil	Nil	Nil	Nil
Untreated control		-	1	Nil	Nil	Nil	Nil	Nil	Nil

Note:
*; Leaf injury considered on visual rating from 1-10 such as, 1= 0-10 %, 2 = 11 – 20 %, 3 = 21-30 %, 4= 31-40 %, 5 = 41 – 50 %, 6 = 51 – 60 %, 7 = 61 – 70 %, 8 = 71 – 80 %, 9 = 81 – 90 % and 10 = 91 – 100%.
Values are mean of three replications recorded 5 days after crop germination

the maximum yield of 11.12 q ha^{-1} which was on par with the spray treatment of Carbendazim 12% + Mancozeb 63 % WG@ 2.5 g kg^{-1} seed dose (11.00 q ha^{-1}), Carboxin 37.5% + Thiram 37.5% DS @ 3.0 g kg^{-1} seed (10.46 q ha^{-1}) and Tebuconazole 2% DS @ 1.25 g kg^{-1} seed (10.0 q ha^{-1}) (Table 7). In fungicide applications number and time of sprays are very significant. In long duration varieties spray time is more important as the yield obtained from fungicide application at 70 DAS (3.16 and 2.94 t ha^{-1} pod) is higher than yield from 40 DAS. (2.38 and 2.22 t ha^{-1} pod) in long duration varieties such as 28-206 and 47-16 (Waliyar *et al.*, 1998).

CONCLUSION

Three sprays of Carbendazim 12% + Mancozeb 63% (WG) found effective to manage Tikka Leaf spot (early), Dry root rot and Collar rot diseases of Groundnut. No single molecule is more effective against both the diseases at a time. Thus, there is a need to evaluate combination of new molecules that can be effective for the control of two or more diseases under field condition.

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CORRELATION AND PATH COEFFICIENT ANALYSIS IN UPLAND COTTON (G*ossypium hirsutum* L.)

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ABSTRACT

Correlation and path coefficient analysis for yield and yield contributing characters in upland cotton were carried with 55 genotypes (45 F_1s and 10 parents) of cotton for seventeen characters in three locations *i.e.* Regional Agricultural Research Station, Lam, Guntur, Agricultural Research Station, Jangamaheswarapuram and Agricultural Research Station, Darsi, Andhra Pradesh. Analysis of pooled data from three locations showed the character association. The plant height, number of sympodia plant^{-1}, number of bolls plant^{-1}, boll weight, seed index, lint index, micronaire value (10^{-6}g/inch) and lint yield plant^{-1} were found to have significant positive association with seed cotton yield plant^{-1} at both phenotypic and genotypic levels. The path analysis indicated that the number of bolls plant^{-1}, boll weight (g), seed index and lint yield plant^{-1} (g) showed direct positive effects and significant positive correlation with seed cotton yield plant^{-1} (g) revealing that due weightage should be given in selection process with more number of bolls plant^{-1} and more boll weight and there should be economic balance among these traits to get higher seed cotton yield plant^{-1}.

Cotton (*Gossypium hirsutum* L.) is an important commercial crop of India, where it is being grown over an area of 126.55 lakh ha with an annual production of 400 lakh bales (1 bale=170 kgs of lint) with a productivity of 537 kg/ha (AICCIP Annual Report, 2015). Yield is a polygenically inherited character resulting from multiplicative interaction of its contributing characters. It is highly influenced by the environment, hence selection based on yield alone may limit the progress, where as the yield component characters are less complex in inheritance and are influenced by the environment to a lesser extent. Genetic correlation measures the magnitude of cause -effect relationship between various plant characters that determines the component characters on which selection can be made for improvement in yield. Further, path coefficient analysis, which splits the correlation coefficients, provides precise information on the direct and indirect effects in order to perceive the most influencing characters to be utilized as selection criteria in cotton breeding programme. Asha *et al.* (2015) reported that correlation studies indicated plant height, sympodia and bolls/plant, boll weight, bundle strength and fibre elongation recorded significant positive association with seed cotton yield/ plant. Path analysis revealed high positive direct effect of monopodia, sympodia, inter boll distance, boll and lint index on seed cotton yield (Chitti *et al.*, 2014). Both the correlation and path coefficient analysis form a basis for selection and also helps in understanding those yield components affecting yield improvement through the study of their direct and indirect effects.

MATERIAL AND METHODS

The present study was conducted during *kharif*, 2013-14 in randomized block design with 55 genotypes (45 F_1s and 10 parents) with three replications following 120 x 60 cm spacing in three locations *i.e.* Regional Agricultural Research Station, Lam, Guntur; Agricultural Research Station, Jangamaheswarapuram; and Agricultural Research Station, Darsi, Andhra Pradesh. Recommended doses of fertilizers 120 N, 60 P_2O_5 and 40 K_2O kg/ha were applied in split doses. Each plot consisted of three rows of 6 m length and observations were recorded on five randomly selected plants from each genotype per replication for 10 characters *viz.*, plant height (cm),

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Table 1. Analysis of variance over environments (pooled) in cotton during *kharif*, 2013-14

Source	d f	Days to 50% flowering	Plant height (cm)	No. of monopodia plant^{-1}	No. of sympodia plant^{-1}	No. of bolls plant^{-1}	Boll weight (g)	Relative chlorophyll content	Seed index (g)	Lint index (g)
Replications	2	5.39	159.89	0.07	0.97	16.24	0.03	0.05	0.33	0.00
Locations	2	58.44**	27224.59**	5.09**	261.14**	4534.32**	117.56**	0.15**	168.61**	86.68**
Interactions	4	1.28	52.32	0.15*	2.20	6.06	0.04	0.00	0.03	0.05
Overall Sum	8	16.60**	6872.28**	1.36**	66.63**	1140.67**	29.42**	0.05**	42.25**	21.70**
Treatments	54	78.73**	143.57**	0.05	5.50**	39.97**	0.86**	0.02**	12.43**	2.30**
Error	432	1.16	85.24	0.05	2.41	11.78	0.21	0.01	2.58	0.44

Source	d f	Ginning out turn (%)	2.5% span length (mm)	Micronaire value (10^{-6} g/inch)	Bundle strength (g/tex)	Uniformity ratio	Elongation (%)	Seed cotton yield plant^{-1} (g)	Lint yield plant^{-1} (g)
Replications	2	0.64	2.12	0.01	1.76	6.96	0.01	185.30	8.99
Locations	2	157.97**	62.47**	6.26**	0.19	119.09**	0.04	348887.50**	42201.89**
Interactions	4	0.57	2.40	0.06	2.17	0.71	0.02	175.92	30.93
Overall Sum	8	39.93**	17.34**	1.60**	1.57	31.87**	0.05	87356.16**	10568.18**
Treatments	54	23.57**	18.45**	0.93**	7.84**	14.35**	0.11**	2510.85**	331.03**
Error	432	8.25	4.10	0.20	1.70	3.07	0.03	631.96	81.06

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

Note :

Table 2. Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficients for seed yield and yield traits of cotton over three environments (pooled) during *kharif*, 2013-14

Character	Days to 50% flowering	Plant height	No. of monopodia plant^{-1}	No. of sympodia plant^{-1}	No. of bolls plant^{-1}	Boll weight	Relative chlorophyll content	Seed index
Days to 50 % flowering	---	0.0156	0.0432	-0.0037	0.0845	-0.1028	0.0520	-0.0748
Plant height	0.1027*	---	0.1370**	0.3350**	0.1305**	0.0837	-0.0335	0.1263**
No. of monopodia plant^{-1}	-0.6991	-2.3733	---	0.0643	0.0288	-0.0559	-0.0370	-0.0435
No. of sympodia plant^{-1}	-0.0064	1.0346**	3.2397**	---	0.1620**	-0.0031	-0.0850	0.0631
No. of bolls plant^{-1}	0.1884**	0.5280**	1.8031**	0.6804**	---	0.0859	-0.0992	-0.0227
Boll weight	-0.2062	0.3690**	-4.2668	0.2370**	0.3802**	---	-0.0481	0.1766**
Relative chlorophyll content	0.1913**	-0.2866	-2.4301	-0.2935	-0.2698	-0.1654	---	-0.1199
Seed index	-0.1046	0.4821**	0.7074**	0.4296**	0.1310**	0.2714**	-0.3877	---
Lint index	-0.2344	0.4144**	-0.1932	0.3815**	0.1616**	0.1393**	-0.5175	0.8378**
Ginning out turn	-0.1154	-0.0451	-1.9335	-0.0249	0.0904*	-0.3170	-0.0374	-0.4593
2.5% span length	0.2160**	-0.2571	0.4757**	-0.1313	-0.1072	0.0434	0.2856**	-0.0660
Micronaire value	-0.1422	0.3202**	1.8363**	0.3648**	0.4445**	0.0166	-0.4931	0.2960**
Bundle strength	0.3815**	-0.0253	-1.4447	0.0119	0.1753**	0.2140**	0.1883**	0.0222
Uniformity ratio	0.1512**	0.2558**	-0.0639	0.0881*	0.4941**	-0.0263	-0.0946	-0.0689
Elongation	0.2742**	0.2232**	-0.1700	0.2058**	0.7601**	-0.0178	-0.0282	-0.0522
Lint yield plant^{-1}	-0.1265	0.4511**	-1.8649	0.5048**	0.7856**	0.7064**	-0.2509	0.0827
Seed cotton yield plant^{-1} (P)	**-0.0408**	**0.1365****	**-0.0334**	**0.0924***	**0.6508****	**0.7359****	**-0.0956**	**0.1009***
Seed cotton yield plant^{-1} (G)	**-0.0663**	**0.5526****	**-1.7329**	**0.5456****	**0.7995****	**0.8844****	**-0.2247**	**0.2706****

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Character	Lint index	Ginning out turn	2.5% span length	Micronaire value	Bundle strength	Uniformity ratio	Elongation	Lint yield plant^{-1}
Days to 50 % flowering	-0.1414	-0.0461	0.1135*	-0.0676	0.1823**	0.0628	0.1338**	-0.0647
Plant height	0.0863	-0.0417	-0.1055	0.1493**	-0.0673	0.0800	0.0161	0.1024*
No. of monopodia plant^{-1}	-0.0434	-0.0018	-0.0420	0.0313	0.0429	0.0641	0.0584	-0.0352
No. of sympodia plant^{-1}	0.0575	-0.0256	-0.0572	0.2048**	-0.0878	0.1291**	0.0424	0.1071*
No. of bolls plant^{-1}	0.0531	0.0868	-0.1282	0.2404**	-0.0801	0.1280**	0.1370**	0.6484**
Boll weight	0.1269**	-0.0592	0.0340	0.0620	0.0367	-0.1361	-0.1016	0.6080**
Relative chlorophyll content	-0.1288	0.0173	0.1086*	-0.1103	0.1226**	-0.0121	-0.0197	-0.0621
Seed index	0.7235**	-0.4584	0.0446	0.2106**	0.0721	-0.0896	-0.0231	-0.1296
Lint index	---	0.2032**	-0.0735	0.2853**	-0.0596	-0.0111	0.0459	0.1934**
Ginning out turn	0.0370	---	-0.1303	-0.0213	-0.1441	0.0406	0.0702	0.4316**
2.5% span length	-0.2713	-0.2080	---	-0.4027	0.5865**	-0.3734	-0.1023	-0.1443
Micronaire value	0.3447**	-0.1033	-0.6894	---	-0.3188	0.3109**	0.2703**	0.1824**
Bundle strength	-0.1315	-0.1889	0.8655**	-0.5116	---	-0.2632	0.1165**	-0.1185
Uniformity ratio	0.1122*	0.2318**	-0.7888	0.6775**	-0.4296	---	0.2474**	0.0515
Elongation	0.0498	0.1042*	-0.2491	0.4693**	0.2590**	0.6555**	---	0.0397
Lint yield plant^{-1}	0.2443**	0.2091**	-0.2038	0.2481**	0.0559	0.3799**	0.4531**	---
Seed cotton yield plant^{-1} (P)	**0.1104***	**0.0094**	**-0.0258**	**0.1576****	**0.0032**	**-0.0352**	**0.0080**	**0.8297****
Seed cotton yield plant^{-1} (G)	**0.1785****	**-0.1940**	**-0.0401**	**0.2473****	**0.2351****	**0.2465****	**0.3992****	**0.9096****

*significant at 5% level **significant at 1% level

no. of monopodia plant^{-1}, no. of sympodia plant^{-1}, no. of bolls plant^{-1}, boll weight (g), relative chlorophyll content, seed index (g), lint index (g), seed cotton yield plant^{-1} (g) and lint yield plant^{-1} (g). The data on days to 50% flowering, ginning out turn (%), 2.5% span length (mm), micronaire value (10^{-6}g/inch), 0bundle strength (g/tex), uniformity ratio and elongation (%) were recorded on plot basis. The fibre quality parameters were studied at Central Institute for Research on Cotton Technology (CIRCOT), RARS, Lam, Guntur, Andhra Pradesh. The data was statistically analysed to estimate genotypic and phenotypic correlation coefficients (Falconer, 1964) and path coefficient analysis (Dewey and Lu, 1959).

RESULTS AND DISCUSSION

The analysis of variance indicated significant differences among the genotypes for all the characters (Table 1.). Genotypic correlation coefficients in general were higher than phenotypic correlation coefficients (Table 2.). Seed cotton yield per plant was significantly and positively correlated with plant height, no. of sympodia plant^{-1}, no. of bolls plant^{-1}, boll weight, seed index, lint index, micronaire value and lint yield plant^{-1} at phenotypic level, where as with plant height, no. of sympodia plant^{-1}, no. of bolls plant^{-1}, boll weight, seed index, lint index, micronaire value, bundle strength, uniformity ratio, elongation and lint yield plant^{-1} at genotypic level. Similar results were reported by Rajamani *et al.* (2013), Rumesh Ranjan *et al.* (2014) and Santosh Kumar *et al.* (2014).

Significant and positive correlations at both the levels were also observed between component characters themselves like that of days to 50% flowering with 2.5% span length, bundle strength, and elongation % (Muraleedhar, 2005); plant height with no. of sympodia plant^{-1}, no. of bolls plant^{-1}, seed index, micronaire value and lint yield plant^{-1} (Kumari Vinodhana *et al.,* 2013 and Chitti *et al.,* 2014); number of sympodia plant^{-1} with no. of bolls plant^{-1}, micronaire value, uniformity ratio and lint yield plant^{-1} (Rajamani *et al.,* 2013 and Krishna Mohan, 2011); number of bolls plant^{-1} with micronaire value, uniformity ratio, elongation %, and lint yield plant^{-1} (Eswar Rao, 2008); boll weight with seed index, lint index and lint yield plant^{-1} (Kumari Vinodhana *et al.,* 2013 and Santosh Kumar Pujer *et al*., 2014); seed index with lint index and micronaire value (Kumari Vinodhana *et al.,* 2013 and Santosh Kumar Pujar *et al*., 2014); lint index with micronaire value and lint yield plant^{-1} (Rajanna *et al*., 2011 and Rajamani *et al.,* 2013); ginning out turn with lint yield plant^{-1} (Krishna Mohan, 2011); 2.5% span length with bundle strength (Kumari Vinodhana *et al.,* 2013 and Santosh Kumar Pujer *et al.,* 2014); micronaire value with uniformity ratio, elongation %, and lint yield plant^{-1} (Eswar Rao, 2008); bundle strength with elongation % (Rajanna *et al*., 2011); and elongation %, uniformity ratio with elongation % (Krishna Mohan, 2011).

The correlation coefficient estimates mostly indicated inter-relationship of different characters but it did not furnish information on cause and effect. Under such situation path analysis helps the breeder to identify the index of selection. Path coefficient analysis was done in order to study the direct and indirect effects of individual component characters on the dependent variable *i.e*., seed cotton yield plant^{-1}. Study of path coefficients enable the breeders to concentrate on the variables which show high direct effect on seed cotton yield. The genotypic and phenotypic correlation coefficients of seed cotton yield with other yield and fibre quality traits was further partitioned into direct and indirect effects and the results were presented in Table 3 and 4.

The component of residual effect of path analysis in yield and fibre quality traits is 0.0450 at genotypic level and 0.3128 at phenotypic level. The lower residual effect indicated that the characters chosen for path analysis were adequate and

Table 3. Direct and indirect effects (phenotypic) of yield components on seed cotton yield of cotton over three environments (pooled) during *kharif*, 2013-14

Character	Days to 50% flowering	Plant height	No. of monopodia plant^{-1}	No. of sympodia plant^{-1}	No. of bolls plant^{-1}	Boll weight	Relative chlorophyll content	Seed index
Days to 50 % flowering	**-0.0197**	-0.0003	-0.0009	0.0001	-0.0017	0.0020	-0.0010	0.0015
Plant height	0.0002	**0.0112**	0.0015	0.0038	0.0015	0.0009	-0.0004	0.0014
No. of monopodia plant^{-1}	-0.0003	-0.0008	**-0.0061**	-0.0004	-0.0002	0.0003	0.0002	0.0003
No. of sympodia plant^{-1}	0.0000	-0.0033	-0.0006	**-0.0098**	-0.0016	0.0000	0.0008	-0.0006
No. of bolls plant^{-1}	0.0343	0.0529	0.0117	0.0657	**0.4056**	0.0348	-0.0403	-0.0092
Boll weight	-0.0485	0.0395	-0.0264	-0.0015	0.0405	**0.4720**	-0.0227	0.0834
Relative chlorophyll content	-0.0008	0.0005	0.0006	0.0013	0.0016	0.0008	**-0.0156**	0.0019
Seed index	-0.0068	0.0114	-0.0039	0.0057	-0.0021	0.0160	-0.0108	**0.0904**
Lint index	0.0121	-0.0074	0.0037	-0.0049	-0.0045	-0.0109	0.0110	-0.0619
Ginning out turn	0.0040	0.0036	0.0002	0.0022	-0.0074	0.0051	-0.0015	0.0393
2.5% span length	0.0025	-0.0024	-0.0009	-0.0013	-0.0029	0.0008	0.0024	0.0010
Micronaire value	0.0010	-0.0023	-0.0005	-0.0032	-0.0037	-0.0010	0.0017	-0.0033
Bundle strength	0.0035	-0.0013	0.0008	-0.0017	-0.0015	0.0007	0.0024	0.0014
Uniformity ratio	-0.0008	-0.0010	-0.0008	-0.0016	-0.0016	0.0017	0.0002	0.0011
Elongation	0.0012	0.0001	0.0005	0.0004	0.0012	-0.0009	-0.0002	-0.0002
Lint yield plant^{-1}	-0.0227	0.0360	-0.0124	0.0376	0.2277	0.2135	-0.0218	-0.0455
Seed cotton yield plant^{-1}	**-0.0408**	**0.1365**	**-0.0334**	**0.0924**	**0.6508**	**0.7359**	**-0.0956**	**0.1009**

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Character	Days to 50% flowering	Plant height	No. of monopodia plant^{-1}	No. of sympodia plant^{-1}	No. of bolls plant^{-1}	Boll weight	Relative chlorophyll content	Seed index
Days to 50 % flowering	**-0.0704**	-0.0072	0.0492	0.0004	-0.0133	0.0145	-0.0135	0.0074
Plant height	0.0025	**0.0246**	-0.0584	0.0254	0.0130	0.0091	-0.0070	0.0119
No. of monopodia plant^{-1}	0.0002	0.0008	**-0.0003**	-0.0011	-0.0006	0.0014	0.0008	-0.0002
No. of sympodia plant^{-1}	0.0000	0.0029	0.0092	**0.0028**	0.0019	0.0007	-0.0008	0.0012
No. of bolls plant^{-1}	0.0236	0.0661	0.2259	0.0852	**0.1253**	0.0476	-0.0338	0.0164
Boll weight	-0.0678	0.1214	-1.4033	0.0780	0.1250	**0.3289**	-0.0544	0.0892
Relative chlorophyll content	-0.0106	0.0159	0.1346	0.0163	0.0149	0.0092	**-0.0554**	0.0215
Seed index	-0.0666	0.3071	0.4506	0.2736	0.0835	0.1728	-0.2469	**0.6370**
Lint index	0.1430	-0.2529	0.1179	-0.2328	-0.0986	-0.0850	0.3157	-0.5112
Ginning out turn	-0.0087	-0.0034	-0.1461	-0.0019	0.0068	-0.0240	-0.0028	-0.0347
2.5% span length	0.0136	-0.0161	0.0299	-0.0082	-0.0067	0.0027	0.0179	-0.0041
Micronaire value	0.0007	-0.0017	-0.0096	-0.0019	-0.0023	-0.0001	0.0026	-0.0015
Bundle strength	0.0140	-0.0009	-0.0532	0.0004	0.0065	0.0079	0.0069	0.0008
Uniformity ratio	0.0148	0.0250	-0.0063	0.0086	0.0484	-0.0026	-0.0093	-0.0067
Elongation	0.0174	0.0142	-0.0108	0.0131	0.0483	-0.0011	-0.0018	-0.0033
Lint yield plant^{-1}	-0.0720	0.2569	-1.0622	0.2875	0.4474	0.4024	-0.1429	0.0471
Seed cotton yield plant^{-1}	**-0.0663**	**0.5526**	**-1.7329**	**0.5456**	**0.7995**	**0.8844**	**-0.2247**	**0.2706**

Residual effect = 0.3128
Bold and diagonal values indicate direct effects

Table 4. Direct and indirect effects (Genotypic) of yield components on seed cotton yield of cotton over three environments (pooled) during *kharif*, 2013-14

Character	Lint index	Ginning out turn	2.5% span length	Micronaire value	Bundle strength	Uniformity ratio	Elongation	Lint yield plant^{-1}
Days to 50 % flowering	0.0028	0.0009	-0.0022	0.0013	-0.0036	-0.0012	-0.0026	0.0013
Plant height	0.0010	-0.0005	-0.0012	0.0017	-0.0008	0.0009	0.0002	0.0011
No. of monopodia plant^{-1}	0.0003	0.0000	0.0003	-0.0002	-0.0003	-0.0004	-0.0004	0.0002
No. of sympodia plant^{-1}	-0.0006	0.0003	0.0006	-0.0020	0.0009	-0.0013	-0.0004	-0.0011
No. of bolls plant^{-1}	0.0215	0.0352	-0.0520	0.0975	-0.0325	0.0519	0.0556	0.2630
Boll weight	0.0599	-0.0279	0.0160	0.0293	0.0173	-0.0642	-0.0480	0.2870
Relative chlorophyll content	0.0020	-0.0003	-0.0017	0.0017	-0.0019	0.0002	0.0003	0.0010
Seed index	0.0654	-0.0414	0.0040	0.0190	0.0065	-0.0081	-0.0021	-0.0117
Lint index	**-0.0856**	-0.0174	0.0063	-0.0244	0.0051	0.0010	-0.0039	-0.0166
Ginning out turn	-0.0174	**-0.0858**	0.0112	0.0018	0.0124	-0.0035	-0.0060	-0.0370
2.5% span length	-0.0016	-0.0029	**0.0223**	-0.0090	0.0131	-0.0083	-0.0023	-0.0032
Micronaire value	-0.0044	0.0003	0.0062	**-0.0155**	0.0049	-0.0048	-0.0042	-0.0028
Bundle strength	-0.0012	-0.0028	0.0113	-0.0062	**0.0193**	-0.0051	0.0022	-0.0023
Uniformity ratio	0.0001	-0.0005	0.0046	-0.0039	0.0033	**-0.0124**	-0.0031	-0.0006
Elongation	0.0004	0.0006	-0.0009	0.0024	0.0010	0.0022	**0.0088**	0.0003
Lint yield plant^{-1}	0.0679	0.1515	-0.0507	0.0640	-0.0416	0.0181	0.0139	**0.3511**
Seed cotton yield plant^{-1}	**0.1104**	**0.0094**	**-0.0258**	**0.1576**	**0.0032**	**-0.0352**	**0.0080**	**0.8297**

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Character	Lint index	Ginning out turn	2.5% span length	Micronaire value	Bundle strength	Uniformity ratio	Elongation	Lint yield plant^{-1}
Days to 50 % flowering	0.0165	0.0081	-0.0152	0.0100	-0.0269	-0.0106	-0.0193	0.0089
Plant height	0.0102	-0.0011	-0.0063	0.0079	-0.0006	0.0063	0.0055	0.0111
No. of monopodia plant^{-1}	0.0001	0.0006	-0.0002	-0.0006	0.0005	0.0000	0.0001	0.0006
No. of sympodia plant^{-1}	0.0011	-0.0001	-0.0004	0.0010	0.0000	0.0003	0.0006	0.0014
No. of bolls plant^{-1}	0.0202	0.0113	-0.0134	0.0557	0.0220	0.0619	0.0952	0.0984
Boll weight	0.0458	-0.1043	0.0143	0.0055	0.0704	-0.0087	-0.0058	0.2323
Relative chlorophyll content	0.0287	0.0021	-0.0158	0.0273	-0.0104	0.0052	0.0016	0.0139
Seed index	0.5337	-0.2926	-0.0421	0.1885	0.0141	-0.0439	-0.0332	0.0527
Lint index	**-0.6101**	-0.0226	0.1656	-0.2103	0.0802	-0.0685	-0.0304	-0.1491
Ginning out turn	0.0028	**0.0756**	-0.0157	-0.0078	-0.0143	0.0175	0.0079	0.0158
2.5% span length	-0.0170	-0.0131	**0.0628**	-0.0433	0.0543	-0.0495	-0.0156	-0.0128
Micronaire value	-0.0018	0.0005	0.0036	**-0.0052**	0.0027	-0.0035	-0.0025	-0.0013
Bundle strength	-0.0048	-0.0070	0.0319	-0.0188	**0.0368**	-0.0158	0.0095	0.0021
Uniformity ratio	0.0110	0.0227	-0.0772	0.0663	-0.0420	**0.0979**	0.0641	0.0372
Elongation	0.0032	0.0066	-0.0158	0.0298	0.0165	0.0416	**0.0635**	0.0288
Lint yield plant^{-1}	0.1391	0.1191	-0.1161	0.1413	0.0318	0.2164	0.2581	**0.5696**
Seed cotton yield plant^{-1}	**0.1785**	**-0.1940**	**-0.0401**	**0.2473**	**0.2351**	**0.2465**	**0.3992**	**0.9096**

Residual effect = 0.0450

Bold and diagonal values indicate direct effects

appropriate. Path coefficient analysis indicated that plant height, number of sympodia plant^{-1}, number of bolls plant^{-1}, boll weight, seed index and lint yield plant^{-1} had shown direct positive effect on seed cotton yield plant^{-1} at both phenotypic and genotypic levels. These results are in conformity with the findings of Kumari Vinodhana *et al.* (2013) and Rumesh Ranjan *et al.* (2014) and Santosh Kumar Pujer *et al.* (2014).

The indirect positive effect on seed cotton yield plant^{-1} at both phenotypic and genotypic levels by days to 50% flowering with number of bolls plant^{-1}; plant height with number of bolls plant^{-1}, boll weight and lint yield plant^{-1}; number of sympodia plant^{-1} with number of bolls plant^{-1} and lint yield plant^{-1}; number of bolls plant^{-1} with boll weight and lint yield plant^{-1}; boll weight with number of bolls plant^{-1} and lint yield plant^{-1}; seed index with boll weight; lint index with boll weight, seed index and lint yield plant^{-1}; ginning out turn with lint yield plant^{-1}; micronaire value with number of bolls plant^{-1} and lint yield plant^{-1}; uniformity ratio with number of bolls plant^{-1}; elongation % with number of bolls plant^{-1} and lint yield plant^{-1}; lint yield plant^{-1} with number of bolls plant^{-1} and boll weight was observed.

CONCLUSION

Selection for high seed cotton yield seems to be possible through number of bolls plant^{-1}, boll weight and lint yield plant^{-1} as they exerted high positive direct effect as well as had significant and positive association with seed cotton yield plant^{-1}.

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EFFECT OF FORTIFIED MUNICIPAL SOLID WASTE COMPOST ON GROWTH, YIELD AND QUALITY OF *OKRA* (*Abelmoschus esculentus* (L.) Moench)

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ABSTRACT

Municipal solid waste compost was collected from the Municipal Solid Waste Compost (MSWC) Plant located at Vellalore, Coimbatore district was fortified separately with Poultry Manure (PM) (10 %) and Single Super Phosphate (SSP) (50 kg tonne^{-1} of MSWC) to study its effect on growth, yield and quality of *okra*. The experiment conducted during November, 2014 with 12 treatments was laid out in randomized block design and replicated thrice. The experimental soil belongs to Irgur series (*Typic Haplustalf*), loamy sand in texture, non-calcareous, slightly alkaline in reaction with low available nitrogen, high available phosphorus and potassium. The soil is sufficient in iron (3.97 mg kg^{-1}) and manganese (11.3 mg kg^{-1}), deficient in zinc (0.93 mg kg^{-1}) and copper (0.66 mg kg^{-1}) and with traces of heavy metals. The maximum plant height, number of leaves and leaf area at all the three stages *viz.,* vegetative, flowering and at harvest were observed in the treatment 100 % Rec. NPK + FYM @ 25 t ha^{-1} (T_2). Number of fruits per plant, fruit weight per plot and fruit yield per hectare were found highest with the application of 100 % Rec. NPK + FYM @ 25 t ha^{-1} (T_2) (49.0, 259 kg plot^{-1} and 25.9 t ha^{-1}, respectively) followed by 100 % Rec. NPK + Fortified Municipal Solid Waste Compost (FMSWC) with poultry manure 10 % (9:1) @ 5.0 t ha^{-1} (T_8) (48.2, 240 kg plot^{-1} and 24.0 t ha^{-1}).The fruit quality parameters *viz.,* crude protein, crude fibre and ascorbic acid contents were improved by the application of 100 % Rec. NPK + FYM @ 25 t ha^{-1} (T_2).

INTRODUCTION

Solid waste management has always been a serious problem for cities throughout the world including developing countries like India. In certain regions of our country, the free disposal facilities have reached their own capacity and even local governments are confronted with difficult decisions. However, with all of the amenities that modern life brings, they also contribute to produce a large quantity of trash that needs to be taken care of. India generates about 65 million tonnes of municipal solid wastes per annum from cities (Central Pollution Control Board, 2005). The increase is expected to 300 million tonnes per annum by the year 2047. (Manju Rawat *et al*., 2013). The C: N ratio of municipal solid waste is generally 40:1 and hence, composting is being encouraged to narrow down the C: N ratios in many countries and researchers have experienced the benefits of using Municipal Solid Waste Compost (MSWC) in agricultural fields (Rajesh Babu Katiyar *et al.,* 2013). Municipal solid waste compost is very low in nitrogen, phosphorus and potassium and rich in micronutrients and heavy metals (Manohara and Belagali, 2014).Municipal solid waste compost restores soil fertility and increases the organic matter content of the soil (Castaldi *et al.,* 2005). Municipal solid waste compost improved the physical, chemical and biological properties of the soil (Lillenberg *et al.,* 2010). Available macro and micronutrients content were found to be higher in soils applied with fortified municipal solid waste compost (Ayoola and Mankinde, 2009).The soil ammonium nitrogen, nitrate nitrogen, phosphorous and potassium content was found to be high in the plots where the fortified municipal solid waste compost was applied (Kavitha and Subramanian, 2013).

Okra is one of the most popular edible vegetable grown throughout India and in tropical

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regions of the world. Major *okra* producing states in India are Uttar Pradesh, Bihar and Orissa with the total production of 3.34 million metric tonnes and productivity of 9.6 Mt ha^{-1} (National Committee on Plasticulture Applications in Horticulture (NCPAH, 2014). *Okra* fruit is a rich source of protein, thiamine, riboflavin, niacin, vitamin A, C, K, vitamin B6 and folate and low in saturated fat and cholesterol. Growth, yield and quality of *okra* are largely influenced by the application of fertilizers, as it is a short duration vegetable crop.

MATERIAL AND METHODS

The experimental field is situated 20 km away from Coimbatore city. The experimental plot is situated at 10.94^0 N latitude, 76.54^0 E longitude with an elevation of 411 m. Maximum temperature of 36.4^{0}C was recorded in February, 2015 and minimum temperature of 20.0^{0}C was recorded in January, 2015. Maximum rainfall was received in November, 2014 (134 mm) and there was no rainfall in January, 2015. The relative humidity ranged from 61.9 to 94.9 percent (Table 1).

The municipal solid waste compost was fortified with poultry manure and single super phosphate to improve its nutrient contents. The municipal solid waste compost was fortified with poultry manure @ 10 % (90 kg of MSWC + 10 kg of poultry manure) and with single super phosphate @ 50 kg per one tonne of municipal solid waste compost. The fortified compost was heaped under aerobic condition for twenty one days. The characteristics of unfortified and fortified municipal solid waste compost were enumerated in Table 2. The experiment was laid out in RBD with 12 treatments replicated thrice. Treatment consisted of T_1 - Control, T_2 - 100 % Rec. NPK + FYM @ 25 t ha^{-1}, T_3 - 100% Rec. NPK + MSWC @ 2.5 t ha^{-1}, T_4 - 100% Rec. NPK + MSWC @ 5.0 t ha^{-1}, T_5 - 75 % Rec. NPK + FMSWC with Poultry manure 10 % (9:1) @ 2.5 t ha^{-1}, T_6 - 100 % Rec. NPK + FMSWC with poultry manure 10 % (9:1) @ 2.5 t ha^{-1}, T_7 - 75 % Rec. NPK + FMSWC with poultry manure 10 % (9:1) @ 5.0 t ha^{-1}, T_8 - 100 % Rec. NPK + FMSWC with Poultry manure 10 % (9:1) @ 5.0 t ha^{-1}, T_9 - 75 % Rec. NPK + FMSWC with SSP @ 2.5 t ha^{-1},T_{10}- 100 % Rec. NPK + FMSWC with SSP @ 2.5 t ha^{-1},T_{11} -75 % Rec. NPK + FMSWC with SSP @ 5.0 t ha^{-1} and T_{12}- 100 % Rec. NPK + FMSWC with SSP @ 5.0 t ha^{-1}. The recommended dose of manure and fertilizers for *okra* CO BH1 hybrid is 25 t ha^{-1} of FYM, 200:100:100 N, P_2O_5 and K_2O kg ha^{-1} respectively. Urea was applied as basal and split application *viz.,* 50% N as basal and 50% N as top dressing at 30 DAS. 100% P and K were applied as basal. Ridges and furrows were formed at 45 cm apart. The plot size was 8 m x 5 m .The seeds were sown at a spacing of 45 cm x30 cm with the seed rate of 2.5 kg ha^{-1}. Five plants in each plot in each replication were selected randomly and tagged for recording observations on growth, yield and quality parameters. Crude protein content was determined by microkjeldhal's method as recommended by Humphries (1956). From the nitrogen content, the crude protein content was computed by employing the standard multiplication factor of 6.25. Crude fibre and ascorbic acid content of fruits was determined as per the method of A.O.A.C (1975).

RESULTS AND DISCUSSION

Growth parameters

The maximum plant height, number of leaves and leaf area at all the three stages *viz.,* vegetative, flowering and at harvest were observed in the treatment 100 % Rec. NPK + FYM @ 25 t ha^{-1} (T_2). At harvest stage, treatment T_2 registered highest plant height, number of leaves and leaf area with the

Table 1. Mean monthly weather data during the crop growth

Month and year	Temperature (^{0}C)		Relative Humidity (%)		No. of rainy days	Rainfall (mm)
	Min.	Max.	Min.	Max.		
November, 2014	23.8	33.3	74.9	90.4	11	134
December, 2014	21.1	32.3	65.1	94.9	4	28.6
January, 2015	20.0	31.6	64.4	89.9	0	0.0
February, 2015	22.2	36.4	61.9	89.2	6	29.6

Table 2. Characteristics of unfortified and fortified municipal solid waste compost

S.No.	Properties	MSWC		
		Unfortified	Fortified with poultry manure	Fortified with SSP
1	Organic C (g kg^{-1})	160	152	127
2	Nitrogen (%)	0.45	1.15	0.65
3	Phosphorus (%)	0.34	0.96	1.03
4	Potassium (%)	1.08	1.98	1.17
5	Calcium (%)	1.71	2.06	2.01
6	Magnesium (%)	0.70	1.13	1.09
7	Iron (mg kg^{-1})	3217	3651	3230
8	Zinc (mg kg^{-1})	426	482	429
9	Copper (mg kg^{-1})	126	148	127
10	Manganese (mg kg^{-1})	211	287	262
11	Lead (mg kg^{-1})	65.0	61.6	62.9
12	Nickel (mg kg^{-1})	25.0	22.4	23.7
13	Cadmium (mg kg^{-1})	1.66	1.84	2.02

values of 109.5 cm, 34.2 and 270.8 cm^2, respectively, followed by 100 % Rec. NPK + FMSWC with PM 10 % (9:1) @ 5.0 t ha^{-1} (T_8) (102.5 cm, 29.9 and 262.4 cm^2 respectively) (Table 3).

The optimum level of N, P and K might have been supplied to the crop resulting in increased metabolic activity and plant height. The higher leaf area and number of leaves of *okra* was favoured by

Table 3. Effect of fortified municipal solid waste compost on growth parameters in *okra*

Treatments		Plant height (cm)	No. of leaves	Leaf area (cm^2)
T_1	Control	59.5	14.3	161.3
T_2	100 % Rec. NPK + FYM @ 25 t ha^{-1}	109.5	34.2	270.8
T_3	100% Rec. NPK + MSWC @ 2.5 t ha^{-1}	82.8	19.9	221.0
T_4	100% Rec. NPK + MSWC @ 5.0 t ha^{-1}	92.7	22.1	234.3
T_5	75% Rec. NPK + FMSWC with PM 10 % (9:1) @ 2.5 t ha^{-1}	73.7	17.5	184.3
T_6	100 % Rec. NPK + FMSWC with PM 10 % (9:1) @ 2.5 t ha^{-1}	95.8	25.2	242.7
T_7	75 % Rec. NPK + FMSWC with PM 10 % (9:1) @ 5.0 t ha^{-1}	85.4	21.8	229.0
T_8	100 % Rec. NPK + FMSWC with PM 10 % (9:1) @ 5.0 t ha^{-1}	102.5	29.9	262.4
T_9	75 % Rec. NPK + FMSWC with SSP @ 2.5 t ha^{-1}	71.3	16.1	179.6
T_{10}	100 % Rec. NPK + FMSWC with SSP @ 2.5 t ha^{-1}	95.6	24.4	237.6
T_{11}	75 % Rec. NPK + FMSWC with SSP @ 5.0 t ha^{-1}	77.7	19.3	191.2
T_{12}	100 % Rec. NPK + FMSWC with SSP @ 5.0 t ha^{-1}	98.8	27.4	254.2
	SEd	**2.29**	**0.93**	**3.86**
	CD @ 5%	**4.61**	**1.94**	**7.74**

the enriched municipal solid waste compost with poultry manure is an indication that slow release of nutrients is one of the characteristics of organic manures which can be combated by enriching the organic materials with inorganic nutrients. The present findings are in line with the findings of Jarin *et al.* (2013) who also observed that application of 100 per cent RD NPK (100:25:75 kg ha^{-1}) + MSWC @ 5 t ha^{-1} + *Rhizobium* + *Trichoderma* recorded maximum plant height (83.7 cm) in wheat. Application of MSW @ 2000 kg ha^{-1} with NPK @ 300 kg ha^{-1} recorded highest plant height (228 cm) in maize as reported by Onwudiwe *et al.* (2014).

Yield parameters

Number of fruits per plant, fruit weight per plot and fruit yield per hectare were found highest with the application of 100 % Rec. NPK + FYM @ 25 t ha^{-1} (T_2) (49.0, 259 kg $plot^{-1}$ and 25.9 t ha^{-1}, respectively) followed by 100 % Rec. NPK + FMSWC with poultry manure 10 % (9:1) @ 5.0 t ha^{-1} (T_8) (48.2, 240 kg $plot^{-1}$ and 24.0 t ha^{-1} respectively) and lowest was recorded in control as 28.1, 90.3 kg $plot^{-1}$ and 9.03 t ha^{-1} respectively (Table 4).

The highest number of fruits per plant of *okra* might be due to the adequate supply of nitrogen from

Table 4. Effect of fortified municipal solid waste compost on yield in *okra*

Treatments		Fruits per plant	Fruit weight (kg plot^{-1})	Fruit yield (t ha^{-1})
T_1	Control	28.1	90.3	9.03
T_2	100 % Rec. NPK + FYM @ 25 t ha^{-1}	49.0	259	25.9
T_3	100% Rec. NPK + MSWC @ 2.5 t ha^{-1}	38.7	166	16.6
T_4	100% Rec. NPK + MSWC @ 5.0 t ha^{-1}	41.7	186	18.6
T_5	75% Rec. NPK + FMSWC with PM 10 % (9:1) @ 2.5 t ha^{-1}	36.9	152	15.2
T_6	100 % Rec. NPK + FMSWC with PM 10 % (9:1) @ 2.5 t ha^{-1}	42.0	194	19.4
T_7	75 % Rec. NPK + FMSWC with PM 10 % (9:1) @ 5.0 t ha^{-1}	40.2	176	17.6
T_8	100 % Rec. NPK + FMSWC with PM 10 % (9:1) @ 5.0 t ha^{-1}	48.2	240	24.0
T_9	75 % Rec. NPK + FMSWC with SSP @ 2.5 t ha^{-1}	39.0	154	15.4
T_{10}	100 % Rec. NPK + FMSWC with SSP @ 2.5 t ha^{-1}	40.5	183	18.3
T_{11}	75 % Rec. NPK + FMSWC with SSP @ 5.0 t ha^{-1}	38.1	159	15.9
T_{12}	100 % Rec. NPK + FMSWC with SSP @ 5.0 t ha^{-1}	46.3	216	21.6
	SEd	**0.37**	**13.1**	**0.73**
	CD @ 5%	**0.75**	**27.1**	**1.52**

FYM and FMSWC, resulting in a slow rate of mineralization and makes the N available in the longer run than in those treated with chemical fertilizer throughout the crop growing period. The highest fruit weight could be attributed to translocation of more carbohydrates due to application of recommended nutrient levels and increased production of photo assimilates and synthesis of protein and better diversion of these assimilates to the developing ovules. Ravi *et al.* (2009) found that application of 75% RDF (125: 75: 62.5 NPK kg ha^{-1}) + vermicompost @ 4 t ha^{-1} + neem cake @ 1 t ha^{-1} + bio fertilizers @ 10 kg ha^{-1} registered maximum fruit yield of 140.7 q ha^{-1} in *okra*. Application of MSWC @ 40 kg ha^{-1} + 50 % RD NPK (90:45:15 kg ha^{-1}) recorded highest pepper yield of 35.7 t ha^{-1} (Nancy Roe *et al.,* 1997).

Quality parameters

The fruit quality parameters *viz.,* crude protein, crude fibre and ascorbic acid contents were improved by the application of 100 % Rec. NPK + FYM @ 25 t ha^{-1} (T_2) with the values of 16.1 per cent, 8.35% and 16.1 mg 100g^{-1}, respectively, followed by 100 % Rec.

Table 5. Effect of fortified municipal solid waste compost on quality parameters in *okra*

Treatments		Crude protein (%)	Crude fibre (%)	Ascorbic acid (mg $100g^{-1}$)
T_1	Control	28.1	90.3	9.03
T_2	100 % Rec. NPK + FYM @ 25 t ha^{-1}	49.0	259	25.9
T_3	100% Rec. NPK + MSWC @ 2.5 t ha^{-1}	38.7	166	16.6
T_4	100% Rec. NPK + MSWC @ 5.0 t ha^{-1}	41.7	186	18.6
T_5	75% Rec. NPK + FMSWC with PM 10 % (9:1) @ 2.5 t ha^{-1}	36.9	152	15.2
T_6	100 % Rec. NPK + FMSWC with PM 10 % (9:1) @ 2.5 t ha^{-1}	42.0	194	19.4
T_7	75 % Rec. NPK + FMSWC with PM 10 % (9:1) @ 5.0 t ha^{-1}	40.2	176	17.6
T_8	100 % Rec. NPK + FMSWC with PM 10 % (9:1) @ 5.0 t ha^{-1}	48.2	240	24.0
T_9	75 % Rec. NPK + FMSWC with SSP @ 2.5 t ha^{-1}	39.0	154	15.4
T_{10}	100 % Rec. NPK + FMSWC with SSP @ 2.5 t ha^{-1}	40.5	183	18.3
T_{11}	75 % Rec. NPK + FMSWC with SSP @ 5.0 t ha^{-1}	38.1	159	15.9
T_{12}	100 % Rec. NPK + FMSWC with SSP @ 5.0 t ha^{-1}	46.3	216	21.6
	SEd	0.37	13.1	0.73
	CD @ 5%	0.75	27.1	1.52

NPK + FMSWC with poultry manure 10 % (9:1) @ 5.0 t ha^{-1} (T_8) (15.7 per cent, 8.43 per cent and 16.0 mg $100g^{-1}$, respectively) (Table 5).

The recommended level of nutrients supplied through FYM and FMSWC with inorganic fertilizers would have favoured protein synthesis and its efficient storage in *okra* fruits. The optimum dosage of fertilizer would have caused accumulation of nutrients in plants which in turn resulted in better quality fruits with less crude fibre. The synthesis of ascorbic acid is closely associated with carbohydrate metabolism. Balanced water, nutrients and space would have enriched the individual plant to accumulate more ascorbic acid content in fresh fruits. Thirunavukkarasu *et al.* (2014) proved that application of pressmud @ 5 t ha^{-1} integrated with 50 % RDF (200:100:100 NPK kg ha^{-1}) registered highest crude protein (20.3 %) in *okra*. Suchitra and Manivannan (2012) reported vermicompost @ 5 t ha^{-1} + humic acid @ 0.2 % recorded minimum crude fibre (16.3 per cent) in *okra*. Tripathy and Maity (2009) found that application of 50% RDF (150: 100: 80 NPK kg ha^{-1}) + Biofertilizer + neem cake @ 1.25 t ha^{-1} resulted in increased ascorbic acid content (16.25 mg 100 g^{-1}).

CONCLUSION

From the study, it was concluded that application of 100 % Rec. NPK + FMSWC with poultry manure 10 % (9:1) @ 5.0 t ha^{-1} (T_8) showed an improvement in growth, fruit yield, fruit quality and soil nutrient status. Hence, MSWC fortified with poultry manure 10 % (9:1) can be effectively utilized in place of farm yard manure along with 100 % RD of inorganic fertilizers to obtain maximum fruit yield in *okra*.

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EFFECT OF SEED COATING WITH POLYMERS AND CHEMICALS ON SEED QUALITY DURING STORAGE IN HYBRID COTTON

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ABSTRACT

A laboratory experiment was conducted at Seed Research and Technology centre, Rajendranagar, Hyderabad to study the effect of seed coating with polymers and chemicals on seed quality during storage in hybrid cotton during 2010-11. The results indicated that seeds coated with polykote @ 3ml kg^{-1} of seed along with vitavax 200 showed higher germination percentage (74 and 73) with seeds stored in polythene bag and cloth bag respectively over a period of 12 months storage while untreated seeds recorded 53 and 56 per cent. It also showed enhancement of other parameters like field emergence, seedling length and seedling vigour index than other treatments. The next best treatment for seed quality parameters was polykote @ 3ml kg^{-1} of seed + Imidacloprid @ 6ml kg^{-1} + Thiram 75% WP @ 2.5g kg^{-1}.

INTRODUCTION

Cotton (*Gossypium* spp.) is one of the most important fibre crops of India ranks first both in area and production. Cotton seed loses viability and vigour rapidly in storage as being the poor storer. To maintain the seed quality it should be protect from seed borne pathogens and storage insect pests by polymer coating, fungicide and insecticide treatments.Seed deterioration could be slowed down either by storing the seeds under controlled conditions or by imposing polymer film coating along with seed treatment chemicals. As the controlled condition is highly expensive, seed treatment remains the best alternative approach to maintain the seed quality.

Film coating technology is a sophisticated process of applying precise amount of active ingredients along with a liquid material directly on to the seed surface without obscuring its shape and the total seed weight may increase upto 1 to 2 per cent. It may act as physical barrier, which reduces leaching of inhibitors from seed covering and restricts oxygen movement and thus reducing the respiration of embryo thereby reducing the ageing effect on seeds (Vanangamudi *et al*., 2003). Jitendra Kumar *et al*. (2007) suggested that it is necessary to develop polymer based seed coats that can prevent moisture entry, fungus penetration and insect attack during storage. Polymer coating improves plant stand and emergency of seeds.Hence, the present study was undertaken to know the suitable polymer-chemical combinations in improving the seed quality of hybrid cotton during storage.

MATERIAL AND METHODS

A laboratory study was conducted at Seed Research and Technology Centre, PJTSAU, Hyderabad in 2010 and 2011 to evaluate the seed quality attributes in order to determine the suitable polymer-chemical combinations for better storage of hybrid cotton Cv.US-25. The experiment was designed as Completely Randomized Block Design in factorial concept with six treatments and four replications. The treatments consists of seeds coated with synthetic polymer alone (Polykote @ 3ml kg^{-1} seed) (T_1), T_1+ Imidacloprid @ 6 ml kg^{-1} (T_2), T_1+ Thiram 75% WP @ 2.5g kg^{-1} (T_3), T_1+Thiram 75% WP @ 2.5g kg^{-1} + Imidacloprid @ 6ml kg^{-1}(T_4) and T_1+Vitavax 200 (Polykote TM containing Thiram, Carboxin, dye and filler) @ 2g kg^{-1} seed (T_5) and

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untreated control (T_0). The treated seeds were packed in cloth bags and polythene bags and stored under ambient conditions. Observations on seed germination per cent (Anonymous, 1996), field emergence, seedling length (cm) and vigour index (Abdul Baki and Anderson, 1973) were recorded at bimonthly interval upto 12 months of storage. The statistical analysis was done as described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Among the different treatment combinations, seeds treated with polykote @ 3ml kg^{-1} of seed+ Vitavax 200 improved the seed quality parameters compared to other treatments and maintained significantly superior germination percentage (74.3) in polythene bag and cloth bag (73.0) over a period of 12 months storage followed by seed coated with polykote @ 3ml kg^{-1} of seed + Imidacloprid @ 6ml kg^{-1} + Thiram 75% WP @ 2.5g kg^{-1} by recording the germination percentage of 72.3 and 71.0 stored in polythene bag and cloth bag, respectively. The untreated seeds stored in cloth bag registered lowest germination of 58.0% at the end of storage period (Table-1). These results are in line with the findings of Pham Long Giang and Rame Gowda (2007) who reported that seeds coated by polymer in combination with chemicals and stored in polythene bag showed higher germination percentage. The reduction in germination in cloth bag could be due to more fluctuation in seed moisture content. The higher germination percentage in polymer coated seeds is due to increase in the rate of imbibition where the fine particles in the coating act as moisture attracting material or perhaps to improve germination. Germination percentage gradually decreased with the advancement of storage period. It may be attributed to ageing effect leading to depletion of food reserves and decline in synthetic activity of embryo apart from loss of viability and storage condition.

After 12 months of storage highest field emergence was observed in seeds coated with polykote @ 3ml kg^{-1} of seed along with Vitavax 200, which stored in polythene bag (71.5 %) and cloth bag (69.0%) while untreated seeds showed 56.0 and 53.0% over a period of 12 months when stored in polythene and cloth bag respectively (Table 1). The decline of field emergence was more in untreated seeds compared to treated seeds. Higher field emergence recorded in chemical treated seeds might be due to the protection of seeds by the chemicals and polymers against micro-organism, which in turn help in better establishment of seedling. Muthuraj *et al*. (2002) and Vijayakumar *et al.* (2007) recorded higher field emergence in polycoated seeds and it might be due to increase in the rate of imbibition where the fine particles in the coating act as moisture attracting material which improves seed soil interphase. Hwang and Sung (1991) reported that seed coating with hydrophilic polymer regulates the rate of water uptake, reduce imbibition damage and improve the emergence of soybean seeds.

Significantly higher vigour index was recorded in seeds coated with polykote @ 3ml kg^{-1} of seed + Vitavax 200(1807, 1689) and polykote @ 3ml kg^{-1} of seed +Imidacloprid @ 6ml kg^{-1} +Thiram 75% WP @ 2.5g kg^{-1} seeds and (1674, 1610) stored in polythene bag and cloth bag respectively as compared to control at the end of the storage period (Table 2). Similarly seed treatment with polykote @ 3ml kg^{-1} of seed + Vitavax 200 showed highest seedling length followed by and polykote @ 3ml kg^{-1} of seed + imidacloprid @ 6ml kg^{-1} + thiram 75% WP @ 2.5g kg^{-1} seeds compared to other treatments. Thiram acts as protective agent against seed deterioration due to fungal invasion and physiological ageing as a result of which the seed viability was maintained for comparatively longer period of time (Savitri *et al*. 1998) and also phytotonic effect of imidacloprid

Table1. Influence of containers and seed coating with polymers, chemicals on germination and field emergence during storage of hybrid cotton

Treatment	Germination (%)												Field emergence (%)											
	2 MAS			6 MAS			10 MAS			12 MAS			2 MAS			6 MAS			10 MAS			12 MAS		
	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M
T_0 : Untreated control	76.5	77.3	76.9	71.4	74.6	73.0	65.8	68.2	67.0	58.5	60.8	59.7	74.0	75.0	74.5	68.5	71.0	69.8	60.0	62.0	61.0	53.0	56.0	54.5
T_1: Polykote@ 3ml kg^{-1} of seed	79.3	81.0	80.2	74.0	76.0	75.0	68.0	71.3	69.7	62.0	64.0	63.0	75.5	77.0	76.3	70.0	73.0	71.5	63.0	66.0	64.5	57.0	59.0	58.0
T_2: T_1+ Imidacloprid @ 6ml kg^{-1}	80.0	83.0	81.5	76.3	78.0	77.2	72.3	74.0	73.2	68.0	70.0	69.0	76.0	80.0	78.0	72.0	75.0	73.5	67.0	68.0	67.5	60.0	64.0	62.0
T_3: T_1+ Thiram 75% WP @ 2.5g kg^{-1}	83.3	85.7	84.5	79.0	80.3	79.7	75.0	76.3	75.7	70.0	71.0	70.5	80.0	81.0	80.5	74.0	76.0	75.0	67.0	70.0	68.5	62.0	65.5	63.8
T_4: T_1+ Imidacloprid @ 6ml kg^{-1} + Thiram 75% WP @ 2.5g kg^{-1}	85.0	87.0	86.0	81.0	83.3	82.2	76.0	78.0	77.0	71.0	72.3	71.7	80.0	82.0	81.0	75.5	79.0	77.3	72.0	74.0	73.0	66.0	68.0	67.0
T_5: T_1+Vitavax 200@2g kg^{-1} seed	86.7	88.0	87.4	82.0	84.7	83.4	78.3	79.0	78.7	73.0	74.3	73.7	82.0	84.0	83.0	78.0	80.0	79.0	73.0	76.0	74.5	69.0	71.5	70.3
Mean	81.8	83.7	82.7	77.3	79.5	78.4	72.6	74.5	73.5	67.1	68.7	67.9	77.9	79.8	78.9	73.0	75.7	74.3	67.0	69.3	68.2	61.2	64.0	62.6
CD at 5%																								
C	2.33			2.91			3.02			3.13			3.13			2.57			1.96			2.19		
T	1.34			1.68			1.74			1.81			1.81			1.48			1.13			1.26		
C x T	3.29			4.12			4.27			4.43			4.43			3.64			2.78			3.10		

C: Container T: Treatment M: Mean C_1 : Cloth bag C_2: Polythene bag MAS: Months after storage

Table 2. Influence of containers and seed coating with polymers, chemicals on seedling length and seedling vigour index during storage of hybrid cotton

Treatment	Seedling length (cm)												Seedling vigour index											
	2 MAS			6 MAS			10 MAS			12 MAS			2 MAS			6 MAS			10 MAS			12 MAS		
	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M	C_1	C_2	M
T_0 : Untreated control	22.3	22.4	22.4	19.6	21.2	20.4	18.8	19.3	19.1	16.4	18.7	17.6	1650	1668	1659	1650	1668	1659	1128	1203	1165	866	1050	958
T_1: Polykote@ 3ml kg^{-1} of seed	23.0	22.9	23.0	22.5	22.6	22.6	21.7	22.1	21.9	20.8	21.8	21.3	1732	1814	1773	1732	1814	1773	1478	1576	1527	1292	1394	1343
T_2: T_1+ Imidacloprid @ 6ml kg^{-1}	22.7	24.3	23.5	22.2	22.7	22.5	21.6	22.3	22.0	22.1	22.8	22.5	1820	2016	1918	1820	2016	1918	1559	1653	1606	1504	1594	1549
T_3: T_1+ Thiram 75% WP @ 2.5g kg^{-1}	24.4	25.2	24.8	23.8	24.7	24.3	23.2	23.6	23.4	22.5	23.3	22.9	2036	2162	2099	2036	2162	2099	1742	1801	1771	1576	1658	1617
T_4: T_1+ Imidacloprid @ 6ml/kg + Thiram 75% WP @ 2.5g kg^{-1}	25.3	24.3	24.8	24.7	23.8	24.3	23.8	23.4	23.6	22.7	23.1	22.9	2152	2112	2132	2152	2112	2132	1812	1825	1818	1610	1674	1642
T_5: T_1+Vitavax 200@2g kg^{-1} seed	25.5	26.4	26.0	23.9	25.8	24.9	23.5	24.9	24.2	23.2	24.3	23.8	2208	2324	2266	2208	2324	2266	1842	1972	1907	1689	1807	1748
Mean	23.9	24.3	24.1	22.8	23.5	23.2	22.1	22.6	22.4	21.3	22.3	21.8	1933	2016	1975	1933	2016	1975	1594	1672	1632	1423	1530	1476
CD at 5%																								
C	2.30			1.49			1.66			1.64			194.09			142.78			139.46			118.30		
T	1.32			0.86			0.96			0.94			112.06			82.43			80.52			68.30		
C x T	3.25			2.11			2.35			2.32			274.5			201.9			197.2			167.3		

C: Container T: Treatment M: Mean C_1: Cloth bag C_2: Polythene bag MAS: Months after storage

maintained the seed viability for longer period (Jarande and Dethe, 1994). The decrease in the vigour index, root length and shoot length may be due to natural ageing induced decline in germination, decrease in dry matter accumulation in seedlings and decrease in seedling length. Such findings were reported by Savitri *et al*. (1998) in groundnut. This reduction in quality in terms of viability and vigour might be due to depletion of stored food that lead to starvation of meristematic tissue (Koostra and Harrington, 1969) and decline in synthetic activity at the embryo apart from death of the seeds due to fungi.

CONCLUSION

Hybrid cotton seeds coated with polykote @ 3ml kg^{-1} along with Vitavax 200 and stored in polythene bags improved the seed quality parameters compared to other treatments. It might be due to synergetic effect of both polymers and chemicals have contributed for better germination and vigour and slow down the process of seed deterioration during storage.

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PERFORMANCE OF *RABI* SORGHUM AS INFLUENCED BY PRECEDING LEGUMES, NITROGEN LEVELS AND IRRIGATION SCHEDULES

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ABSTRACT

A field experiment was conducted for two consecutive years during 2012 and 2013 at Indian Institute of Millet Research, Rajendranagar, Hyderabad. The plants attained maximum height (225.6 cm and 217.2 cm), highest dry matter production (8197 and 9151 kg ha^{-1}), grains per panicle (1160 and 1247) and ear head weight (46.3 and 47.1 g) with *in situ* incorporation of dhaincha during 2012 and 2013 followed by irrigation at panicle initiation, boot leaf stage, anthesis and milk stage at harvest, and a high dose of 90 kg ha^{-1} N significantly increased the growth and yield components. The *in situ* incorporation of dhaincha was 2511 and 3024 kg ha^{-1} during both years. Irrigation at four critical phases recorded 2528 kg ha^{-1}during 2012 and 3047 kg ha^{-1} during 2013. Further, 2686 kg ha^{-1} and 3269 kg ha^{-1} during 2012 and 2013, respectively, by the application of N 90 kg ha^{-1}.

INTRODUCTION

Sorghum, the fifth important cereal food crop after corn, rice, wheat and barley on the globe (Fageria *et al*., 2014), is considered as the king of millets and extensively grown both for grain as food, animal feed and stalks as animal fodder. It is the major cereal of rainfed agriculture in the semi-arid tropics. Organic manures and crop residues have been proved to be viable components of nitrogen management, which can supplement and successfully replace costly fertilizer nitrogen. The practice of residue incorporation after the harvest is feasible and economical, where a period of 30 days is available before planting of maize and the practice can contribute to about 50 to 60 kg N ha^{-1} (Kulakarni and Pandey, 1988). As the crop is raised mostly under rainfed condition with the help of stored moisture, the moisture deficit, especially during later stages of crop growth poses a serious threat to the crop consequently the yield levels of *rabi* sorghum are very low. Besides water, fertilizer is also one of the important basic inputs for realizing yield potential of fertilizer responsive high yielding varieties have further increased the demand for important crop nutrients. However, the low yield potential of *rabi* sorghum is attributed mainly due to moisture stress cycles, during the flowering and grain formation stages (Mohiuddin and Yaseen, 1973). Application of one or two supplemental irrigations during such stress cycles gives a manifold increase in the grain yield of *rabi* sorghum (Ramshe *et al*., 1985 and Bhoi and Jadhav, 1986). In the light of above, the present investigation was planned and carried out.

MATERIAL AND METHODS

A field experiment was conducted for two consecutive years during the years 2012 and 2013 at the ICAR- Indian Institute of Millet Research, Rajendranagar, Hyderabad. The soil was clay loam in texture. The pH was 7.7 and EC was 0.38 dS m^{-1}. The organic carbon was 0.23% and the available N was 162 kg ha^{-1}. Their status was low. However, the soil fertility was medium in available phosphorus with 29.1 kg P_2O_5 ha^{-1} and available potassium with 282.8 kg K_2O ha^{-1}.The layout of the design was strip-split plot with 3 replications. There were four strips of legumes in *kharif viz*., dhaincha, green gram, cowpea and fallow. Sorghum was sown in split plot layout in each strip in the following *rabi* with four main plots of irrigation and four sub-sub plots of nitrogen levels. Dhaincha was grown till the commencement of

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Table 1. Sorghum growth parameters as influenced by irrigation schedules and levels of nitrogen preceded by *kharif* legumes at harvest

Treatment	Plant height (cm)		LAI		Drymatter production (kg ha^{-1})	
	2012	2013	2012	2013	2012	2013
Preceding legumes in *kharif*						
C_1: Sorghum preceded by Dhaincha	225.6	217.2	2.1	2.3	8197	9151
C_2: Sorghum preceded by Greengram for seed	221.5	217.3	2.0	2.1	7933	9005
C_3: Sorghum preceded by Cowpea for fodder	220.6	213.3	1.3	1.6	7830	8946
C_4: Sorghum preceded by Fallow	218.5	208.3	1.3	1.4	7776	8949
S Em ±	1.34	1.98	0.21	0.14	76.9	68.2
CD at 5 %	4.6	6.8	NS	0.5	266	236
Irrigation schedules						
I_1: Panicle initiation	210.4	201.1	1.5	1.9	7649	8700
I_2: PI and booting	218.1	209.9	1.6	1.9	7832	8882
I_3: PI, booting and anthesis	225.3	217.5	1.8	1.8	8047	9138
I_4: PI, booting, anthesis and milk stage	232.5	227.6	1.7	1.7	8209	9333
S Em ±	1.27	1.70	0.07	0.07	31.8	13.5
CD at 5 %	4.5	5.8	NS	NS	110	47
Nitrogen (kg ha^{-1})						
N_1: No Nitrogen	199.6	190.1	1.5	1.7	6902	7777
N_2: 30	220.6	210.6	1.6	1.8	7685	8719
N_3: 60	230.1	222.5	1.8	1.9	8358	9560
N_4: 90	235.9	232.8	1.8	2.0	8790	9995
S Em ±	4.95	4.60	0.28	0.07	223.0	220.9
CD at 5 %	13.8	13.0	NS	NS	625	619
Interaction						
***Kharif* legumes × Irrigation**						
S Em ±	3.32	5.16	0.42	0.35	298.7	239.0
CD at 5 %	NS	NS	NS	NS	NS	NS
***Kharif* legumes × Nitrogen**						
S Em ±	17.26	16.48	0.14	0.14	787.5	777.4
CD at 5 %	NS	NS	NS	NS	NS	NS
Irrigation × Nitrogen						
S Em ±	17.26	16.41	0.14	0.14	775.0	765.9
CD at 5 %	NS	NS	NS	NS	NS	NS
***Kharif* legumes × Irrigation × Nitrogen**						
S Em ±	4.95	4.60	0.28	0.42	223.0	220.9
CD at 5 %	NS	NS	NS	NS	NS	NS

flowering and then incorporated *in situ*. The greengram pods were picked for grain and haulms were then turned down into the soil. The cowpea foliage was harvested for fodder and the stubbles turned down into the soil for decomposition. The irrigations were scheduled at critical stages *viz.*, panicle initiation, boot leaf stages anthesis and milk stage of grain sorghum. The levels of nitrogen were 0, 30, 60 and 90 kg ha^{-1}. The test varieties of dhaincha as green manure, greengram for seed and cowpea for fodder were Sesbania cannabina, LGG-407 and EC – 4216, respectively, while the test variety of sorghum was SPV-2048 (Phule Suchitra).

RESULTS AND DISCUSSION

Effect on Growth Characters

The *rabi* sorghum crop influenced by different crop residues, irrigation at critical stages and nitrogen management practices to sorghum noticeably altered the growth parameters. The decomposing residue of dhaincha improved the vegetative growth of sorghum in the *rabi* season. There was a significant increase in the plant height, LAI and drymatter production of the crop from seedling stage to maturity. The plants attained maximum height to *in situ* incorporation of dhaincha followed by irrigation at panicle initiation, boot leaf stage, anthesis and milk stage at harvest, there was a significant increase in the plant height due to successive increase in the number of irrigations at the critical phases and a high dose of 90 kg ha^{-1} N. This response was consistent during both 2012 and 2013 years. The *in situ* incorporation of dhaincha significantly increased the dry matter 8197 kg ha^{-1} during 2012 and 9151 kg ha^{-1} (Table 1) at harvest, respectively. Dhaincha harvested at the beginning of flowering was succulent with high moisture content, maximum nutrient accumulation in the foliage and expected optimum C: N ratio of about 25. This was ideal for early decomposition. The haulms of greengram were less succulent and more lignified because of their incorporation late at maturity when the pods were harvested. The stubbles of cowpea added least biomass to the soil. Confirming the positive role of residual effect of legumes, Mahadkar and Saraf (1988) recorded significant improvement in the dry matter production of sorghum by the incorporation of blackgram haulms in the preceding season. Kambale (1983) reported that irrigation at grand growth stage increased the plant height, number of leaves, leaf area index and dry matter of the crop. Refay (1989) reported that the water stress reduced the ear head exertion, ear head length, plant height and dry weight. Mastronelli *et al*. (1995) reported that the water stress at booting stage remarkably reduced the dry matter and yield of sorghum.

Effect on Yield Components

Sorghum preceded by dhaincha developed more number of grains per panicle and weight of the ear head while the panicle length and 1000 grain weight did not change significantly. The number of grains per panicle was significantly influenced by the residual effect of green mass incorporation of legumes in the preceding *kharif* season. The green manure of dhaincha was most effective among others. Maximum number of 1160 and 1247 grains were produced per panicle in the year 2012 and 2013 due to the beneficial carry over effects of this legume. Significantly less number of 1037 and 1164 grains per panicle were recorded in the fallow - sorghum. Sorghum grown in the fallow land was less responsive to irrigations. It produced 969 and 1132 grains per panicle by irrigating the crop only at panicle initiation stage in 2012 and 2013. Additional number of 144 and 61 grains per panicle were produced during the corresponding years by irrigating the crop at 4 critical stages (Table 2). The interaction effect of sorghum grown after the incorporation of cowpea stubbles and irrigated at panicle initiation produced 983 and 1149 grains per panicle in the corresponding years. Sorghum utilized the water more efficiently than in fallow at high levels of irrigation. Hence, significantly more number of additional 171 and 118 grain per panicle were obtained during the two years by irrigating the crop at four critical stages preceding cowpea. The ear head weight of sorghum grown in fallow and irrigated at the panicle initiation stage increased from 42.4 g in 2012 and 43.2 g in 2013 to 47.2 and 44.0 g by irrigating the crop at 4 critical stages. The gain in weight due to increase in irrigation was thus 4.8 g in the first year and 0.8 g in the second year. Henadez *et al*. (1992) reported that the ear head weight decreased due to moisture stress at all the critical stages, except when stressed at physiological

Table 2. Sorghum yield components as influenced by irrigation schedules and levels of nitrogen preceded by *kharif* legumes

Treatment	Panicle length (cm)		Grains panicle^{-1}		1000 grain weight (g)		Earhead weight (g)	
	2012	2013	2012	2013	2012	2013	2012	2013
Preceding legumes in *kharif*								
C_1: Sorghum preceded by Dhaincha	16.1	18.2	1160	1247	26.0	25.9	46.3	47.1
C_2: Sorghum preceded by Greengram for seed	16.0	17.8	1126	1206	25.9	25.8	44.2	45.9
C_3: Sorghum preceded by Cowpea for fodder	15.6	18.5	1073	1201	26.0	26.1	43.6	46.4
C_4: Sorghum preceded by Fallow	16.1	17.9	1037	1164	26.3	25.6	44.6	44.7
S Em ±	0.07	0.07	4.24	4.24	0.21	0.71	0.07	0.14
CD at 5 %	0.2	0.2	14	15	NS	NS	0.2	0.6
Irrigation schedules								
I_1: Panicle initiation	14.6	16.6	1030	1152	24.5	24.4	41.6	44.1
I_2: PI and booting	15.5	17.6	1078	1189	25.6	25.3	44.0	45.4
I_3: PI, booting and anthesis	16.6	18.7	1123	1217	26.5	26.5	44.9	46.7
I_4: PI, boot, anthesis and milk stage	17.2	19.5	1165	1259	27.6	27.2	48.2	47.9
S Em ±	0.07	0.07	3.54	4.24	0.21	0.71	0.07	0.14
CD at 5 %	0.2	0.2	13	13	0.7	2.4	0.2	0.5
Nitrogen (kg ha^{-1})								
N_1: No Nitrogen	13.7	15.9	906	1055	22.9	22.8	39.4	39.3
N_2: 30	15.2	17.5	1059	1156	25.0	25.1	43.3	44.3
N_3: 60	16.7	18.7	1171	1259	27.2	27.0	45.7	48.4
N_4: 90	18.2	20.3	1261	1348	29.1	28.5	50.4	52.1
S Em ±	0.35	0.42	26.17	26.87	0.64	1.49	0.99	0.99
CD at 5 %	1.3	1.4	91	93	1.8	4.1	3.4	3.5
Interaction								
***Kharif* legumes × Irrigation**								
S Em ±	0.14	0.21	12.02	12.02	0.21	0.28	0.14	0.78
CD at 5 %	NS	NS	41	42	NS	NS	0.4	2.7
***Kharif* legumes × Nitrogen**								
S Em ±	1.34	1.41	91.94	93.35	2.62	2.76	3.39	3.54
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS
Irrigation × Nitrogen								
S Em ±	1.34	1.41	91.23	93.35	2.62	2.90	3.39	3.54
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS
***Kharif* legumes × Irrigation × Nitrogen**								
S Em ±	0.35	0.42	26.17	26.87	0.78	0.78	0.99	0.99
CD at 5 %	NS	NS	NS	NS	NS	NS	NS	NS

maturity. Nitrogen improved the yield components remarkably. A low dose of 30 kg ha^{-1} N increased the panicle length, grains per panicle, 1000 grain weight and the ear head weight both in 2012 and 2013. These components showed further improvement to high level of nitrogen and the maximum response was at 90 kg ha^{-1} N.

Effect on Grain and Stover Yield

Maximum grain yield of 2528 and 3047 kg ha^{-1} was obtained by irrigating the crop at panicle initiation, boot leaf, anthesis and milking stage of grain during the two years. Sorghum irrigated at the panicle initiation stage produced 2338 and 2870 kg grain ha^{-1} during 2012 and 2013, respectively.

Table 3. Grain and stover yield (kg ha^{-1}) of sorghum as influenced by irrigation schedules and levels of nitrogen preceded by *kharif* legumes

Treatment	Grain yield (kg ha^{-1})		Stover yield (kg ha^{-1})	
	2012	2013	2012	2013
Preceding legumes in *kharif*				
C_1: Sorghum preceded by Dhaincha	2511	3024	5686	6127
C_2: Sorghum preceded by Greengram for seed	2446	2942	5487	6063
C_3: Sorghum preceded by Cowpea for fodder	2389	2947	5441	5999
C_4: Sorghum preceded by Fallow	2409	2930	5367	6019
S Em ±	17.0	24.8	7.8	8.5
CD at 5 %	59	85	27	29
Irrigation schedules				
I_1: Panicle initiation	2338	2870	5311	5830
I_2: PI and booting	2413	2929	5419	5953
I_3: PI, booting and anthesis	2477	2997	5570	6141
I_4: PI, booting, anthesis and milk stage	2528	3047	5681	6286
S Em±	13.4	6.4	36.1	37.5
CD at 5 %	46	22	124	131
Nitrogen (kg ha^{-1})				
N_1: No Nitrogen	2039	2466	4863	5311
N_2: 30	2380	2886	5305	5833
N_3: 60	2650	3222	5708	6338
N_4: 90	2686	3269	6104	6726
S Em ±	54.5	57.3	131.5	140.0
CD at 5 %	188	199	457	484
Interaction				
***Kharif* legumes × Irrigation**				
S Em ±	46.0	64.4	49.5	54.5
CD at 5 %	NS	NS	NS	NS
***Kharif* legumes × Nitrogen**				
S Em ±	190.9	204.4	456.9	484.4
CD at 5 %	NS	NS	NS	NS
Irrigation × Nitrogen				
S Em ±	189.5	199.4	461.8	485.1
CD at 5 %	NS	NS	NS	NS
***Kharif* legumes × Irrigation × Nitrogen**				
S Em ±	54.5	57.3	131.5	140.0
CD at 5 %	NS	NS	NS	NS

Irrigation at panicle initiation and boot leaf stage yielded significantly more quantity of 2413 and 2929 kg grain ha^{-1}. The production increased further to 2477 and 2997 kg ha^{-1} during the corresponding years by giving three irrigations at panicle initiation, boot leaf and anthesis stage. Mishra *et al.* (2011) also reported that green manure of dhaincha increased the production of sorghum compared to the yield from fallow-sorghum. In an earlier investigation, Pawar and Bhogi (2009) reported that the legumes differed in their influence on the relative performance of sorghum. Additional mean grain yield of 67, 133 and 184 kg ha^{-1} was obtained due to 2, 3 and 4 irrigations over 1. Similarly, the stover yield increased from 5311 kg ha^{-1} due to irrigation at panicle initiation to 5419 kg ha^{-1} by irrigating the crop at panicle initiation and

boot leaf stage in the first year and from 5830 to 6286 kg ha^{-1} in the second year. More quantity of 5570 and 6141 kg ha^{-1} stover was obtained by irrigation at panicle initiation, boot leaf and anthesis stage during the two years. Maximum stover yield of 5681 and 6286 kg ha^{-1} (Table 3) was obtained when the soil was not deprived of moisture stress at panicle initiation, boot leaf, anthesis and milk stage of grains.

CONCLUSIONS

It is inferred that the beneficial effects of growing dhaincha and its *in situ* incorporation at flowering in *kharif* as a preceding crop increased the production of sorghum grain and fodder *vis-a-vis* their nutrient value as food for man and fodder for cattle. The crop should be irrigated at the critical stages *viz*., panicle initiation, boot leaf, anthesis and milking stage of the grains to improve the vegetative growth, yield components and ultimately increasing their production.

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POTASSIUM RELEASE CHARACTERISTICS OF RICE GROWING SOILS IN KURNOOL DISTRICT

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ABSTRACT

An investigation was carried out during the year 2014 to study the potassium releasing characteristics of thirty rice growing soils in Kurnool district. The samples were analysed for different properties and forms of potassium .The soils under study were moderately coarse to fine in texture. The order of dominance of different forms of potassium was fixed K > non exchangeable K > available K > exchangeable K > water soluble K. The study revealed that the black soils released higher amounts of mean cumulative K (864 mg kg^{-1}) and step K (773 mg kg^{-1}) than red soils. Whereas, mean constant K release was high in red soils than black soils. Lower amounts of cumulative K was observed in all soils except in Midthuru soil in the present investigation. Strong positive correlation existed between step K and cumulative K with clay content in soil showed that clay is the major K supplying source in these soils.

INTRODUCTION

Plants feed not only from exchangeable K^+ but also from non exchangeable K, which mainly consists of K trapped in the interlayer's of non expanded clay minerals. Major contribution of non exchangeable K by crop removal was reported particularly in soils under continuous cropping without K application. (Srinivasa Rao *et al.,* 2007). Rice is one of the major field crops in Kurnool district, the crop is cultivated an area of 91,568 ha. However, application of potassium to rice crop in Kurnool district is 80 Kg ha^{-1}, where as K removals by rice crop extends up to 150 to 200 kg ha^{-1}. Therefore, inadequate K supply of most of crop K needs is met from soil reserve sources of K. Under these conditions, the ability of soil to supply K to crop nutrition under long-term cropping assumes most significance. Haylock (1956) proposed a technique of step and constant K to assess the long-term K supplying power of particular soil. Information on the K release behaviour of these soils is mearge. Hence, the present investigation was conducted to study the potassium releasing characteristics of thirty rice growing soils of Kurnool district in relation to soil properties and different forms of potassium.

MATERIAL AND METHODS

Surface soils were collected from eighty locations of rice growing soils of Kurnool district and thirty samples were selected for present investigation based on K status. The soil samples collected were air dried and passed through 2 mm sieve. Each sample was then sub-sampled, by quartering and finally a representative soil sample was preserved in a polythene bag for laboratory analysis .The selected soils were analyzed for their salient characteristics, different forms of K and potassium release characteristics. The particle size analysis was carried out by Bouyoucous hydrometer method (Piper, 1966). The pH and EC were determined in 1:2 soil: water suspension using pH meter and EC meter (Jackson, 1973). The free $CaCO_3$ content was determined as per procedure given by Piper (1966). Water soluble potassium was determined in 1:5 soil : water extract, after five minutes shaking (Kanwar and Grewal, 1966). The available potassium was determined by neutral normal ammonium acetate extract (1:5 soil: extractant), after five minutes shaking as described by Jackson (1973). The exchangeable potassium was obtained as a difference of the available and water

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soluble potassium. The fixed form of potassium was determined by boiling with 1 N HNO_3 (1:10 soil : acid ratio) for 10 minutes (Wood and Deturk, 1941). The non-exchangeable potassium was obtained by deducting the available potassium from fixed potassium contents. Potassium supplying capacity in terms of different K release parameters *viz.*,, step K, constant rate K and cumulative K soils were derived as per the procedure developed by Heylock (1956) as modified by McLean (1961) using 1N HNO_3 as an extractant. This method involved removal of exchangeable K by soaking 5g of soil in 50 ml of 0.01 N HNO_3 overnight and leaching the soil with 10 ml portion of 0.01N HNO_3 (4-5 times), then the soil sample was boiled with 1N HNO_3 (1:10 soil: 1N HNO_3) exactly for 10 min and then cooled and filtered. Extractions were carried out with the same reagent to a stage where the release of K from soil continuous at more or less constant rate. By subtracting the amount of constant rate K from the amount of K released in each step of successive extraction, the amount of relatively easily soluble from of K (step-K) computed (important precaution was that the soil sample come to boiling in 3 minutes and then the sample was allowed to boil for 7 ½ min).

RESULTS AND DISCUSSION

The pH of the soils used in the study varied from 7.2 (Pamulapadu) to 8.5 (Korrapoluru), with the mean value of 8.0 (Table 1). Thus, the soils under study are neutral to slightly alkaline in reaction. The EC of soils varied from 0.14 dS m^{-1} in Pamulapadu to 1.52 dS m^{-1} in Bathanur with a mean value of 0.52 dS m^{-1}. The soils were non-calcareous and texture of the soils varied from sandy loam to clay, which are moderately coarse to fine in texture (Table 1).

Forms of K in soils

The data pertaining to content of different forms of potassium *viz.* water soluble, exchangeable, available, non exchangeable and fixed potassium are presented in the Table 2.The water soluble potassium content varied from 10.5 mg kg^{-1} (Thellapuri) to 39.5 mg kg^{-1} (Bollavaram) with a mean value of 20.4 mg kg^{-1}. The available potassium (K_{av}) varied from 69.0 mg kg^{-1} (Bandi Atmakuru) to 431.0 mg kg^{-1}(Midthuru) with a mean value of 189.6 mg kg^{-1}.The exchangeable potassium (K_{ex}) content varied from 48.5 to 393.5mg kg^{-1} with a mean value of 169.2 mg kg^{-1}. The lowest value was recorded in Bandi Atmakuru soil and highest values in Midthuru soil, whereas non-exchangeable potassium (K_{non-ex}) ranged between 190.5 mg kg^{-1} (Machenipalle) to 711.0 mg kg^{-1} (Midthuru) with a mean value of 329.6 mg kg^{-1}. The fixed potassium in the selected soils varied from 261.0 mg kg^{-1} (Machenipalle) to 1142 mg kg^{-1} (Midthuru) with a mean amount of 519.2 mg kg^{-1}. The order of dominance of different forms of potassium was fixed K > non exchangeable K > available K > exchangeable K > water soluble K. The distilled water extracted lower amounts of K than that of the other extractants because distilled water is the softest extractants possible (Rathore *et al.*, 2000). Ammonium acetate is the most commonly used extractant, which extracts, both exchangeable and water soluble K. Higher amounts of K was extracted by 1 N HNO_3 because in addition to exchangeable K, some of the non-exchangeable K is brought into solution by the breakdown of primary and secondary clay minerals (Kalyani, 2012).

Release of non-exchangeable K by repeated extractions with boiling 1N HNO_3

The non-exchangeable K extracted with 1N HNO_3 attained constancy at the end of the 6th extraction in most of the soils. Potassium release was rapid in first four extractions in most of the soils and there was a gradual decrease in amount of K released and reached constant value in either 7th or 8th extraction (Table 3).

Table 1. Physico-chemical properties of soils under investigation

S.No	Village Name	pH	EC (dS m^{-1})	$CaCO_3$ (%)	Clay %	Silt %	Sand %	Texture
1	Nandipalli	7.3	0.59	1.90	16.08	7.36	76.56	Sandy loam
2	Kambalapalli	7.8	0.25	1.10	41.00	10.36	48.64	Sandy clay
3	Chennuru	7.9	0.83	1.80	33.08	15.36	51.56	Sandy clay loam
4	Yerraguntla	8.1	0.41	2.70	34.08	11.36	54.56	Sandy clay loam
5	Abdullapuram	7.9	0.22	3.80	35.08	2.36	62.56	Sandy clay
6	Bathunuru	8.0	1.52	2.50	37.08	9.36	53.56	Sandy clay
7	Bachapuram	7.8	0.51	2.20	33.18	12.36	54.46	Sandy clay loam
8	Gadivemula	8.3	0.87	4.20	34.08	11.36	54.56	Sandy clay loam
9	Nallagatla	7.9	0.84	2.20	39.08	16.36	44.56	Sandy clay
10	RARS,Nandyal	8.1	0.26	2.76	43.08	14.36	42.56	Clay
11	Padakandla	8.2	0.35	1.90	36.08	17.36	46.56	Sandy clay loam
12	Nagulavaram	8.2	0.24	4.90	31.08	0.36	68.56	Clay loam
13	Mandalluru	8.0	0.79	2.90	25.08	14.36	60.56	Sandy clay loam
14	M.C.Farm,College	7.8	0.19	1.13	19.00	12.36	68.64	Sandy loam
15	Rollapadu	8.1	0.28	3.70	37.08	13.36	49.56	Sandy clay
16	Korrapoluru	8.5	0.62	3.50	36.08	6.36	57.56	Sandy clay
17	Midthur	8.3	0.61	3.60	39.08	12.36	48.56	Sandy clay
18	Alaganuru	8.1	0.31	1.60	39.08	12.36	48.56	Sandy clay
19	Bollavaram	8.1	0.67	3.80	31.08	12.36	56.56	Sandy clay
20	Bereli	8.1	0.38	1.10	31.08	4.36	64.56	Sandy clay loam
21	Thellapuri	8.2	0.31	3.85	39.08	16.36	44.56	Sandy clay
22	Gorukallu	8.0	0.42	4.94	35.08	6.36	58.56	Sandy clay
23	Brahmanapalli	7.8	1.01	1.97	31.08	16.36	52.56	Sandy clay loam
24	Ayyavari Koduru	7.9	0.47	1.41	31.08	4.36	64.56	Sandy clay loam
25	Pamulapadu	7.2	0.14	2.90	19.00	14.36	66.64	Sandy loam
26	Nehrunagar	8.1	0.51	1.70	34.08	11.36	54.56	Sandy clay loam
27	Parnapalle	7.3	0.37	3.10	29.78	15.96	54.26	Sandy clay loam
28	Machenipalle	8.2	0.75	2.10	25.08	18.36	56.56	Sandy clay loam
29	Bandi Atmakuru	8.5	0.25	3.50	30.08	19.36	50.56	Sandy clay loam
30	Krishnarao peta	8.1	0.51	3.90	33.08	18.36	48.56	Sandy clay loam
Mean		**8.0**	**0.52**	**2.76**	**32.60**	**11.91**	**55.49**	
Range		**7.2-8.5**	**0.14-1.52**	**1.1-4.94**	**16.08-43.08**	**0.36 - 19.36**	**42.56-76.56**	

Table 2. Distribution of different forms of potassium in soils (mg kg^{-1} soil)

S.No	Village Name	Water soluble K	Available K	Exchangeable K	Non-Exchangeable K	Fixed K
1	Nandipalli	16.5	103.0	86.5	237.0	340.0
2	Kambalapalli	24.5	283.0	258.5	449.0	732.0
3	Chennuru	13.5	144.0	130.5	247.0	391.0
4	Yerraguntla	31.5	221.0	189.5	348.0	569.0
5	Abdullapuram	11.0	115.0	104.0	239.0	354.0
6	Bathuunuru	15.0	157.0	142.0	264.0	421.0
7	Bachapuram	15.0	123.0	108.0	276.0	399.0
8	Gadivemula	15.5	243.5	228.0	277.5	521.0
9	Nallagatla	30.5	287.5	257.0	344.5	632.0
10	RARS,Nandyal	13.5	194.5	181.0	297.5	492.0
11	Padakandla	17.5	207.5	190.0	385.5	593.0
12	Nagulavaram	12.0	128.0	116.0	311.0	439.0
13	Mandalluru	16.0	111.0	95.0	367.0	478.0
14	M.C.Farm, College	19.0	369.0	350.0	315.0	684.0
15	Rollapadu	32.5	209.5	177.0	363.5	573.0
16	Korrapoluru	15.5	206.0	190.5	286.0	492.0
17	Midthur	37.5	431.0	393.5	711.0	1142.0
18	Alaganuru	23.5	169.0	145.5	269.0	438.0
19	Bollavaram	39.5	199.5	160.0	343.5	543.0
20	Bereli	23.5	234.0	210.5	439.0	673.0
21	Thellapuri	10.5	198.5	188.0	392.5	591.0
22	Gorukallu	17.0	185.5	168.5	347.5	533.0
23	Brahmanapalli	28.0	140.5	112.5	322.5	463.0
24	Ayyavari Koduru	14.0	203.0	189.0	379.0	582.0
25	Pamulapadu	13.0	171.5	158.5	258.5	430.0
26	Nehrunagar	20.5	184.5	164.0	336.5	521.0
27	Parnapalle	23.0	101.0	78.0	266.0	367.0
28	Machenipalle	15.5	70.5	55.0	190.5	261.0
29	Bandi Atmakuru	20.5	69.0	48.5	222.0	291.0
30	Krishnarao peta	27.5	228.0	200.5	404.0	632.0
	Mean	20.4	189.6	169.2	329.6	519.2
	Range	10.5-39.5	69.0-431.0	48.5-393.5	190.5-711.0	261.0-1142

Table 3. Release pattern of non-exchangeable K (mg kg^{-1}) by boiling 1N HNO_3

S.No	Village Name	Soil type	Number of extractions								
		Black soils	**1st**	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	**8th**	**9th**
1	Kambalapalli	Black soils	445	250	175	105	65	30	30		
2	Abdullapuram	Black soils	235	125	90	45	15	15			
3	Gadivemula	Black soils	275	195	120	85	40	5	5		
4	Nallagatla	Black soils	340	220	155	95	50	20	10	10	
5	RARS, Nandyal	Black Soils	295	195	115	70	40	5	5		
6	Padakandla	Black Soils	385	210	155	95	55	35	15	15	
7	Nagulavaram	Black soils	310	175	120	90	45	15	15		
8	Mandalluru	Black soils	365	165	100	65	45	10	10		
9	Rollapadu	Black soils	360	165	105	60	40	10	10		
10	Korrapoluru	Black soils	285	150	100	55	30	5	5		
11	Midthur	Black soils	710	440	305	215	155	95	50	25	25
12	Bollavaram	Black Soils	340	190	120	50	20	5	5		
13	Bereli	Black Soils	435	200	145	70	30	10	10		
14	Thellapuri	Black soils	390	195	115	50	30	10	10		
15	Gorukallu	Black soils	340	188	100	65	35	15	15		
16	Brahmanapalli	Black soils	320	195	110	55	30	5	5		
17	Ayyavari Koduru	Black soils	375	210	170	105	80	20	20		
18	Nehrunagar	Black soils	335	180	105	45	15	15			
19	Krishnarao peta	Black soils	400	235	155	95	50	15	15		
		Red soils									
20	Nandipalli	Red soils	235	115	75	40	25	25			
21	Chennuru	Red soils	245	135	75	30	10	10			
22	Yerraguntla	Red soils	345	155	110	60	20	20			
23	Bathunuru	Red soils	260	160	120	70	40	10	10		
24	Bachapuram	Red soils	275	155	110	60	15	15			
25	M.C.Farm, College	Red soils	315	110	80	50	20	10	10		
26	Alaganuru	Red soils	265	150	105	60	25	15	15		
27	Pamulapadu	Red soils	255	140	55	30	10	10			
28	Parnapalle	Red soils	265	145	90	45	15	15			
29	Machenipalle	Red soils	190	110	80	35	10	10			
30	Bandi Atmakuru	Red soils	220	100	65	20	20				

Table 4. K release parameters (mg kg^{-1}) with boiling 1N HNO_3

S.No	Village Name	Soil type	Cumulative K	Constant K	Step K
		Black soils			
1	Kambalapalli	Black soils	1100	30	890
2	Abdullapuram	Black soils	525	15	435
3	Gadivemula	Black soils	725	5	690
4	Nallagatla	Black soils	900	10	820
5	RARS, Nandyal	Black Soils	725	5	690
6	Padakandla	Black Soils	965	15	845
7	Nagulavaram	Black soils	770	15	665
8	Mandalluru	Black soils	760	10	690
9	Rollapadu	Black soils	750	10	680
10	Korrapoluru	Black soils	630	5	595
11	Midthur	Black soils	2020	25	1795
12	Bollavaram	Black Soils	730	5	695
13	Bereli	Black Soils	900	10	830
14	Thellapuri	Black soils	800	10	730
15	Gorukallu	Black soils	758	15	653
16	Brahmanapalli	Black soils	720	5	685
17	Ayyavari Koduru	Black soils	980	20	840
18	Nehrunagar	Black soils	695	15	605
19	Krishnarao peta	Black soils	965	15	860
		Mean	**864**	**12.6**	**773**
		Range	**525-2020**	**5-30**	**435-1795**
		Red soils			
20	Nandipalli	Red soils	515	25	365
21	Chennuru	Red soils	505	10	445
22	Yerraguntla	Red soils	710	20	590
23	Bathunuru	Red soils	670	10	600
24	Bachapuram	Red soils	630	15	540
25	M.C.Farm, College	Red soils	595	10	525
26	Alaganuru	Red soils	635	15	530
27	Pamulapadu	Red soils	500	10	440
28	Parnapalle	Red soils	575	15	485
29	Machenipalle	Red soils	435	10	375
30	Bandi Atmakuru	Red soils	425	20	325
		Mean	**563**	**14.6**	**475**
		Range	**425-710**	**10-25**	**325-600**
		Total Mean	**754**	**13.3**	**664**
		Total Range	**425-2020**	**5-30**	**325-1795**

Cumulative K

The total cumulative K release of black and red soils ranged from 425 to 2020 mg kg^{-1} with a mean value of 754 mg kg^{-1} soil (Table 4). The pattern of K release was different in different soils. In black soils, it ranged from 525 to 2020 mg kg^{-1} with a mean value of 864 mg kg^{-1} soil. Midthuru soil released highest amount of non-exchangeable K (2020 mg kg^{-1}), while Abdullapuram soil released the lowest (525 mg kg^{-1}) amount. In red soils cumulative K ranged from 425 to 710 mg kg^{-1} with a mean value of 563 mg kg^{-1}. Yerraguntla and Bandi Atmakuru soils released the highest and lowest amounts of cumulative K with 710 and 425 mg kg^{-1}, respectively. Relatively lowest amounts of cumulative K was observed in red soils than the black soils (Table 4).Srinivasa Rao *et al.* (2007) reported that cumulative K is considered higher if it exceeds more than 1500 mg kg^{-1} of soil with 1N HNO_3. Lower cumulative K was observed in all soils except in Midthuru soil in the present investigation. Lower cumulative K and continuous cropping are lead to depletion of soil K reserves and result in K deficiency.

Step K

Conceptually step-K is a measure of plant utilizable non-exchangeable K. In present study total step K varied from 325 to 1795 mg kg^{-1} with a mean value of 664 mg kg^{-1}(Table 4). In black soils it ranged from 435 to 1795 mg kg^{-1} with a mean value of 773 mg kg^{-1}. Midthuru and Abdullapuram soils are recorded highest and lowest amounts of step-K with values of 1795 mg kg^{-1} and 435 mg kg^{-1}, respectively. In red soils it ranged from 325 to 600 mg kg^{-1} with a mean value of 475 mg kg^{-1}. Red soils with low levels of clay and Kaolinite as dominant mineral with little quantities of associated K contributing mineral showed lesser step and cumulative K. Lower levels of K release in red soils could be due to presence of large proportion of K in the form of K feldspars, which are resistant to dissolution in HNO_3. Similar results were obtained by Srinivasa Rao *et al.* (2007). BandiAtmakuru recorded lowest (325 mg kg^{-1}) and Bathunuru recorded highest (600 mg kg^{-1}) amounts of step K (Table 4). Srinivasa Rao *et al.* (2007) reported that step K was higher if it exceeds more than 500 mg kg^{-1} of soil with 1N HNO3. In the present investigation most of the red soils recorded lower step K values.

Constant K

The constant K release of both black soils and red soils are ranged from 5 to 30 mg kg^{-1} with a mean value of 13.3 mg kg^{-1}. In black soils it ranged from 5 to 30 mg kg^{-1} with a mean value of 12.6 mg kg^{-1}. Gadivemula, RARS Nandyal, Korrapoluru, Bollavaram and Brahmanapalli villages showed the lowest (5 mg kg^{-1}) amount of Constant K, while Kambalapalli recorded the highest (30 mg kg^{-1}) amount of Constant K. Among red soils Chennuru, Bathunuru, M.C. Farm (college), Pamulapadu and Machenipalle villages recorded the lowest amount of constant K, while Nandipalli recorded highest amount with the values of 10 mg kg^{-1} and 25 mg kg^{-1}, respectively (Table 4).The potassium release parameters *viz.*, cum-K and step K showed positive correlation with pH , EC , $CaCO_3$ and clay and negative correlation with sand and silt (Table 5).The K release parameters were positively correlated with the clay fraction of soil indicating that potassium was mainly extracted from the clay fraction in soil. Negative relationship of the K release parameters with sand fraction might be due to the indirect effect of the negative relationship between sand and clay content in soil. Similar results were obtained by Das and Jena (2010) in some *Alfisols* of Orissa.

Table 5. Relationship between potassium release parametres and soil characteristics

Parametre	pH	EC	$CaCO_3$	clay	silt	sand
Cumulative K	0.251	0.025	0.054	0.422**	-0.059	-0.298
Step-K	0.291	0.071	0.085	0.443**	-0.035	-0.330

Table 6. Relationship between potassium release parametres and different forms of K

Parametre	Water soluble K	Available K	Exchangeable K	Non Exchangeable K	Fixed K
Cumulative-K	0.481**	0.736**	0.718**	0.958**	0.915**
Step-K	**0.489****	**0.749****	**0.731****	**0.954****	**0.919****

The data presented in the Table 6 indicated that among various potassium release parameter *viz.,* cumulative-K and step-K showed significant positive correlation with all forms of potassium. Highly significant positive correlation of cum-K and step-K with non exchangeable K indicated that boiling IN HNO_3 which estimates non exchangeable K can serve as a good index of the K supplying capacity of these soils.

CONCLUSIONS

It can be concluded that lower cumulative K was observed in all soils except in Midthuru soils in the present investigation. Lower cumulative K and continuous cropping led to depletion of soil K reserves and resulted in K deficiency. Strong positive correlation existed between step K and cumulative K with clay content in soil indicated that clay is the major K supplying source in these soils.

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RESPONSE OF SAFFLOWER VARIETIES TO DIFFERENT NITROGEN LEVELS IN VERTISOLS

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ABSTRACT

A field experiment was conducted during *Rabi* 2012 to study the response of safflower varieties to different nitrogen levels in calcareous vertisols in a randomized block design with factorial concept and replicated thrice. The treatments consisted of three varieties/hybrids (Manjira, TSF-1, NARI-6) and four nitrogen levels (0, 20, 40, 60 kg ha^{-1}). Nitrogen fertilizers were applied as per treatments. The recommended dose of phosphorus (20 kg P_2O_5) was applied as basal along with 50% of N, while the remaining half of N was applied at 35 DAS. Among the varieties, TSF-1 produced higher seed yield (1452 kg ha^{-1}) but was at par with NARI-6 (1277 kg ha^{-1}) which was in turn was at par with Manjira (1228 kg ha^{-1}). Increase in N fertilization from 0 to 60 kg ha^{-1} increased the safflower yield significantly irrespective of varieties, highest being with 60 kg N ha^{-1} but was at par with 40 kg N ha^{-1} . Increased availability of nutrients resulting in better growth of crop might be the reason for higher seed yield at 60 kg N ha^{-1}. The results corroborates with the findings of Das and Ghosh (1993). Interaction effect of TSF-1 with 60 kg of N ha^{-1} recorded the highest yield but was at par with 40 kg of N ha^{-1}, while significantly lower yield was recorded with Manjira with no fertilization. Safflower variety TSF-1 produced higher gross (Rs. 36,812/-) and net (Rs. 24,562/-) returns followed by NARI-6 with gross (Rs. 32,373/-) and net (Rs. 20,123/-) per ha, respectively, while the lower with Manjira.

INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is an important *rabi* oilseed crop of spiny nature, which thrives well at ideal temperatures and rainfall of 22^0 C - 35^0 C and 60 cm -100 cm, respectively. It is sensitive to frost and water logged conditions. It produces high quality oil rich in polyunsaturated fatty acids, which helps in reducing blood cholesterol. Safflower yields about 32% - 40% seed oil. Oil has good drying properties and is used in the manufacture of paints, varnishes and linoleum. The oil obtained by hot dry distillation is used in the preparation of 'Roghan', which is used in preservation of leather and production of water-proof cloth. India is the largest producer of safflower in the world, with a growing area of 178.4 lakh ha, a total production of 145.3 lakh tonnes and an average productivity of 498 kg ha^{-1} (2014) (www. indiastat.com). Accelerated production is possible mainly by the use of appropriate cultivars in fertile, fairly deep and well drained soils. Seed is one of the least expensive but most important factors influencing yield potential since crop seeds contain all the genetic information to determine yield potential, adaptation to environmental conditions and resistance to insect pests and disease. Nitrogen need of safflower depends on the adequate nitrogen in the soil, soil productivity and preceding crop (Armah-Agyeman *et al*., 2002; Siddiqui and Oad, 2006). The present study was under taken to find out suitable safflower variety for growing in calcareous vertisols and to understand the variation in response to nitrogen by different varieties.

MATERIAL AND METHODS

A field experiment was conducted during the *Rabi,* 2012 at Regional Agricultural Research Station, Nandyal, Andhra Pradesh. The soil was clayey in texture, slightly alkaline in reaction (pH 8.6) and low in available nitrogen (159 kg ha^{-1}), high in available phosphorus (46 kg P_2O_5 ha^{-1}) and medium in available potassium status (223 kg K_2O ha^{-1}). The experiment was laid out in a randomized block design with factorial concept and replicated thrice. The treatments

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consisted of three varieties/hybrids (Manjira, TSF-1, NARI-6) and four nitrogen levels (0, 20, 40, 60 kg ha^{-1}). The size of the gross plot was 5.4 m x 4.2 m and net plot was 3.6 m x 2.8 m. Nitrogen fertilizers were applied as per treatments. The recommended dose of phosphorus (20 kg P_2O_5) was given as basal along with 50% of N, while the remaining half of N was applied at 35 DAS. Observations on plant height, number of branches per plant, number of capitulum per plant, number of seeds per capitulum, 1000 seed weight (g) and yield (kg ha^{-1}) were recorded. Data was analysed statistically as suggested by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Plant height was highest with NARI-6 but was at par with TSF-1 and significantly lowest with Manjira. Increase in nitrogen level increased the plant height significantly up to 20 kg of N ha^{-1} only and further increase in N levels did not influence the plant height (Table 1) significantly. Higher number of branches/plant was recorded with NARI-6 followed by Manjira and lowest was with TSF-1. Number of branches/plant was non-significant with N levels. Higher number of capitula/plant was recorded with Manjira (32.2) compared to NARI-6 (28.1) and TSF-1 (23.1). Application of N at 60 kg ha^{-1} produced

Table 1. Yield attributes and yield (kg ha^{-1}) of safflower as influenced by varieties and nitrogen levels

Treatments	Plant height (cm)	No. of branches/ plant	No. of capitulum/ plant	No. of seeds/ capitulum	1000 seed wt. (g)
Varieties					
Manjira	58.5	12.3	32.2	14.1	35.4
TSF-1	75.7	8.9	23.1	20.8	39.3
NARI-6	81.8	14.8	28.1	23.0	35.0
SEm±	2.3	0.57	0.94	0.89	0.93
CD @ 5 %	6.7	1.7	2.7	2.6	2.7
N Levels (kg/ha)					
0	67.0	10.3	21.1	16.1	29.4
20	72.6	12.0	27.9	18.6	34.2
40	73.0	12.9	30.4	19.9	38.0
60	75.4	12.7	31.8	22.5	44.6
SEm±	2.6	0.66	1.09	1.03	1.07
CD @ 5 %	7.7	1.9	3.2	3..0	3.6
Varieties X Nitrogen Levels					
SEm±	4.6	1.15	1.89	1.79	1.86
CD @ 5 %	13.5	3.3	5.5	5.2	N.S

significantly higher number of capitula/plant (31.8) compared to 20 kg N ha^{-1} (27.9) and control (21.1). Nitrogen serves as the source for the dark green color in the leaves, reflects high concentration of chlorophyll. Nitrogen combined with high concentrations of chlorophyll utilizes the sunlight as an energy source to carryout essential plant functions including nutrient uptake. Better nutrient uptake of the crop might have resulted into good yield attributes. Singh *et al*. (1992) also reported significant increase in number of capitulum/plant with increasing doses of nitrogen.

Number of seeds/capitulum was highest (23.0) with NARI-6 but was at par with TSF-1 while, the lowest was with Manjira (14.1). With increase in levels of nitrogen from 0 to 60 kg ha^{-1} number of seeds/ capitulum was increased. However, application of 60 kg N ha^{-1} was at par with 40 kg N ha^{-1} which was in turn at par with 20 kg N ha^{-1}. Significantly higher test weight was recorded with TSF-1 and with increase in N levels, test weight of seed also increased significantly recording highest with N at 60 kg ha^{-1} and lowest 0 kg N ha^{-1}. Application of nitrogen might have increased the protein percentage which in turn increased the seed weight.

Varieties and N levels (Table 2) exerted significant effect on safflower yield. Among the varieties, TSF-1 produced higher seed yield (1452 kg ha^{-1}) but was at par with NARI-6 (1277 kg ha^{-1}) which was in turn at par with Manjira (1228 kg ha^{-1})

Table 2 . Yield and economics of safflower as influenced by varieties and nitrogen levels

Treatments	Seed yield (kg ha^{-1})	Gross Returns (Rs ha^{-1})	Net Returns (Rs ha^{-1})	B:C Ratio
Varieties				
Manjira	1228	31138	18888	2.5
TSF-1	1452	36812	24562	3.0
NARI-6	1277	32373	20123	2.6
SEm±	61.6	-	-	-
CD @ 5 %	180	-	-	-
N Levels (kg/ha)				
0	1130	28633	17133	2.5
20	1238	31374	19374	2.6
40	1434	36339	23839	2.9
60	1476	37416	24416	2.9
SEm±	71.1	-	-	-
CD @ 5 %	208	-	-	-
Varieties X Nitrogen Levels				
SEm±	123.2	-	-	-
CD @ 5 %	361	-	-	-

(Table 2). Increase in N fertilization from 0 to 60 kg ha^{-1} increased the safflower yield significantly irrespective of varieties, highest being with 60 kg N ha^{-1} but was at par with 40 kg N ha^{-1}. Increased availability of nutrients resulting in better growth of crop might be the reason for higher seed yield at 60 kg N ha^{-1}. Higher number of capitula/plant and increase in test weight of seed due to adequate N nutrition is explainable in terms of possible increase in nutrient mining capacity of plant as a result of better root development and increased translocation of carbohydrates from source to growing points in well-fertilized plots, which finally resulted in to higher yields. The results corroborates with the findings of Das and Ghosh (1993). Interaction effect of TSF-1 with 60 kg of N ha^{-1} recorded the highest yield but was at par with 40 kg of N ha^{-1}, while significantly lower yield was recorded with Manjira with no fertilization.

Safflower variety TSF-1 produced higher gross (Rs.36,812/-) and net (Rs. 24,562/-) returns followed by NARI-6 with gross (Rs. 32,373/-) and net (Rs. 20,123/-) per ha, respectively while the lowest returns were observed with Manjira. As regards to N levels, increase in N level from 0 to 60 kg ha^{-1} increased the gross and net returns irrespective of the varieties and the highest being with 60 kg N ha^{-1}. Interaction between TSF-1 and 60 kg ha^{-1} of nitrogen application produced the highest gross and net returns. B: C ratio followed the same trend as that of gross and net returns. Kulekci *et al*. (2009) reported that 60 kg of N ha^{-1} was optimum and economic dose for higher seed yield, gross returns, net returns and B: C ratio.

CONCLUSION

The present study suggest that safflower hybrid TSF-1 could be grown profitably on rainfed vertisols with 40 kg of N ha^{-1} for realizing higher seed yield and remunerative returns.

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PERFORMANCE EVALUATION OF SEED METERING MECHANISMS WITH DIFFERENT SEED DRILLS FOR BENGALGRAM

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ABSTRACT

In the present study five types of seed drills were evaluated for Bengalgram crop to assess their performance. The highest field capacity was found to be 0.47 ha h^{-1} with field efficiency of 66.75 per cent for Ananta planter among all treated seed drills. The lowest seed rate obtained in the field was observed as 64.37 kg ha^{1} for Ananta planter among all seed drills whereas the highest seed rate was observed as 79.15 kg ha^{-1} for local seed cum fertilizer drill. The highest seed yield obtained was found to be 929.60 kg ha^{-1} for Ananta planter among all seed drills whereas the lowest seed yield was found to be 783.30 kg ha^{-1} for TNAU model seed cum fertilizer drill. The cost of cultivation for Bengal gram crop obtained were that Rs.12,034, Rs.12,331, Rs.12,425, Rs.12,681 and Rs.12,680 per ha for Ananta planter, Nandyala planter, Gujarat seed cum fertilizer drill, TNAU model seed cum fertilizer drill and Local seed drills respectively. The highest net profit was found to be Rs.29,798 ha^{-1} for Ananta planter among all seed drills. The lowest net profit was found to be Rs. 22,568 ha^{-1} with TNAU model seed cum fertilizer among all seed drills.The study conferred that out of five seed drills the Ananta planter has given best performance as compared to others.

INTRODUCTION

Dry farming or dry land farming is a practice of growing a profitable crop without irrigation in areas which receive an annual rainfall of 500 mm or even less. India has about 47 million hectares of dry lands, out of 108 million hectares of total rain fed area. Dry lands contribute more than 40 per cent food grains (80 per cent maize, 95 per cent of pearl millet and sorghum). About 95 per cent of pulses and 75.5 per cent of oilseeds are also grown in these areas. Thus, dry lands and rain fed farming will continue to play a dominant role in agricultural production. Ground nut, Bengal gram and red gram are three important crops grown in dry land and also they are drought resistant crops. (Pandey and Ganesan, 2005).

Bengalgram (*Cicer arietinum* L.) is also called chickpea or gram in South Asia and garbanzo bean in most of the developing countries in the world. India is the major producer of Bengalgram in the world, accounting for 61.65 per cent of the total world area under Bengalgram and 68.13 per cent of the total world production. The area in India is 8.25 million hectares with productivity of 855 kg ha^{-1} (2008-2009). The important Bengal gram growing states in India are Madhya Pradesh, Uttar Pradesh, Andhra Pradesh and Karnataka. In dry land agriculture, soil moisture dictates the priorities with regard to field operation and sowing. Sowing has to be expeditious to take advantage of limited soil moisture. Swiftness in sowing should not be at the cost of optimal plant stand. One of the major constraints has been lack of appropriate machines and implements to meet timeliness and precision needs of dry land crops. One of the most important factors that influence the germination of seeds is the uniformity of distribution of seeds at proper depth. These results in a better crop stand there by increasing the crop yield (Behera *et al.* (1995), Afzal Tabassum and Abdul Shakoor Khan (1992) and Vasta and Sukbir Singh (2010)). Most of the farmers in India use traditional methods for planting such as broad casting and seed dropping behind the plough. Traditional methods of crop planting have involved planting of excess seed and increase human drudgery. Seed drills of different types and capacities were developed and now being extensively

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used in the country for sowing different kinds of seeds. It reduces sowing time and thus overcomes the shortages of labor. In the context of the above knowledge, there is a strong need for assessing the performance evaluation of tractor drawn seed drills with different seed metering mechanisms and assess the economics of operation to suitable for Bengalgram in dry land. This study was therefore undertaken to evaluate the performance of commercial tractor drawn seed drills with various seed metering mechanisms for Bengalgram and to compare the economics of seed drills with different seed metering mechanisms.

MATERIAL AND METHODS

The field and laboratory experiments were conducted to study the performance evaluation of tractor drawn seed drills, modification of seed metering mechanisms suitable for Bengalgram and compare the economics of operation with various seed drills at Agricultural Research Station, Anantapur and in the farmer's field at Pothu reddypalli village, Putlur mandal, Anantapur District for Bengalgram crop during the year of 2011-2012. The soil of the experimental site was black sandy loam soil. A field extent of 720 m^2 area was selected for Bengal gram crop and it was divided into five plots of 144 m^2 for five seed drills. The laboratory and field experiments were conducted using five commercial tractor drawn seed drills with different seed metering mechanisms suitable for Bengalgram. The mechanisms of existing seed drills with different seed metering mechanisms are shown in the fig. 1, fig. 2, fig. 3, fig. 4 and fig. 5 and the main features of seed drills are given in Table 1.

Fig.1. Ananta planter with inclined plate seed metering mechanism

Fig.2. Nandyala planter with horizontal plate seed metering mechanism

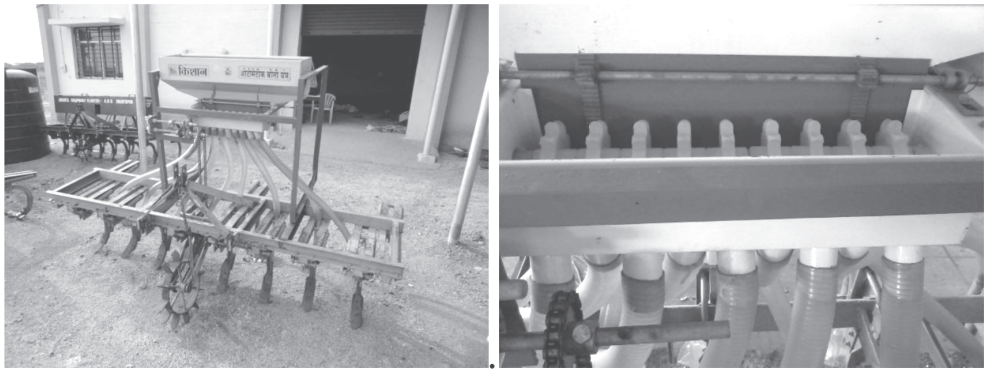

Fig. 3. Gujarat seed cum fertilizer drill with trough feed seed metering mechanism

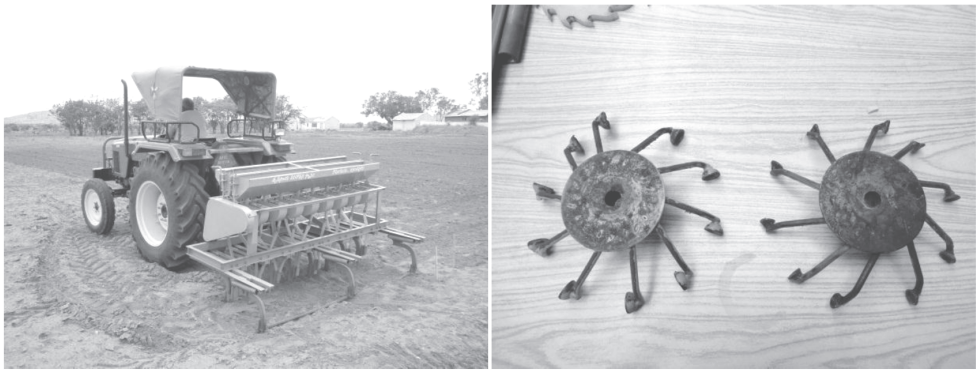

Fig. 4. TNAU model seed cum fertilizer drill with spoon feed type seed metering mechanism

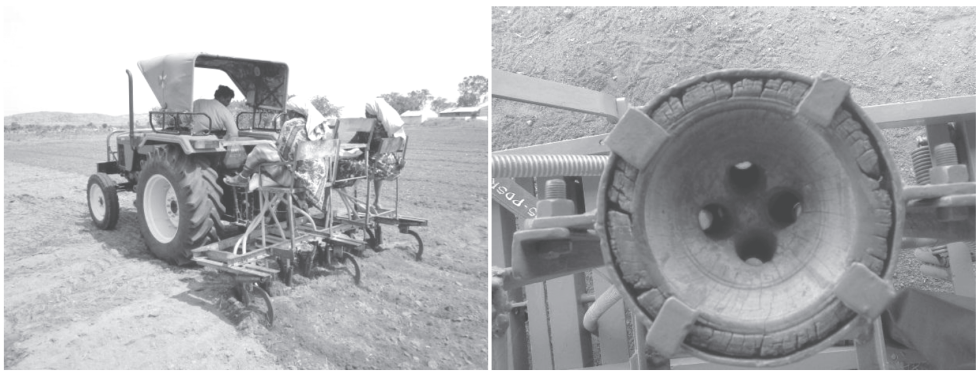

Fig. 5. Local seed drill with manual dropping seed metering mechanism

Table 1. Main features of five types of seed drills

S. No.	Name of seed drill	No. of furrow openers	Row spacing (m)	Effective operating width (m)	Type of seed metering mechanism	Overall dimensions of seed drills (lxbxh) (cm)
1.	Ananta planter	8	0.30	2.4	Inclined plate	255x97x110
2.	Nandyala planter	8	0.30	2.4	Horizontal plate	255x97x128
3.	Gujarat seed cum fertilizer drill	8	0.30	2.4	Trough feed	255x98x157
4.	TNAU model seed cum fertilizer drill	8	0.30	2.4	Spoon feed	243x107x130
5.	Local seed drill	8	0.30	2.4	Manual dropping	255x92x161

It was necessary to calibrate the seed drills for Bengal gram to find desired seed rate before field test. Calibration was done to get the pre-determined seed rate of the machine. The seed drills were calibrated in the laboratory at ARS, Anantapur as per BIS test code IS 6316: 1993 for Bengal gram. After completion of calibration test of five seed drills, the field experiment was conducted. During the experiment the machine and operational parameters *viz.,* speed of operation, effective field capacity, theoretical field capacity, field efficiency, field machine index and fuel consumption were recorded. Effective field capacity was measured by the actual area covered by the implement, based on its total time consumed and its width. Theoretical field capacity is the rate of field coverage of the implement, based on 100 per cent of time at the rated speed and covering 100 per cent of its rated width. Field efficiency is the ratio of effective field capacity to theoretical field capacity.

Field machine index indicates the influence of field geometry on working capacity of a machine.

$$FMI = \frac{T_p}{T_p + T_t} \quad x\ 100$$

Where,

FMI= Field machine index, %, T_p= Total productive time, min and T_t= Turning time loss, min

Moreover, the data on sowing and crop parameters *viz*., seed rate, depth of sowing, seed to seed spacing, plant population, number of pods per plant, pod/seed yield, halum/ stalk yield and harvest index at the time of harvesting were recorded. The cost analysis was also carried out to find out the best economical seed drill. The seed rate was determined by taking the weight of seed before and after sowing operation. Then subtracted the final weight of seed from initial weight of seed so that the seed rate was obtained and the results were expressed in terms of kg ha^{-1} and harvest index is the ratio of grain yield to the total biological yield (grain+straw) and expressed in percentage. The total cost of operation of the seed drill in Rs. ha^{-1} was estimated by considering the fixed cost and operational cost of the machine. The cost of operation was based on the prevailing market rates during the season and location. Fixed cost includes depreciation, interest, housing, insurance and taxes. Operating cost includes fuel cost, lubricants, repairs, maintenance, and other costs. Fuel cost was calculated on the basis of actual fuel consumption of the machine. Cost of repairs and maintenance was taken as five per cent of the initial investment of the machine. Other costs include wages for operator, labour cost based on the prevailing market rates per day of eight hours.

RESULTS AND DISCUSSION

Laboratory test was performed on seed drills with Bengal gram (JG-11 variety). Seed rates for the Bengal gram seed observed were 63.23 kg ha^{-1}, 67.65 kg ha^{-1}, 72.13 kg ha^{-1} and 74.55 kg ha^{-1} for the tractor drawn seed drills *viz*., Ananta planter, Nandyala planter, Gujarat seed cum fertilizer drill and TNAU model seed cum fertilizer drill respectively in the calibration test. The recommended seed rate for Bengal gram was 60-80 kg ha^{-1}. The calibrated values were just approaching to the recommended value. Therefore, these values of seed drills were recommended for Bengal gram crop. The results obtained for Bengal gram seed by calibration test for seed drills are presented in Table 2.The field evaluation was carried out after calibration test. During the field test the highest field capacity was found to be 0.47 ha h^{-1} for Ananta planter with field efficiency of 66.75 per cent at an average speed of 2.97 kmph followed by 0.45 ha h^{-1}, 0.42 ha h^{-1} and

Table 2. Observations with Bengalgram in calibration test

Type of seed drill	Test no.	Weight of seed from each furrow opener, kg								Weight of seed collected from all furrow openers, kg	Seed rate, kg ha^{-1}	Average seed rate kg ha^{-1}
		No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7	No. 8			
Ananta planter	1	0.32	0.31	0.31	0.30	0.32	0.31	0.31	0.32	2.52	63.07	63.23
	2	0.31	0.32	0.31	0.31	0.32	0.31	0.32	0.31	2.54	63.47	
	3	0.32	0.32	0.31	0.30	0.31	0.31	0.31	0.31	2.53	63.17	
Nandyala planter	1	0.34	0.33	0.34	0.34	0.32	0.34	0.33	0.34	2.71	67.74	67.65
	2	0.33	0.34	0.34	0.33	0.33	0.34	0.34	0.34	2.72	68.11	
	3	0.34	0.33	0.34	0.33	0.32	0.34	0.33	0.34	2.71	67.71	
Gujarat seed cum fertilizer drill	1	0.35	0.36	0.36	0.35	0.36	0.36	0.37	0.35	2.88	72.13	72.13
	2	0.35	0.36	0.36	0.36	0.36	0.35	0.36	0.35	2.88	71.98	
	3	0.35	0.36	0.36	0.35	0.36	0.36	0.36	0.35	2.89	72.28	
TNAU model seed cum fertilizer drill	1	0.37	0.36	0.37	0.37	0.36	0.37	0.38	0.36	2.98	74.64	74.55
	2	0.37	0.37	0.37	0.38	0.36	0.36	0.37	0.37	2.97	74.47	
	3	0.37	0.36	0.37	0.38	0.36	0.37	0.38	0.36	2.98	74.54	

0.41 ha h^{-1} with an field efficiency of 65.53%, 65.98 % and 63.44 % at an average speed of 2.88 kmph, 2.66 kmph and 2.73 kmph for Nandyala planter, Gujarat seed cum fertilizer drill and Local seed drill, respectively. The lowest field capacity was found to be 0.37 ha h^{-1} for TNAU model seed cum fertilizer drill with field efficiency of 64.11% at an average speed of 2.46 kmph. The results obtained for Bengal gram seed in the field are presented in Table 3. The operating speed of the Ananta planter was higher compared to other seed drills due to lesser weight than others and, also, the seeds were not falling down. (if any obstacles in field while operation due to closed type of inclined plated metering unit). The operating speed of TNAU model seed cum fertilizer drill was less compared to other seed drills due to

Table 3. Machine and operational parameters of seed drills for Bengalgram

Sl. No.	Parameters	Ananta planter	Nandyala planter	Gujarat seed cum fertilizer drill	TNAU model seed cum fertilizer drill	Local seed drill
1	Plot area, m^2	144	144	144	144	144
2	Speed of operation, kmph	2.97	2.88	2.66	2.46	2.734
3	Effective field capacity, ha h^{-1}	0.47	0.45	0.42	0.37	0.41
4	Theoretical field capacity, ha h^{-1}	0.71	0.71	0.64	0.59	0.65
5	Field efficiency, %	66.78	65.53	65.98	64.11	63.44
6	Actual operating time for test plot, h	0.0302	0.0318	0.0341	0.038	0.0346
7	Time lost for turnings and adjustments, s	10	12	13	16	19
8	Field machine index, %	91.57	90.51	90.42	89.52	86.76
9	Fuel consumption, l h^{-1}	4.26	4.07	3.83	3.448	3.66
10	Fuel consumption, l ha^{-1}	8.94	8.99	9.08	9.10	9.25

the weight is more and the ground wheel of unit was not freely rotated on the seed bed due to lesser length of pegs on the ground wheel.

Sowing parameters were calculated during the field evaluation. The recommended seed rate and average depth of sowing for Bengal gram crop was 60-80 kg ha^{-1} and 8-10 cm, respectively. The lowest seed rate obtained in the field for Bengal gram was observed as 64.37 kg ha^{-1} with an average seed spacing of 7.16 cm for Ananta planter, whereas, highest seed rate obtained was found to be 79.15 kg ha^{-1}with an average seed spacing of 9.33 cm for local seed drill. The seed rates obtained in the field were almost within the range of recommended seed rate for Bengal gram. The highest average depth of sowing was obtained as 8 cm for local seed drill and lowest depth of sowing was obtained as 4.6 cm for TNAU model seed cum fertilizer drill. The results of sowing parameters are presented in Table 4.

Table 4. Sowing parameters of seed drills for Bengalgram

Sl. No.	Name of seed drill	Seed rate obtained (kg ha^{-1})	Average depth of sowing (cm)	Average seed to seed spacing(cm)
1	Ananta planter	64.37	7.33	7.16
2	Nandyala planter	69.14	7.66	8.4
3	Gujarat seed cum fertilizer drill	73.72	4.6	8.0
4	TNAU model seed cum fertilizer drill	76.45	7.16	10.33
5	Local seed drill	79.15	8.0	9.33

Crop parameters were calculated during the field evaluation.The highest plant population for Bengal gram crop was found to be 38.31 with local seed drill whereas the lowest plant population was found to be 29.33 with Gujarat seed cum fertilizer drill. The highest pod yield obtained for Bengal gram crop was found to be 929.6 kg ha^{-1} with Ananta planter whereas the lowest pod yield was found to be 783.3 kg ha^{-1} with TNAU model seed cum fertilizer drill. The highest halum yield was found to be 3831 kg ha^{-1} with Ananta planter and the lowest halum yield was found to be 3178 kg ha^{-1} with TNAU model seed cum fertilizer drill. Crop parameters sown by different seed drills were shown in Table 5.

Table 5. Crop parameters of Bengalgram sown by various seed drills

Sl. No.	Name of seed drill	Average plant population per (m^2)	Number of pods per plant	Seed yield (kg ha^{-1})	Halum yield (kg ha^{-1})	Harvest index (%)
1	Ananta planter	33.49	16.4	929.6	3831	19.52
2	Nandyala planter	35.84	15.6	866.6	3818	18.49
3	Gujarat seed cum fertilizer drill	29.33	15.33	846.2	3764	18.35
4	TNAU model seed cum fertilizer drill	31.91	14.85	783.3	3178	19.77
5	Local seed drill	38.31	15.33	815.4	3564	18.61

The cost analysis for various seed drills are presented in Table 6. The cost of cultivation for Bengal gram crop were obtained that Rs.12,034, Rs.12,331, Rs.12,425, Rs.12,681 and Rs.12,680 per ha for Ananta planter, Nandyala planter, Gujarat seed cum fertilizer drill, TNAU model seed cum fertilizer drill and Local seed drills respectively. The gross income was determined by market price. The market price

for Bengal gram cost was found to be Rs. 450/t. The net income was determined by deduction of cost of cultivation from the gross income. The highest net income was found to be Rs. 29,798 per ha with Ananta planter, whereas, the lowest net income was found to be Rs.22568 with TNAU model seed cum fertilizer drill for Bengal gram crop. The benefit-cost ratio was determined by dividing cost of cultivation by net income. The highest Benefit-cost ratio was obtained that 2.47 for Ananta planter, whereas, the

Table 6. Cost economics of various seed drills for Bengal gram crop

Sl. No.	Observations	Ananta planter	Nandyala planter	Gujarat seed cum fertilizer drill	TNAU model seed cum fertilizer drill	Local seed drill
1	Initial cost, Rs.	55000	75000	35000	65000	25000
2	Life of the machine, years	10	10	10	8	8
3	Working hours per year(hr)	200	200	200	250	250
4	Total fixed cost, Rs h^{-1}	48.125	65.625	30.625	51.35	19.75
5	Variable cost, Rs h^{-1}	27.5	37.5	17.5	26	47.5
6	Operating cost of tractor Rs h^{-1}	447.327	436.621	422.289	399.708	412.227
7	Operating cost of seed drill, Rs h^{-1}	522.952	539.746	470.414	477.058	479.477
8	Operating cost of seed drill, Rs. ha^{-1}	1099	1195	1116	1263	1154
9	Cost of inputs, Rs. ha^{-1}	8360	8360	8360	8360	8360
10	Seed cost, Rs. ha^{-1} (Rs. 40 kg^{-1})	2575	2766	2949	3058	3166
11	Total cost of cultivation, Rs.ha^{-1}	12034	12331	12425	12681	12680
12	Gross Return, Rs. ha^{-1}	41832	38997	38079	35249	36693
13	Net income, Rs. ha^{-1}	29798	26667	25655	22568	24014
14	Benefit- Cost ratio	2.47	2.16	2.06	1.77	1.89

lowest benefit – cost ratio was obtained as 1.77 for TNAU model seed cum fertilizer drill.

CONCLUSIONS

It was observed that the performance of Ananta planter was satisfactory for Bengalgram crop among all seed drills. The highest field capacity was found to be 0.47 ha h^{-1} with field efficiency of 66.75% for Ananta planter among all treated seed drills, whereas, the lowest field capacity was found to be 0.37 ha h^{-1} for TNAU model seed cum fertilizer drill with field efficiency of 64.11% for Bengalgram crop among all seed drills. The lowest seed rate obtained in the field was observed as 64.37 kg ha^{1} for Ananta planter among all seed drills whereas the highest seed rate was observed as 79.15 kg ha^{-1} for local seed cum fertilizer drill. The highest seed yield obtained was found to be 929.60 kg ha^{-1} for Ananta planter among all seed drills whereas the lowest seed yield was found to be 783.30 kg ha^{-1} for TNAU model seed cum fertilizer drill. The cost of cultivation for Bengal gram crop were obtained that Rs.12,034, Rs.12,331, Rs.12,425, Rs.12,681 and Rs.12,680 per ha for Ananta planter, Nandyala planter, Gujarat seed cum fertilizer drill, TNAU model seed cum fertilizer drill and Local seed drills respectively. The highest net profit and benefit-cost ratio were found to be Rs.29,798 $ha^{-1}$and 2.47, respectively for Ananta planter among all seed drills whereas the lowest were found to be Rs. 22,568 ha^{-1} and 1.77, respectively, for TNAU model seed cum fertilizer drill among all seed drills.

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SITUATIONAL ANALYSIS OF FEMALE FOETICIDE AND FEMALE INFANTICIDE IN UNITED ANDHRA PRADESH

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ABSTRACT

The present study analyses the reasons and practices adopted for female foeticide and infanticide existing in the rural, urban and tribal areas of Andhra Pradesh. A sample of four hundred and twenty men and women were interviewed to study the incidence of female foeticide and infanticide in the Andhra, Rayalaseema and Telangana regions. Results of the study indicated that the son preference, dowry and the poor implementation of the MTP and PCPNDT acts were the major reasons for the declining sex ratio in all the three regions. The urban educated respondents working in ICDS, health, legal, NGO and education departments were found to have better understanding of the declining sex ratio in A.P. state compared to rural and tribal respondents. The grass root level functionaries opined that the legal awareness and strict implementation of the MTP, PNDT and Dowry prohibition acts should be done in order to improve the girl child status and sex ratio. The cultural and traditional values significantly contributed to the perceptions related to the girl child in all the three regions. Among the three religions, Hindu religion respondents were more conservative in their perceptions followed by Islam and Christian religion. The female foeticide rate is increasing than the female infanticide rate in all the three regions. In the rural and urban areas sex determination of the foetus tests are easily accessible compared to tribal areas. People were found to believe in the indigenous methods for sex determination in all the three regions. Overall, the number of years of education, social status and prestige, achievement as a competence related goal were the variables that determined response to general perception on girl child.

INTRODUCTION

Female foeticide and infanticide is a matter of grave concern because both are the worst form of crime against the womanhood in contemporary Indian society. The most shocking fact is that the innovative and high end technologies are brutally killing the female foetus and the girl child. This has been the reason that sex ratio is 1000:914 among 0-6 year old boys and girls which is declining day by day (Dhar, 2011). In the era of science and technology people are being remedied from rarest of rare diseases by medical science, however, this boon of medical science is being misused. Today, people are carrying out abortion knowing the female sex by ultra-sonography, amniotesis and other techniques. If baby girl takes birth, she is deprived of love and affection because she is abandoned to die on canals, coverts and footpath, etc. Female foeticide and infanticide is not the only issues with a girl child in India but also every stage of life she is discriminated and neglected for the basic nutrition, education and living standard. According to United Nations report 750,000 girls are aborted every year in India. Moreover, In India more than 10,000 girl babies are victims of infanticide each year. Punjab and Haryana are such states where the highest numbers of abortions (80%) are carried out every year.

Female Foeticide

Sex selective abortions cases have become a significant social phenomenon in several parts of India. It transcends all castes, class and communities and even the north- south dichotomy. The girl children become target of attack even before they are born. Sex determination tests are widely resorted to even in the remotest rural areas. Since most deliveries in rural areas take place at home there is no record of the exact number of births/deaths that take place. Hence, it is difficult to assess the magnitude of the problem. However, the fact remains that the right to be born are being denied to the female child. Since

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all religions treated abortion as immoral, and contrary to divine law, this blanket ban on abortion, resulted in illegal abortions and risking the life of the woman.

Female Infanticide

It is a deliberate and intentional act of killing a female child within one year of its birth either directly by using poisonous organic and inorganic chemicals or indirectly by deliberate neglect to feed the infant by either one of the parents or other family members or neighbors or by the midwife. It is unfortunate that the parents also view her as a liability. This attitude is rooted in a complex set of social, cultural, and economic factors. It is the dowry system, lack of economic independence, social customs and traditions that have relegated the female to a secondary status. The degree may vary but the neglect of the girl child and discrimination goes hand-in-hand. Poverty, ignorance of family planning, cost of dowry, etc. have been reported as the possible causes for this crime (Tandon, 1999). The twin process of 'elimination of unborn daughters' and the 'slow killing' through neglect and discrimination of those that are born has become a matter of concern. Hence, the present study was investigated with the objectives of exploring the causes of foeticide and infanticide and to find out the female foeticide and infanticide practices existing in the three regions.

MATERIAL AND METHODS

Four hundred and twenty people were selected for the study. A total of 420 (70 men and 70 women from each region) were selected from Andhra, Rayalaseema and Telangana of Andhra Pradesh state (2013-14). Three villages from each region where the girl child sex ratio is less were selected for the study. The sample covered rural, urban and tribal areas and respondents belonged to Hindu, Muslim and Christian religions. A questionnaire and interview schedule was developed for the purpose of study. Data collection was done in the selected villages and the respondents were selected randomly who fit into the criteria. Stratified random sampling method was used. The sample for the study was selected based on the 2011 census data of the Andhra Pradesh state. Three major regions of united Andhra Pradesh state *i.e.* Andhra, Rayalaseema and Telangana were chosen for the study which represents the different social and cultural settings.Three major religions of the state *i.e.* Hindu, Islam and Christian were selected purposively to understand the religious and cultural factors responsible for the declining sex ratio in Andhra Pradesh state. The urban sample was selected from the mandal head quarters. The literate men and women respondents of ICDS, health, education, legal and NGOs departments were selected for the study. In toto, 150 respondents were selected from the urban areas. (50 from each region). Three mandals were selected from each region where the girl child sex ratio was less as per the 2011 census data. The rural and tribal sample was selected from three villages located in the selected mandal. These three villages were selected by taking the lowest sex ratio data in the mandal with the help of ICDS supervisors. A sample of 45 men and 45 women in the age group of 21-60 years were selected from three villages. A sample of 30 from each village was interviewed.

Data analysis

The data was analysed by calculating the weighted scores for each statement on female foeticide and female infanticide. Based on the weighted scores the order of preference was again ranked in three regions. Few descriptive tables are also included to reflect the cultural and social variations in the responses given by the respondents belonging to three regions for the open ended questions.

RESULTS AND DISCUSSION

Table 1 and 2 indicate that majority of the male respondents from the Rayalaseema region felt that if there are more than one female child in the family it is a burden. Hence, they opt for aborting the female foetus. They opined that the first child in the family should be a boy. The respondents said that the negative attitude towards the girl child is due to the fear of dowry and sexual abuse. Sometimes if the child is born with deformity and failure of the family planning method, then they opt for aborting the female foetus. Good looking appearance of the child does not matter much and ranked last by the sample. Similar responses were reported by the female sample. However, the female respondents reported that more number of female foeticides is due to the husband and in law's force and their opinion is not taken into consideration. They had opined that due to dowry problem and other social reasons female foeticide and infanticide are increasing in our society.

The Andhra region respondents opined that fear of dowry, family with more than one girl child and son preference are the major reasons for female foeticide and hence ranked them on the top whereas child born with deformity and not being fair in complexion and good looking are the reasons for female infanticide. Both male and female respondents opined that the socio economic conditions of the family play an important role in going for this heinous crime. They said that if a woman refuses for female foeticide then she would be thrown out of the family by the in laws. In many cases it is the higher birth order female infants who are becoming the victims.

In the Telangana region the male respondents felt that if there are more than two girl children in the family then they go for aborting the female foetus as raising a girl child is a costly affair. They had expressed that society is not girl friendly and number of crimes on girls are on the rise. The female respondents expressed that their in laws and husband force them to go for sex determination tests and if it is a girl child then they are forced to go for aborting the foetus. Majority of the respondents opined that the first child should be a boy. They expressed that girl child sexual abuse and crimes are increasing in the present society and parents always need to protect the girls. The respondents said that if a girl child is born with a deformity and ugly features then the child is killed by the *dai* or birth attendant immediately after birth. They did not consider it as a crime as they feel that the child is saved from the parasitic life and curse from the family members and society. However, if a male child is born with such deformity then it is not killed but accepted by the family.

Table 3 depicts various indigenous foetal sex determination methods in the three regions of Andhra Pradesh. Mostly the elders in the family or *dai*s who conduct deliveries in villages identify the sex of the foetus by observing some of the signs and symptoms in the mother. Most of the signs and symptoms appear during the fifth month of the pregnancy. In Andhra region *dai*s observed that if the size of the belly is big and the foetal movements are vigorous then it is a boy. If the foetal implantation is towards the right side of the mother then it is a girl, whereas, if the foetal position is towards left then it is a boy. Similarly, in the Rayalaseema region also some of the beliefs exist about the sex of the foetus. The elder age group of respondents said that if the mother's neck becomes darker in the last trimester then it is a baby girl. In the Telangana region the rural and tribal respondents reported that by observing the outward signs and symptoms of the mother, the sex of the foetus is determined. The respondents expressed that in many cases the guess turned out to be correct. Though there is no scientific base for these beliefs people still consider these indigenous methods in their families. In few villages of Rayalaseema and Telangana regions, pregnant woman is given medicine which is prepared by using certain herbs and root extracts in the third month, fifth month and seventh month of pregnancy for giving birth to a male child.

Table 1. Reasons for female foeticide / infanticide – Male respondents (N= 420)

S.no	Rayalaseema (N=140)			Andhra (N=140)			Telangana (N=140)		
	Reason	Weighted score	Rank	Reason	Weighted score	Rank	Reason	Weighted score	Rank
1	Family with more than two girl children	825	1	Fear of dowry and other expenses	844	1	Family with more than two girl children	875	1
2	Fear of dowry and other expenses	714	2	Family with more than two girl children	747	2	Fear of dowry and other expenses	735	2
3	First child should be boy	665	3	First child should be Boy	638	3	Poverty	664	3
4	Force from husband / In laws family	543	4	Poverty	582	4	Force from husband / In laws family	547	4
5	Society is not girl child friendly	420	5	Society is not girl child friendly	448	5	Society is not girl child friendly	425	5
6	Fear of child abuse/ sexual assault	318	6	Fear of child abuse/ sexual assault	322	6	Fear of child abuse/ sexual assault	315	6
7	Unwanted pregnancy and child birth	310	7	Unwanted pregnancy and child birth	315	7	Unwanted pregnancy and child birth	288	7
8	Poverty	286	8	Force from husband / In laws family	275	8	First child should be Boy	275	8
9	Born with deformity / loss of body part	220	9	Born with deformity / loss of body part	250	9	Born with deformity / loss of body part	250	9
10	Not fair in complexion and good looking	186	10	Not fair in complexion and good looking	232	10	Not fair in complexion and good looking	217	10

Table 2. Reasons for female foeticide / infanticide – Female respondents (N= 420)

S.No	Rayalaseema (N=140)			Andhra(N=140)			Telangana (N=140)		
	Reason	Weighted score	Rank	Reason	Weighted score	Rank	Reason	Weighted score	Rank
1	Family with more than two girl children	807	1	Family with more than two girl children	786	1	Force from husband / In laws family	814	1
2	Fear of dowry and other expenses	724	2	First child should be Boy	755	2	Family with more than two girl children	736	2
3	First child should be boy	635	3	Fear of dowry and other expenses	545	3	Fear of dowry and other expenses	640	3
4	Force from husband / In laws family	554	4	Force from husband / In laws family	472	4	First child should be Boy	554	4
5	Society is not girl child friendly	484	5	Society is not girl child friendly	426	5	Society is not girl child friendly	478	5
6	Fear of child abuse/ sexual assault	369	6	Poverty	350	6	Poverty	379	6
7	Unwanted pregnancy and child birth	374	7	Fear of child abuse/ sexual assault	335	7	Fear of child abuse/ sexual assault	350	7
8	Poverty	275	8	Unwanted pregnancy and child birth	243	8	Unwanted pregnancy and child birth	227	8
9	Born with deformity / loss of body part	217	9	Born with deformity / loss of body part	220	9	Born with deformity / loss of body part	210	9
10	Not fair in complexion and good looking	210	10	Not fair in complexion and good looking	214	10	Not fair in complexion and good looking	195	10

Table 3. Indigenous methods of sex determination

Andhra region	Rayalaseema region	Telangana region
• If the size of the mother's belly is big, it is a boy • If the line from naval to the pit of the stomach is straight , it is a boy otherwise it is a girl. • By observing the position of the foetus- girls to the right and boys to the left • Foetal movement – weak in case of girls and vigorous in case of boys	• If the size of the mother's belly is big, it is a boy • If the mother has vomiting till the ninth month then it is a boy. • By observing the position of the foetus- girls to the right and boys to the left • If the mother's neck part becomes dark by last trimester of pregnancy, then it is a girl. • If the placenta of the first child has outward protrusions then the second child would be a boy and if the placenta is smooth then the next child would be a girl.	• If the size of the mother's belly is big, it is a boy • By observing the position of the foetus- girls to the right and boys to the left • If the mother becomes fair and beautiful then it is a girl. • By feeling the ribs of the pregnant woman – if they are soft then it is girl and if they are hard then it is a boy. • If the mother's belly protrudes outwards then it is a boy.

Table 4. Sources of information about the foetal sex determination – Rayalaseema region

Sl.no	MALES (N=70)			FEMALES(N=70)		
	Source	Weighted score	Rank	Source	Weighted score	Rank
1	Health functionaries	784	1	Health functionaries	640	1
2	Private clinics/ Labs	647	2	Private clinics/ Labs	596	2
3	Friends	532	3	Private practitioners	564	3
4	Private practitioners	482	4	ICDS functionaries	448	4
5	ICDS functionaries	426	5	Friends	410	5
6	Government doctors	364	6	Government doctors	342	6
7	Relatives	325	7	Relatives	318	7
8	Hoardings	286	8	Hoardings	252	8
9	Pamphlets	244	9	Media (TV, Radio)	236	9
10	Media (TV, Radio)	224	10	Pamphlets	216	10

In the Rayalaseema region male and female respondents said that the mains sources of information about the foetal sex determination were health functionaries such as ANMs and Asha workers in the villages. The persons working in the private clinics and diagnostic labs also give information about sex determination, hence, they were ranked on top by the respondents. Private practitioners having their own nursing homes, friends and ICDS functionaries such as *anganwadi* teacher, helper and supervisors also provide the needed information at village level. Few respondents said that government doctors who are working as medical officers in Primary health Centres provide information and refer them to the concerned clinics or scanning centers in the mandal and district head quarters. The electronic and print media were ranked in the last preferences as the sex determination was done secretly and the information was not disclosed to the public in view of legal actions.

Table 5. Sources of information about the foetal sex determination – Andhra region

Sl.no	MALES (N=70)			FEMALES (N=70)		
	Source	Weighted score	Rank	Source	Weighted score	Rank
1	Health functionaries	866	1	Health functionaries	824	1
2	Private practitioners	725	2	Private clinics/ Labs	775	2
3	Friends	614	3	Private practitioners	637	3
4	Private clinics/ Labs	552	4	ICDS functionaries	614	4
5	ICDS functionaries	428	5	Government doctors	558	5
6	Government doctors	375	6	Relatives	462	6
7	Relatives	342	7	Friends	384	7
8	Hoardings	269	8	Pamphlets	242	8
9	Pamphlets	254	9	Hoardings	225	9
10	Media (TV, Radio)	242	10	Media (TV, Radio)	210	10

In the Andhra region majority of the respondents said that health functionaries, private clinics, friends and ICDS personnel play an important role in providing the information to the people about the sources of foetal sex determination. The educated urban people get the information from the pamphlets and electronic media, whereas, the uneducated rural and tribal respondents reported that they get the information from the local health workers and other clinic assistants. In some cases the medical officer refers to the scanning center to check the foetal health and growth. However, the person who does the scanning reveals the sex of the foetus when bribed. The health and ICDS functionaries reported that people get the sources of foetal sex determination from their friends and relatives who have the network at gross root level. The health officials do physical checkups in the Primary health centres (PHCs) and refer them to the scanning centers to detect any abnormality in the growing foetus.

Table 6. Sources of information about the foetal sex determination methods – Telanagna region

Sl.no	MALES (N=70)			FEMALES (N=70)		
	Source	Weighted score	Rank	Source	Weighted score	Rank
1	Health functionaries	814	1	Health functionaries	776	1
2	Private clinics/ Labs	747	2	Private clinics/ Labs	655	2
3	Friends	638	3	Private practitioners	545	3
4	Private practitioners	582	4	ICDS functionaries	472	4
5	ICDS functionaries	448	5	Friends	426	5
6	Government doctors	322	6	Government doctors	350	6
7	Relatives	315	7	Relatives	335	7
8	Hoardings	275	8	Hoardings	243	8
9	Pamphlets	250	9	Pamphlets	220	9
10	Media (TV, Radio)	232	10	Media (TV, Radio)	214	10

Majority of the male and female respondents from the Telangana region said that health functionaries, private doctors and private clinics and labs followed by ICDS functionaries are the main sources of providing information about the foetal sex determination in the rural and tribal areas. Hence, they were ranked on the top. The print and electronic media has a little role to play in providing the sources of foetal sex determination. Hence, these were ranked in the last by the respondents. The local health workers and *anganwadi* workers play an important role in providing the information to the mothers. At present, the tribal mothers are also going for foetal sex determination when they have girl child earlier and did not want another girl child. The health workers said that female foeticide cases are increasing in this area. The rural and tribal mothers go for sex determination in the scanning centers maintained secretly in the mandal head quarters and if there is a female child in the womb then they go for forced abortion in their village using the local ayurvedic medicines prepared by the tribal quacks.

Table 7 explains about the female infanticide practices observed in the three regions of Andhra Pradesh. In the rural areas of Andhra region if a female child is born who is not wanted by the family then they simply leave the child in the hospital after the delivery and come home without anybody's notice or throw the infant into the garbage bin or nearby well. In the remote villages the *dai* puts the paddy seeds in the newly born infant's throat which causes death of the infant. Few traditional birth attendants or elder women in the family mix the poison or milk of calotropis and feed the infant resulting in blood vomiting and immediate death of the infant. Few people put clay or mud inside the throat and block the air passage. In few cases, the female child is not breast fed and denied of any kind of feeding and

Table 7. Practices adopted for female infanticide

Andhra region	Rayalaseema region	Telangana region
• Leaving the baby • Throwing in the garbage /wells/ drainage • Putting paddy seeds in the throat • Making the infant breathless • Mixing poison in milk • Milk of calotropis • Putting clay or mud in the throat • Neglecting • Denying medical care	• Leaving the baby • Throwing in the garbage /wells/ drainage • Putting paddy seeds in the throat • Making the infant breathless • Starving the baby to death • Not giving proper medical and health care • Wrapping the baby tightly in the towel	• Throwing in the garbage /wells/ drainage • Putting paddy seeds in the throat • Making the infant breathless • Mixing poison in milk • Milk of calotropis • Throat splitting • Starving the baby to death • Burying infant alive • Exposing to smoke and cause choking

medical care ultimately leading to death. Similar types of practices are also observed in the Rayalaseema region. In addition to the above practices, *dai* in the village said that the female child is wrapped tightly in the towel immediately after birth and buried in the ground. In few villages if the mother dies after delivering a female child then the live infant is also buried along with the mother. If it is a male child then it is given to somebody for rising. Similarly, in some villages if the mother gives birth to twins – one male child and one female child then the female child is killed with a belief that the strength of the female child would be taken by the male child and he would survive for long. In the tribal Telangana region female infanticide is a common practice and the birth attendant slits the throat of the female infant immediately after birth if it is an unwanted child. Many deliveries are attended by the local quacks or *dai*s in their homes. Hospital deliveries are rare. If there is any emergency they go to hospital. In some tribal villages female infants are buried alive by the *dai*s. Few infants were left neglected and no feed is given for two to three days. The infant dies ultimately due to starvation. In few rural and tribal families infants are exposed to smoke and cause choking and breathlessness leading to death. Sometimes the elder woman or mother in law presses pillow over the infant's face for few minutes and the infant dies. In some cases parents take a false death certificate by bribing the doctor and bury the live female infant secretly. The number of female infanticides is reduced compared to the previous years where the number of female foeticides is on the rise due to technological advances and easy accessibility of sex determination tests in the rural and urban areas. This is the reason why the rural female sex ratios are declining in the recent years.

CONCLUSIONS

Sex selective abortion is the result of son-preference and the dowry system; however, the major cause is the social status of women in India. Women are still the subject of domination and subordination. They are still subjected to their husbands' decision. The cultural and social context of India does not provide the base for women to stand up for themselves. They are taught to be subordinates to their husbands and in-laws. The gender issues in India, be it sex-selective abortion, or women violence, will not be successfully addressed until and unless women themselves value their being and their identity. Government regulations are important to control the number of sex-selective abortions. Nevertheless, government should make policies that empower women and support their identity as a human being rather than someone's wife or a mother.

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EFFECT OF POTTING MEDIA ON THE GROWTH OF RANGPUR LIME (*Citrus limonia* Osbeck) AND AUSTRALIAN SOUR ORANGE (*Citrus aurantium*) ROOT STOCK SEEDLINGS

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ABSTRACT

Present investigation was carried out at AICRP on Fruits, Citrus Research Station, Tirupati, during the year 2014-2015. Two months old Rangpur lime and Australian sour orange seedlings were selected for transplanting into different potting media contained poly bags to study their effect on growth and establishment. The results indicated that in Rangpur lime seedlings, highest values for plant height (26.84 cm), number of leaves per seedling (33.95), stem girth (0.78 cm), length of tap root (22.85 cm), number of secondary roots per seedling (15), canopy spread (15.32 cm^2), leaf area per seedling (67.27 cm^2), SCRM readings (70.64), leaf dry weight per plant (5.17 g), root dry weight per plant (3.65 g), total dry weight of plant (10.35 g) were recorded in the treatment-7 containing Soil + Sand + Vermicompost @ 1:1:1 v/v + AM + *Trichoderma reesei* (TCT-10) @ 5g bag^{-1} each per bag followed by treatment-5 composed of Soil + Pressmud + Vermicompost @ 1:1:1 v/v + AM [5g]. Highest number of fibrous roots per plant was recorded in treatment-5 (Soil + Pressmud + Vermicompost @ 1:1:1 v/v + AM [5g]). Lowest growth values were recorded in control treatment where standard potting mixture of soil, sand, FYM used in 1:1:1: ratio. In Australian sour orange seedlings, highest values for plant height (22.75 cm), number of leaves per seedling (28.97), stem girth (0.62 cm), length of tap root (19.59 cm), number of secondary roots per seedling (14.87), number of fibrous roots (122.61), canopy spread (12.87 cm^2), leaf area per seedling (52.44 cm^2), SCMR readings (68.45), leaf dry weight per plant (4.37 g), root dry weight per plant (2.51 g), total dry weight of plant (9.94 g) were recorded with treatment-7 combination of Soil + Sand + Vermicompost @ 1:1:1 v/v + AM + *Trichoderma reesei* (TCT-10) @ 5g bag^{-1} followed by Trearment-5 (Soil + Pressmud + Vermicompost @ 1:1:1 v/v + AM [5g]). Lowest values for all parameters were recorded in control plants.

INTRODUCTION

The genus *Citrus* and its relatives are horticulturally important comprising of prominent fruit crops *viz*., mandarins, oranges, lemons, limes and grape fruit, etc. It belongs to the family Rutaceae and confined to 0^0-40^0 latitude from North to South of the equator covering different regions having different soil and climatic conditions. It is the third most important fruit crop of India next to mango and banana and is one of the world's most important fruit crops grown in more than 100 countries. Different species of citrus fruits have different chemical compositions. While in the sweet group, the principle constituents of the edible portion are sugars (glucose and sucrose) and acids (primarily citric acid and little of malic acid), the fruits of acid groups contain primarily the acids (citric acid) in the fruit juice. The rind of citrus fruits is rich in pectin and certain essential oils. Citrus fruits contain 25 to 85 mg 100 ml^{-1} of juice, ascorbic acid, the vitamin C. The citrus fruits are bottled and canned on large scale. The flowers, leaf and rind of citrus contain oils of good fragrance and have good commercial value. Rangpur lime (*Citrus limonia* L.) is the most popular root stock for sweet orange in AndhraPradesh. It is vigorous and hardy rootstock with good adaptability to wide range of soil, particularly for heavy soils. It is tolerant to tristeza virus and certain soil born diseases. Australian sour orange (*Citrus aurantium*) has extensively used in the past for propagating sweet orange, mandarin orange, grape fruit and lemon. It is hardy to cold, adapted to heavy soils, resistant to many soil born diseases like dry root rot, citrus greening (Gopal *et al*., 2011 and 2012) in sweet orange, imparts semi dwarfing effect on the scion and improves the fruit quality. Rootstocks are propagated generally under

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open field conditions and the nursery site is often infected with citrus nematodes, foot rot and perennial weeds. These are major problems for nurserymen to grow healthy citrus nursery stock. Production of containerized citrus nursery plants has increased greatly in recent years and found to be a possible solution against the soil related problems. In Andhra Pradesh, however, little work has been done on production of containerized citrus nursery plants.

In the production of sweet orange budlings, root stock (Rangpur lime) plants are raised through seeds by raising primary nursery for 2-3 months on raised beds, there after seedlings are transplanted to secondary nursery. In the secondary nursery beds seedlings take 6-7 months time to attain buddable stem girth. After budding it takes another 3-4 months time to attain saleable stage. Hence, it takes nearly 11-14 months to prepare budlings of salable size from the date of sowing rootstock seed in the primary nursery beds. The entire process is time consuming and labor intensive as, irrigations , weeding, fertilization and plant protection measures are to be taken up at regular intervals at all nursery stages thereby increases cost of production. Efforts have been made earlier by many workers to sow the root stock seed directly in poly bags containing standard potting mixture of soil + FYM + sand(1:1:1) with the intention of cutting down the lengthy nursery period (secondary) and also to conserve all inputs used in raising of sweet orange budlings. However, from the observations made it was found that initial growth of rootstock seedlings in poly bags is very slow compared to those raised on beds. The present study was taken up to standardize the potting media to enhance the growth of Rangpur lime and Australian sour orange seedlings thereby minimizing the production period and cost involved in raising of the rootstock seedlings.

MATERIAL AND METHODS

The experiment was carried out to evaluate the effect of different potting media on the growth and establishment of Rangpur lime and Australian sour orange root stock seedlings during the year 2014 to 2015 at Citrus Research Station, Tirupati which comes under Rayalaseema region of Andhra Pradesh state located at $13^0 65^1$ North latitude and $79^0 42^1$ East longitude, with an altitude of 162 meters above mean sea level. The climate of the research station is tropical with maximum temperature ranging from 36-42°C during summer season, minimum temperature ranging from 22 to 24°C during winter season. The meteorological data during this study is presented in Table 4.

The experiment was laid out in RBD with eight treatments and three replications. Treatments consisted of T_1 - Soil + Coco peat + FYM @ 1:1:1 v/v + AM [5g], T_2 - Soil + Press mud + FYM @ 1:1:1 v/v + AM [5g], T_3 - Soil + Vermicompost + FYM @ 1:1:1 v/v + AM [5g], T_4 - Soil + Coco peat + Vermicompost @ 1:1:1 v/v + AM [5g], T_5 Soil + Pressmud + Vermicompost @ 1:1:1 v/v + AM [5g], T_6 - Soil + Sand + FYM + AM + *Trichoderma reesei* (TCT-10) @ 5g bag^{-1}, T_7 - Soil + Sand + Vermicompost + AM + *Trichoderma reesei* (TCT-10) @ 5g/bag, T_8 - Soil + Sand + FYM@ 1:1:1 v/v [Control]. Freshly extracted seeds of Rangpur lime and Australian sour orange were treated with mancozeb @ 5g kg^{-1} of seed, shade dried for 24 hours. Treated seeds were sown in nursery beds. 60 days old seedlings are lifted from seed beds and roots are dipped in mancozeb solution (2g lit^{-1}) for two minutes. Next, seedlings have been transplanted poly covers containing different potting media. Data on biometric and physiological observations have been recorded (by destructive method of seedling sampling) at monthly intervals starting from one month after transplanting of seedlings. A sample size of five plants per replication was used for recording of observations. Nutrient for status of potting media was recorded twice before initiation of experiment and at the end. Plant samples (leaves and stem) were analysed for nutrient status at the end of the experiment.

RESULTS AND DISCUSSION

Shoot parameters

In Rangpur lime seedlings, highest values for plant height (26.84 cm), number of leaves per seedling (33.95), stem girth (0.78 cm), canopy spread (15.32 cm^2), leaf area per seedling (67.27 cm^2), SCRM readings (70.64), leaf dry weight per plant (5.17 g), root dry weight per plant (3.65 g), total dry weight of plant (10.35 g) were recorded in the treatment-T_7 containing Soil + Sand + Vermicompost @ 1:1:1 v/v + AM + *Trichoderma reesei* (TCT-10) @ 5g bag^{-1} each per bag followed by treatment-5 composed of Soil + Pressmud + Vermicompost @ 1:1:1 v/v + AM [5g]. Highest number of fibrous roots per plant was recorded in treatment-5 (Soil + Pressmud + Vermicompost @ 1:1:1 v/v + AM [5g]) (Table 1). All parameters were recorded lowest values in control treatment where standard potting mixture of soil, sand, FYM used in 1:1:1: ratio. In Australian sour orange seedlings, highest values for plant height (22.75 cm), number of leaves per seedling (28.97), stem girth (0.62 cm), canopy spread (12.87 cm^2), leaf area per seedling (52.44 cm^2), SCMR readings (68.45), leaf dry weight per plant (4.37 g), root dry weight per plant (2.51 g), total dry weight of plant (9.94 g) were recorded with treatment- T_7 combination of Soil + Sand + Vermicompost @ 1:1:1 v/v + AM + *Trichoderma reesei* (TCT-10) @ 5g bag^{-1} followed by Treatment-T_5 (Soil + Pressmud + Vermicompost @ 1:1:1 v/v + AM [5g]). Lowest values for all parameters were recorded in control plants. The increase in the shoot growth parameters due to application of Soil + Sand + Vermicompost @ 1:1:1 v/v + AM + *Trichoderma reesei* (TCT-10) @ 5g bag^{-1} could be attributed to the conducive effect of this medium mixture on water holding capacity, porosity, soil aeration and supplying substantial amount of nutrients especially nitrogen and micro nutrients to plants which might have facilitated for better growth in seedling (Chopde *et al.*, 1999). Increase in number of leaves might be mainly due to corresponding increase in plant height (Govind and Chandra, 1993). The treatment also has higher leaf chlorophyll content which might certainly improved the photosynthetic rate, dry matter production and their by resulted in more fresh and dry weight of shoots.

Root parameters

In Rangpur lime seedlings highest length of tap root (22.85 cm) and maximum number of secondary roots per seedling (15) was observed in treatment 7 *i.e.*, Soil + Sand + Vermicompost @ 1:1:1 v/v + AM + *Trichoderma reesei* (TCT-10) 5g bag^{-1}. In Australian sour orange seedlings highest length of tap root (19.59 cm), number of secondary roots per seedling (14.87) and number of fibrous roots (122.61) also observed in T7(Table 2). This might be due to improved soil texture, structure, porosity, water holding capacity, activity of useful soil micro fauna and flora, maintained soil temperature and improved soil health and nutrient status of medium (Hartmann and Kester, 1997). Further, the vermicompost also provides close contact between seed and media; increases steady moisture supply facilitates root respiration and encourages overall root growth (Chatterjee and Choudhuri, 2007).

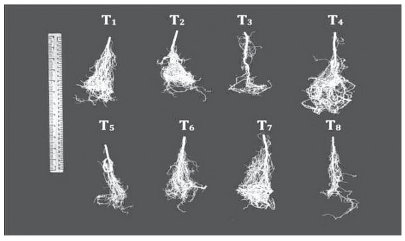

Fig. 1. Effect of different potting media on root growth of Rangpur lime seedlings (at 150 DAT)

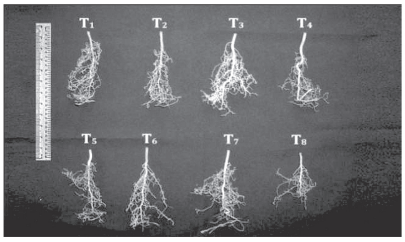

Fig. 2. Effect of different potting media on root growth of Australian sour orange seedlings (at 150 DAT

Table 1. Effect of media on shoot parameters of Rangpur lime and Australian sour orange seedlings

S. No.	Treatments	Plant height (cm)		Number of leaves per plant		Leaf area per seedling (cm^2)		Leaf dry weight per seedling (g)		Canopy spread (cm)		Stem girth (cm)	
T_1	Soil + Cocopeat + FYM @ 1:1:1 v/v + AM [5g]	23.07	19.38	23.27	22.74	33.68	30.36	1.82	2.26	11.23	9.75	0.46	0.53
T_2	Soil + Pressmud + FYM @ 1:1:1 v/v + AM [5g]	23.90	19.74	24.67	21.54	36.76	28.51	2.98	2.41	11.65	9.89	0.50	0.54
T_3	Soil + Vermicompost + FYM @ 1:1:1 v/v + AM [5g]	24.35	21.32	31.20	27.31	39.05	34.82	4.74	3.86	12.05	10.40	0.64	0.61
T_4	Soil + Cocopeat + Vermicompost @ 1:1:1 v/v + AM [5g]	26.38	22.41	29.50	25.21	33.39	37.09	2.93	2.65	13.65	10.87	0.64	0.59
T_5	Soil + Pressmud + Vermicompost @ 1:1:1 v/v + AM [5g]	22.75	17.15	27.06	23.83	34.29	36.16	4.18	3.59	14.54	12.32	0.58	0.57
T_6	Soil + Sand + FYM @ 1:1:1 v/v + AM + *Trichoderma reesei* (TCT-10) @ 5g bag^{-1}	20.41	15.33	25.73	21.74	42.98	34.63	3.81	2.92	13.02	11.45	0.62	0.56
T_7	Soil + Sand + Vermicompost @ 1:1:1 v/v + AM + *Trichoderma reesei* (TCT-10) 5g bag^{-1}	26.85	22.75	33.95	28.97	67.27	52.44	5.17	4.37	15.32	12.87	0.78	0.62
T_8	Soil + Sand + FYM @ 1:1:1 v/v [Control]	20.61	14.36	19.00	17.44	12.46	13.19	1.64	1.63	10.32	8.97	0.42	0.48
	Mean	**23.54**	**19.06**	**26.80**	**23.60**	**37.49**	**33.40**	**3.41**	**2.96**	**12.72**	**10.82**	**0.58**	**0.56**
	SE(m) ±	1.56	1.29	1.81	1.59	2.68	2.30	0.31	0.20	0.83	0.70	0.04	0.038
	C.D @ 5%	NS	3.95	5.57	4.89	8.21	7.05	0.95	0.62	2.54	2.16	0.12	NS

Table 2. Effect of media on shoot & root parameters of Rangpur lime and Australian sour orange seedlings

S. No.	Treatments	Length of tap root (cm)		Number of secondary roots per seedling		Number of fibrous roots per seedling		Root dry weight per seedling (g)		Total dry weight per seedling (g)	
T_1	Soil + Cocopeat + FYM @ 1:1:1 v/v + AM [5g]	16.48	16.25	12.45	10.35	132.22	99.32	2.48	1.93	5.42	6.17
T_2	Soil + Pressmud + FYM @ 1:1:1 v/v + AM [5g]	17.21	16.89	10.85	10.84	144.16	96.45	2.35	1.99	6.22	6.37
T_3	Soil + Vermicompost + FYM @ 1:1:1 v/v + AM [5g]	20.57	18.21	12.23	13.41	156.64	107.78	2.85	2.26	8.51	8.61
T_4	Soil + Cocopeat + Vermicompost @ 1:1:1 v/v + AM [5g]	18.77	17.91	13.85	12.72	138.19	89.45	2.22	2.18	6.12	8.49
T_5	Soil + Pressmud + Vermicompost @ 1:1:1 v/v + AM [5g]	16.83	17.18	12.71	12.11	176.74	116.71	3.29	2.15	8.40	7.70
T_6	Soil + Sand + FYM @ 1:1:1 v/v + AM + *Trichoderma reesei* (TCT-10) @ 5g bag^{-1}	22.45	19.21	11.73	11.24	154.71	83.94	3.06	1.95	8.10	6.79
T_7	Soil + Sand + Vermicompost @ 1:1:1 v/v + AM + *Trichoderma reesei* (TCT-10) 5g bag^{-1}	22.85	19.59	15.00	14.87	162.53	122.61	3.65	2.51	10.35	9.94
T_8	Soil + Sand + FYM @ 1:1:1 v/v [Control]	15.51	13.26	9.65	8.47	92.86	66.31	1.65	1.75	4.44	5.12
	Mean	**18.83**	**17.31**	**12.31**	**11.75**	**144.76**	**97.82**	**2.69**	**2.09**	**7.20**	**7.40**
	SE(m) ±	1.29	1.17	0.81	0.79	9.6	6.47	0.18	0.13	0.50	0.49
	C.D @ 5%	3.96	3.58	2.50	2.43	29.41	19.82	0.55	0.42	1.53	1.51

Table 3. Effect of different potting media on Nitrogen, Phosphorous, Potassium levels in leaves and stems of Rangpur lime and Australian sour orange seedlings

S. No.	Treatments	Rangpur lime						Australian sour orange seedlings					
		Leaves			Stems			Leaves			Stems		
		N%	P%	K%	N%	P%	K%	N%	P%	K%	N%	P%	K%
T_1	Soil + Cocopeat + FYM @ 1:1:1 v/v + AM [5g]	2.11	0.15	1.21	1.85	0.12	0.75	2.14	0.14	1.12	1.81	0.13	0.68
T_2	Soil + Pressmud + FYM @ 1:1:1 v/v + AM [5g]	2.24	0.17	1.14	1.77	0.16	0.87	2.20	0.16	1.25	1.90	0.15	0.88
T_3	Soil + Vermicompost + FYM @ 1:1:1 v/v + AM [5g]	2.49	0.18	1.08	1.95	0.15	0.80	2.35	0.15	1.18	1.86	0.16	0.74
T_4	Soil + Cocopeat + Vermicompost @ 1:1:1 v/v + AM [5g]	2.38	0.17	1.31	1.98	0.14	0.92	2.29	0.17	1.28	1.92	0.17	0.86
T_5	Soil + Pressmud + Vermicompost @ 1:1:1 v/v + AM [5g]	2.55	0.20	1.44	2.11	0.19	0.99	2.58	0.19	1.51	2.01	0.18	0.97
T_6	Soil + Sand + FYM @ 1:1:1 v/v + AM + *Trichoderma reesei* (TCT-10) @ 5g bag^{-1}	1.85	0.14	1.12	1.66	0.13	0.73	1.97	0.12	1.06	1.71	0.13	0.70
T_7	Soil + Sand + Vermicompost @ 1:1:1 v/v + AM + *Trichoderma reesei* (TCT-10) 5g bag^{-1}	2.62	0.21	1.59	2.05	0.18	2.02	2.61	0.20	1.55	2.10	0.19	2.06
T_8	Soil + Sand + FYM @ 1:1:1 v/v [Control]	1.61	0.12	0.97	1.42	0.10	0.47	1.75	0.10	0.89	1.52	0.08	0.55
	Mean	2.23	0.17	1.23	1.85	0.15	0.94	2.24	0.15	1.23	1.85	0.15	0.93
	SE(m) ±	0.15	0.01	0.08	0.12	0.22	0.07	0.15	0.01	0.08	0.12	0.01	0.06
	C.D @ 5%	0.45	0.03	0.24	0.37	0.68	0.20	0.44	0.03	0.24	NS	0.03	0.09

Table 4. Economics of potting media treatments (Cost - Benefit ratio)

Treatments		Cost-Benefit Ratios
T_1	Soil + Coco peat + FYM @ 1:1:1 v/v + AM [5g]	1.43
T_2	Soil + Press mud + FYM @ 1:1:1 v/v + AM [5g]	1.41
T_3	Soil + Vermicompost + FYM @ 1:1:1 v/v + AM [5g]	1.60
T_4	Soil + Coco peat + Vermicompost @ 1:1:1 v/v + AM [5g]	1.58
T_5	Soil + Press mud + Vermicompost @ 1:1:1 v/v + AM [5g]	1.55
T_6	Soil + Sand + FYM + AM + *Trichoderma reesei* (TCT-10) @ 5g bag^{-1}	1.54
T_7	Soil + Sand + Vermicompost + AM + *Trichoderma reesei* (TCT-10) 5g bag^{-1}	1.72
T_8	Soil + Sand + FYM@ 1:1:1 v/v [Control]	1.35

Table 5. Mean weekly weather data during August 2014 to December 2014

Standard Week	Month (2014-15)	Maximum Temperature (˚C)	Minimum Temperature (˚C)	RH max (%)	RH min (%)	Evaporation (mm.d-1)	Rainfall (mm)
33	August	37.29	26.11	51.86	36.14	6.20	0.29
34	August	37.01	24.33	58.14	38.29	6.10	9.57
35	August	36.21	24.57	53.71	35.71	5.29	17.14
36	August	32.23	23.71	83.71	51.29	4.87	7.86
37	September	34.43	23.07	81.86	56.43	5.10	3.14
38	September	33.29	22.61	84.29	46.71	5.61	2.86
39	September	31.50	19.79	86.43	61.14	5.29	2.29
40	September	31.64	21.00	87.71	61.71	5.37	4.43
41	October	34.24	23.07	84.86	46.00	5.54	20.71
42	October	32.54	21.20	87.00	52.71	5.56	4.50
43	October	33.57	20.36	86.00	46.57	5.69	0.00
44	October	29.43	19.67	89.57	72.29	5.21	8.29
45	November	34.81	20.07	86.43	49.71	7.13	3.14
46	November	32.21	20.87	81.71	48.43	5.66	4.29
47	November	31.04	18.51	85.00	64.14	4.79	0.67
48	November	31.59	18.73	87.43	54.43	5.61	0.16
49	December	32.21	18.36	82.14	48.86	4.90	0.00
50	December	31.64	17.97	76.57	55.29	3.66	0.00
51	December	30.86	16.40	84.43	59.00	2.97	1.86
52	December	29.40	18.77	78.57	63.29	2.46	9.71

Source: Regional Agricultural Research Station, Tirupati, A.P.

CONCLUSION

The study revealed that the potting mixture containing soil + sand + vermicompost@1:1:1 v/v + AM (5 g) and *Trichoderma reesei* (TCT - 10) @ 5g bag^{-1} was best potting media for both Rangapur lime and Australian sour orange seedlings grown in the poly bags.

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PERCEIVED CONSTRAINTS AND SUGGESTIONS OF SCIENTISTS AND EXTENSIONISTS IN GENERATION AND TRANSFER OF LIVESTOCK TECHNOLOGIES IN VETERINARY AND ANIMAL SCIENCE UNIVERSITIES

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ABSTRACT

The present study has made an attempt to identify the constraints faced by scientists and extensionists in effective generation and transfer of livestock technologies and its extent of seriousness under six categories *viz.,* financial, human resource, infrastructural or institutional, technological, socio-economic and any other constraints. The data was collected from scientists and extensionists of four Universities and Institutes in North India through questionnaire and discussion. The study revealed that non-availability of skilled staff and lack of public- private partnership were the major constraints in the universities. Further, irregular or untimely budget receipt and highly engaged in other works were the most serious constraints faced by the scientists. Among various constraints faced by extensionists, non-availability of inputs and lack of motivation were the major constraints, while non-availability of skilled staff, lack of incentives were the most serious constraints faced by extensionists. The study concluded that there is a need to reorient the research and extension system to produce need based technologies through empirical efforts in livestock sector. Further, to strengthen generation and transfer of livestock technologies, there is a need to find suitable solutions based on the suggestions proposed so that need based and field relevant technologies can be generated and transferred effectively for the farming community.

INTRODUCTION

The poor productivity and quality of production and products remains a cause of concern in Indian livestock and dairy sector (Chander *et al*., 2010). In an attempt to increase productivity and improve food security at both national and household level, efforts are underway through National Agricultural Research System (NARS) for promoting technological innovations and human resource development. India has the largest agricultural research and development (R&D) system with Indian Council of Agricultural Research (ICAR), which directly oversees 100 agencies, including 4 deemed universities, 54 research institutes, 14 national research centers, six national bureaus, and 22 project directorates. Although NARS has been responding to the challenges faced by Indian agriculture, it often faces poor linkages between research and extension systems (Desai *et al*., 2011). Further, State Agricultural and Veterinary/Animal Science universities have greatly expanded in number with funding support from state governments but their research capacity has weakened (Pal *et al*., 2012) leading to poor interface of research, extension and education. There has been no parallel increase in the number of scientists implying lower research staff at the universities and increased overhead costs due to the proportionally larger administrative burden of more institutes. Hence, there is an acute need for analysis of significant challenges and constraints *viz.,* insufficient funding, difficulties in training and maintaining good scientists, obstacles to accessing new scientific knowledge and technology, and other significant constraints (Pardey and Beintema, 2001; Byerlee and Fischer, 2001). With this theoretical background, an attempt was made to identify the constraints faced by the scientists and extensionists in effective generation and transfer of livestock technologies in universities under six categories *viz.,* financial, human resource, infrastructural or

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institutional, technological, socio-economic and any other constraints. Further, the suggestions proposed by scientists and extensionists for effective generation and transfer of technologies also have been highlighted in the study.

MATERIAL AND METHODS

Four Veterinary / Animal Husbandry Universities and Institutes, which are at the forefront of research in livestock sector, were selected. All the selected Universities/ Institutes have carried out various research and extension activities in livestock sector. The scientists or teaching faculty of the universities were randomly selected considering the fact that they were involved in Teaching, Research and Extension activities of- the university. During the selection of respondents care was taken that among 30 scientists selected, 10 were extensionists from universities or allied *Krishi Vigyan Kendras* (KVKs) and remaining 20 were involved in research activities of the university (Table 1).

Table 1. Locale and sample size of the study

Universities under study (for scientists and extensionists)	States	Scientists (N=80)	Extensionists (N=40)
Indian Veterinary Research Institute (IVRI), Izatnagar	Uttar Pradesh	20	10
G.B. Pant University of Agriculture & Technology (GBPUA&T), Pantnagar	Uttarakhand	20	10
National Dairy Research Institute (NDRI), Karnal	Haryana	20	10
Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana	Punjab	20	10

The data was collected from the scientists and extensionists during November 2013 to June 2014 to know the different constraints faced by the scientists and extensionists in generation and transfer of livestock technologies using a pre-tested questionnaire developed for the purpose. Among the respondents, who perceived 'yes' for the constraints, the seriousness of such constraints was studied on a three point continuum as 'most serious', 'serious' and 'least serious'. The suggestions proposed by the scientists and extensionists for effective generation and transfer of technologies also have been enlisted under different heads. The statistical tools *viz.*, frequencies and percentage were used for analysis of the data.

RESULTS AND DISCUSSION

A) Perceived constraints of Scientists and their seriousness

Among the pooled data from the Table 2, it was indicated that non-availability of skilled staff and lack of public private partnership were the major constraints, followed by irregular or untimely budget receipt and engagement in other activities. It was noted that majority of the scientists at IVRI and NDRI perceived non-availability of skilled staff and lack of public private partnership as the major constraints. A cursory look at the Table 2 indicates that irregular or untimely budget receipt and costly inputs or technologies were considered as the major constraints faced by GBPUA&T scientists, while GADVASU scientists perceived irregular or untimely budget receipt and non-availability of skilled staff as the major constraints.

Table 2. Perceived constraints of Scientists in effective generation and transfer of livestock technologies

Sl No	Constraints perceived by the scientists	'Yes' response by Universities Scientists				
		IVRI (20)	NDRI (20)	GBPUAT (20)	GADVASU (20)	Pooled (N=80)
I	**Financial constraints**					
1	Lack of incentives	12 (60.0)	12 (60.0)	14 (70.0)	17 (85.0)	55 (68.75)
2	Paucity of budget	15 (75.0)	13 (65.0)	13 (65.0)	16 (80.0)	57 (71.25)
3	Irregular/untimely budget receipt	14 (70.0)	11 (55.0)	15 (75.0)	19 (95.0)	59 (73.75)
II	**Human resource constraints**					
4	Non-availability of skilled staff	16 (80.0)	18 (90.0)	11 (55.0)	18 (90.0)	63 (78.75)
5	Lack of orientation to the functionaries	11 (55.0)	13 (65.0)	09 (45.0)	17 (85.0)	50 (62.5)
6	Frequent transfers	07 (35.0)	02 (10.0)	07 (35.0)	05 (25.0)	21 (26.25)
7	Highly engaged in other works	14 (70.0)	12 (60.0)	14 (70.0)	18 (90.0)	58 (72.5)
III	**Infrastructural/Institutional constraints**					
8	Logistical problems such as transport etc.	13 (65.0)	06 (30.0)	06 (30.0)	11 (55.0)	36 (45.0)
9	Poor support from higher authorities	08 (40.0)	02 (10.0)	07 (35.0)	11 (55.0)	30 (37.5)
10	Poor extension system	08 (40.0)	06 (30.0)	08 (40.0)	10 (50.0)	32 (40.0)
11	Lack of co-ordination with other departments/ disciplines	12 (60.0)	09 (45.0)	12 (60.0)	16 (80.0)	50 (62.5)
IV	**Technology constraints**					
12	Incompatible technologies	05 (25.0)	05 (25.0)	11 (55.0)	12 (60.0)	35 (43.75)
13	Poor response during field testing	13 (65.0)	07 (35.0)	13 (65.0)	09 (45.0)	42 (52.5)
14	Complex technologies	08 (40.0)	03 (15.0)	11 (55.0)	10 (50.0)	32 (40.0)
V	**Social and Economic constraints**					
15	Non-availability of inputs	12 (60.0)	08 (40.0)	14 (70.0)	11 (55.0)	45 (56.25)
16	Costly inputs/technologies	13 (65.0)	07 (35.0)	15 (75.0)	12 (60.0)	47 (58.75)
17	Lack of farmers' knowledge	15 (75.0)	08 (40.0)	13 (65.0)	14 (70.0)	50 (62.5)
18	Lack of motivation	14 (70.0)	06 (30.0)	15 (75.0)	12 (60.0)	47 (58.75)
19	Self-centered attitude of farmers	8 (40.0)	05 (25.0)	12 (60.0)	08 (40.0)	33 (41.25)
VI	**Any other constraints**					
20	Lack of public-private partnership	16 (80.0)	15 (75.0)	14 (70.0)	15 (75.0)	60 (75.0)

Figures in the parenthesis indicate percentage

Further, the seriousness of the constraints as perceived by the scientists of universities is presented in Table 3. Among the pooled data, it can be pointed out that irregular or untimely budget receipt and highly engaged in other works were the most serious constraints, while poor extension system and paucity of budget were considered as the serious constraints of the scientists. A cursory look at the Table 3 highlights that irregular or untimely budget receipt and frequent transfers were the most serious constraints at IVRI, while non-availability of inputs and lack of public-private partnership were the most serious constraints faced by scientists at NDRI, Karnal. The study also indicated that irregular or untimely budget receipt and complex technologies were the most serious constraints for the scientists of GBPUA&T, while, irregular or untimely budget receipt and highly engaged in other works were the most serious constraints for the scientists of GADVASU, Ludhiana.

Table 3. Extent of seriousness of the constraints as perceived by the Scientists

Sl No	Constraints perceived by the scientists	Seriousness (N=80)		
		Most Serious	Serious	Least Serious
I	**Financial constraints**			
1	Lack of incentives	10(18.18)	28(50.91)	17(30.91)
2	Paucity of budget	14(24.57)	34(59.65)	09(15.78)
3	Irregular/untimely budget receipt	29(49.16)	23(38.98)	07(11.86)
II	**Human resource constraints**			
4	Non-availability of skilled staff	22(34.93)	31(49.20)	10(15.87)
5	Lack of orientation to the functionaries	17(34.0)	22(44.0)	11(22.0)
6	Frequent transfers	05(23.80)	08(38.10)	08(38.10)
7	Highly engaged in other works	21(36.20)	22(37.94)	15(25.86)
III	**Infrastructural/Institutional constraints**			
8	Logistical problems such as transport etc.	07(19.44)	15(41.67)	14(38.89)
9	Poor support from higher authorities	05(16.66)	14(46.67)	11(36.67)
10	Poor extension system	07(21.88)	20(62.5)	05(15.62)
11	Lack of co-ordination with other departments/ disciplines	12(24.0)	26(52.0)	12(24.0)
IV	**Technology constraints**			
12	Incompatible technologies	10(28.57)	19(54.29)	06(17.14)
13	Poor response during field testing	08(19.04)	23(54.77)	11(26.19)
14	Complex technologies	07(21.87)	17(53.13)	08(25.0)
V	**Social and Economic constraints**			
15	Non-availability of inputs	15(33.34)	22(48.89)	08(17.77)
16	Costly inputs/technologies	10(21.28)	28(59.58)	09(19.14)
17	Lack of farmers' knowledge	09(18.0)	29(58.0)	12(24.0)
18	Lack of motivation	08(17.02)	28(59.58)	11(23.40)
19	Self-centered attitude of farmers	06(18.18)	19(57.58)	08(24.24)
VI	**Any other constraints**			
20	Lack of public-private partnership	17(28.33)	34(56.67)	09(15.0)

Figures in the parenthesis indicate percentage

It was observed in the study that with various constraints existing in the universities, the scientists were forced to perform good quality research and extension activities. It was also perceived by the scientists that they had lack of quality human resources and financial constraints to perform various research and extension activities. The study conducted by Flaherty *et al.* (2013) also reported that India had poor human resource of 43 researchers to million farmers as against few Asia Pacific countries such as Malaysia and Sri Lanka. Further, Pal *et al.* (2012) also reported that there has been no parallel increase in the number of scientists implying lower research staff at the universities and increased overhead costs due to the proportionally larger administrative burden of more institutes. Ramasamy (2013) also reported that ICAR institutions were comparatively better equipped in terms of infrastructure since they were in advantage position to get the required funding to strengthen their infrastructure. The SAUs were frequently the victims of poor funding support for infrastructural development. A study conducted by Sharma *et al.* (2013) in Rajasthan and Manjunath *et al.* (2008) in Karnataka revealed that poor infrastructural facilities and lack of need based appropriate researches, lack of proper working conditions, poor interpersonal relationship among the scientists were the major problems confronted by the professionals followed by poor linkages, reduction in budget outlays and over burdened extension personnel.Further, the Asian Development Bank (ADB, 1993) study on policies and strategies for livestock improvement in developing countries concluded that the primary reason for policy failure was promotion of inappropriate technology. Although, animals or necessary inputs were often provided free or at subsidised levels, supported by subsidised loan packages, these projects often failed because of inappropriate technologies.

B. Constraints in effective generation and transfer of innovations as perceived by the Extensionists

The constraints faced by the extensionists in effective generation and transfer of livestock technologies are presented in Table 4. The pooled data indicated that non-availability of inputs and lack of motivation was the major constraints faced by the extension experts which indicated that experts faced socio-economic constraints to the greater extent. However, among the other categories, it was found that lack of incentives and non-availability of skilled staff were considered as the major constraints in the pooled data. It can be noted that extensionists of IVRI perceived that costly inputs or technologies, poor knowledge of farmers, self-centered attitude of farmers and lack of public private partnership were the major constraints while the extensionists at GBPUA&T reported that they faced the major constraints of poor response during field testing, non-availability of inputs and lack of motivation. The study also revealed that lack of incentives, paucity of budget, non-availability of skilled staff, lack of orientation to the functionaries, complex technologies, non-availability of inputs, lack of motivation and lack of public private partnership were considered as the major constraints at NDRI, Karnal. A cursory look at the Table 4 reveals that extensionists at GADVASU perceived “non-availability of skilled staff and lack of public private partnership” as the major constraints faced by them in effective generation and transfer of livestock technologies.

Table 4. Perceived constraints of Extensionists in effective generation and transfer of livestock technologies

Sl No	Constraints perceived by extensionists	'Yes' response by the Extensionists				
		IVRI (10)	NDRI (10)	GBPUAT (10)	GADVASU (10)	Pooled **(N=40)**
I	**Financial constraints**					
1	Lack of incentives	07 (70.0)	06 (60.0)	07 (70.0)	06 (60.0)	26 (65.0)
2	Paucity of budget	07 (70.0)	06 (60.0)	06 (60.0)	05 (50.0	24 (60.0)
3	Irregular/untimely budget receipt	06 (60.0)	05 (50.0)	06 (60.0)	06 (60.0)	23 (57.5)
II	**Human resource constraints**					
4	Non-availability of skilled staff	07 (70.0)	06 (60.0)	05 (50.0)	07 (70.0)	25 (62.5)
5	Lack of orientation to the functionaries	06 (60.0)	06 (60.0)	06 (60.0)	05 (50.0)	23 (57.5)
6	Frequent transfers	03 (30.0)	02 (20.0)	05 (50.0)	06 (60.0)	16 (40.0)
7	Highly engaged in other works	06 (60.0)	05 (50.0)	07 (70.0)	05 (50.0)	23 (57.5)
III	**Infrastructural/Institutional constraints**					
8	Logistical problems such as transport, etc.	05 (50.0)	04 (40.0)	06 (60.0)	06 (60.0)	21 (52.5)
9	Poor support from higher authorities	06 (60.0)	03 (30.0)	05 (50.0)	04 (40.0)	18 (45.0)
10	Poor extension system	06 (60.0)	04 (40.0)	07 (70.0)	04 (40.0)	21 (52.5)
11	Lack of co-ordination with other departments/ disciplines	06 (60.0)	05 (50.0)	07 (70.0	04 (40.0)	22 (55.0)
IV	**Technology constraints**					
12	Incompatible technologies	05 (50.0)	05 (50.0)	06 (60.0)	02 (20.0)	18 (45.0)
13	Poor response during field testing	05 (50.0)	05 (50.0)	08 (80.0)	04 (40.0)	22 (55.0)
14	Complex technologies	07 (70.0	06 (60.0)	06 (60.0)	02 (20.0)	21 (52.5)
V	**Social and Economic constraints**					
15	Non-availability of inputs	07 (70.0)	06 (60.0)	08 (80.0)	06 (60.0)	27 (67.5)
16	Costly inputs/technologies	08 (80.0)	05 (50.0)	07 (70.0)	06 (60.0)	26 (65.0)
17	Lack of farmers' knowledge	08 (80.0)	05 (50.0)	07 (70.0	06 (60.0)	26 (65.0)
18	Lack of motivation	07 (70.0	06 (60.0)	08 (80.0)	06 (60.0)	27 (67.5)
19	Self-centred attitude of farmers	08 (80.0)	05 (50.0)	07 (70.0)	05 (50.0)	25 (62.5)
VI	**Any other constraints**					
20	Lack of public-private partnership	08 (80.0)	06 (60.0)	07 (70.0)	07 (70.0)	28 (70.0)

Figures in the parenthesis indicate percentage

Further, the seriousness of the constraints as perceived by the extensionists of universities is presented in Table 5. Among the pooled data, it was pointed out that non-availability of skilled staff, lack of incentives and irregular or untimely budget receipt were the most serious constraints, while poor support from higher authorities and incompatible technologies were considered as the serious constraints by the extensionists. A cursory look at the Table 5 also highlights that lack of incentives and costly inputs or technologies were the most serious constraints at IVRI, while non-availability of skilled staff followed by paucity of budget and irregular or untimely budget receipt were the most serious constraints faced by

Table 5. Extent of seriousness of constraints as perceived by the Extensionists

Sl No	Constraints perceived by extensionists	Seriousness (N=40)		
		Most Serious	Serious	Least Serious
I	**Financial constraints**			
1	Lack of incentives	13(50.0)	10(38.4)	03(11.5)
2	Paucity of budget	10(41.6)	09(37.5)	05(20.8)
3	Irregular/untimely budget receipt	11(47.8)	09(39.1)	03(13.0)
II	**Human resource constraints**			
4	Non-availability of skilled staff	13(52.0)	09(36.0)	03(12.0)
5	Lack of orientation to the functionaries	09(39.13)	11(47.83)	03(13.04)
6	Frequent transfers	04(25.0)	08(50.0)	04(25.0)
7	Highly engaged in other works	10(43.48)	10(43.48)	03(13.04)
III	**Infrastructural/Institutional constraints**			
8	Logistical problems like transport etc.	08(38.09)	11(52.39)	02(9.52)
9	Poor support from higher authorities	06(33.33)	10(55.56)	02(11.11)
10	Poor Extension system	07(33.34	08(38.09)	04(28.57)
11	Lack of co-ordination with other departments/ disciplines	10(45.46)	08(36.36)	04(18.18)
IV	**Technology constraints**			
12	Incompatible technologies	06(33.33)	10(55.56)	02(11.11)
13	Poor response during field testing	07(31.81)	12(54.55)	03(13.64)
14	Complex technologies	08(38.09)	09(42.86)	04(19.05)
V	**Social and economic constraints**			
15	Non-availability of inputs	12(44.45)	10(37.04)	05(18.51)
16	Costly inputs/technologies	12(46.16)	09(34.61)	05(19.23)
17	Lack of farmers' knowledge	09(34.62)	13(50.0)	04(15.38)
18	Lack of motivation	09(33.33)	12(44.45)	06(22.22)
19	Self-centered attitude of farmers	09(36.0)	12(48.0)	04(16.0)
VI	**Any other constraints**			
20	Lack of public-private partnership	10(35.72)	14(50.0)	04(14.28)

(Figures in the parenthesis indicate percentage)

experts at GBPUA&T, Pantnagar. Further, extensionists at NDRI perceived that non-availability of skilled staff and irregular or untimely budget receipt were the most serious constraints, while lack of coordination with other departments or disciplines and non-availability of skilled staff were the most serious constraints at GADVASU, Ludhiana. It was observed in the study that inspite of various constraints existing in the universities; the extensionists were expected to perform good quality research and extension activities. A study conducted by Sharma *et al.* (2013) in Rajasthan and Manjunath *et al.* (2008) in Karnataka revealed that poor infrastructural facilities and lack of need based appropriate researches, lack of proper working conditions, poor interpersonal relationship among the scientists were the major problems confronted by the professionals followed by poor linkages, reduction in budget outlays and over burdened extension personnel. On the similar lines, Karbasioun and Mulder (2004) also reported that shortcomings in extension systems originate from the lack of effective and constructive linkages between extension organizations and other institutions, e.g. universities and research centers.

C. Suggestions of Scientists and Extensionists to overcome the constraints

The study also made an attempt to enlist various suggestions proposed by the scientists and extensionists for effective generation and transfer of livestock technologies.

Table 6 indicates the suggestions proposed by the scientists and extensionists to overcome the specific constraints faced in conducting research and extension activities in the universities. The experts felt that excellent research and extension activities in the university must be supported in the form of incentives or recognitions which may motivate other professionals also to get involved in good quality research and extension activities. Further, the experts also felt that budget must be allotted at regular intervals including the simplified procedure for budget allocation and expenditure in the universities. Similar findings were also reported by Singh *et al.* (2013) and Chander and Rathod (2015) who also revealed similar suggestions for the universities. The experts in the universities suggested that there was a need for skilled staff with basic idea or orientation to facilitate research and extension. The study also noted that frequent transfer of the experts must be avoided and human resources must be involved in activities relevant to research and extension rather than other engagements. Further, with regards to infrastructural/ institutional constraints, it was proposed that problems such as transport, electricity, etc. must be solved at the earliest on priority basis. Similar suggestions were also proposed by Chander and Rathod (2015) who also focused on infrastructural/ institutional building for animal science universities in India. The scientists and extensionists also felt that higher authorities must support need based and relevant research for the farming community and promote adequate co-ordination with other departments/disciplines for effective research and extension activities.

The study also pointed out that field relevant, compatible, simple and cost effective technologies must be developed and transferred to the farming community after field testing. Later, these technologies must be further evaluated and reconsidered for modifications or changes if any. The professionals also suggested that communication and information gap among the farmers and professionals must be reduced so that technologies can be developed on participatory mode. The scientists and

Table 6. Suggestions proposed by the Scientists and Extensionists to overcome the constraints

Suggestions to overcome financial constraints
• The scientists and extensionists must be given incentives for excellent research and extension activities • The budget may be allotted to research and extension activities at regular intervals • The procedure for budget allocation and expenditure may be simplified • The budget must be utilised for relevant and need-based research.
Suggestions to overcome human resource constraints
• Skilled staff must be made available depending on the specialization of staff • The human resources must be oriented towards different activities to facilitate research and extension • Strict transfer guidelines may be followed among the staff and avoid frequent transfers. • The human resources must be involved in relevant activities rather than other engagements which is not relevant to research and extension.
Suggestions to overcome Infrastructural/Institutional constraints
• Constraints such as transport, electricity etc. has to be solved to conduct research and extension activities • The higher authorities must support need based and relevant research for the farming community • The extension system of the university must be strengthened for effective transfer of technology • There should be adequate co-ordination with other departments/disciplines for effective research and extension activities
Suggestions to overcome technology constraints
• Field relevant and compatible technologies must be developed for the farming community • The response of farmers during field testing about any technology has to be evaluated and reconsidered accordingly. • The technologies developed must be simple and cost effective for the farmers. • The pros and cons of each technology developed must be demonstrated and supported accordingly for diffusion and adoption. • The communication and information gap among the farmers and professionals must be reduced so that technology can be developed on participatory mode.
Suggestions to overcome social and economic constraints
• The inputs for any technology generation and development must be available at farmers' conditions at very nominal costs. • The knowledge level of farmers must be improved leading to effective diffusion and adoption of technologies. • The farmers must be internally motivated and all their unfelt needs must be converted to felt needs
Suggestions to overcome other constraints
• Public-private partnership may be promoted at the universities for effective generation and transfer of technologies. • The scientists and extensionists have to maintain positive mindset towards research and extension activities. • The linkage between farmers, scientists and extensionists has to be strengthened for effective generation and transfer of technologies.

extensionists suggested that inputs for any technology generation and development must be available at farmers' conditions at very nominal costs to overcome social and economic constraints. In order to conduct good quality research and extension activities, there is a need to promote public-private partnership, create positive mindset towards research and extension activities and strengthen the linkage between farmers, scientists and extensionists for effective generation and transfer of technologies. Rathod and Chander (2015) and Chander and Rathod (2015) also proposed similar suggestions for the universities to conduct research and extension activities in India.

CONCLUSIONS

The scientists and extensionists faced the problems of non-availability of skilled staff, lack of public-private-partnership, irregular or untimely budget receipt and highly engaged in other works to a greater extent. The study concluded that there is a need to reorient the research and extension system to produce need based technologies through empirical efforts in livestock sector. Further, to strengthen generation and transfer of livestock technologies, there is a need to find suitable solutions based on the suggestions proposed by them, so that need based and field relevant technologies can be generated and transferred effectively for the farming community.

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REMITTANCES EARNED BY THE MIGRANTS AND THEIR PURPOSE OF UTILIZATION BY THE MIGRANTS OF UTTARAKHAND

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ABSTRACT

The study conducted in the Almora district of Uttarakhand revealed that majority of migrants (56.67%) earned low remittances from Rs 5,000 to Rs 15,000 due to migration, followed by 20.83% earning very low remittances upto Rs.5000. These remittances were utilized for children education and purchase of food by majority of respondents *i.e.* 94.16% and 90.83%, respectively. The purpose of this article is to refine and extend the debate concerning the amount of remittances earned by the migrants and how much of these remittances are spent on different purposes.

INTRODUCTION

Migration in the Himalayan mountainous area of the world is common phenomenon. Migration has long been an important livelihood strategy for the people of the Himalayan region in general and Uttarakhand state in particular with increasing climatic stresses, particularly erratic rainfall and harsh climate mountain agriculture is increasingly becoming less reliable livelihood strategy, increasing the need to migrate. The remittances earned by people thus migrated play an important and significant role in meeting the household expenses of the families of migrants and helps in their development on economic and social front. Official international remittances to developing countries were estimated at $221 billion per year during the year 2006 (World Bank., 2008), making them about twice as large as the level of official aid-related flows to the developing world. Some individuals migrate with the predetermined motive of making a specific investment or purchase and migration will be temporary, and migrants will tend to remit and carry large sums home. Remittances can have long-run beneficial effects if they promote productive projects (Amuedo *et al*., 2004). Internal remittances do have a positive impact on receiving households in terms of repayment of debts, better nutrition, better education and investment in enterprise (Afsar, 2003). Remittances have been used for education, health, to pay off debts, perpetuate emigration, and for conspicuous consumption, including large homes (Brad, 2002). From the stand point of agricultural development, if the migrant sends remittances, these could be used directly for household consumption, substituting for agricultural production, and/or for hiring labor to compensate for the absent household member. Remittances could also be invested in the intensification of land use and the purchase of agricultural inputs such as fertilizer or pesticides (Katz, 2003). Keeping in view of the burning problem of migration in the Uttarakhand state, the present study was designed to unearth the amount of remittances earned by migrants and their

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purpose of utilization. The study refined the debate concerning the remittances of migrants.

MATERIAL AND METHODS

Ex-post-facto research design was followed to conduct the study. The study was conducted in the Almora district of Uttarakhand during the year 2013-14. Dwarahat and Chaukhutia, blocks were selected for the study. Two villages each from these blocks were selected purposively based on intensity of migration. Thus, a total of four villages namely Barati and Kaney villages from Dwarahat block and Gangolihat and Seemapali from Chaukhutia block, were selected for the study. From each selected village, 30 migrants were selected as respondents at random, thus making a sample of 120 respondents for the study. A migrant is defined as the member of the family, who has left the place of origin for getting income in the destination place. Data was collected from the selected respondents by using the interview schedule developed for the study.

RESULTS AND DISCUSSION

Amount of remittances earned per month

Results indicated in Table 1 clearly reveal that majority (56.67%) of the respondents were earning low remittance (Rs 5,000-15,000) followed by very low (20.83%) (upto Rs 5,000) medium (10.83%) in the range of Rs 15,000-25,000, high (7.5%) remittances in the range of 25,000-35,000 and very high (4.17%) remittances in the range of Rs. 35,000-45,000 per month.

During the investigation, it was observed that migrants who worked as waiters in hotel and restaurants, assistant in small shops, drivers of govt. and private vehicles, security guards and got remittances. Some of the respondents who were engaged in weaving, carrying load on thellas, brick making, laundry works, auto drivers, rickshaw pullers, construction workers in govt. and private buildings, etc. that earned very low wages. Few other respondents who worked as middle men, clerks, estate agents, etc. got medium remittances. Very

Table 1. Distribution of respondents according to the amount of remittances earned per month

(N=120)

S. No.	Category	Frequency	Percentage (%)
1	Very low (Upto Rs 5,000)	25	20.83
2	Low (Rs 5,000-15,000)	68	56.67
3	Medium (Rs 15,000-25,000)	13	10.83
4	High (Rs 25,000-35,000)	9	7.50
5	Very high (>Rs 35,000)	5	4.17

Table 2. Distribution of respondents according to the purpose of utilization of remittances

S.No.	Purpose of utilization	Frequency	Percentage (%)
1.	Purchase of food	109	90.83
2.	Children education	113	94.16
3.	Purchase of farm inputs (fertilizers, pesticides, seeds, implements)	47	39.16
4.	Hiring farm labour	32	26.67
5.	Health care	98	81.67
6.	House construction	107	89.16
7.	Purchase of household goods	105	87.5
8.	Clearing of debts	79	65.83
9.	Purchase and maintenance of cattle / poultry, etc.	43	35.83
10	Saving for future	61	50.83

few of them with high education did permanent jobs such as teachers in public or private schools, technical jobs in corporate sectors, junior engineer in Government agencies, etc. that yielded high and very high remittances

Purpose of utilization of remittances

Table 2 clearly revealed the different purposes of utilization of the remittances earned by the migrant. The whole amount of remittance was not totally utilized by the family of the migrants, some- portion was kept as savings for future use by most of the respondents (50.83%). Majority of the respondents (more than 50 per cent) had utilized the remittances for their children's education (94.16%), followed by purchase of food (90.83%), house construction (89.16%), purchase of household goods (87.5%), health care (81.67%), and clearing of debts (65.83%).Less than half of the migrants utilised remittances for purchase of farm inputs (fertilizers, pesticides, seeds, implements) (39.16%), purchase and maintenance of cattle / poultry etc. (35.83%) and for hiring farm labour (26.67%).

Majority of the respondents spent remittance money on their children's education. They sent their children outside the village for higher education and most of their children stay in urban areas, hence, the migrants had to spend more money to meet out their expenses. The remittances were also utilized for purchasing food items and household goods, house construction and purchasing household goods to increase their status of living. It was also observed during interview that half of the migrants also saved some portion of remittances for future use, this reflected that the family of migrants had received surplus income after meeting their family requirements. The respondents also spent money on

health care of the family members. The respondents used the remittances to clear off their debts which they took previously for different reasons. It was also noticed during study that very few of the migrant families had took debts after the migration of migrants. Very few of the family members of the migrants used remittances for agricultural purposes such as purchase of farm inputs (fertilisers, pesticides, seeds, implements), purchase and maintenance of cattle / poultry, etc and hiring farm labour as they got enough money to fulfill their dietary need. Agriculture in hilly areas does not provide food throughout the year and is also non remunerative so they preferred to save the money for future use instead of spending for agricultural purposes.

CONCLUSIONS

From the results it can be concluded that though migrants are leaving their village due to unproductive agriculture and lack of other livelihood options, the remittances earned out of migration were also not reinvested in agriculture. This result cautions all the stakeholders of agriculture that very shortly agriculture is going to disappear in the study area, if precautionary measures are not taken. Research and outreach organizations should focus on value addition, enterprise diversification, development and dissemination of location specific technology. Government should encourage entrepreneurs for establishment of agro based industries by extending loans.

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OBSTACLES IN APPLICABILITY OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN AGRICULTURAL EXTENSION SYSTEM

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ABSTRACT

Indian agriculture is harnessing the potential of information and communication technologies (ICTs) from last more than two decades. There are various dimensions of ICTs tools which are benefitting the Indian farmers in various forms *viz.,* audio, video, Short message Service(SMS), conferencing, expert system, kiosks, community radio and much more. But there are some problems that are hindering with the smooth running of the ICTs for the development of the system and thus affecting overall economy. Thus, a study was conducted in Ranga Reddy district of Andhra Pradesh to study the obstacles associated with applicability of ICTs in agricultural extension system. In toto, 180 respondents were selected from public and private sectors. Results shows that the major obstacles perceived by the respondents were low budget for ICTs, authentic sources of information, location specific content development and management, infrastructural issues and capacity building.

INTRODUCTION

The ICT enabled agricultural extension in India has been talked about for the last two decades and it is also well known that in India, agriculture constitutes a major livelihood sector and most of the rural poor depend on rainfed agriculture and fragile forests for their livelihoods. Farmers in rural areas have to deal with failed crops and animal illness frequently and due to limited communication facilities, solutions to their problems remain out of reach (World Bank, 2009). This communication gap may be in terms of knowledge, skill or any other form. With this respect Bell (2004) has rightly pointed out that the knowledge gap is compounded by the lack of essential skills, particularly in communication and management that extension workers must have if they are to effectively transfer technologies to farmers in a manner that leads to sustainability. It is important to realize that the information that extension workers need includes not only technical knowledge but also knowledge and skills that increase the effectiveness of delivery. Improving access to these vital extension skills will lead to better designed, delivered, and supported technologies. Supporting to this, Richardson (2005) stated that a key challenge facing extension planners and policy-makers in enabling extension workers to harness ICTs is handling subject matter and policy issues that are not strictly in the domain of agriculture. To address this challenge, extension planners and policymakers need appropriate arguments backed with data to strengthen the case for agricultural extension playing a broader role in promoting ICTs. Keeping the above facts in mind, a study was planned to know about the obstacles faced by the agricultural extension personnel while handling ICTs in agricultural technology dissemination and integration.

MATERIAL AND METHODS

The present study was conducted in Ranga Reddy district of Andhra Pradesh purposively as it is the one of the major states where a number of ICTs projects are being implemented. A proportionate number of respondents were selected both from public and private sectors. Respondents from State Department of Agriculture, Ministry of Agriculture-National Institute of Agricultural Extension Management (MANAGE) GOI, State Agricultural University-Acharya N G Ranga Agricultural University (ANGRAU), ICAR institutes, were selected

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purposively for the study under public organizations. Respondents from Nagarjuna fertilizers, ETV, TV5, e-choupal(ITC), etc. were selected purposively for the study under private sector. Therefore, a proportionate sample of 60 respondents was selected randomly respectively from State Department, Research and development (R&D) sector and Private Organizations for the study. Thus, a total of 180 respondents were selected for the study. R&D sector has respondents from SAU (ANGRAU)-KVKs, DAATTCs and ICAR institutes. Rank based quotient (RBQ) was calculated to have a clear picture about the major problems faced by the agricultural extension personnel while handling ICTs in technology dissemination and integration process.

RESULTS AND DISCUSSION

Personal profile of the respondents has the basic information on age, gender, education, nativity, number of years of service and major job responsibility area. The same was presented in Table 1.It is clear from the table that slightly more than half (51.67%) of the respondents were young followed by middle (28.33%) and old age (20.00%). With respect to gender, it is evident from the table that about 65 per cent respondents were male while only about 35 per cent respondents were female. Although the percentage of male is more in comparision to the female, still the percentage of women, who had experience in using ICTs, is encouraging. With respect to educational status of the respondents, majority of them were post-graduate (60.56%) followed by doctorates (21.11%) and graduates (18.33%). The percentage of the graduate respondents in the present study was high in State Department of Agriculture(DoA). Not a single respondent from Research and Development (R&D) and private sector belonged to graduate category as they should be either post-graduate or the doctorate as the minimum educational criteria for R&D and private sector was post-graduate. In the area of nativity, majority (36.11%) of the respondents belonged to urban area followed by rural (32.78%) and semi-urban (31.11%). Numbers of years of service was categorized as low, medium and high. Majority of the respondents fell into low category of years of service (59.44%) followed by medium (22.22%) and high (18.33%). The low percentage of number of years of service might be due to the reason that majority of them belonged to the young age category. The major job responsibility area was the area where the respondent was giving their services to a major portion. It was categorized as extension, research, training and the administration. From the Table it is clear that majority (70.00%) of respondents belonged to the area of extension as the major job responsibility followed by research (13.33%), training (11.11%) and administration (5.56%).

It could be seen from Table 1 that from the R&D sector, majority (36.37%) of the respondents were old age followed by middle (33.33%) and young (30.00%) whereas in SDA, majority of the respondents belong to young age (60.00%) followed by middle (21.67%) and old age (18.33%). The same trend was observed in private sector *i.e*. majority of the respondents (65.00%) were young followed by middle (30.00%) and old age (5.00%). The reason of variability in terms of age between R&D sector, SDA sector and Private sector respondents may be due to minimum educational criteria to be employed in the respective departments.

With respect to gender, same trend was found in R&D sector, SDA and private sector. Majority (65.00%) of respondents from R&D sector were male followed by female (35.00%). In SDA, the majority of the respondents were male (60.00%) followed by female (40.00%). About 69 per cent respondents were

Table 1. Personal profile of the respondents working in R&D, SDA and private sector

S.No.	Characteristics	Category	R&D Sector (n=60)	SDA (n=60)	Private Sector (n=60)	Total (N=180)
1.	Age	Young	18 (30.00)	36 (60.00)	39 (65.00)	93 (51.67)
		Middle	20 (33.33)	13 (21.67)	18 (30.00)	51 (28.33)
		Old	22 (36.67)	11 (18.33)	03 (05.00)	36 (20.00)
2.	Gender	Male	39 (65.00)	36 (60.00)	41 (68.33)	116 (64.44)
		Female	21 (35.00)	24 (40.00)	19 (31.67)	64 (35.56)
3.	Education	Graduate	00 (00.00)	33 (55.00)	00 (00.00)	33 (18.33)
		Post graduate	25 (41.67)	27 (45.00)	57 (95.00)	109 (60.56)
		Doctorate	35 (58.33)	00 (00.00)	03 (05.00)	38 (21.11)
4.	Nativity	Rural	22 (36.67)	25 (41.67)	12 (20.00)	59 (32.78)
		Semi-urban	16 (26.67)	17 (28.33)	23 (38.33)	56 (31.11)
		Urban	22 (36.67)	18 (30.00)	25 (41.67)	65 (36.11)
5.	No. of years of Service	Low (less than 5 years)	31 (51.67)	40 (66.67)	36 (60.00)	107 (59.44)
		Middle (5 to 10 years)	14 (23.33)	13 (21.67)	13 (21.67)	40 (22.22)
		High (more than 10 years)	15 (25.00)	07 (11.67)	11 (18.33)	33 (18.33)
6.	Major job responsibility area	Extension	32 (53.33)	53 (88.33)	41 (68.33)	126 (70.00)
		Research	14 (23.33)	00 (00.00)	10 (16.67)	24 (13.33)
		Training	11 (18.33)	00 (00.00)	09 (15.00)	20 (11.11)
		Administration	03 (05.00)	07 (11.67)	00 (00.00)	10 (05.56)

Figures in parentheses indicate percentage

male followed by female (31.67%) from private sector. It is evident that the percentage of women taken for study was more in R&D and SDA in comparison to private sector. The reason behind this difference might be due to more work specialization focus in R&D and SDA in comparison to private sector.

The educational status of the respondents' shows that from R&D sector not a single respondent was graduate. Majority (58.33%) of the respondents were doctorate followed by post-graduate (41.67%). The reason of absence of exclusive graduate respondents is the minimum essential educational level of entry to the occupation was post-graduation. In SDA, a slightly more than half of the respondents were graduate (55.00%) followed by post-graduate (45.00%). Not a single respondent from SDA was doctorate. The reason might be that the minimum essential qualification to entry into the SDA is graduation, so the higher education is not seen in comparison to R&D and private sector. In private sector also, majority of respondents was post-graduate (95.00%) followed by doctorate (05.00%). Not a single respondent was found graduate in private sector as well as in R&D sector.

With regard to number of years of service, from R&D sector, a slightly higher than half of the respondents (51.56%) were belonged to low years of service followed by high (25.00%) and middle (23.33%). About 67 per cent respondents from SDA were falling into low category of number of years of service followed by middle (21.67%) and high (11.67%). From private sector, 60 per cent respondents were falling into low years of service followed by middle (21.67%) and high (18.33%).

In R & D sector, majority (53.33%) of the respondents were involved in extension followed by research (23.33%), training (18.33%) and administration (05.00%). About 89 percent respondents from SDA sector were involved in extension followed by 12 per cent respondents major job area was administration. Not a single respondent from SDA was involved in either research or training as major job responsibility. About 69 per cent respondents from private sector were involved in extension followed by research (16.67%) and training (15.00%). Not a single respondent was in administration side of the job.

Possession of smart gadgets

Possession of smart gadgets **(**ICTs) was shown sector wise (Table 2). The Table 2 shows that about 93 per cent of R&D sector respondents and 90 per cent private sector respondents have personnel computers/laptop while only 63 per cent SDA respondents have personal computers/laptops. About 84 per cent R&D sector respondents and about 79 per cent private sector respondents have personal computer/laptop with internet connection whereas much less than half (43.33%) of the SDA respondents have personnel computer/laptop with internet connection. Cent per cent respondents from all the three sectors have mobile phones. With respect to smart phone possession, 65 per cent private sector respondents have smart phones, followed by 45% SDA respondents and about 27 per cent R&D sector respondents possess smart phone. With the use of internet in mobile phone/smart phone, it is encouraging finding that about 47% R&D sector respondents, about 37% SDA respondents and about 57% private sector respondents have internet connection to their mobile phones. This opportunity can be better utilize to train extension personnel at their time and pace. Moreover, it could be evident from the table 2 that although SDA sector employees does not possess computer/laptop at personnel level but they are using mobiles/smart phone with internet facility. This trend

Table 2. Distribution of respondents working in R&D, SDA and Private sectors according to possession of smart gadgets

S.No.	Smart Gadgets (ICTs)	R&D (n=60)	SDA (n=60)	Private (n=60)
1.	Personal Computer / Laptop	56 (93.33)	38 (63.33)	54 (90.00)
2.	Personal Computer/ Laptop with Internet Connection	50 (83.33)	26 (43.33)	47 (78.33)
3.	Mobile Phone	60 (100.00)	60 (100.00)	60 (100.00)
4.	Smart Phone	16 (26.67)	27 (45.00)	39 (65.00)
5.	Mobile Phone/Smart Phone with Internet Facility	28 (46.67)	22 (36.67)	34 (56.67)

Figures in parentheses indicate percentage

is showing the very good possibility of capacity building of SDA sector extension personnel through mobiles/smart phones at their ease level, time and pace to speed up the technology transfer skills and knowledge. In conclusion, the study revealed a good picture of ICTs possession by the respondents at their personal level.

Access and availability of ICTs Tools to the respondents

The Table 3 highlights the access and availability of ICT tools to the respondents. It is clear from the table that in R&D sector, there is cent per cent availability of Computer/Laptops/Desktops/, internet and e-mail and landline. The availability of other ICTs tools are Scanner (83.33%), printer (93.33%), TV/LCDs (60.00%), digital camera (90.00%), video camera (75.00%), handy cam (55.00%), video conferencing (60.00%), CD/DVD Player (80.00%) and Fax (86.67%). With regard to use of the available ICTs tools, in R &D computers, all the available ICTs tools are cent per cent in use. The same trend is visible with the SDA sector and private sector.The availability of ICTs tools to SDA department can be understood from the same table. Cent per cent respondents from SDA have computer, internet, e-mail, mobile and landline. Availability of scanner and printer was about 39 per cent. LCD projector was available with about 49 per cent followed by digital camera (65.00%), video camera (41.67%, handy cam (21.67%), teleconferencing (30.00%), video conferencing (76.67%) and fax (46.67%).

The availability of ICTs tools in private sector shows that computer, internet, e-mail, scanner, printer, mobile, fax and landline are cent per cent available. LCD projector was available with 90 per cent followed by video camera (81.67%), handy cam (76.67%), teleconferencing (53.33%) and videoconferencing (80.00%).

The availability of the ICTs tools are varying with respect to R & D sector, SDA sector and private sector. Availability of ICTs tools is better both in R&D sector and private sector in comparison to SDA sector. The use of the ICTs also affecting the availability of ICTs tools in different sectors. Findings of the present research work are in line with Adesope *et al.* (2007), Salau and Saingbe (2008) and Oladosu (2008).

Table 3. Access and availability of ICTs tools by different sector respondents

S.No.	ICTs resources	R&D (n=60)		SDA (n=60)		Private (n=60)	
		Available	If available, in use	Available	If available, in use	Available	If available, in use
		Yes	Yes	Yes	Yes	Yes	Yes
1.	Computer/ Laptops/Desktops	60 (100.00)	60 (100.00)	60 (100.00)	46 (76.67)	60 (100.00)	60 (100.00)
2.	Internet	60 (100.00)	60 (100.00)	60 (100.00)	60 (100.00)	60 (100.00)	60 (100.00)
3.	e-mail	60 (100.00)	60 (100.00)	60 (100.00)	60 (100.00)	60 (100.00)	60 (100.00)
4.	Scanner	50 (83.33)	50 (83.33)	23 (38.33)	23 (38.33)	60 (100.00)	60 (100.00)
5.	Printer	56 (93.33)	56 (93.33)	23 (38.33)	23 (38.33)	60 (100.00)	60 (100.00)
6.	Radio	11 (18.33)	11 (18.33)	00 (00.00)	00 (00.00)	18 (30.00))	18 (30.00)
7.	Television/LCDs	36 (60.00)	36 (60.00)	18 (30.00)	18 (30.00)	28 (46.67)	28 (46.67)
8.	LCD Projector	49 (81.67)	49 (81.67)	29 (48.33)	29 (48.33)	54 (90.00)	54 (90.00)
9.	Digital Camera	54 (90.00)	54 (90.00)	39 (65.00)	39 (65.00)	60 (100.00)	60 (100.00)
10.	Video Camera	45 (75.00)	45 (75.00)	25 (41.67)	25 (41.67)	49 (81.67)	49 (81.67)
11.	Handy Cam	33 (55.00)	33 (55.00)	13 (21.67)	13 (21.67)	46 (76.67)	46 (76.67)
12.	Tele Conferencing	28 (46.67)	28 (46.67)	18 (30.00)	18 (30.00)	32 (53.33)	32 (53.33)
13.	Video Conferencing	36 (60.00)	36 (60.00)	46 (76.67)	46 (76.67)	48 (80.00)	48 (80.00)
14.	CD/DVD Player	48 (80.00)	48 (80.00)	26 (43.33)	26 (43.33)	38 (63.33)	38 (63.33)
15.	Mobile	60 (100.00)	60 (100.00)	60 (100.00)	60 (100.00)	60 (100.00)	60 (100.00)
16.	Fax	52 (86.67)	52 (86.67)	28 (46.67)	28 (46.67)	60 (100.00)	60 (100.00)
17.	Landline	60 (100.00)	60 (100.00)	60 (100.00)	60 (100.00)	60 (100.00)	60 (100.00)

Figures in parentheses indicate percentages

Problems perceived by the respondents with reference to use of Information and Communication Technologies (ICTs) in agricultural extension system

The Table 4 gives clear picture of the problems faced by the respondents in the use of ICTs. For easy understanding, problems faced in effective utilization of ICTs categorized into six broad categories, *i.e.*, problems related to acquisition of ICTs facilities and services, problems related to information acquisition, problems related to information processing, problems related to information storage and retrieval, problems related to information diffusion and problems related to information utilization.

Two main problems were identified by the respondents under the category problems related to acquisition of ICTs facilities and services. The very first problem was provision of fewer funds received far below the standard costs of ICTs facilities. The second one was the poor perception of ICTs services by the top officials in the parent institutions.

About 89 per cent respondents suggest that provision of fewer funds received far below the standard costs of ICTs facilities hinders the effective utilization of the ICTs. In general, the agricultural extension system has from many years receiving the very little funds from the government. Normally there are no specific funds allocated for acquisition of ICTs facilities. This implies that funds for acquisition of new ICT facilities and services can only be found by reallocating or redirecting the funds obtained. The present research work findings are coincide with the findings of Khan (2001), Kushner and Chong (2004), and Stribhadung (2006) that stressed that inadequate financial resources are a challenge and the high cost of buying and maintaining a system adversely affected the deployment of ICTs. The importance of technical factors has been pointed out by several authors including Barajas and Owen (2006), Surry (2002), Bheenick and Brizmohunr (2003), Ebadi (2005), and Castels (1996).

About 51 per cent respondents perceived the problem of Poor perception of ICTs services by the top officials in the parent institutions. Lack of knowledge about the potential and value of ICTs in TOT by the top officials will discourage the employees to use the ICTs in their job which is correctly perceived by the respondents. There were two main problems faced by the respondents in information acquisition. The problem 'Identification of the credible source of information' ranked first with about 82 per cent followed by the problem 'Lack of skill in acquiring information about ICTs' with about 85 per cent.

With regard to problems faced in information processing, there were six main problems perceived by the respondents. 'Difficulty in developing content in local language' was the major problems faced by the respondents followed by ICTs are not in workable condition. The development of content in local language is pivotal to ensuring equitable access to ICTs. Linguistic diversity and widespread illiteracy are the particular challenges. The expertise in understanding, familiarization and use of local languages is not an easy task. Hence, the respondents correctly perceived this problem. The content delivered through ICTs should be in vernacular language matching with the diverse needs of the widespread and various categories of the respondents. This content should be validated proper before delivering it to the intended users. However, absence of content validation was another important problem perceived by the respondents which ranked among the problems of information processing. The objective behind the use of ICTs IS that more and better information and communication furthers the development of farming community. The extension

Table 4. Problems perceived by the respondents with reference to use of ICTs in agricultural extension system

S.No.	Problems	Frequency	Rank										RBQ (%)	Ranking within category	Overall Rank
			1	2	3	4	5	6	7	8	9	10			
1.	**Problems related to acquisition of ICTs facilities and services**														
i.	Provision of fewer funds for ICTs	160 (88.89)	108	52	-	-	-	-	-	-	-	-	71.11	I	VI
ii.	Poor perception of ICTs services by the management	145 (80.56)	94	51	-	-	-	-	-	-	-	-	66.39	II	VII
2.	**Problems related to information acquisition**														
i.	Identification of the credible source of information	147(81.67)	131	16	-	-	-	-	-	-	-	-	77.22	II	V
ii.	Lack of skills in information acquisition through ICTs	153(85.00)	143	10	-	-	-	-	-	-	-	-	82.22	I	II
3.	**Problems related to information processing**														
i.	Difficulty in developing content in local language	167(92.78)	105	29	11	10	04	08	-	-	-	-	80.09	I	IV
ii.	Matching content for the various stakeholders in their form	85 (47.22)	30	19	16	06	10	04	-	-	-	-	35.67	VI	
iii.	Difficult to compiled and disseminate Huge information	117(65.00)	38	24	16	09	14	16	-	-	-	-	44.72	V	
iv.	Absence of content validation	112(62.22)	40	24	18	12	10	08	-	-	-	-	45.93	IV	
v.	Most of the ICTs are not in workable condition	142(78.89)	52	28	25	19	12	06	-	-	-	-	59.17	II	VIII
vi.	No availability of expertise	121(67.22)	47	24	10	15	15	10	-	-	-	-	48.80	III	
4.	**Problems related to information storage and retrieval**														
i.	Virus problem	156(86.67)	134	12	10	-	-	-	-	-	-	-	80.74	I	III
ii.	Outdated ICTs	96(25.56)	65	21	10	-	-	-	-	-	-	-	45.74	III	
iii.	No Technical know how	134(74.44)	78	26	30	-	-	-	-	-	-	-	58.52	II	X
5.	**Problems related to information dissemination**														
i.	Power cut/interrupted power supply	180(100.00)	160	20	-	-	-	-	-	-	-	-	97.78	I	I
ii.	No Technology know how	134(74.44)	59	35	12	18	10	-	-	-	-	-	57.44	III	
iii.	Lack of proper communication tools	106(58.89)	36	26	24	12	08	-	-	-	-	-	43.11	V	
iv.	Lack of awareness about ICTs tools	143(79.44)	63	32	20	18	10	-	-	-	-	-	52.00	IV	
v.	Slow internet connectivity	118(65.56)	58	26	14	12	08	-	-	-	-	-	58.67	II	IX
6.	**Problems related to information utilization**														
i.	Lack of proper knowledge on usage of different internet modules	104(57.78)	54	30	10	10	-	-	-	-	-	-	46.67	II	
ii.	No timely availability of Resource person	82 (45.56)	45	15	10	12	-	-	-	-	-	-	39.17	IV	
iii.	Latest ICTs mostly not available	92 (51.11)	43	26	13	10	-	-	-	-	-	-	39.72	III	
iv.	Lack of trainings on ICTs	114 (63.33)	79	15	10	10	-	-	-	-	-	-	54.31	I	

Figures in parentheses indicate percentages

personnel be sure that the information provided by them should be reasonable, valid, useful and solve the problems of farming community. ICTs cannot check the data whether it is correct or not. It is the extension personnel should verify, check and validate the information before dissemination to the intended users. For this, if validated information is readily available, no problem but identifies the reliable sources of content is of prime importance. For proper content development ICTs are not in working condition and there should be proper facility, this problem expressed by majority of the respondents ranked second as well as non-availability of expertise to process the complex information also felt by the respondents and ranks third.

The other challenge in use of ICTs is that 'development of matching content suitable to various stakeholders'. Firstly, the extension personnel have to identify and analyze stakeholders and their interests. Developing content separately for all the stakeholders is waste time and budget. Development of matching content for all the stakeholders is really a herculean task and need lot of expertise and familiarization. Hence, the respondents correctly perceived this problem in information processing.

Information storage and retrieval is another important advantage of ICTs which facilitate creation, searching and modification of stored data. It should be accessible to all the stakeholders but not all the information. For storage and retrieval it requires strong centralization network with latest hardware and should rapidly adapt to changing demands and resources. Otherwise, it may ensure catastrophic data loss. In this context, the respondents rightly pointed out that 'Virus problem', 'no technical knowhow' and 'outdated ICTs' were the main problems in information storage and retrieval.

Five problems were identified by the respondents in information dissemination. The major problem was Power cut/interrupted power supply followed by Slow internet connectivity, No Technology know how, Lack of awareness about ICTs tools and Lack of proper communication tools. When one is planning about the technology dissemination through ICTs, regular power supply is the most important fact as dissemination of right information at a right time to right users at right cost matters a lot. For this, one should also know about the proper communication tools/ICTs tools which are suitable for particular type of information and its dissemination. For effective information dissemination not only the proper technology but the proper techniques for content development and technology dissemination is also necessary.

The last category of the problem identified was problems in information utilization and four problems were perceived by the respondents under this category. The most important problem identified was lack of trainings on ICTs followed by lack of proper knowledge on usage of different internet modules, latest ICTs mostly not available and no timely availability of resource person. It could be interpreted from the table trainings are vital in developing ICTs starting from the information acquisition to diffusion and utilization. Besides trainings, availability of experts and the knowledge of using ICTs are also very important. Results also agree with the findings of Lynch (2001) which reflects that positive attitude and knowledge and skills of experts directly impact the application of ICTs.

To sum up, it can be reiterated from the findings that power supply is one of the major problems identified by the respondents in all stages of effective use of ICTs followed by content development, expert availability, trainings and working conditions of ICTs. As all these problems are connected to each other so these problems should handle with care and in

integrated mode instead of isolation mode. Supporting to this finding, Flor and Hazelman (2004), Bheenick and Brizmohunr (2003), and Schmitz (2003) maintain that any extension organization, in order to fulfill its function, has to overcome technical challenges along with human, regulatory, financial and social challenges because these are the main constraints in deploying ICTs. Technical challenges are always potentially troublesome in applying ICTs.

From the same Table, it could be inferred that on an average, 'electricity cut problem' was ranked first followed by lack of skills in in information acquisition through ICTs. The third ranked problem was 'virus problem during storage or retrieval' followed by 'difficulty in developing content in local language'. The fifth and sixth ranked problems were 'identification of the credible source of information' followed by 'provision of less budget/fewer funds for ICTs'. Consequently other problems were 'poor perception of ICTs services by the management' as seventh ranked problem, 'most of the ICTs were not in working conditions' as eight ranked problem, 'slow internet connectivity' as ninth ranked problem and 'no technical know how' as tenth ranked problem.

CONCLUSION

From the findings it could be viewed that only implementation of ICTs is not important for the success of any ICTs initiative. Instead all the items such as budget, policy, administration, infrastructural, capacity building and other soft issues has to be catered to make ICTs more successful and profitable in agricultural extension system with the focus on sustainability.

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SYNTHESIS AND PROPERTIES OF NANO LIMING MATERIALS FOR RECLAMATION OF ACID SOILS

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Occurrence of acid soils in Indian subcontinent is highly varied in nature and it is due to wide variation of climatic conditions. Soil acidity is caused by free release of hydrogen, aluminium, manganese and iron toxic concentration (Das *et al.,* 1996). It is estimated that of pproximately 49 m ha are acid soils with a pH of 4 - 5.5 (Biswas and Mukherjee, 2002). In acid soils, free release H^+ and Al^{3+} concentrations become toxic to plant root growth. Historically, limestone (pure calcium carbonate) application is the most common management practice, which is used to neutralize the toxic concentrations of H^+,Al^{3+},Mn, Fe and increase the exchangeable Ca and Mg(Adams, 1984). Pure crystalline CaCO3 is called calcite or calcitic limestone and has a neutralising value of 100%. Limestone is slightly soluble in pure water, however, if the water is saturated with carbon dioxide at ordinary temperatures, it is soluble to the extent of about one part by weight in 1000 parts of water, forming bicarbonates. The carbonate forms in finely divided form may also react directly with soil colloids. The colloids are thus charged with bases, where reaction is accompanied by the liberation of carbon dioxide. It also modifies the soil property and improves nutrient availability for root growth. Usually, plants grow well at a pH range of 6.5-7.5 due to the optimum availability of essential nutrient sand liming is important to maintain the pH at this range. Liming enhances the physical (structure), chemical (essential nutrients) and biological (microbial population) properties of soil through its direct effect on the amelioration of soil acidity and indirectly promotes root distribution.

The effectiveness of agricultural limestone also depends on the neutralizing value, physical properties and particle size (Brady, 2008).The rate of reaction of liming materials with acid soils depends upon its fineness because finer materials increase the surface contact with the soil. If the liming materials are coarse, the rate of reaction will be slow (Alley *et al.*,1980). The amount of finer fraction of liming materials required much less as compared to coarser fractions of the material to achieve a certain pH.

Nanotechnology deals with small particles with the dimension of 1-100nm. Nano particles with extremely high reactivity and deliverability can be applied as amendments to improve soil quality, mitigate soil contaminations. These particles have high surface mass ratio and are capable of improving the agricultural inputs such as nano-gypsum reclaimed alkaline soil (Santhosh, 2012). Nanotechnology applications in agriculture are gradually transforming the theoretical possibilities into practical applications (Subramanian and Tarafdar, 2011). The role of nanotechnology in soil reclamation is yet to be attempted. The present study was carried out on synthesis of the nano lime and its structural characterization by using various spectroscopic as well as microscopic studies. Also, the study was aimed to determine the effects of synthesized nano-lime on soil acidity reclamation under laboratory conditions. Physical and chemical properties of the acid soil were assessed through the standard protocols of soil analysis. The results of the soil analysis are shown in Table 1.

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Table 1. Physico - chemical properties of acid soil

S.No	Particulars	Values of various parameters evaluated
I	**Physical properties**	
1.	Mechanical analysis	
	Clay (%)	33.4
	Silt (%)	20.2
	Fine sand (%)	28.6
	Coarse sand (%)	17.0
2.	Textural class	Sandy loam
3.	Physical constants	
	Bulk density (Mg m^{-3})	1.42
	Particle density (Mg m^{-3})	2.65
	Pore space (%)	35.71
	Hydraulic conductivity (cm hr^{-1})	0.44
II	**Physico-chemical properties**	
1.	pH (1:2.5 soil: water)	5.2
2.	EC (dS m^{-1})	0.32
III	**Chemical properties**	
1.	Organic carbon (g kg^{-1})	0.318
2.	CEC (c mol (p^+) kg^{-1})	11.5
3.	Available nitrogen (kg ha^{-1})	256.00
4.	Available phosphorus (kg ha^{-1})	9.52
5.	Available potassium (kg ha^{-1})	352.00
6.	Exchangeable calcium (c mol (p^+) kg^{-1})	2.40
7.	Exchangeable magnesium (c mol (p^+) kg^{-1})	2.51
8.	Total calcium (%)	0.280
9.	Total magnesium (%)	0.202
10.	pH of soil buffer suspension	5.20
11.	Lime requirement (tonnes $acre^{-1}$)	8.6-10

Nano-materials were synthesized from two raw materials such as conventional forms of lime and dolomite using ball milling (top down) approach. The particle size was reduced significantly with time and speed (rpm). Lime particle dimensions at the initial, one, two, four and six hours of ball milling were 878, 475, 398, 257 and 121 nm, respectively. Among the three speeds tested, 500 rpm was found effective in achieving near-nano dimensions. The surface areas measured in the corresponding same set of particles, were 41, 55, 72, 83 and 110 $m^2 g^{-1}$. Similarly, the particle sizes of dolomite at the initial, one, two, four and six hours of ball milling were 940, 656, 420, 270 and 127 nm, respectively, at 500 rpm. The surface areas of the same set of particles were 57, 76, 88, 96 and 101 m^2g^{-1}, respectively.In order to stabilize the nano-particles, 1% chitosan was used to encapsulate the particles. The physical and chemical properties of nano-lime and nano-dolomite are

Table 2. Physico- Chemical properties of nano-lime and nano-dolomite

Parameters	Nano-lime	Nano-dolomite
Physical Properties		
Size (nm)	100-120 nm	100-115 nm
Shape	Trigonal	Trigonal
Surface Area ($m^2 g^{-1}$)	1000	900
Density (Mg m^{-3})	0.45	0.48
Color	5Y 8/1	2.5Y 8/1
Chemical Properties		
pH	12.30	8.40
EC (dSm^{-1})	0.02	0.03
CEC (c mol(p^+) kg^{-1})	187	189

Characterization of nano-lime was undertaken using particle size analyser (PSA)(Horiba Scientific Nanopartica SZ-100), X-ray diffraction (XRD) patterns by Powder XRD (Bruker D8 Advance Powder X-ray Diffractometer, Germany), Fourier-transform infrared spectroscopy (FT-IR) by Shimadzu Model-FTIR, Raman Spectroscopy by (R-3000 QE TM),Scanning electron microscopy (SEM) and Energy dispersive X-ray spectroscopy (EDS) by SEM (FEI Quanta 250) as per standard procedures (Das and Ansari 2009; Manikandan and Subramanian, 2014). All graphs were prepared using Microcal origin 6.0 software.

The percolation reactor was designed in order to assess the efficacy of nano-lime in a column of soil with a constant flow of solution as fabricated by (Hemandez *et al.*, 1994). The percolation reactor consists of a cylinder (internal diameter of 2.5 cm and height of 15 cm) through the top of which deionised water is continuously pumped at a flow rate of 50 ml per day. In this technique, a column of test soil was loaded in a sample chamber. About one g of nano-lime homogenised with varying levels of soil column. The leachate was collected from the 5^{th} day for a period of 60 days at an interval of 5days.The Ca^{2+}

content was measured in the leachate regularly (Jackson, 1973) to assess the efficiency of nano-lime.

Nano sized (approximately 115-120 nm) particles of lime are obtained after 6 hrs of ball milling. It got reduced from 1000 to119 nm to 115 nm and encapsulation of chitosan increased the particle size. The reduction size is due to grinding action of balls on lime under dry condition. Similar results were observed in biochar and zeolite by Thirunavukkarsu (2014). This top-down approach has facilitated extensive surface area for adsorption of cationic nutrients and anionic nutrients on surface modification of the lime with cationic surfactant. Surface modification helps in stability of synthesized nano particles of lime. Our study has clearly shown that the zeta potentials (-50.9 mV and -49.4) (Table 3). Particles range of +30 to +60 and-30 to -60 indicating the highly stable minimal aggregation. The results are confirmation with Santhosh (2012).

Table 3. Particle size and Zeta potential of liming materials

Forms	Particle size (nm)	Zeta potential (mV)
Lime		
Conventional lime	896	-6
Nano-lime	102	-23.7
Encapsulated nano-lime	115	-50.9
Dolomite		
Conventional dolomite	750	-4
Nano-dolomite	101	-21.2
Encapsulated nano-dolomite	119	-49.4

Raman spectroscopy is a form of vibrational spectroscopy similar to infrared spectroscopy. A raman spectrum is a plot of the intensity of raman scattered radiation as a function of its frequency difference from the incident radiation(Schrader, 1995).The data on Raman shift peak values confirmed for nano-lime is given Fig.1. The broad signal collected at 282, 713, 1086 and1325 cm^{-1} for nano lime, respectively. This data is useful for chemical analysis for several reasons. X-ray powder diffraction is a non-destructive technique widely applied for the characterization of crystalline materials. Results are commonly presented as peak positions at 2è and X-ray counts (intensity) in the form of x-y plot (Bish and Post, 1989).The data was confirmed with XRD peak values which are given Fig. 2.The 2è values shows 26.2, 21.64, 30.58, and 23.84 for nano lime, that corresponded to *d* spacing = 2.89, 3.97, 3.33, and 3.96 Aº respectively. The average modern infrared instrument records spectra from 400-4000 cm^{-1}.The data was confirmed with FT-IR spectra which are given in the Fig.3. that has characteristic peaks of nano lime that shows 844.77, 1172.65, 1838.06, 2245.03, 2313.52. This group frequencies help to characterize a compound and the combination of the bands associated with these group frequencies and the

skeletal frequencies are used to identify a specific compound.

The characteristics of nano-lime performed using high resolution microscope *viz.*, SEM and spectroscopies clearly indicated the successful synthesis of nano-lime. The SEM image of nano-lime was clustered and consolidated while its carrier, chitosan is scattered and sparse. The Raman spectra and FTIR which measures the functional groups of nano materials have confirmed the presence of lime loaded into the chitosan as depicted by the presence of functional groups. Further, the XRD picture showed the reduction in d-spacing that coincide with ion attachment between the lattices.

The efficiency of nano-lime was examined using the percolation reactor. The data on Ca^{2+} of the leachate clearly showed that, the Ca^{2+} content declined proportionately with the progress of the experiment. Initially, the Ca^{2+} content measured was in the range of 5.18 me l^{-1}, while in the last stage of the experiment (55-60 days), the Ca^{2+} content was reduced to a minimum of 0.2 to 0.4 me l^{-1} (Fig. 6).The Ca^{2+} concentration almost ceased to exist in the leachate at the end of the experimental period. Nano-lime possesses extensive surface area and adsorptive sites to exchange Ca^{2+} with Al^{3+} and H^{+} in the soil exchangeable complex. Since nano-lime efficiently retained Ca^{2+} and displaced, Al^{3+} and $H^{+,}$ the Ca^{2+} content of the leachate linearly declined with the progress of the experiment. The study further indicates a long lasting effect (60 days) of nano-lime to regulate the retention of Ca^{2+} in the chitosan, while having considerable low amounts of Ca^{2+} in the solution. The data corroborates with the observations of our pot culture experiment, where the leachate of surface drainage were determined for the concentration Ca^{2+} and Al^{3+} and H^{+} ions (Fig. 6).

It could be concluded that after the encapsulation of nano lime with chitosan the particle size slightly increased and zeta potential of encapsulated nano lime particles getting stability. Raman spectroscopy, FTIR and XRD study confirmed the calcium attachment in the surface modified nano-lime.SEM and TEM images show the trigonal shape of calcium particles. Finally, the percolation reactor study showed that amount of exchange ca^{2+} release from encapsulated nano lime was extensive surface area and adsorptive sites to exchange Ca^{2+} with Al^{3+} and H^{+} in the soil exchangeable complex. Since, nano-lime efficiently retained Ca^{2+} and displaced Al^{3+} and H^{+} the Ca^{2+}, content of the leachate linearly declined with the progress of the experiment. The study further indicates a long lasting effect of nano-lime to regulate the retention of Ca^{2+} in the chitosan complex, while having considerable low amounts of Ca^{2+} in the solution.

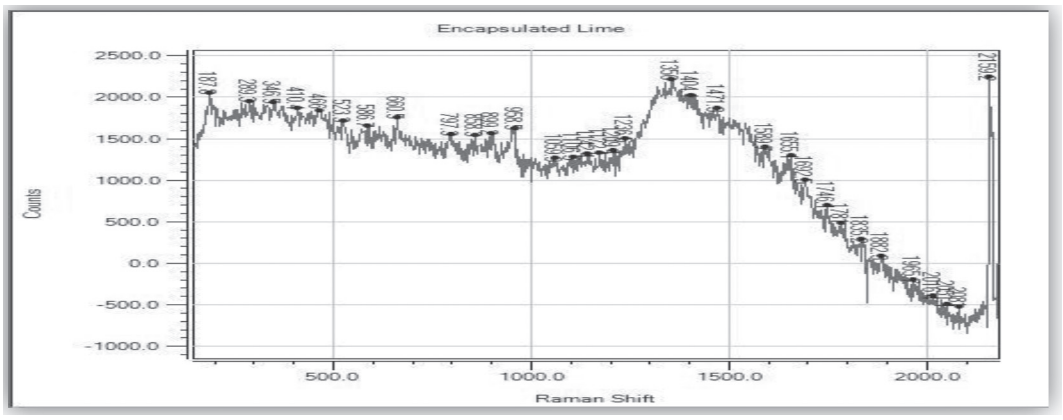


Fig. 1. Raman spectra of Nano Lime

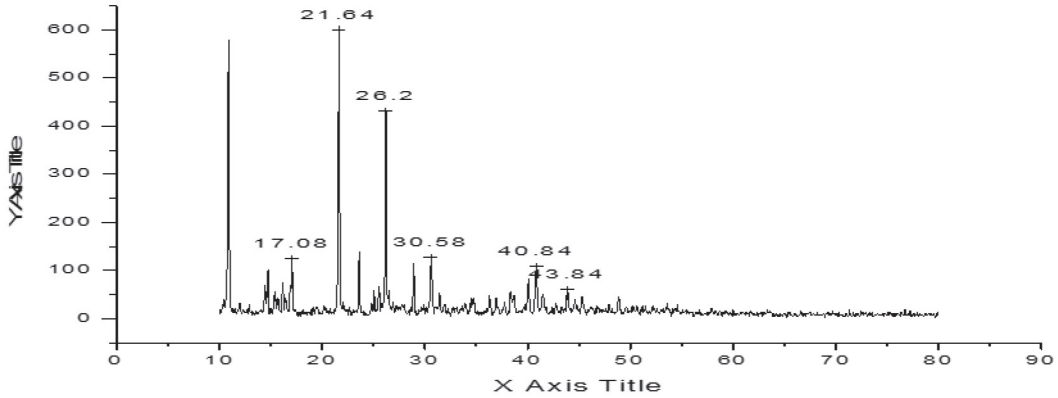


Fig. 2. XRD pattern of Nano Lime

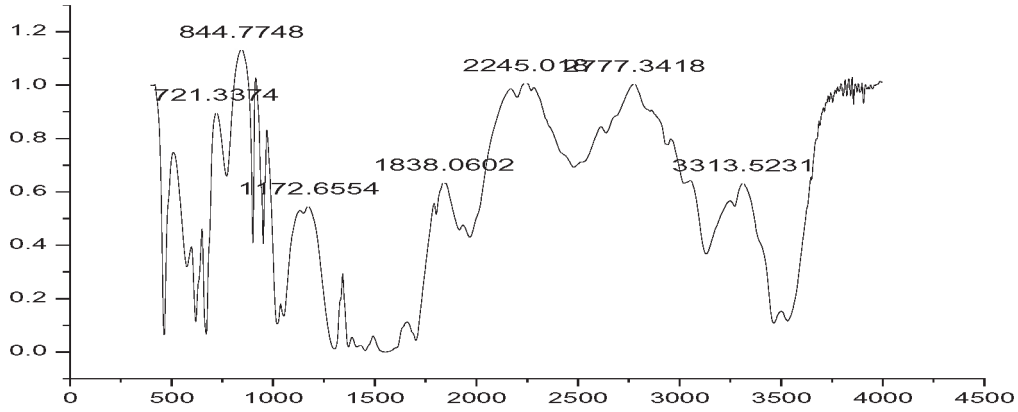


Fig. 3. FT-IR spectra of Nano Lime

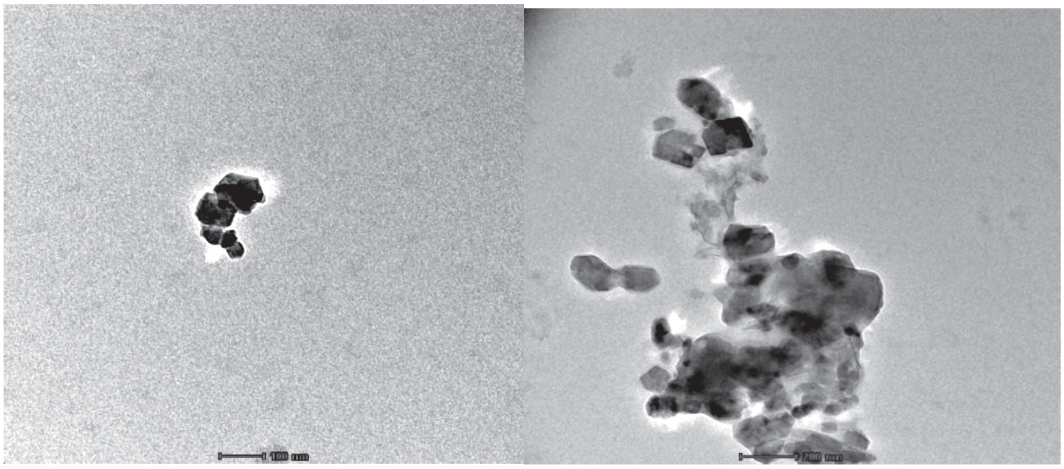
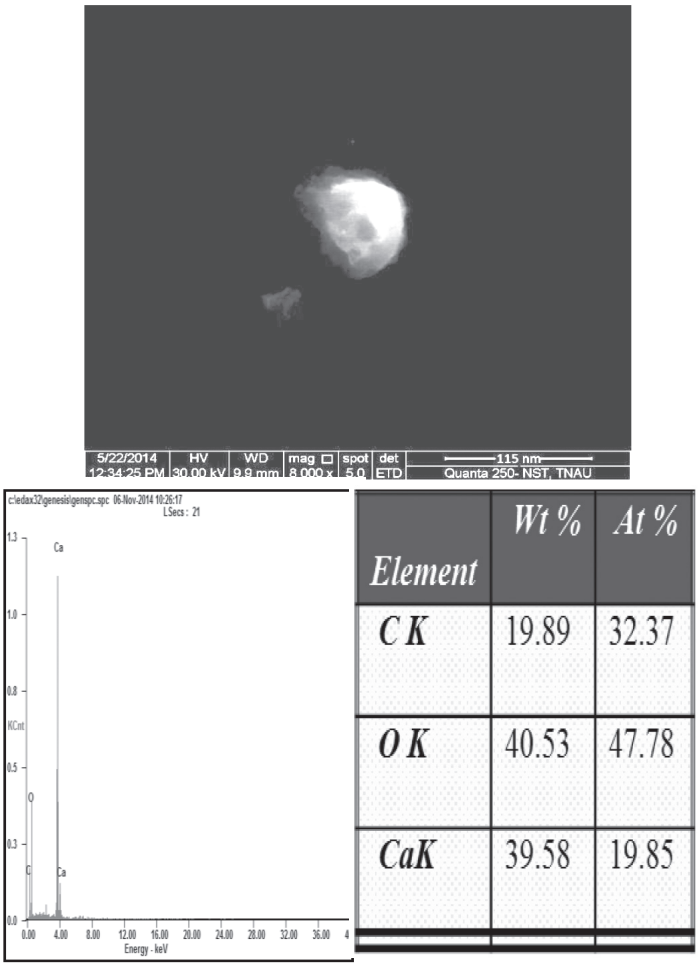


Fig. 4.TEM image of nano liming materials



Element	Wt %	At %
C K	19.89	32.37
O K	40.53	47.78
CaK	39.58	19.85

Fig. 5. SEM with EDAX image of Nano Lime

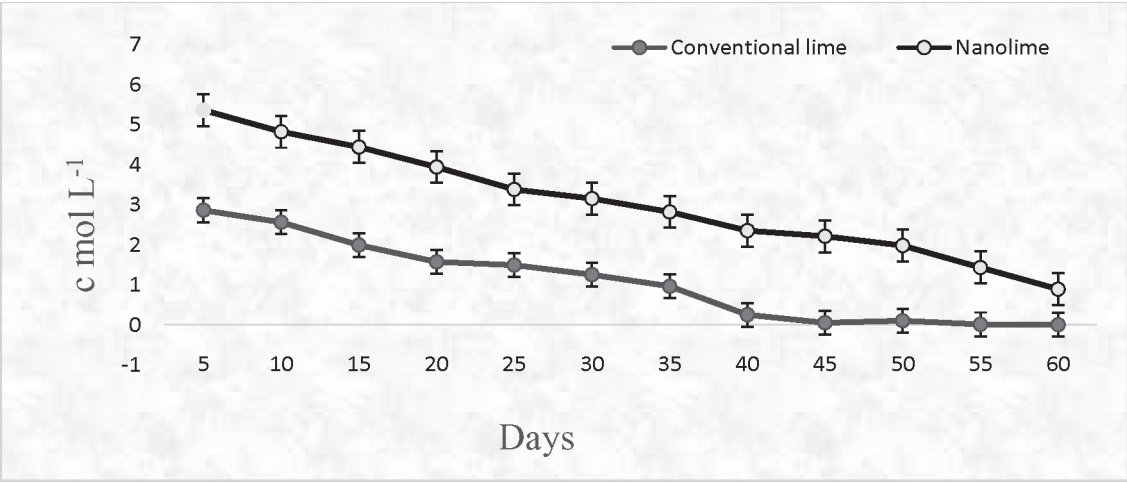


Fig. 6. Amount of exchangeable calcium from nano-liming materials (Percolation study)

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Research Note
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ESTIMATES OF HERITABILITY FOR SEED YIELD AND YIELD COMPONENTS OF SAFFLOWER (*Carthamus tinctorius* L.)

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Safflower is usually considered to be a self-pollinated crop. However, the detectable crossing ranged from 5 to 40 per cent. Safflower is traditionally grown for its flowers which were used for colouring, flavouring and making dyes. Besides, in Indian varieties it contains 30% oil. Safflower oil is primarily used for cooking. The oil contains high amount of linoleic acid (76%), which is very useful for patients suffering from heart diseases. The unsaturated fatty acids of safflower lower the serum cholesterol (Nimbkar, 2002). The conventional breeding methods have not been very efficient for improving quantitatively inherited characters *viz*., seed yield, oil content, tolerance to stresses and horizontal resistance to diseases and insects. Moreover, the crossing and record keeping procedures are often both money and time consuming for the rate of progress attained. Conventional methods have several limitations such as limited use of available genetic variability resulting in the development of varieties with a narrow genetic base, successive loss of genes in the segregating generation with no chance of recombination for genes linked for yield and oil content. These limitations can be overcome by application of recurrent selection method in self-pollinating crops including Safflower. Considering the above facts the present study was taken with the objective to determine the narrow-sense heritability for seed yield and its components from half-sib selection method.

The experimental material consisted of Safflower population developed by crossing HUS-MS-305 and 62 male parents. Out of which 25 crosses were developed at All India Coordinated Research Project, Akola, 25 crosses at AICRP, Solapur and 12 crosses were developed at Botany Section, College of Agriculture, Nagpur during *rabi,* 2008. The F_1s were raised in the year 2009 in respective research stations and equal amount of seeds of F_1s were mixed and base population was constructed. The base population was raised in the year 2010 and composited to form random mating population. Half sib seed were harvested from individual male sterile plants and 105 families were developed from random mating population.

These 105 half-sib families were grown in *rabi* 2011-12 along with checks *viz*., Bhima, A1, AKS-207 and AKS-68 for evaluation in augmented block design with five blocks. Each block consisted of 21 half-sibs and four checks. Row to row and plant to plant spacing was maintained as 45 x 45 cm. The recommended packages of practices were followed to raise good crop. The data was recorded on five competitive fertile plants from each family on seven characters *viz*., plant height (cm), number of primary branches plant^{-1}, number of capitula plant^{-1}, number of seeds capitulum^{-1}, 100 seed weight (g), oil content (%) and seed yield plant^{-1} (g) except days to 50% flowering and days to maturity for which data was recorded on plot basis. The mean data of five observational plants from each family were used for statistical analysis,

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Table 1. Estimation of half-sib family components of variance and heritability for different agronomic traits.

Half-sib family component	Days to 50% flowering	Plant height (cm)	Days to maturity	No. of primary branches plant^{-1}	No. of capitula plant^{-1}	No. of seed capitulum^{-1}	100 seed weight (g)	Seed yield Plant^{-1} (g)	Oil (%)
$\sigma^2_{H.S.}$	11.60	82.37	22.85	3.03	114.37	41.27	0.50	219.95	2.23
$\sigma^2_A = 4\sigma^2_{H.S.}$	46.40	329.48	91.40	12.12	457.48	165.08	2.00	879.80	8.92
$\sigma^2_P = ¼\ \sigma^2_A + \sigma^2_e$	14.97	92.69	41.58	4.67	140.52	62.82	0.88	321.61	2.23
h^2 (n.s.) $= \frac{¼\sigma^2_A}{¼\sigma^2_A + \sigma^2_e}$	0.77	0.88	0.54	0.64	0.81	0.65	0.56	0.68	0.99

analysis of variance for experimental design as suggested by Federer (1961) and the estimation of family components and estimation of heritability in narrow sense as suggested by Hallauer and Miranda (1989).

The estimates of half- sib family components of variance and heritability for each agronomic trait were calculated and presented in Table 1. For recurrent selection programme, significant and large genetic variation among half-sib families is prerequisite. The genetic variance among half- sib families ($ó^2_{H.S.}$) and additive variance ($ó^2_{A.}$) was high for seed yield plant^{-1} (219.95 and 879.80) followed by number of capitula plant^{-1} (114.37 and 457.48), plant height (82.37 and 329.48), number of seeds capitulum^{-1} (41.27 and 165.08), days to maturity (22.85 and 91.40), days to 50 % flowering (11.60 and 46.40), number of primary branches plant^{-1} (3.03 and 12.12), oil content (2.23 and 8.92) and 100 seed weight (0.50 and 2.00), respectively. The high genetic variance among half-sib families were also reported by Reddii (2002), Mummaneni (2003), Naole (2004), Panchbhai (2004), Goyal (2006), Metker (2008), Gawande (2010), Chapade (2010) and Awchar (2011) in random mating population of safflower. Estimates of heritability in safflower populations segregating for genetic male sterility are useful in determining the best method of selection to improve the population for specific traits. The most important function of heritability in determining the best method of selection to improve population for specific traits and the genetic study of quantitative traits in its predictive role, expressing the reliability of the phenotypic value as a guide to the breeding value. In the present study the narrow sense heritability estimates on family mean basis were high for oil content (0.99) followed by plant height (0.88), number of capitula plant^{-1} (0.81), days to 50% flowering (0.77), seed yield plant^{-1} (0.68), number of seed capitulum^{-1} (0.65), number of primary branches plant^{-1} (0.64), 100 seed weight (0.56) and days to maturity (0.54) respectively. High estimates of heritability were also reported in random mating population of safflower for several agronomic traits like days to 50 % flowering, plant height, days to maturity, number of primary branches plant^{-1}, number capitula plant^{-1}, number of seed capitulum^{-1} , 100 seed weight and seed yield plant^{-1} by Reddii (2002), Mummaneni (2003), Naole (2004), Goyal (2006), Pavithran (2007), Metker (2008), Gawande (2010), Chapade (2010) and Awchar (2011). The narrow-sense heritability estimates exhibited the importance of seed yield plant^{-1} and number of capitula pant^{-1} for selection of half sib families that will be used for next recombination cycle.

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Research Note
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DEVELOPMENT AND ORGANOLEPTIC EVALUATION OF VALUE ADDED PRODUCTS OF BOTTLE GOURD

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Bottle gourd (*Lagenaria siceraria*) is one of the important vegetable crops which belong to family the Cucurbitaceae. Bottle gourd has its origin in India and Africa and is cultivated all over the world. It has high medicinal value and hence used in some Ayurvedic medicines. It is widely used as folkloric remedies in indigestion, constipation, liver complications and urinary disorders (Rahman 2003). It is also used as diuretic, cardiotonic, cardioprotective and nutritive agent (Hassanpour *et al.,* 2008). *L. siceraria* fruits are reported to contain more soluble dietary fibers (SDF) than insoluble cellulose fibers (ICF) and SDF has profound effect in lowering cholesterol (Rahman, 2003). Bottle gourd is commonly used as a tropical vegetable and is also a good source of vitamin C. The vegetable has been widely used by the cardiac patients probably due to its radical scavenging activity. Cardiovascular diseases (CVD) are the leading causes of deaths and disability worldwide (Mendis *et al.,* 2011). In most of the developed countries, hypercholesterolemia and atherosclerosis lead to cardiac illness and ultimately death. Cardiovascular disorder is claimed to be relieved by regular intake of bottle gourd juice for about 4-6 months. Fresh juice of bottle gourd along with juice of fresh leaves of basil, mint and black pepper and rock salt is recommended to the patients of coronary atherosclerosis (Kothari, 2005). It is not only low cost food but also available round the year and is widely grown in many parts of our country. Studies have also shown that bottle gourd possesses potent antioxidant properties and may provide protection against CVD via a number of mechanisms, including inhibition of low density lipoprotein oxidation.So, keeping in mind the desirable nutritional value of bottle gourd the study was planned to develop and organoleptically evaluate traditional recipes incorporating bottle gourd at different levels.Commonly consumed food items *i.e.* milk, rice, sugar and cardamom were purchased from the local market. Bulk samples of bottle gourd were procured from the Department of Vegetable Crops, PAU Ludhiana. The products were standardized and developed in the Food and Nutrition laboratory of the Department of Food and Nutrition, College of Home Science, PAU in the year 2014.

Development of Products: Products namely *ghia kheer* and *ghia* balls were prepared with the supplementation of bottle gourd at different levels in the laboratory.

A. Method of preparation of *ghia kheer*: Ingredients- Milk- 1L, Bottle gourd- 500 g, Cardamom powder- pinch, Sugar- 90 gm.

1. Put milk in a pan, bring to boil.
2. Add boiled bottle gourd in boiling milk, then simmer and heat till it is reduced to three-fourths.
3. Add the sugar and stir until completely dissolved.
4. Remove the *kheer* from heat and serve either warm or chilled.

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B. Method for preparation of *ghia* balls: *Ghia* balls were prepared from milk, powdered sugar and different levels of bottle gourd flakes.

1. Boil the milk
2. Stir till pasty consistency
3. *Khoa* is prepared at dough stage
4. Peel the bottle gourd and grate it with a grater
5. Pressure cook the bottle gourd flakes
6. Addition of powdered sugar, cardamom powder and bottle gourd flakes as per the treatments to the *khoa*
7. Remove the pan and allow the contents to cool
8. Make round balls of about 30g to give the shape of *ghia* balls.

The organoleptic evaluation was done to select the most acceptable level of bottle gourd in all the recipes. The developed products were organoleptically evaluated by a trained panel of 10 judges by using 9 point hedonic rating scale. The panel of judges including faculty of Department of Food and Nutrition were provided with score card of Hedonic Rating Scale to score the test samples for their colour, appearance, flavor, texture feel, taste and overall acceptability, compared to the control recipe.Different samples of *ghia kheer* and *ghia* balls were prepared using the basic ingredients for control and test samples. The test samples were supplemented with various levels of bottle gourd in the preparation of *ghia kheer* and *ghia* balls.

Sensory evaluation of products (*Ghia kheer* and *Ghia Balls*)

Five samples of *ghia* balls were prepared using rice *kheer* as control and supplementation with bottle gourd at 25, 50, 75 and 100% levels (B1, B2, B3 and B4 respectively). The mean scores of acceptability trials of *ghia kheer* by an expert panel of 10 judges using 9 point hedonic scale are presented in the Table 1. The results (Table 1) revealed that the highest scores for all the sensory parameters amongst the supplemented levels was obtained by B4 ranging from 7.2 to 7.5 with an overall acceptability score of 7.38 being liked moderately, followed by B1 with an overall acceptability score of 7.12. Overall acceptability scores were highest for control *i.e.*, 7.52. The mean scores for overall acceptability was lowest for B2 *i.e.*, 6.94 which was liked slightly. The score for taste of control (7.9) and B4 (7.5) were found to be significantly (CD@5%) higher than the scores for B1 (6.9) and B2 (7.0). Similarly, the scores for the Flavor of B1, B2 and B4 were found to be significantly (pd"0.05) different than the scores for B3. Kaur (2013) developed *kheer* with the incorporation of potato flour at 30% and it was found to be highly acceptable on the nine point hedonic scale. In comparison with the control *kheer*, the scores did not vary significantly with respect to appearance, color and texture characteristics.

Four samples of *ghia* balls were prepared using *Khoa* for control and *Khoa* supplemented with bottlegourd at 50, 65 and 80% levels (B1, B2 and B3 respectively). The mean scores of acceptability trials of *ghia balls* by an expert panel of 10 judges using 9 point hedonic scale are presented in the Table 2.The results revealed that the highest scores for appearance, color, texture, taste and flavor was obtained by B2 (65%) ranging from 8.5 to 8.7 with an overall acceptability score of 8.58 being liked very much, followed by B1 (50%) with an overall acceptability score of 8.3. Supplementation of *ghia balls* even with B3 (80%) bottlegourd flakes, did not show any significant (CD@5%) changes in the overall

Table 1. Organoleptic scores of *Ghia Kheer*

Levels	Appearance	Colour	Texture	Taste	Flavor	Overall Acceptability
Ghia Kheer						
C	$7.3^{a}\pm0.67$	$7.3^{a}\pm0.48$	$7.5^{a}\pm0.53$	$7.9^{a}\pm0.74$	$7.7^{a}\pm0.48$	$7.52^{a}\pm0.40$
B1	$7.2^{a}\pm0.42$	$7.1^{a}\pm0.88$	$7^{a}\pm0.94$	$6.9^{b}\pm0.74$	$7.3^{ab}\pm0.48$	$7.12^{ab}\pm0.51$
B2	$6.9^{a}\pm0.99$	$6.8^{a}\pm0.63$	$6.9^{a}\pm0.57$	$7^{b}\pm0.67$	$7.1^{ab}\pm0.57$	$6.94^{b}\pm0.46$
B3	$7.1^{a}\pm0.88$	$6.9^{a}\pm0.74$	$7.3^{a}\pm0.67$	$7.3^{ab}\pm0.48$	$6.7^{b}\pm0.67$	$7.06^{ab}\pm0.47$
B4	$7.3^{a}\pm0.48$	$7.4^{a}\pm0.52$	$7.5^{a}\pm0.53$	$7.5^{ab}\pm0.53$	$7.2^{ab}\pm0.42$	$7.38^{ab}\pm0.24$

Tukey's test has been applied for different parameters at different levels. Values followed with different superscripts are significant (CD@5%).
Control- 100 parts of rice
B1- 75 parts of rice+25 parts of bottlegourd
B2- 50 parts of rice+50 parts of bottlegourd
B3- 25 parts of rice+75 parts of bottlegourd
B4- 100 parts of bottlegourd

Table 2. Organoleptic scores of *Ghia* Balls

Levels ***Ghia Balls*** ***Ghia* Balls**	Appearance	Colour	Texture	Taste	Flavor	Overall Acceptability
C	$7.9^{a}\pm0.57$	$7.9^{a}\pm0.57$	$8.2^{a}\pm0.79$	$8.3^{a}\pm0.95$	$8.1^{a}\pm0.88$	$8.08^{a}\pm0.48$
B1	$8.3^{a}\pm0.67$	$8.3^{a}\pm0.67$	$8.3^{a}\pm0.48$	$8.2^{a}\pm0.63$	$8.4^{a}\pm0.52$	$8.30^{a}\pm0.50$
B2	$8.5^{a}\pm0.53$	$8.5^{a}\pm0.53$	$8.6^{a}\pm0.52$	$8.6^{a}\pm0.52$	$8.7^{a}\pm0.48$	$8.58^{a}\pm0.45$
B3	$8.3^{a}\pm0.67$	$8.3^{a}\pm0.48$	$8.4^{a}\pm0.52$	$8.1^{a}\pm0.74$	$8.2^{a}\pm0.92$	$8.26^{a}\pm0.50$

Tukey's test has been applied for different parameters at different levels. Values followed with different superscripts are significant (CD@5%).
Control- 100 parts of *khoa*
B1- 50 parts of bottlegourd flakes + 50 parts of *khoa*
B2- 65 parts of bottlegourd flakes + 35 parts of *khoa*
B3- 80 parts of bottlegourd flakes + 20 parts of *khoa*

acceptability score (8.26) of the *ghia balls.* The *ghia balls* developed by incorporating bottle gourd were found to be acceptable at all three levels of supplementation. Ghule *et al.* (2012) also prepared *pedha* using different levels of bottle gourd and observed high overall acceptability scores using 5% bottle gourd pulp.

The results of the study revealed a possibility of fresh as well as dehydrated bottle gourd could be a better nutritional substituent food for commercially available food industries. The developed products of bottle gourd were highly acceptable at 50-65% level of supplementation. The processing of bottle gourd into ready-to-eat products maximizes its uses and

creates nutritional benefits as well as new economical and employment opportunities for farmers and health food industry.Nutrition education can be imparted to the people regarding the nutritional benefits, preparation and use of bottle gourd in their daily diet. Since bottle gourd is rich in antioxidants, people should be encouraged to use them in their diets for lowering the bad cholesterol and prevention of coronary heart diseases and associated diseases.

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PREVALENCE OF ANTAGONISTIC RHIZOSPHERIC MICROFLORA IN RICE AND THEIR POTENTIALITY IN MANAGING STEM ROT DISEASE (*Sclerotium oryzae* Catt.) IN *in vitro* CONDITIONS

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ABSTRACT

Trichoderma spp. and Plant Growth-Promoting Rhizobacteria (PGPR) such as *Pseudomonas fluorescens* and *Bacillus* spp. were prevalent antagonists in rice rhizosphere. Dual culture assays indicated that the strains *T. viride* (T_1) and *P. fluorescens* (B_1) were superior among other rhizospheric isolates such as *Aspergillus niger*, *A. flavus* (fungal) and *Bacillus* spp. (bacterial). Pesticide compatibility studies indicated that *T. viride* (T_1) was completely sensitive (100% inhibition) to fungicides such as hexaconazole and propiconazole; whereas butachlor (weedicide) exhibited up to 61% inhibition of the fungal antagonist. The *P. fluorescens* (B_1) was found to be compatible with the fungicides and herbicide under study with inhibitions of <10%. Overall, our results determined the prevalence of *Trichoderma* spp. and PGPR in rice rhizosphere, their sensitivity to different agrochemicals and potential suppressing abilities against stem rot pathogen.

INTRODUCTION

Rice (*Oryzae sativa* L.) is an important staple food crop for majority of the human population in the world. Global rice production is hampered by several biotic stresses of which soilborne diseases cause economically significant yield losses. Of several soilborne diseases affecting rice cultivation, stem rot induced by *Sclerotium oryzae* Catt. is a major one, and is reported from all the rice growing countries (Cother and Nicol, 1999). If the control of this disease is relegated to the backdrop, the damage it induces is phenomenal. Symptoms are usually seen at the later stages of crop growth stages. Necrotic lesions begin on the outer leaf sheath near the water line that spread gradually to the inner sheaths and the stem base. At maturity, lodging may occur and sclerotia are formed within the tissues (Kumar *et al*., 2003). Timely management of stem rot disease in rice therefore gains significance in this context. Though, this disease is managed through application of chemical fungicides, their efficacy at field level is not satisfactory and moreover, stem rot disease epidemics are being reported all over the world. On an average, grain losses to a tune of 5–80 % (Cother and Nicol, 1999) are reported from stem rot disease affected rice fields.

With increased awareness on the environmental and food safety issues, aspects on managing plant diseases using sustainable, ecologically safe tactics is gaining importance. In this context, biological control of rice diseases is gaining momentum and is demonstrated successfully against several foliar and soilborne diseases. Of different biocontrol agents, use of plant growth-promoting rhizobacteria (PGPR) is gaining significance and are widely used antagonists in several crops against major diseases (Rangajaran *et al.,* 2003,).

IDM strategies in rice are being practiced in rice to manage diseases like sheath blight, sheath rot and stem rot besides foliar diseases such as blast, brown spot and narrow brown leaf spot (Surulirajan and Janki Kandhari, 2005). Our studies therefore assumes significance in managing this hitherto difficult to manage the stem rot in rice in a sustainable manner through use of fungal and bacterial bioagents, with environmental safety as an important factor.

MATERIAL AND METHODS

Plant samples of rice cv. MTU 1010, MTU 1001, BPT 5204, JGL 384 showing the typical symptoms of stem rot disease were collected from

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farmer's field of Warangal / Khammam districts. Culture of the pathogen was obtained by placing surface sterilized diseased stem pieces of 2-3 mm size on PDA and incubated at 25±1°c. Pure culture was then obtained using single sclerotial transfer method. Identification of pathogen culture was done based on Barnett and Hunter (1972).

Pathogenicity tests were conducted in the laboratory by soil inoculation method using the 22 days old seedlings of rice cv. MTU 3626. About 15 g of the inoculum of the pathogen (mycelial mat and sclerotia) grown on PDA or PDB medium was mixed in sterile soil (3 kg) in earthen pots. Susceptible rice variety MTU 3626 @ 6 seeds per pot were sown in each inoculated pot and maintained in the polyhouse for further symptom expression. A check was also maintained in the experiment in which the pots were filled with sterile soil without the addition of the inoculum.

Rhizosphere microflora of healthy and diseased samples collected from Khammam and Warangal districts were isolated by following serial dilution technique (Peck and Haugh, 1998). Rhizosphere mycoflora were isolated on rose bengal agar medium by using a dilution of 10^{-4} and bacteria were isolated on soil extract agar medium by using a dilution of 10^{-6}.

Rhizosphere mycoflora were identified based on mycological characters using standard procedure. Rhizosphere bacteria were identified based on Bergey's Manual of Determinative Bacteriology (Holt *et al*., 2000). Mycoflora were maintained by periodical transfer onto PDA, whereas bacteria were maintained by periodical transfer onto nutrient agar medium.

Rhizosphere isolated native antagonistic fungus were tested against test pathogen using dual culture technique. Three days old mycelial disc of 6 mm diameter test fungus was placed at one corner of PDA plated Petri plate and on the opposite side antagonistic fungi was placed and incubated at 28 ± 2°C for 6 days (Muniaraj et al., 2008).

Rhizosphere isolated native antagonistic bacteria were tested against test pathogen using dual culture technique. Three-days-old mycelial disc of 6 mm diameter test fungus was placed at one corner of PDA plated Petri plate and on the opposite side antagonistic bacterium was streaked and incubated at 28 ± 2°C for 6 days (Muniaraj et al., 2008).

The per cent reduction in radial growth of the test pathogen was calculated using the following formula:

$$I = \frac{C - T}{C} \times 100$$

Where,

I : Percent reduction in growth of test pathogen

C : Radial growth (mm) in control

T : Radial growth (mm) in treatment

The potential bacterial and fungal antagonists that have shown highest inhibition of test pathogen, *S. oryzae*, were selected for testing their sensitivity to commonly used agrochemicals in rice.

The compatibility of the antagonistic fungus with the effective fungicides was determined using poisoned food technique methods. Two fungicides, propiconazole (Tilt® xx Ec) and hexaconazole (Contof® xx Ec) and one herbicide, butachlor (Machete® xx Ec) are used at recommended concentrations of 1000ppm, 2000ppm and 400ppm respectively. A control without fungicide/ herbicide was maintained. Each treatment was carried out in six replications. The plates were incubated at 28 ± 2°C for 4 days.

Percent inhibition of the growth of the antagonistic fungus was calculated using the following formula

$$I = \frac{C - T}{C} \times 100$$

Where,

I : Percent reduction in growth of test pathogen

C : Radial growth (mm) in control

T : Radial growth (mm) in treatment

The compatibility of antagonistic bacterium with the effective fungicides/ herbicide was determined by using inhibition zone technique (Nene and Thapliyal, 1993). Fifteen ml of nutrient agar was plated in Petri plates over which five ml of lukewarm nutrient agar seeded with bacterium was poured and rotated gently for uniform distribution. Four discs of sterilized Whatman No.1 filter paper of 10 mm diameter dipped in fungicide solution and air dried were placed over bacteria seeded NA plates. Plates along with a control (discs in sterile water) were incubated at 28+2^{0}C for seven days. The inhibition zone (mm) around the discs was measured and per cent inhibition of antagonistic bacterium was calculated as described previously.

RESULTS AND DISCUSSION

The fungus was isolated on to PDA medium from the rice stems cv. MTU 1061, WGL 44, MTU 1075, BPT 5204, MTU 1010, MTU 1001, WGL-14 , JGL 384, MTU 1078, NP 360, RNR 2465, NLR 34449 and PT 1042 showing the typical symptoms of stem rot. On PDA medium the fungus formed distinct white colonies with abundant globose, white sclerotia from the fourth day onwards. Sclerotia that were formed in the culture were initially white in colour later turned to reddish brown and finally they became dark brown to almost black with spherical shape measuring 418 (185-685) x 355 (165-545) µm in size. Based on the morphological and colony characteristics the causal organism was identified as *Sclerotium oryzae* using standard procedure.

Mycoflora and bacteria that were isolated from rice rhizosphere were identified based on colony and morphological characters using standard procedures (Bergey's Manual of Determinative Bacteriology). Five fungi *viz.*, *Aspergillus flavus*, *A. niger*, *Cladosporium* sp.*, Trichoderma* sp. isolate-1 and *Trichoderma* sp. isolate-2 were isolated and five bacterial isolates *viz.*, *Pseudomonas fluorescens* (B_1) *Bacillus* spp. (B_2, B_3, B_4 & B_5). The concentration of fungal microflora ranged from 12 x 10^6 to 27 x 10^6 CFU g^{-1} soil. Of these, the *Trichoderma* spp. ranged from 12 x 10^6 (T_1) to 21 x 10^6 (T_2, *T. viride*). Of the bacterial microflora, one isolate of *P. fluorescens* (B_1) had prevalence in the rhizosphere up to 67 x10^6 CFU g^{-1}, whereas the *Bacillus* spp. ranged from 64 x 10^6 to 109 x 10^6 CFU g^{-1} soil (Table 1).

Based on the dual culture assays, the fungal antagonist, *T. viride* (T_1) was found to be significantly superior in inhibiting the radial growth of *S. oryzae* (75.3%) (Plate 1) over others. Similarly, among the bacterial isolates, *P. fluorescens* (B_1) was found to be significantly superior over others with per cent reduction of *S. oryzae* up to 70.2% (Plate 2). These two (fungal and bacterial) antagonists were further selected for determining their sensitivity to commonly used fungicides and herbicides in rice.

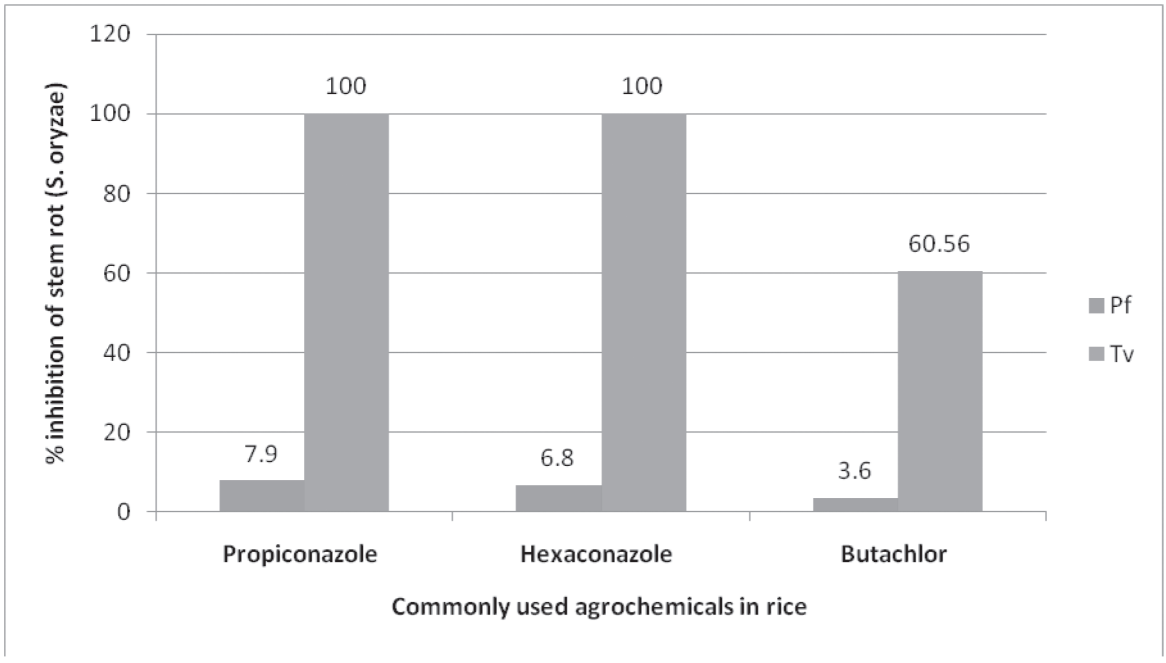
Of the three agrochemicals screened, the fungicides, hexaconazole and propiconazole exhibited complete inhibition (100%) of *T. viride* (T_1). However, the weedicide, butachlor exhibited an inhibitory effect up to 60.6% on the fungal bioagent, T_1.

In general, *P. fluorescens* (B_1) was found to be compatible with all the three agrochemicals under study (Fig. 1). Of these agrochemicals, least inhibitory effect was shown by the weedicide, butachlor (3.6%), whereas the fungicides hexaconazole and propiconazole has inhibitory effects of 6.8% and 7.9% respectively. Overall, the *P. fluorescens* (B_1) was found to be less sensitive to these agrochemicals under study (Fig. 1).

Table 1. Details on rhizospheric microflora isolated from rice seedlings collected from Khammam and Warangal districts of Telangana

Rhizospheric microflora of rice	Concentration of microflora (x 10^5 CFU g^{-1} soil)*
Aspergillus flavus	27
Aspergillus niger	12
Cladosporium sp.	15
Trichoderma viride (T_1)	21
Trichoderma sp. (T_2)	12
Pseudomonas fluorescens (B_1)	67
Bacillus spp.(B_2)	72
Bacillus spp. (B_3)	64
Bacillus spp. (B_4)	89
Bacillus spp. (B_5)	102

*Values are means of five replications and two plates per replication



Tv: Trichoderma viride (T_1) &*Pf*: *Pseudomonas fluorescens*(B_1)
Propiconazole (1000 ppm); hexaconazole (2000 ppm) & butachlor (400 ppm) were used
Values are means of 10 replications

Fig 1. *In vitro* compatibility of fungal and bacterial antagonists in rice with commonly used agrochemicals

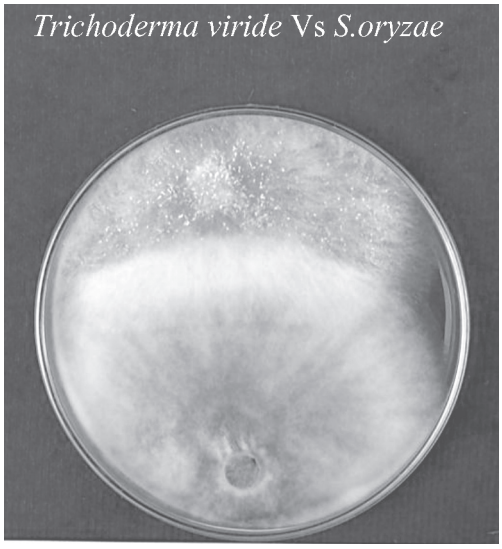


Fig. 2. In *vitro* efficacy of *Trichoderma viride* (T_1) in inhibiting the radial growth of *Sclerotium oryzae*.

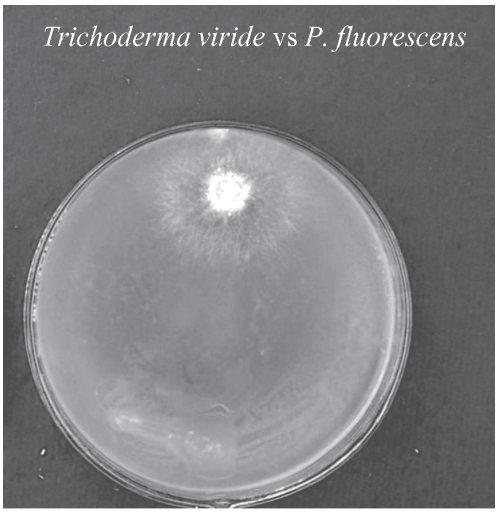


Fig. 3. In *vitro* efficacy of *P. fluorescens* (T_1) in inhibiting the radial growth of *Sclerotium oryzae*

In our studies, *Trichoderma* spp, *P. fluorescens* and *Bacillus* spp. were found to be the common antagonists in the rhizosphere of rice. These beneficial microflora are prevalent in rice and their biocontrol potentiality against soilborne pathogens besides plant growth-promotion in rice is well established (Narasimha Rao *et al*., 2004).

Role of these PGPR and *Trichoderma* spp. in controlling stem rot pathogen of rice is also previously established (Narasimha Rao *et al*., 2004). In our studies, the antagonists, *T. viride* (T1) and *P. fluorescens* (B1) have exhibited high inhibitory effect on stem rot pathogen under *in-vitro* conditions (Fig.1. and Fig. 2). However, for effective control of stem rot disease under field conditions, identification of specific antibiotic producing strains of *Trichoderma* and PGPR is essential. For this, molecular characterization of fungal and bacterial antagonists for specific traits of pathogen suppression is mandatory, prior to taking these strains to field level.

Sensitivity of these antagonists to commonly used chemicals in rice is another area that needs attention. Information in this area would immensely benefit in determining the time of delivery of these bioagents to rice ecosystem. In our studies, the fungal antagonist, *Trichoderma* spp. has exhibited 100% sensitivity to the fungicides, hexaconazole and propiconazole (Fig. 1). Under Asian conditions, these two fungicides are majorly used as foliar sprays for controlling stem rot and sheath blight (*Rhizoctonia solani*). However, when these fungicides are to be advocated for seed treatment, application of *Trichoderma* spp. as to rice spermospheres has to be done with extra precaution. On the other hand, butachlor exhibited inhibition of *T. viride* strain up to 61% in our present study (Fig. 1). Butachlor is a selective chloroacetanilide chemical and is used as pre-emergence or early post-emergence herbicide in rice (Rao and Singh., 1997). Based on our results, coincidence of the time of delivery of *Trichoderma* spp. may be avoided into rice ecosystem as soil application on a standing crop with butachlor can be avoided for better performance of fungal bioagent. On the other hand, *P. fluorescens* in our studies exhibited less sensitivity to both fungicides and herbicides (Fig. 1), thus indicating high compatibility under the ambit of rice IDM.

Application of bioagents to rice ecosystem is majorly through seed treatment, transplanting dip and foliar sprays (Lakshmi Tewari and Rajbir Singh, 2005). In our studies, the superior strains *T. viride* and *P. fluorescens* that are identified against stem rot disease need to be tested for their growth-promoting activities and disease suppressing abilities under greenhouse and field conditions for effective management of disease.

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Research Note
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GENETIC VARIABILITY IN SELECTED MINICORE GERMPLASM OF CHICKPEA (*Cicer arietinum* L.)

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Chickpea is the most important pulse crop of India and accounts for 30% and 38% of national pulse acreage and production, respectively. India also contributes the largest share (72%) of chickpea area and production in the world. In India, chickpea cultivation was done in 9.93 mha during 2013-14 with a production and productivity of 9.53 mt and 959 kg ha^{-1}, respectively (AICRP on Chickpea Annual Report, 2014-15). Inspite of India being the largest chickpea producing country, a deficit exists in domestic production which is met through imports. In Andhra Pradesh there is dramatic increase in chickpea area from 71,000 ha in 1992-93 to 5.86 lakh ha during 2013-14 and the productivity increased from 621 kg ha^{-1} to 1449 kg ha^{-1}.

Study of variability for the characters of economic importance in the available germplasm is the basic prerequisite for chickpea improvement. Many reports on genetic variability of chickpea are available but in limited number of germplasm lines. A set of minicore germplasm of chickpea received from ICRISAT, Patancheru, India, represents the whole range of variation of cultivated species is an ideal material for assessing the exact nature of genetic variability

which helps in formulating appropriate selection criteria in improving chickpea productivity. Hence the present investigation was carried out for three years to gather information on genetic variability in the selected set of minicore collections of chickpea germplasm for nine quantitative characters of economic importance.

Minicore collection of chickpea germplasm (n=215) (Upadhayay and Oritz, 2001) were obtained from ICRISAT. Initially 215 lines were studied at Regional Agricultural Research Station, Nandyal located at Scarce Rainfall Zone of A.P. Based on the plant type, 93 lines were selected. These lines were assessed for genetic variability of agronomic and yield traits during three consecutive Rabi seasons of 2007-08 (Y1), 2008-09 (Y2) and 2009-2010 (Y3). The experiment was carried out in a Randomized Block Design with two replications. Each genotype was grown in a single row of 4m length with 30 cm spacing between the rows and 10 cm within the plants in a row. Recommended agronomic practices were followed during the crop growth period in all the three years to raise a good crop. Observations were recorded on nine quantitative characters *viz*., days to 50% flowering, days to maturity, plant height (cm), number of branches per plant, number of pods per plant, shoot biomass (g), seed yield per plant (g), 100 seed weight (g) and harvest index.Analysis of variance for different characters was carried out using the mean data in order to partition the variability due to different sources as per Panse and Sukhatme (1961). In order to assess and quantify the genetic variability among the genotypes for the characters under study, genetic parameters such as genotypic coefficient of variability (GCV), phenotypic coefficient of variability (PCV), heritability (h^2), genetic advance and genetic advance as per cent of mean (GAM) were estimated. The method adopted by Burton and Devane (1953) was used to calculate phenotypic and genotypic coefficient of variation. Heritability in broad

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Table 1. Analysis of variance for nine traits in 93 chickpea germplasm accessions during *Rabi*, 2007-2010

Source	df	Days to 50% flowering			Days to matuirty			Plant height		
		2007-08	2008-09	2009-10	2007-08	2008-09	2009-10	2007-08	2008-09	2009-10
Replication Sum of squares	1	15.10	0.91	7.76	7.76	19.35	84.01	20.40	16.56	0.003
Treatment Sum of squares	92	6742.32**	3175.46**	6420.29**	6103.66**	7641.58**	10959.59**	4807.66**	9915.76**	4437.00**
Error Sum of squares	92	213.40	65.59	2585.24	192.24	243.65	118.49	269.33	465.33	115.00
		No.of branches per plant			No. of pods per plant			Shoot biomass		
Replication Sum of squares	1	1.55	2.00	0.20	0.37	2.79	1.82	1.96	50.58	0.009
Treatment Sum of squares	92	1360.19**	3304.02**	1283.61**	9791.44**	11838.02**	5680.87**	1214.17**	1325.22**	796.59**
Error Sum of squares	92	151.56	91.79	66.46	149.65	92.34	89.08	44.57	55.69	38.92
		Seed yield			100 seed weight			Harvest index		
Replication Sum of squares	1	2.15	0.41	0.01	0.13	0.92	1.28	75.88	288.88	1.74
Treatment Sum of squares	92	293.89**	821.56**	205.51**	5292.85**	2481.20**	3866.78**	31269.34**	29056.46**	7492.00**
Error Sum of squares	92	30.94	81.28	12.33	94.37	121.07	55.85	1955.80	3538.16	2270.14

** Significant at 1% level

Table 2. Genetic variability, heritability and genetic advance for nine traits during *Rabi*, 2007-2010 in chickpea germplasm accessions

Year	2007-08				2008-09				2009-10			
Character	GCV%	PCV%	h^2 (%)	GAM%	GCV%	PCV%	h^2 (%)	GAM%	GCV%	PCV%	h^2 (%)	GAM%
Days to 50% flowering	10.06	10.22	96.8	26.13	7.02	7.09	97.9	18.34	7.66	9.91	59.7	15.63
Days to maturity	5.80	5.90	96.9	15.08	6.19	6.29	96.8	16.09	8.35	8.39	98.9	21.92
Plant height	15.92	16.39	94.4	40.85	20.61	21.11	95.3	53.12	15.80	16.01	97.4	41.18
No of branches	17.95	19.04	88.9	44.67	27.01	27.40	97.2	70.3	31.39	32.24	94.8	80.70
No. of pods	27.22	27.43	98.5	71.32	27.17	27.28	99.2	71.45	51.68	52.09	98.4	135.38
Shoot biomass	22.36	22.78	96.3	57.95	17.76	18.14	95.8	45.9	41.26	42.31	95.1	106.24
Seed yield	21.80	23.10	89.5	54.56	26.18	27.58	90.1	65.61	50.08	51.66	94.0	128.21
100 seed weight	30.47	30.75	98.2	79.73	20.07	20.58	95.1	51.69	30.85	31.07	98.6	80.85
Harvest index	25.11	25.94	93.7	64.20	22.53	24.04	87.8	55.75	13.10	15.69	69.7	28.88

sense was derived based on Hanson *et al.* (1956),whereas genetic advance was obtained by the formula prescribed by Johnson *et al.* (1955).

RESULTS AND DISCUSSION

The results of the present investigation revealed the prevalence of significant differences among 93 genotypes studied during three years (2007-2010) for all the nine characters (Table 1). Genetic variability parameters for nine traits were presented in table 2. The differences between GCV and PCV were low in magnitude for all the characters under study indicating less influence of environment on the traits studied. High GCV was observed for seed yield and 100 seed weight in all the three years. GCV was low for days to 50% flowering and days to maturity during all the three years with slight deviation for days to 50% flowering during Y1 where a moderate GCV was observed. GCV was moderate for plant height, whereas number of branches per plant, shoot biomass and harvest index recorded moderate to high levels of GCV. The results are supported by the reports of Parameshwarappa *et al.* (2011) and Sidaramappa *et al.* (2008) for plant height, seed yield per plant and days to flowering; Jeena and Arora (2000), Lawrence (2004), Vaghela *et al. (*2009) for days to maturity and Upadhyaya *et al.* (2002) for 100 seed weight.

The estimates of GCV and PCV values indicate only the extent of variability present and not the heritable portion. To obtain the heritable portion of variability, it is essential to compute the heritability estimates for different characters which separate the environmental influence from the total variability and indicate the accuracy with which a genotype can be identified by its phenotypic performance, thus making the selection more effective (Chavan *et al.*,1994). In the present study heritability estimates were high for all the characters studied in all the three years. However, heritability estimates in broad sense alone is not a true indicator of effectiveness of selection for the trait since their scope is restricted by their interaction with the environment (Johnson *et al.,* 1955). Hence heritability along with the genetic advance increases the usefulness of the parameter as a tool in selection programme and gives an idea about the nature of gene action governing a particular character.

Genetic advance as percent of mean was low for days to maturity in all the years but it was moderate for days to 50 per cent flowering in Y2 and Y3 but high in Y1. For all other traits high GAM values were recorded.

Moderate levels of GCV coupled with high heritability and high genetic advance as percent of mean were observed for plant height in all the three years. Earlier same results are obtained by Sidaramappa *et al.* (2008) for plant height. High estimates of GCV, heritability coupled with high genetic advance as percent of mean was observed for all traits understudy except for plant height, days to flowering and maturity indicates the presence of additive gene action and simple selection can be predicted in improving these traits. Similar results are reported for 100 seed weight (Singh and Rao,1991), seed yield per plant (Jahagirdhar *et al.* 1994); number of pods per plant,100 seed weight (Sidaramappa *et al.* 2008) and harvest index (Vaghela *et al.,* 2009).

In order to identify the elite lines the mean performance of the test entries for different traits with the experimental mean has been compared. The mean performance of chickpea germplasm for various characters is presented in Table 3. Since chickpea is mainly grown as *Rabi* crop the terminal water stress is going to affect the yield potentiality of the crop. So, one has to identify the lines which are early in flowering and maturity and hence they can escape

Table 3. *Per se* performance of top ten chickpea germplasm accessions for nine traits during Rabi, 2007-2010.

S.No	Entry	Seed yield (g plant^{-1})	100 seed weight (g)	Harvest index (%)	No of pods plant^{-1}	Entry	Seed yield (g plant^{-1})	100 seed weight (g)	Harvest index (%)	No of pods plant^{-1}	Entry	Seed yield (g plant^{-1})	100 seed weight (g)	Harvest index (%)	No of pods plant^{-1}
	2007-08					**2008-09**					**2009-10**				
1	ICCV-4918	11.2	19.5	76.3	34.1	ICCV-13219	11.5	20.3	65.9	26.6	ICCV-4948	6.5	16.7	50.3	21.8
2	ICCV-7308	9.2	25.0	61.6	18.6	ICCV-4814	11.5	15.4	72.3	21.5	ICCV-5639	6.0	15.0	49.9	9.2
3	ICCV-8607	8.0	13.5	65.8	27.5	ICCV-7255	10.6	25.5	69.3	44.0	ICCV-3362	4.9	13.1	42.0	32.5
4	ICCV-15333	7.7	37.5	66.0	11.5	ICCV-1431	10.5	20.2	69.6	37.3	ICCV-7950	4.5	22.5	41.1	16.3
5	ICCV-13863	7.5	18.0	65.4	25.5	ICCV-9862	10.5	19.0	72.3	31.4	ICCV-15612	4.1	16.6	52.4	11.8
6	ICCV-1205	7.4	16.0	61.4	39.3	ICCV-16524	10.5	17.0	68.5	31.8	ICCV-4918	3.6	19.5	48.4	18.2
7	ICCV-1510	7.3	14.5	52.0	25.0	ICCV-7950	10.5	17.7	69.9	28.7	ICCV-456	3.5	17.4	38.3	25.0
8	ICCV-15996	7.3	19.0	60.2	28.5	ICCV-637	10.3	15.3	68.75	48.5	ICCV-12824	3.2	10.4	51.0	18.6
9	ICCV-4533	7.1	18.5	79.9	19.0	ICCV-13124	10.1	33.7	61.1	37.5	ICCV-13124	3.2	27.4	45.1	10.0
10	ICCV-1882	6.9	15.5	47.6	22.9	ICCV-867	10.1	18.3	69.5	38.7	ICCV-1398	3.2	17.6	57.2	9.9
	Mean	5.5	17.4	50.2	26.6	Mean	7.7	17.8	52.2	29.4	Mean	2.0	14.8	40.6	10.7
	CD at 5%	1.2	2.0	9.1	2.5	CD at 5%	1.9	2.3	12.3	1.9	CD at 5%	0.7	1.5	9.9	2.0
	C.V.	10.6	5.8	9.2	4.8	C.V.	12.3	6.4	11.9	3.4	C.V.	17.9	5.3	12.2	9.2

Table 4. Promising chickpea accessions for various traits

S.No	Character	Selection criteria	Superior germplasm accessions found common in three years
1	Days to 50% flowering	Early	ICC 10393, ICC 10945, ICC 12726, ICC 12851, ICC 12866, ICC 14098, ICC 14402, ICC 14669, ICC 15612, ICC 15618, ICC 1882, ICC 1923, ICC 4872, ICC 4918, ICC 5434, ICC 5879, ICC 867, ICC 8740, ICC 8855
2	Days to maturity	Early	ICC 10399, ICC 1083 ,ICC 10945, ICC 13219, ICC 1398,ICC 14098, ICC 1422, ICC 14402, ICC14669, ICC 15567, ICC15612, ICC 15618, ICC 15996, ICC 1882, ICC 4918, ICC 5434, ICC 5639, ICC 5878, ICC 8621, ICC 867
3	Plant height	Tall	ICC 12028, ICC 12328, ICC 12726, 12866, ICC 15294, ICC 15333, ICC 7255, ICC 7272, ICC 7308, ICC 8607
4	No of branches	High	ICC 12824, ICC 1397, ICC 1510, ICC 1882, ICC 283, ICC 3362, ICC 4872, ICC 4918, ICC 5878, ICC 5879
5	No. of pods	High	ICC 1230, ICC 12824, ICC 12851, ICC 1923, ICC 7441, ICC 867
6	Shoot biomass	High	ICC 10399, ICC 1230, ICC 13124
7	Seed yield	High	ICC 4918, ICC 7308, ICC 13219, ICC 4814, ICC 4948, ICC 5639
8	100 seed weight	High	ICC 1230, ICC 13124, ICC 1392, ICC 1397, ICC 1398, ICC 1431, ICC 15294, ICC 15333, ICC 4533, ICC 867
9	Harvest index	High	ICC 1083, ICC 1194, ICC 13863, ICC 1398, ICC 14669, ICC 1510, ICC 2263, ICC 4814, ICC 5434, ICC 5639, ICC 5878, ICC 8607

the terminal drought condition. The lines which are early in flowering and maturity have been identified in three years Y1, Y2 and Y3. In Y1 out of 93 genotypes 44 genotypes showed significantly lower values for days to 50% flowering whereas, 45 and 40 genotypes are early flowering in Y2 and Y3. Over all among three years, 21 entries in common were found to be significantly earlier in flowering. 22 entries were found to be early maturing below the experimental mean of 97 days. Plant height ranged from 16.85-53 cm and the mean was 32.41 cm. In total, nine genotypes in common had exceeded the mean significantly in all the three years. The mean number of pods per plant was 22.19 and 6 genotypes surpassed the mean significantly. The average experimental mean value of shoot biomass is 10.32 g and three genotypes viz., ICC 10399, ICC 1230 and ICC 13124 had exceeded the experimental mean over all the years. Six genotypes surpassed the experimental mean for seed yield in all the three years. For 100 seed weight ten entries were found to be common in all the three years over the

experimental mean value of 16.67 and 12 entries recorded higher values than the average 47.77 for harvest index.Promising chickpea accessions showing good *per se* performance for different traits in all the three years were represented in Table 4. On overall basis ICC 1230, ICC 12824, ICC 12851, ICC 1923, ICC 7441 and ICC 867 were promising for number of pods per plant, whereas ICC 1083, ICC 1194, ICC 13863, ICC 15567, ICC 1923, ICC 8855, were identified for harvest index. ICC 1230, ICC 13124, ICC 1392, ICC 1397, ICC 1398, ICC 1431, ICC 15294, ICC 15333 ICC 4533 and ICC 867 were found promising for 100 seed weight. ICC 4918, ICC 7308, ICC 13219, ICC 4814, ICC 4948 and ICC 5639 were top ranking genotypes for seed yield.

The main purpose of minicore collection is to provide a representative sample of germplasm collection from a large germplasm to assist plant breeders for more efficient management for greater utilization. On the basis of mean performance and other relative traits seven diverse and superior genotypes namely ICC 867, ICC 8607, ICC 5878, ICC 4918, ICC 10399, ICC 13124, ICC 1230 and ICC 12844 were exceptionally good for two or more characters with an acceptable level of other characters. Therefore, these genotypes can be involved in multiple crossing programme to recover transgressive segregants after studying their combining ability and gene action for various traits.

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