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Research Article
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COMBINING ABILITY AND HETEROSIS OVER LOCATIONS FOR YIELD AND YIELD COMPONENTS IN HYBRID RICE (*Oryza sativa* L.)

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ABSTRACT

A set of 32 newly developed hybrids along with their parents (B and R lines) and standard checks *viz*., RNR 15048 and PA 6444 were evaluated for thirteen grain yield and its contributing traits to estimate heterosis and combining ability effects in rice through Line × Tester analysis. The mean performance of hybrids for most of the characters was higher than that of parents except for milling percent. The analysis of variance revealed significant differences among parents, lines and hybrids for most of the characters studied. Degree of dominance was less than unity for days to 50 percent flowering, plant height, panicle length, panicle weight, 1000 grain weight, number of filled grains per panicle and spikelet fertility indicating the existence of partial dominance. SCA variances were higher than GCA variances for most of the characters, which indicated the predominance of non-additive gene action. The *gca* effects revealed that the line JMS 14B and three testers *viz*., RNR 26059, RNR 26072 and PAU 2K10-23-451-2-37-34-0-3 were found to be good general combiners for yield and majority of the yield contributing traits in desirable direction. Of the thirty two hybrids, JMS 14A × RNR 26083, JMS 14A × RNR 26084, CMS 64A × PAU 2K10-23-451-2-37-34-0-3, CMS 23A × RNR 26072 and CMS 64A × RNR 26059 were found good specific combiners. Eight and five hybrids had positive and significant standard heterosis over varietal check (RNR 15048) and hybrid check (PA 6444), respectively. Based on *sca* and heterosis, hybrids JMS 14A × RNR 26083, JMS 14A × RNR 26059, CMS 64A × PAU 2K10-23-451-2-37-34-0-3, CMS 23A × RNR 26072 and CMS 64A × RNR 26059 were found promising for further exploitation.

Rice is one of the foremost cereal crops feeding over more than half of world's population. However, to meet the demand of growing population rice production need to be stepped up continuously (Kumar *et al*., 2014). It is the only crop in the world that is grown in the most fragile ecosystem and hence, second green revolution is possible only if rice research is undertaken vigorously. This elucidates reorientation of our research towards yield improvement. Theoretically, rice crop still has great yield potential to be tapped and this can be achieved through many approaches including molecular breeding, new ideotype breeding and hybrid rice technology. Exploitation of heterosis in rice through hybrid technology seems to be more effective, as commercial rice hybrids exhibited 38% more yield superiority compared to the best commercial variety (Singh *et al*., 2013).

At present commercial exploitation of heterosis in hybrid rice is being explored in many rice growing countries. In China hybrid rice technology has revolutionized the rice farming due to impressive gains achieved in productivity levels from 35 to 40 q ha^{-1} in straight varieties to the tune of 65 to 70 q ha^{-1} in hybrids. As a result, farmers could gain more profits and the area under straight varieties is being replaced with hybrids (Yuan *et al*., 1989) at a faster rate.

The first step in generating promising hybrids is the selection of desirable parents. The contribution of parents in a cross and combining ability of parents in crosses can be assessed by biometrical methods. Line × Tester analysis devised by Kempthorne (1957) is one of the effective mating designs used to estimate combining ability effects and aids in selection of desirable parents and crosses for the exploitation of heterosis (Sarker *et al*., 2002). The knowledge of combining ability is useful to elucidate the nature and magnitude of gene actions involved and provides to the breeder an insight into the nature and relative magnitude of fixable and non-fixable genetic variances i.e. due to dominance or epistatic components (Pratap *et al*., 2013). Hence, in the present investigation an attempt is made to estimate the combining ability and magnitude of heterosis for grain yield and important yield attributes in 32 rice hybrids developed by using new CMS lines and testers.

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MATERIAL AND METHODS

Four stable Wild Abortive cytoplasm based CMS lines (Table 1) and eight restorer lines were utilized in the present study and crosses were effected between these CMS lines and restorers in Line x Tester mating design during *rabi* 2018-19 and obtained 32 hybrids. During *kharif* 2019, a total of 32 hybrids along with 8 testers and 4 'B' lines of corresponding male sterile lines and 2 checks were evaluated in a single row of 3 m length with 2 replications in RBD by adopting a spacing of 20 × 15 cm at three diverse locations (representing three agroclimatic zones) *viz*., Regional Sugarcane & Rice Research Station, Rudrur (Northern Telangana Zone), Regional Agricultural Research Station, Warangal (Central Telangana Zone) and Rice Research Centre, Agriculture Research Institute, Rajendranagar, Hyderabad (Southern Telangana Zone). Recommended agronomic practices were followed to raise a healthy crop.

Table 1. Details of rice parental material used in the study

S. No	Genotype	Source
	Lines	
1.	RNR 26059	RRC, ARI, Hyderabad
2.	RNR 26072	RRC, ARI, Hyderabad
3.	RNR 26074	RRC, ARI, Hyderabad
4.	RNR 26083	RRC, ARI, Hyderabad
5.	RNR 26084	RRC, ARI, Hyderabad
6.	Pusa 1701-10-5-8	IIRR, Hyderabad
7.	PAU 2K10-23-451-2-37-34-0-3	IIRR, Hyderabad
8.	RP 5898-54-21-9-4-2-2	IIRR, Hyderabad
	Testers	
1.	CMS 23B	IRRI, Philippines
2.	CMS 64B	IRRI, Philippines
3.	JMS 14B	RARS, Jagital
4.	JMS 20B	RARS, Jagital

Observations were recorded on 5 randomly selected plants for different traits *viz.*, plant height (cm), number of productive tillers per plant, panicle length (cm), panicle weight (g), spikelet fertility (%) and grain yield per plant (g). However, for days to 50% flowering the data were recorded on whole plot basis, whereas data on number of grains per panicle, 1000 grain weight (g), hulling percent, milling percent and head rice recovery (%) were recorded on a random sample taken in each plot. Per day productivity was calculated by dividing grain yield in hectare with days to maturity. The character means of each replication over locations was subjected to analysis of variance (Panse and Sukhatme, 1967), combining ability analysis (Kempthorne 1957) and heterobeltiosis and standard heterosis (Fonseca and Patterson, 1968). Computer software Windostat version 9.1 was used for analysis of the data.

RESULTS AND DISCUSSION

The pooled analysis of variance over locations revealed significant differences among locations, genotypes, parents and crosses for all the characters studied (Table 2). The variance due to hybrid was partitioned into variance due to lines, testers and lines × testers for all the characters. Variance due to lines was significant for days to 50% flowering and spikelet fertility, while variance due to testers was significant for panicle length and panicle weight and both were significant for plant height, 1000 grain weight and number of grains per panicle. The variance due to lines × testers was significant for all the characters. Similar findings were reported by Saidaiah *et al.,* (2010) and Parimala (2016). Parents × hybrids showed significant variance for all the characters except number of filled grains per panicle and milling percent indicating sufficient variability in the material and good scope for identifying promising parents and hybrid combinations for improving yield through its components.

In the present investigation, the degree of dominance was more than unity for number of productive tillers (1.87), hulling percent (2.25), milling percent (2.15), head rice recovery (2.28), grain yield per plant (1.26) and per day productivity (1.39) suggesting the preponderance of dominance in controlling these traits and less than one for other characters (Table 3). SCA variances were higher than GCA variances for most of the characters, which indicated the predominance of non-additive gene action. The traits *viz*., number of productive tillers per plant (0.29), hulling percent (0.20), milling percent (0.21), head rice recovery % (0.19), grain yield per plant (0.64) and per day productivity (0.52) had non-additive gene action, while days to 50 per cent flowering (1.16), plant height (3.44), panicle length (1.31), panicle weight (1.31), 1000 grain weight (1.79), number of grains per panicle (1.87) and spikelet fertility (1.27) exhibited additive gene action. The importance of additive as well as non-additive gene effects with predominance of non-additive gene effects in inheritance of grain yield and yield components of rice were earlier reported by Saleem *et al*. (2010), Saidaiah *et al.* (2010), Rashid *et al*. (2007), Saravanan *et al.* (2006) and Vanaja *et al.* (2003).

Among the parents, the line JMS 14A (3.54) and three testers *viz.,* RNR 26059 (4.02), RNR 26072 (1.97) and PAU 2K10-23-451-2-37-34-0-3 (0.94) had positive and significant *gca* effects for grain yield per plant. JMS 14A had significant *gca* effects in desired direction for yield contributing traits like number of productive tillers per plant, panicle length, panicle weight, number of grains per panicle, spikelet fertility and per day productivity (Table 4). Among the testers, RNR 26059 exhibited significant positive *gca* effects for the traits *viz.,* grain yield, plant height flowering, panicle length, panicle weight, 1000 grain weight, number of filled grains, spikelet fertility and per day productivity. Whereas RNR 26072 was observed to be a good general combiner for the traits *viz*., grain yield per plant, days to 50 per cent flowering, panicle length, hulling percent, milling percent, head rice recovery and per day productivity. PAU 2K10-23-451-2-37-34-0-3 was a good general combiner for the traits *viz*., grain yield per plant, number of productive tillers per plant, panicle weight, 1000 grain weight, number of grains per panicle, head rice recovery. It was observed in certain instances that the lines and testers with good *per se* performance have not been good general combiners and *vice versa*, but the in the present study association between *per se* performance and GCA effects was evident indicating the effectiveness of choice of parents based on *per se* performance alone was not appropriate to predict the combining ability of the parents.

Of the thirty two hybrids, nine hybrids had shown positive and significant *sca* effects for grain yield per plant and of these highest effect was exhibited in the cross JMS 14A × RNR 26083 (9.36) followed by CMS 23A × RNR 26072 (7.06) and CMS 64A × PAU 2K10-23-451-2-37-34-0-3 (6.63) (Table 5). Six hybrids exhibited significant and negative *sca* effects for days to flowering and CMS 64A × RNR 26072 (-14.40) had highest effect followed by JMS 14A × RNR 26074 (-10.46) and CMS 23A × RNR 26083 (-10.21) and were considered to be highly desirable for earliness.

Ten hybrids *viz*., CMS 23A × RNR 26072 (9.84), CMS 23A × RNR 26083 (1.54), CMS 64A × RNR 26059 (2.66), CMS 64A × RNR 26074 (1.75), CMS 64A × RNR 26084 (1.84), CMS 64A × PAU 2K10-23-451-2-37-34-0-3 (5.53), JMS 14A × RNR 26084 (4.03), JMS 14A × Pusa 1701-10-5-8 (3.96), JMS 20A × RNR 26072 (4.80), JMS 20A × RNR 26084 (3.32) had significant positive *sca* effects for spikelet fertility (%).

For 1000 grain weight, eight hybrids had positive and significant effects and of these CMS 23A × RNR 26072 (3.04) exhibited highest effect followed by JMS 20A × RNR 26072 (2.23) and were considered as bold. One line JMS 20A (-1.67) and three testers *i.e.,* Pusa 1701-10-5-8 (-2.87), RP 5898-54-21-9-4-2-2 (-2.80) and JMS 20A × RNR 26072 (-0.81), and five hybrids *viz*., CMS 64A × RNR 26072 (-5.26), CMS 23A × PAU 2K10-23-451-2-37-34-0-3 (-1.88), JMS 20A × RNR 26059 (-0.76), CMS 23A × RNR 26083 (-1.04), and JMS 20A × RNR 26084 (-1.18) possessed fine grain and recorded significant negative *gca* and *sca* effects, respectively for 1000 grain weight.

The cross combinations *viz.,* JMS 14A × RNR 26083, JMS 14A × RNR 26084, CMS 64A × PAU 2K10-23-451-2-37-34-0-3, CMS 23A × RNR 26072 and CMS 64A × RNR 26059 were found to be good specific combiners for grain yield and yield attributing traits.

Heterosis studies showed that the heterobeltiosis over better parent ranged from -18.49

Table 2. Pooled analysis of variance for combining ability for yield and yield components in rice over locations

Source of variation	DF	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12	X13
Replications	1	7.33	13.23	0.82	3.34	0.05	0.85	270.03	9.61*	1.20	2.37	4.73	0.12	0.696
Environments	2	209.27**	218.36**	7.07*	29.92**	2.17**	6.46**	1266.47**	13.55**	145.37**	120.33**	72.78**	23.93**	714.33**
Treatments	43	566.05**	1382.45**	10.47**	35.52**	5.30**	54.39**	13314.55**	164.02**	80.41**	83.31**	111.46**	108.17**	839.43**
Parents	11	481.13**	2292.65**	3.73**	48.82**	7.00**	87.71**	14803.13**	19.80**	34.01**	51.13**	131.10**	18.79**	211.44**
Lines	3	1203.47*	1166.65**	10.98	9.05	4.16	103.15**	29023.51**	825.44**	65.53	64.09	32.39	292.67	1162.68
Testers	7	580.48	3275.29**	8.74	64.42**	12.53**	86.74**	30089.77**	96.33	68.63	78.32	104.88	142.23	1310.67
Line × Tester	1	260.21**	221.03**	11.37**	10.06**	2.16**	18.36**	5322.98**	123.16**	111.15**	108.46**	117.22**	115.94**	805.35**
Parents × hybrids	1	5909.43**	3157.65**	76.38**	301.17**	5.53**	71.52**	209.81	1098.14**	72.48**	1.55	57.94**	136.35**	4194.63**
Hybrids	31	423.81**	1002.22**	10.74**	22.24**	4.69**	42.01**	13209.08**	185.07**	97.14**	97.36**	106.22**	138.98**	954.03**
Error	43	5.81	7.30	0.56	0.87	0.10	0.76	106.89	2.40	2.11	1.35	1.41	3.48	41.07

*Significant at P=0.05 level **Significant at P=0.01 level

X1 = Days to 50% flowering, **X2** = Plant height (cm), **X3** = No of productive tillers, **X4** = Panicle length (cm),
X5 = Panicle weight (g), **X6** = 1000 grain weight (g), **X7** = No. of grains per panicle, **X8** = Spikelet fertility (%)
X9 = Hulling percent, **X10** = Milling percent, **X11** = Head rice recovery, **X12** = Grain yield per plant (g),
X13 = Per day Productivity, **DF =** degrees of freedom

to 45.65 % for grain yield (Table 6) and eight hybrids showed significant positive heterosis. Highest significant positive heterobeltiosis was exhibited in the hybrid JMS 14A × RNR 26083 (45.45%) followed by CMS 64A × PAU 2K10-23-451-2-37-34-0-3 (28.80%) and CMS 23A × RNR 26072 (27.69%), JMS 14A × RNR 26059 (27.47%) and JMS 14A × RNR 26084 (27.26%).

Eight hybrids had positive and significant standard heterosis over check variety (RNR 15048) and the cross JMS 14A × RNR 26083 had shown highest heterosis of 49.14% followed by JMS 14A × RNR 26059 (30.53%) and JMS 14A × RNR 26084 (30.31%). Five hybrids exhibited positive and significant standard heterosis over the hybrid PA 6444 and of these highest heterosis was shown by the cross JMS 14A × RNR 26083 (31.58%) followed by JMS 14A × RNR 26059 (15.16%) and CMS 64A × PAU 2K10-23-451-2-37-34-0-3 (13.56%). Among these, JMS 14A × RNR 26083, JMS 14A × RNR 26059, CMS 64A × PAU 2K10-23-451-2-37-34-0-3, CMS 23A × RNR 26072 and CMS 64A × RNR 26059 were identified as potential hybrids with respect to all the characters based on their *perse* performance and heterosis estimates. Marked variation in the expression of heterobeltiosis and standard heterosis for yield and yield components was observed among all the cross combinations. These finding are consistent with those of Saravanan *et al*. (2008), Saidaiah *et al.,* (2010), Kumar et al. (2012), Singh *et al*. (2013), Sharma *et al*. (2013), Pratap *et al.* (2013), Bhati *et al*. (2015), Satheesh kumar *et al*. (2016), Yogita *et al.* (2016) and Galal Bakr Anis *et al*. (2017).

CONCLUSION

Results of the present investigation showed that none of the hybrids had expressed superior performance for all the characters. The *gca* effects revealed that among the lines JMS 14A and among the testers, RNR 26059, RNR 26072 and PAU 2K10-23-451-2-37-34-0-3 had significant *gca* effects in the desired direction for several traits including grain yield. Hence, these lines and testers could be considered as potential donors in improving grain yield per plant and associated components in development of hybrids in

Table 3. Estimates of general and specific combining ability variances and degree of dominance for different traits in rice

Character	Source of variation			Degree of Dominance ($(\sigma^2 sca / \sigma^2 gca)^{1/2}$)
	σ^2 ***gca***	σ^2 ***sca***	σ^2 ***gca*** / σ^2 ***sca***	
Days to 50% flowering	49.20	42.31	1.16	0.93
Plant height (cm)	123.02	35.72	3.44	0.54
Number of productive tillers per plant	0.52	1.81	0.29	1.87
Panicle length (cm)	1.99	1.52	1.31	0.87
Panicle weight (g)	0.46	0.35	1.31	0.87
1000 grain weight (g)	5.23	2.93	1.79	0.75
Number of grains per panicle	1030.03	870.03	1.87	0.72
Spikelet fertility (%)	25.47	20.13	1.27	0.89
Hulling percent	3.59	18.11	0.20	2.25
Milling percent	3.87	17.81	0.22	2.15
Head Rice Recovery (%)	3.72	19.26	0.19	2.28
Grain yield per plant (g)	11.87	18.68	0.64	1.26
Per day productivity (kg ha^{-1} day^{-1})	66.44	127.44	0.52	1.39

σ^2: variances; *gca*: general combining ability; *sca*: specific combining ability.

Table 4. Estimates of general combining ability effects of lines and testers for yield and yield contributing characters in rice

Parents	Days to 50% flowering	Plant height (cm)	Number of productive tillers per plant	Panicle length (cm)	Panicle weight (g)	1000 grain weight (g)	Number of grains per panicle	Spikelet fertility %	Hulling percent	Milling percent	Head rice recovery %	Grain yield per plant (g)	Per day productivity (kg ha^{-1} day^{-1})
LINES													
CMS 23A	-4.41 **	-6.08 **	-0.04	-0.36 *	-0.30 **	1.89 **	-24.00 **	-5.93 **	-0.29	-0.10	0.09	-1.95 **	-3.63 **
CMS 64A	5.35 **	0.84 *	-0.64 **	0.26	0.03	-0.03	-2.13	0.22	1.70 **	1.64 **	1.08 **	-0.22	-2.55 **
JMS 14A	3.17 **	5.89 **	0.21 *	0.47 **	0.39 **	-0.18	34.18 **	2.97 **	-0.94 **	-0.97 **	-0.30	3.54 **	7.20 **
JMS 20A	-4.12 **	-0.65	0.47 **	-0.37 **	-0.12 **	-1.67 **	-8.04 **	2.74 **	-0.47 *	-0.57 **	-0.86 **	-1.37 **	-1.01
S.E.±	0.36	0.37	0.11	0.14	0.03	0.13	1.42	0.22	0.23	0.18	0.19	0.28	0.92
TESTERS													
RNR 26059	-1.14 *	10.41 **	-0.05	1.45 **	1.36 **	1.71 **	30.08 **	3.88 **	-0.49	-0.76 **	-0.33	4.02 **	11.60 **
RNR 26072	-5.26 **	-3.12 **	0.17	1.49 **	-0.58 **	-0.81 **	-30.10 **	-0.03	1.86 **	1.38 **	1.76 **	1.97 **	9.01 **
RNR 26074	-0.51	2.75 **	0.56 **	0.77 **	-0.40 **	0.58 **	-13.48 **	-2.74 **	-1.21 **	-0.98 **	-0.88 **	0.04	0.72
RNR 26083	8.98 **	16.52 **	-0.87 **	1.35 **	0.33 **	1.19 **	5.70 **	-0.12	0.93 **	1.28 **	1.69 **	-0.06	-4.93 **
RNR 26084	-3.05 **	5.33 **	-0.26	0.11	-0.18 **	0.89 **	-23.44 **	1.01 **	0.49	0.58 *	0.23	-0.77	-0.007
Pusa 170 1-10-5-8	-4.72 **	-21.85 **	-0.51 **	-2.99 **	-1.00 **	-2.72 **	-35.00 **	-0.30	0.97 **	0.92 **	0.34	-3.76 **	-7.82 **
PAU 2K10-23-451-2-37-34-0-3	0.48	-5.06 **	1.04 **	-0.51 *	0.31 **	1.95 **	5.30 **	-2.04 **	0.89 **	1.38 **	1.72 **	0.94 *	0.37
* RP 5898-54-21-9-4-2-2	5.23 **	-4.98 **	-0.07	-1.67 **	0.15 **	-2.80 **	00.34 **	0.36	-3.45 **	-3.82 **	-4.53 **	-2.38 **	-8.95 **
S.E. ±	0.51	0.53	0.15	0.20	0.05	0.18	2.01	0.31	0.32	0.26	0.26	0.40	1.30

* Significant at 0.05% level, **Significant at 0.01%

Table 5. Specific combining ability effects for yield contributing traits for the crosses possessing significant effects for grain yield per plant in rice

Hybrids	Days to 50% flowering	Plant height (cm)	Number of productive tillers per	Panicle length (cm)	Panicle weight (g) plant	1000 grain weight (g)	Number of filled grains per panicle	Spikelet fertility (%)	Hulling percent	Milling percent	Head rice recovery %	Grain yield per plant (g)	Per day productivity (kg/ha/day)
CMS 23A × RNR 2607	8.53**	-1.07	1.43**	0.30	1.04 **	3.04**	23.25 **	9.84**	1.15	-0.02	1.05 *	7.06 **	15.17 **
CMS 23A × RP 5898-54-21-9-4-2-2	-2.96**	7.97**	-0.63*	0.39	-1.12 **	0.44	-28.12 **	-1.62*	4.47 **	3.68 **	5.18 **	1.66 *	3.31
CMS 64A × RNR 26059	2.47*	0.06	-0.25	0.40	-0.03	1.22**	-9.66 *	2.66**	0.95	-0.24	-1.62 **	3.23 **	7.31 **
CMS 64A × RNR 26074	5.84**	1.14	-0.94**	0.05	-0.03	1.80**	-5.82	1.75**	1.91 **	1.10 *	1.37 *	2.47 **	1.88
CMS 64A × PAU 2K10-23-451-2-37-34-0-3	0.84	-0.7	2.92**	0.08	0.15	1.55**	-18.03 **	5.53**	1.13	1.89 **	2.77 **	6.63 **	17.61 **
JMS 14A × RNR 26083	7.87**	7.87**	1.24**	-0.52	0.58 **	1.72**	42.10 **	0.80	2.23 **	2.28 **	3.02 **	9.36 **	17.57 **
JMS 14A × RNR 26084	-5.75**	0.98	-1.44**	-0.09	-0.21 *	0.52	-4.84	4.03**	1.47 *	1.31 *	2.80 **	5.01 **	18.91 **
JMS 20A × RNR 26074	5.32**	8.88**	-1.36**	0.95*	0.33 **	-0.46	-11.24 **	-2.37**	5.29 **	4.23 **	4.30 **	2.43 **	3.08
JMS 20A × RP 5898-54-21-9-4-2-2	-0.08	0.46	0.14	-0.26	0.89 **	-0.48	24.25 **	0.96	-12.25 **	-11.83 **	-11.50 **	3.21 **	9.21 **
S.E.±	1.03	1.06	0.30	0.40	0.09	0.36	4.03	0.63	0.65	0.52	0.52	0.80	2.61

* Significant at 0.05% level, **Significant at 0.01%

Table 6. Standard heterosis over hybrid (SHH) and variety (SHV) for yield contributing traits for the crosses with significant heterotic effects for grain yield per plant in rice

Cross	Days to 50% flowering		Plant height (cm)		Number of productive tillers per plant		Panicle length (cm)		Panicle weight (g)		1000 grain weight (g)		Number of filled grains per panicle	
	SHH	SHV	SHH	SHV	SHH	SHV	SHH	SHV	SHH	SHV	SHH	SHV	SHH	SHV
CMS 23A × RNR 26059	-20.24**	-11.64**	8.36**	14.79	-0.31	-11.48**	21.32**	24.51**	-2.70	-1.06	1.11	74.40**	-5.63*	-42.78 **
CMS 23A × RNR 26072	-16.44**	-7.42**	-7.84**	-2.37	11.94 **	-0.61	15.85**	18.89**	-18.71**	-17.34 **	2.57	76.92**	-38.51**	-62.71 **
CMS 64A × RNR 26059	-9.28**	0.51	11.38**	17.99	-11.47 **	-21.39**	18.63**	21.75**	3.65	5.40 *	-2.77	67.70**	-7.53**	-43.93 **
CMS 64A × RNR 26074	-5.63**	4.55**	3.50**	9.64	-12.09 **	-21.94**	14.48**	17.48**	-28.99**	-27.79 **	-5.17*	63.56**	-30.06**	-57.59 **
CMS 64A × PAU 2K10-23 -451-2-37-34-0-3	-9.28**	0.51	-3.07*	2.68	28.39 **	14.00**	9.43**	12.30**	-12.39**	-10.92 **	-0.26	72.03**	-27.02**	-55.75 **
JMS 14A × RNR 26059	-8.52**	1.35	12.97**	19.67	-2.73	-13.63**	19.60**	22.74**	17.33**	19.31 **	-11.63**	52.42**	-0.99	-39.96 **
JMS 14A × RNR 26083	2.89*	14.00**	28.25**	35.86	2.95	-8.59*	15.32**	18.35**	2.55	4.27	-3.55	66.36**	17.20**	-28.93 **
JMS 14A × RNR 26084	-20.55**	-11.97**	12.17**	18.82	-16.43 **	-25.80**	12.05**	15.00**	-21.66**	-20.34 **	-10.10**	55.05**	-17.58**	-50.02 **

* Significant at 0.05% level, **Significant at 0.01%

Cross	Spikelet fertility (%)		Hulling percent		Milling percent		Head rice recovery (%)		Grain yield per plant (g)		Per day Productivity (kg/ha/day)	
	SHH	SHV	SHH	SHV	SHH	SHV	SHH	SHV	SHH	SHV	SHH	SHV
CMS 23A × RNR 26059	-8.62**	-8.63**	-0.43	-3.97**	-6.08**	-6.50 **	-3.07 **	-8.43 **	-3.15	9.78 *	12.96 *	17.24 **
CMS 23A × RNR 26072	0.07	0.05	3.46**	-0.21	-5.63**	-6.05 **	0.00	-5.53 **	12.68 **	27.72 **	27.43 **	32.27 **
CMS 64A × RNR 26059	3.24**	3.22**	2.72*	-0.92	-6.48**	-6.89 **	-5.78 **	-10.99 **	12.50 **	27.51 **	21.76 **	26.38 **
CMS 64A × RNR 26074	-5.03**	-5.04**	3.03*	-0.63	-4.95**	-5.38 **	-2.04	-7.45 **	-3.08	9.86 *	-0.29	3.49
CMS 64A × PAU 2K 10-23-451-2-37-34-0-3	-0.12	-0.13	4.76**	1.04	-0.68	-1.12	4.07 **	-1.68	13.56 **	28.72 **	20.51 **	25.08 **
JMS 14A × RNR 26059	3.29**	3.28**	-3.03*	-6.47**	-11.46**	-11.86 **	-5.60 **	-10.82 **	15.16 **	30.53 **	21.24 **	25.83 **
JMS 14A × RNR 26083	-0.19	-0.20	2.81*	-0.84	-3.83**	-4.26 **	2.29 *	-3.37 **	31.58 **	49.14 **	26.47 **	31.27 **
JMS 14A × RNR 26084	4.61**	4.59**	1.25	-2.34*	-6.08**	-6.50 **	-0.25	-5.77 **	14.97 **	30.31 **	34.93 **	40.05 **

* Significant at 0.05% level, **Significant at 0.01%; SHH = Standard Heterosis over hybrid (PA 6444); SHV = Standard Heterosis over variety (RNR 15048).

Table 7 . Top ranking hybrids based on mean, heterosis and *sca* effects

S. No.	Hybrids	Grain yield plant^{-1} (g)	Heterosis over varietal check (%)	Heterosis over hybrid check (%)	*sca* effect
1	JMS 14A × RNR 26083	40.02	49.14 **	31.58 **	9.36 **
2	JMS 14A × RNR 26084	34.97	30.13 **	14.97 **	5.01 **
3	CMS 64A × PAU 2K10-23-451-2-37-34-0-3	34.54	28.72 **	13.56 **	5.66 **
4	CMS 23A × RNR 26072	34.28	27.72 **	12.68 **	7.06 **
5	CMS 64A × RNR 26059	34.22	27.51 **	12.20 *	3.23 **

future breeding programmes. Finally, among 32 hybrids, JMS 14A × RNR 26083, JMS 14A × RNR 26059, CMS 64A × PAU 2K10-23-451-2-37-34-0-3, CMS 23A × RNR 26072 and CMS 64A × RNR 26059 (Table 7) were identified as promising hybrids based on *per se* grain yield per plant, heterosis and specific combining ability which would be further tested in multilocation trials.

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Research Article
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EFFECT OF POTASSIUM AND FOLIAR NUTRITION OF SECONDARY (Mg) AND MICRONUTRIENTS (Zn & B) ON YIELD ATTRIBUTES AND YIELD OF *Bt* - COTTON

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ABSTRACT

A field experiment was conducted during *kharif,* 2015-16 and 2016-17 in split plot design to access the performance of *Bt*- cotton hybrid (MRC 7201 BGII) at Hyderabad with potassium fertilization (K @ 0, K @ 60 and K @ 90 kg ha^{-1}) as main treatments and secondary (Magnesium) and micro nutrients (Zinc and Boron) as sub plot treatments. Among the potassium levels during both the years 2015 and 2016, K @ 90 kg ha^{-1} recorded significantly more number of bolls plant^{-1} (34.4, 36.4), boll weight (2.4, 2.5 g), seed cotton yield (1941, 2591 kg ha^{-1}), stalk yield (1967, 2755 kg ha^{-1}) and harvest index (58.1, 47.4 %) respectively in comparison to K @ 0 and K @ 60. Among the secondary (Magnesium) and micro nutrients (Zinc and Boron), during 2015 and 2016, treatment $Mg_{1\%}Zn_{0.5\%}B_{0.1\%}$ showed more number of bolls plant^{-1} (33.0, 36.2), boll weight (2.43, 2.80 g), seed cotton yield (1512, 2324 kg ha^{-1}), stalk yield (1622, 2708 kg ha^{-1}) and harvest index (52.5, 44.1 %) when compared with all other treatments.

Cotton (*Gossypium hirsutum* L.) is the most important commercial crop of India, cultivated in an area of 125.84 lakh hectare with a productivity of 486 kg lint ha^{-1} which is below the world average of 764 kg ha^{-1} and in Telangana state, the cotton crop is grown in an area of 17.61 lakh ha with the productivity of 486 kg ha^{-1} (Annual report, CICR, 2019). Changes in the soil fertility caused by the imbalanced use of fertilizers and continuous use of high analysis fertilizers without organic manures lead to problems like declining organic matter and mining of nutrients especially those which are not applied in sufficient quantities. This has lead to an era of multi nutrient deficiencies and widespread deficiencies of at least six elements *viz*., nitrogen, phosphorus, potassium, sulphur, zinc and boron. Among major nutrients, potassium has an important role in the translocation of photosynthates from source to sink. Physiologically, K is an essential macronutrient for plant growth and development. While K is not a component of any singular plant part, K affects many fundamental physiological processes such as cell pH stabilization, regulating plant metabolism by acting as a negative charge neutralizer, maintaining cell turgor by acting as an osmiticum activating enzymes and regulating the opening and closing of stomata. Potassium is required in large amounts by cotton for normal crop growth and fiber development. Cotton is more sensitive to potassium availability and often shows signs of potassium deficiency in soils, not considered deficient (Cassman *et al.,* 1989). Further, the role and importance of potassium in cotton growth and productivity is increasing due to the widespread potassium deficiency aggravated due to low potassium additions or recommendations.

Secondary (Ca, Mg, S) and micronutrients especially Zn, B are essential for higher productivity of cotton. Besides increasing nutrient use efficiency, Magnesium is essential for the production of the green pigment in chlorophyll, which is the driving force of photosynthesis. It is also essential for the metabolism of carbohydrates (sugars).It is necessary for cell division and protein formation. It is not only an enzyme activator in the synthesis of nucleic acids (DNA and RNA), but also regulates uptake of the other essential elements and serves as a carrier of phosphate compounds throughout the plant. It also facilitates the translocation of carbohydrates (sugars and starches), enhances the production of oils and fats.

Micronutrient deficiencies not only hamper crop productivity but also deteriorate produce quality. Micronutrients requirement though small, act as catalyst in the uptake and use of macronutrients. Nutritional status of plants has a considerable impact on

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partitioning of carbohydrates and dry matter between plant shoots and roots. The increasing deficiencies of these nutrients affects the crop growth and yields and low response to their applications are being noticed. Zinc has important functions in protein and carbohydrate metabolism of plant. Furthermore, zinc is an element directly affecting the yield and quality because of its role in activity of biological membrane stability, enzyme activation ability and auxin synthesis. Boron plays an essential role in the development and growth of new cells in the growing meristem and also required for protein synthesis where nitrogen and carbohydrates are converted into protein. It also plays an essential role in plant cell formation, integrity of plasma membranes, pollen tube growth and increases pollination and seed development.

Besides, actual yield levels are low due to poor agronomic practices, especially fertilization. Squaring, blooming and boll development are the stages where cotton needs the highest nutrients. Augmentation of nutrient supply through foliar application at such critical stages may increase yield (Bhatt and Nathu, 1986). Foliar nutrition when used as a supplement the crop gets benefitted from foliar applied nutrients when the roots are unable to meet the nutrient requirement of the crop at its critical stage (Ebelhar and Ware, 1998). Hence the present study was undertaken to find the response of *Bt* cotton to different levels of potassium and secondary and micronutrient supplementation for higher kapas yield.

MATERIAL AND METHODS

The investigation was carried out during *Kharif,* 2015-16 and 2016-17 at College Farm, Rajendranagar, Hyderabad situated at an altitude of 542.3 m above mean sea level at 17°19' N latitude and 78°23' E longitude. It is in the Southern Telangana agro-climatic zone of Telangana

The soil was sandy clay loam in texture, neutral in reaction, non saline, low in organic carbon, available N, high in available P and medium in available K. The experiment was laid out in a Split plot design comprising of 3 Main treatments and 8 Sub plot treatments, replicated thrice. The treatments include basal application of Potassium @ M_1 – 0 kg K_2O ha^{-1}, M_2-60 kg K_2O ha^{-1} and M_3 - 90 kg K_2O ha^{-1} as main plots and sub plot includes foliar sprays with different combinations of Mg, Zn and B (2 sprays- first at flowering and second at boll opening stage) *i.e.,* S_1- Mg (0 %) + Zn (0 %) + B (0%) {Control}, S_2- Mg (1 %) + Zn (0 %) + B (0 %), S_3- Mg (0%) + Zn (0.5 %) + B (0 %), S_4- Mg (0%) + Zn (0 %) + B (0.1 %) , S_5- Mg (1 %) + Zn (0.5 %) + B (0 %), S_6- Mg (1 %) + Zn (0 %) + B (0.1 %), S_7- Mg (0%) + Zn (0.5 %) + B (0.1%) and S_8- Mg (1 %) + Zn (0.5 %) + B (0.1 %) with sources of fertilizer are K - MOP, Mg- Epsom salt, Zn- $ZnSO_4$ and B-Borax.

During the crop growing period rainfall of 375.3 mm was received in 27 rainy days in first year and 740.9 mm in 37 rainy days in second year of study, respectively as against the decennial average of 616.2 mm received in 37 rainy days for the corresponding period indicating 2016-17 as wet year comparatively.

Cotton crop was sown on July 11, 2015 and June 26, 2016 by dibbling seeds in opened holes with a hand hoe at depth of 4 to 5 cm as per the spacing in treatments *viz.*, 90 cm X 60 cm. The recommended dose of 120-60 NP kg ha^{-1} were applied in the form of urea and single super phosphate respectively. Entire dose of phosphorus was applied as basal at the time of sowing, while nitrogen were applied in 4 splits, one at the time of sowing as basal and remaining three splits at 30, 60 and 90 days after sowing (DAS) respectively. Main treatments of Potassium (0, 60 & 90 kg ha^{-1}) were imposed to the field as basal dose. Whereas, foliar sprays with different combinations of Mg, Zn and B were applied twice to crop, *i.e.,* at flowering (55 DAS) and at boll opening stage (70 DAS) of the cotton.

Pre emergence herbicide pendimethalin @ 2.5 ml l^{-1} was sprayed to prevent growth of weeds. Post emergence spray of quizalofop ethyl 5% EC @ 2 ml l^{-1} and pyrithiobac sodium 10% EC @ 1 ml l^{-1}. Hand weeding was carried out once at 35 DAS. First irrigation was given immediately after sowing of the crop to ensure proper and uniform germination. Later irrigations were scheduled uniformly by adopting climatological approach *i.e.,* IW/CPE ratio of 0.60 at 5 cm depth. During crop growing season sucking pest incidence was noticed. Initially at 25 DAS spraying of monocrotophos @ 1.6 ml l^{-1} was done. During later stages, acephate @ 1.5 g l^{-1} and fipronil @ 2 ml l^{-1} were sprayed alternatively against white fly and other sucking pests complex during the crop growth period as and when required.

Table 1. No. of bolls plant^{-1} of cotton as influenced by secondary and micro nutrient supplementation under graded levels of potassium

Treatment	Potassium levels										
Secondary & micro nutrients	0 kg ha^{-1}			60 kg ha^{-1}			90 kg ha^{-1}			Mean	
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016
$Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$	25.3	28.2	26.75	29.6	26.2	27.9	33.6	32.7	33.15	29.5	29.0
$Mg_{1\%}$	27.1	32.5	29.80	31.1	33.5	32.30	38.7	32.5	35.6	32.3	32.8
$Zn_{0.5\%}$	28.4	30.3	29.35	27.2	30.6	28.90	30.0	33.3	31.65	28.5	31.4
$B_{0.1\%}$	31	27.7	29.35	28.8	27.2	28.00	32.1	37.3	34.70	30.6	30.7
$Mg_{1\%}$ $Zn_{0.5\%}$	27.5	26.1	26.80	32.1	34.8	33.45	35.3	35.8	35.55	31.6	32.2
$Mg_{1\%}$ $B_{0.1\%}$	27.2	27.5	27.35	29.4	34	31.70	31.6	39.4	35.50	29.4	33.6
$Zn_{0.5\%}$ $B_{0.1\%}$	25.9	32.1	29.00	27.5	34.2	30.85	36.1	39.2	37.65	29.8	35.2
$Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$	25.8	29.2	27.50	35.7	38.4	37.05	37.5	41.1	39.30	33.0	36.2
Mean	27.3	29.2		30.2	32.4		34.4	36.4		30.6	32.7
	2015		2016								
	SE m(±)	CD (p=0.05)	SE m (±)	CD (p=0.05)							
Main plots (A)	0.11	0.43	0.77	1.10							
Sub plots (B)	0.13	0.38	0.78	1.10							
Interaction (A x B)	0.23	0.66	1.35	1.91							
Interaction (B x A)	0.24	0.74	1.48	2.10							

Table 2. Boll weight (gm) of cotton as influenced by secondary and micro nutrient supplementation under graded levels of potassium

Treatment	Potassium levels										
Secondary & micro nutrients	0 kg ha^{-1}			60 kg ha^{-1}			90 kg ha^{-1}			Mean	
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016
$Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$	1.9	1.9	1.9	2.1	2	2.05	2.2	2.1	2.15	2.07	2
$Mg_{1\%}$	2	2.1	2.05	2.2	2.2	2.2	2.3	2.3	2.3	2.17	2.2
$Zn_{0.5\%}$	2	2.2	2.1	2.4	2.4	2.4	2.5	2.2	2.35	2.3	2.27
$B_{0.1\%}$	2.1	2.3	2.2	2.5	2.5	2.5	2.2	2.7	2.45	2.27	2.5
$Mg_{1\%}$ $Zn_{0.5\%}$	2.1	2.4	2.25	2.2	2.5	2.35	2.4	2.6	2.5	2.23	2.5
$Mg_{1\%}$ $B_{0.1\%}$	1.8	1.8	1.8	2.1	2.4	2.25	2.4	2	2.2	2.1	2.07
$Zn_{0.5\%}$ $B_{0.1\%}$	2	2.1	2.05	2.4	2.6	2.5	2.5	2.8	2.65	2.3	2.5
$Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$	2.1	2.6	2.35	2.5	2.8	2.65	2.7	3	2.85	2.43	2.8
Mean	2	2.2		2.3	2.4		2.4	2.5		2.23	2.37
	2015		2016								
	SEm(±)	CD (p=0.05)	SEm(±)	CD (p=0.05)							
Main plots (A)	0.011	0.043	0.0166	0.065							
Sub plots (B)	0.02	0.057	0.0244	0.07							
Interaction (A x B)	0.031	0.103	0.047	0.13							
Interaction (BxA)	0.034	0.102	0.043	0.13							

Table 3. Seed cotton yield (kg ha^{-1}) as influenced by secondary and micro nutrient supplementation under graded levels of potassium

Treatment	Potassium levels										
Secondary & micro nutrients	0 kg ha^{-1}			60 kg ha^{-1}			90 kg ha^{-1}			Mean	
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016
$Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$	915	1423	1169	1257	1799	1528	1755	2432	2093.5	1309	1885
$Mg_{1\%}$	956	1427	1191.5	1265	2025	1645	1854	2449	2151.5	1358	1967
$Zn_{0.5\%}$	1016	1491	1253.5	1246	2072	1659	1880	2486	2183	1381	2016
$B_{0.1\%}$	1040	1497	1268.5	1298	2154	1726	1894	2534	2214	1411	2062
$Mg_{1\%}$ $Zn_{0.5\%}$	1123	1586	1354.5	1314	2160	1737	1962	2619	2290.5	1466	2122
$Mg_{1\%}$ $B_{0.1\%}$	1111	1653	1382	1316	2187	1751.5	2006	2667	2336.5	1478	2169
$Zn_{0.5\%}$ $B_{0.1\%}$	1109	1776	1442.5	1338	2202	1770	2083	2688	2385.5	1510	2222
$Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$	1141	1787	1464	1302	2328	1815	2093	2858	2475.5	1512	2324
Mean	1051	1580		1292	2116		1941	2591		1428	2096
SEm(±)	CD (p=0.05)	SEm(±)	CD (p=0.05)								
Main plots (A)	7.67	30.15	12.85	50.44							
Sub plots (B)	11.45	32.67	17.54	50.05							
Interaction (A x B)	19.82	56.58	30.38	86.7							
Interaction (BxA)	20.07	60.43	31.18	94.68							

Table 4. Stalk yield (kg ha^{-1}) of cotton as influenced by secondary and micro nutrient supplementation under graded levels of potassium

Treatment	Potassium levels										
Secondary & micro nutrients	0 kg ha^{-1}			60 kg ha^{-1}			90 kg ha^{-1}			Mean	
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016
$Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$	879	2072	1475	1257	2432	1844	1880	2347	2113	1339	2284
$Mg_{1\%}$	1244	1799	1521	1265	2449	1857	1755	2712	2233	1421	2320
$Zn_{0.5\%}$	1088	2025	1556	1246	2486	1866	1854	2556	2205	1396	2356
$B_{0.1\%}$	1105	2154	1629	1298	2534	1916	1894	2573	2233	1432	2420
$Mg_{1\%}$ $Zn_{0.5\%}$	1470	2160	1815	1314	2619	1966	1962	2938	2450	1582	2572
$Mg_{1\%}$ $B_{0.1\%}$	1508	2187	1847	1316	2667	1991	2006	2876	2441	1610	2577
$Zn_{0.5\%}$ $B_{0.1\%}$	1435	2202	1818	1338	2688	2013	2083	2903	2493	1619	2598
$Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$	1470	2328	1899	1302	2858	2080	2093	2938	2515	1622	2708
Mean	1287	2116		1292	2591		1967	2755		1507	2487
	SE m (±)	CD (p=0.05)	SE m (±)	CD (p=0.05)							
Main plots (A)	7.94	31.21	15.9	62.44							
Sub plots (B)	12.55	35.82	26.27	74.97							
Interaction (A x B)	21.74	62.05	45.51	129.85							
Interaction (B x A)	21.83	65.42	45.43	135.63							

Table 5. Harvest index (%) of cotton as influenced by secondary and micro nutrient supplementation under graded levels of potassium

Treatment	Potassium levels										
Secondary & micro nutrients	0 kg ha^{-1}			60 kg ha^{-1}			90 kg ha^{-1}			Mean	
	2015	2016	Mean	2015	2016	Mean	2015	2016	Mean	2015	2016
$Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$	42.4	34.41	38.405	41.6	35.76	38.68	49.9	42.93	46.415	44.6	37.7
$Mg_{1\%}$	46.8	35.83	41.315	49.4	42.28	45.84	58.9	46.98	52.94	51.7	41.7
$Zn_{0.5\%}$	53.6	38.85	46.225	49.7	43.15	46.42	59.9	47.67	53.78	54.4	43.2
$B_{0.1\%}$	48.5	36.78	42.640	50.7	44.11	47.40	60.0	48.15	54.07	53.1	43.0
$Mg_{1\%}$ $Zn_{0.5\%}$	43.3	35.05	39.175	48.1	42.81	45.45	58.1	47.58	52.84	49.8	41.8
$Mg_{1\%}$ $B_{0.1\%}$	40.9	34.95	37.925	44.8	43.08	43.94	56.6	48.16	52.38	47.4	42.1
$Zn_{0.5\%}$ $B_{0.1\%}$	43.6	36.95	40.275	48.6	43.29	45.94	59.5	48.23	53.86	50.6	42.8
$Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$	43.7	37.82	40.760	51.8	44.80	48.30	62.1	49.75	55.92	52.5	44.1
Mean	45.3	36.50		48.1	42.40		58.1	47.40		50.5	42.1
	SE m (±)	CD (p=0.05)	SE m (±)	CD (p=0.05)							
Main plots (A)	0.21	0.84	0.25	0.98							
Sub plots (B)	0.43	1.24	0.33	0.94							
Interaction (A x B)	0.75	2.14	0.57	1.62							
Interaction (B x A)	0.73	2.16	0.59	1.79							

The number of opened bolls on five labelled plants from net plot were counted at each picking, averaged and expressed plant^{-1}. Harvested bolls of each picking from labeled plants of each treatment was weighed, averaged and expressed as boll weight in g boll^{-1}. The cumulative yield of seed cotton from each picking in each treatment from net plot was weighed and expressed in kg ha^{-1}.

Harvest index is defined as the ratio of economic yield to the total biological yield. It is calculated by using the formula given by Donald (1962).

$$\text{Harvest index (\%)} = \frac{\text{Seed cotton yield (kg ha}^{-1}\text{)}}{\text{Biological yield (seed cotton yield + stalk yield kg ha}^{-1}\text{)}}$$

Data on different characters *viz*., yield components and yield, were subjected to analysis of variance procedures as outlined for split plot design (Gomez and Gomez, 1984). Statistical significance was tested by F–value at 0.05 level of probability and critical difference was worked out wherever the effects were significant.

RESULTS AND DISCUSSION

Number of bolls plant^{-1}

Data pertaining to number of bolls plant^{-1} was significantly affected by major (Potassium) and secondary (Magnesium), micro nutrients (Zinc and Boron) and their interaction (Table 1). Significantly higher number of bolls plant^{-1} were recorded with K @ 90 kg ha^{-1} (34.4, 36.4), when compared with K @ 60 kg ha^{-1} and K @ 0 kg ha^{-1} treatments during 2015 and 2016.. The probable reason for increased numbers of bolls was attributed to potassium, which penetrates the leaf cuticle and translocate to the young developing tissues (Pettigrew, 2003) and there by resulting in better partitioning of dry matter. These findings corroborate with Sukham Madaan *et al*. (2014).

Significantly more numbers of bolls plant^{-1} were observed in $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ (33.0, 36.2) and less number of bolls plant^{-1} were obtained with $Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$ treatment during both the years. The probable reason of this might be due to enhancement of photosynthetic and enzymatic activity, production of more number of fruiting branches and flower production which lead to marked influence in partitioning of vegetative and reproductive growth, production of more number of lateral branches and also increase in number of bolls and squares Karademir and Karademir, (2020). These results are in closer conformity with the findings of More et al., (2018). Data pertaining to interaction effect between potassium levels and secondary and micro nutrient supplementation on bolls plant^{-1} was significant at all growth stages during both the years. A combination of $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ along with K@90 kg ha^{-1} recorded highest (37.5 and 41.1) bolls plant^{-1} which was closely followed by $Zn_{0.5\%}$ $B_{0.1\%}$ at same level of potassium (36.1 and 39.2) . However lowest bolls plant^{-1} were recorded with $Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$ at zero level of potassium.

Boll weight (g)

The boll weight was significantly affected by graded levels of potassium and secondary and micronutrient supplementation during both the years. The interaction effect was also significant and the results were presented in the (Table 2).

In 2015, higher boll weight was observed in K@90 kg ha^{-1} (2.4 g) and significantly superior to K@60 kg ha^{-1} and K@ 0 kg ha^{-1}.In 2016, maximum boll weight (2.5 g) was recorded and was significantly superior over K@60 kg ha^{-1} and K@ 0 kg ha^{-1}, while K@ 0 kg ha^{-1} recorded the lowest boll weight (2.0 g). The probable reason for this might be due to higher nutrient uptake resulting in higher LAI, there by higher supply of photo assimilates towards reproductive structures (bolls) (Norton *et al.,* 2005). These results are in tune with Sukham madaan *et al.* (2014), Vinayak Hosmani *et al.* (2013) and Aladakatti *et al.* (2011).

Among different treatments of secondary nutrient and micronutrients supplementation, $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ treatment recorded highest boll weight (2.43 g, 2.8 g) during 2015 and 2016 years. Further, $Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$ treatment recorded lower boll weight at 2.07 g, 2.00 during 2015 and 2016, respectively. This might be due to production of more number of fruiting points and flower production, photosynthesis, energy restoration and protein synthesis. Further availability of nutrients leads to higher nutrient uptake, acceleration of photosynthates from source to sink resulting in more number of branches, squares, bolls and boll weight (Karademir and Karademir, 2020), and Shivamurthy and Biradar, (2014). Interactions (Norton between major (Potassium) and secondary (Magnesium), micro nutrients (Zinc and Boron) were found statistically significant on boll weight of the crop during both years. K@90 kg ha^{-1} with $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ treatment recorded significantly higher boll weight over K@60 kg ha^{-1} and K@0 kg ha^{-1}. Lowest boll weight was recorded with $Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$ along K@0 kg ha^{-1} as compared to K@60 kg ha^{-1} and K@90 kg ha^{-1}.

Seed Cotton Yield

Data pertaining to seed cotton yield is presented in Table No.3. Scrutiny of data indicates that yield of cotton was significantly influenced by both potassium graded levels, secondary and micro nutrient supplementation and also their interaction effect .

Potassium levels have exerted significant influence on seed cotton yield during both the years. Significantly higher seed cotton yield was recorded with the basal application of potassium @ 90 kg ha^{-1} (1941 kg) than K @ 60 kg ha^{-1} (1292 kg) and K @ 0 kg ha^{-1} (1051 Kg). Potassium @ 90 kg ha^{-1} recorded significantly higher seed cotton yield (2591 kg) followed by potassium @ 60 kg ha^{-1} (2116 kg) and potassium @ 0 kg ha^{-1} (1580 kg) during 2016. Higher seed cotton yield might be due to better partitioning of dry matter and photo assimilates towards reproductive structures *et al.,* 2005) and there by higher biomass (Shivamurthy and Biradar, 2014), which resulted in higher squares number $plant^{-1}$. There by more number of bolls and boll weight realized to higher yield $plant^{-1}$, there by higher yield. Similar results were reported by Ratna Kumari *et al.* (2009).

Significantly higher seed cotton yield obtained with $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ (1512 kg) which is on par with $Zn_{0.5\%}$ $B_{0.1\%}$ treatment (1510 kg) followed by $Mg_{1\%}B_{0.1\%}$(1478 kg) when compared with all other treatments during 2015. While in 2016, significantly higher cotton yield was obtained with $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ resulted (2324 kg) followed by $Zn_{0.5\%}$ $B_{0.1\%}$ treatment (2222 kg) and $Mg_{1\%}B_{0.1\%}$((2169 kg) when compared with rest of all treatments. And significantly lower yield was obtained with control treatment *i.e.,* $Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$ (1309 kg and 1885 kg) during 2015 and 2016, respectively. Highest yield obtained in $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ was due to increased boll number, boll weight and finally increased seed cotton yield. Similar results were recorded by Karademir and Karademir, (2020). Interaction effect between potassium and Magnesium, Zinc and boron, Magnesium and Zinc, Zinc and boron, Magnesium and boron, Potassium, Magnesium, Zinc and boron on seed cotton yield was found significant. Treatment $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ in combination with K @ 90 kg ha^{-1} recorded higher seed cotton yield (2093 kg and 2858 kg) in the year, 2015 and 2016, respectively. Similarly lowest was registered with $Mg_{0\%}Zn_{0\%}B_{0\%}$ in combination with K@0 kg ha^{-1} (915, 1423 kg ha^{-1}) in the corresponding years, respectively

Stalk yield

Perusal of data indicated significant effect of major nutrient, graded potassium levels, secondary nutrient (Magnesium) and micro nutrients (Zinc and Boron) and their interaction on stalk yield during 2015 and 2016 (Table 4). The data on stalk yield indicated that significantly higher stalk yield was produced with basal application of potassium @ 90 kg ha^{-1} (1967 kg) when compared with other treatments *i.e.,* potassium @ 60 kg ha^{-1}(1292 kg) for the year, 2015. The lower stalk yield was obtained with control plot *i.e.* potassium @ 0 kg ha^{-1} (1287 kg). The similar trend was followed during the year, 2016 in which the basal application of K@ 90 kg ha^{-1} recorded maximum stalk yield of 2755 kg which was followed by K@ 60 kg ha^{-1} (2591 kg) and lower stalk yield was obtained with control treatment K@ 0 kg ha^{-1} (2116). Increased seed and stalk yield has resulted in higher harvest index. These results are in line with Ratna Kumari *et al.* (2009).

Significantly higher stalk yield was obtained with treatment consisting of $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ (1622 kg) which is followed by $Zn_{0.5\%}$ $B_{0.1\%}$ (1619 kg) and lower stalk yield was obtained with $Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$ (1339 kg) for the year 2015. During 2016, $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ (2708 kg) followed by $Zn_{0.5\%}$ $B_{0.1\%}$ (2598 kg). The treatment consisting of $Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$ has recorded lower stalk yield when compared with rest of the treatments. Similar results were recorded by Karademir and Karademir, (2020) and Santhosh *et al.*(2016). Interactions between major (Potassium levels) and secondary (Magnesium), micro nutrients (Zinc and Boron) were found statistically significant during both years.

Harvest index

Data pertaining to major nutrient, graded potassium levels, secondary nutrient (Magnesium) and micro nutrients (Zinc and Boron) and its influence on harvest index was found to vary significantly during 2015 and 2016 (Table 5).

Among varied potassium levels, treatment with K @ 90 kg ha^{-1} has registered significantly superior harvest index (58.1%) than K @ 60 kg ha^{-1} (48.1%) and K@0 kg ha^{-1} (45.3%) during 2015. The same trend was observed for the year, 2016 in which significantly maximum harvest index was recorded with K @ 90 kg ha^{-1} (47.4%) over K @ 60 kg ha^{-1} (42.4%) and lowest was recorded in K @ 0 kg ha^{-1} (36.5%) for the year 2016. These results are in line with Ratna Kumari *et al.* (2009).

During both the years of investigation, significantly higher harvest index was found in $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ (52.5, 44.1) during the years, 2015 and 2016. Whereas low harvest index were obtained with $Mg_{0\%}Zn_{0\%}B_{0\%}$treatment (44.6, 37.7) during 2015 and 2016 when compared with all other treatments. Increased harvest index obtained might be due to higher seed cotton yield and stalk yield because of increased growth and yield parameters, higher nutrient uptake, better partitioning of photo assimilates towards reproductive structures (Deshpande *et al*., 2014 and Shivamurthy and Biradar, 2014). Significant interaction effect between major (Potassium) and secondary (Magnesium), micro nutrients (Zinc and Boron) on harvest index of the crop was found during both the years. K@ 90 kg ha^{-1} with $Mg_{1\%}$ $Zn_{0.5\%}$ $B_{0.1\%}$ treatment recorded higher harvest index which was on par with K@ 90 kg ha^{-1} with $Zn_{0.5\%}$ $B_{0.1\%}$ but were significantly higher over rest of the treatments combination. However, control treatment K@ 0 kg ha^{-1} with $Mg_{0\%}$ $Zn_{0\%}$ $B_{0\%}$ recorded lower harvest index when compared with all treatments combination.

The results from the current investigation clearly reveal that K @ 90 kg ha^{-1} recorded significantly more number of bolls plant^{-1}, boll weight, seed cotton yield, stalk yield and harvest index during both the years of study in comparison to K @ 0 and K @ 60 kg ha^{-1}. The treatment $Mg_{1\%}Zn_{0.5\%}B_{0.1\%}$ showed more number of bolls plant^{-1}, boll weight, seed cotton yield, stalk yield and harvest index when compared with all other treatments. Among the interaction treatments K @ 90 kg ha^{-1} along with $Mg_{1\%}Zn_{0.5\%}B_{0.1\%}$ showed highest bolls plant^{-1}, boll weight, seed cotton yield, stalk yield and harvest index during both the years of study.

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Research Article
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ECONOMIC THRESHOLD LEVEL (ETL) OF STEM GIRDLER *(OBEREOPSIS BREVIS)* Swedenbord IN SOYBEAN

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ABSTRACT

Stem girdler, *Obereopsis brevis* Swedenbord is a major pest of soybean in Telangana. Indiscriminate insecticidal application for management of this pest from seedling to harvesting stage has resulted in increased pesticidal residues in soybean. Studies on management of the pest based on economic threshold level (ETL) carried out during 2017 and 2018 revealed that three sprayings with triazophos @ 1.5 ml l^{-1} effectively managed stem girdler, *O. brevis* in soybean. More than three sprayings *i.e.,* four and five sprayings though reduced the pest incidence to five percent and absolute zero respectively but were not cost economical and didnot increase the yield significantly. Three sprayings with triazophos at 10 percent incidence was on par with the recommendations of University (PJTSAU) and it was concluded that 10 percent damage can be treated as economic threshold level for stem girdler, *O.brevis* in soybean.

Soybean is cultivated in an area of 109.714 lakh ha with a production potential of 114.907 lakh tonnes. Madhya Pradesh (57.168 lakh tons), Maharashtra (39.456 lakh tons) and Rajasthan (9.499 lakh tons) are the largest producers of soybean in India. Telangana also cultivates soybean in an area of 1.77 lakh ha with a production potential of 2655 tonnes and productivity of 1500 kg ha^{-1} (Soybean - pjtsau). One of the major constraints for production and productivity of soybean is infestation of insect pests. Soybean is infested by more than 275 insect pests on different plant parts throughout its crop growth period and among them 12 were reported to cause serious damage to soybean from sowing to harvesting (Ramesh Babu, 2010). Stem girdler is considered as the most serious pest among the 12 major pests causing damage to soybean crop. The effective management of most of the pests in soybean depends on the use of synthetic chemical insecticides, but its use should be judicious, need based and based on ETL concepts. The earlier concept of “pest control” aiming cent percent elimination of pests from the agricultural ecosystem was replaced by the term “pest management” which aims at reducing the pest population to a level that does not cause economic injury or economic loss. In the “pest management concept”, the determination of action thresholds of any pest species is a pre-requisite. Considering these points present investigation was undertaken to determine the economic threshold level (ETL) of soybean stem girdler.

MATERIAL AND METHODS

Field experiment was laid in a Randomized Block Design (RBD) at Agricultural Research Station (ARS), Adilabad during *kharif* 2017 and 2018. Eight treatments were taken where in triazophos was sprayed @ 1.5 ml l^{-1} as follows: T1 (0 percent damage), T2 (5 percent damage), T3 (10 percent damage), T4 (15 percent damage), T5 (20 percent damage), T6 (25 percent damage), T7 (University recommended plant protection schedule) and T8 (Untreated control). All the eight treatments were replicated thrice. The insecticide was applied in T1 as and when the pest incidence was observed to keep the plots pest free. Similarly in T2 only after the damage crossed 5 percent. The T3, T4 and T5 and T6 treatmental plots were sprayed when the damage of 10 percent, 15 percent, 20 percent and 25 percent respectively was reported. The University (PJTSAU) recommendation of three blanket applications of triazophos @ 1.5 ml l^{-1} was practiced in T7 plots and an untreated control with water spray was used as a check. The percent damage data was assessed by recording the weekly observations on stem girdler incidence in the five randomly selected meter row

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lengths in each treatment. The cumulative incidence of the pest (tunneling percent) was also recorded at 60 days after sowing. The economic threshold level of stem girdler was worked out based on fixed level of infestation as suggested by Cancelado and Radeliffe (1979). As soon as the crop had recorded a particular level (40%) of infestation, the crop was sprayed with triazophos at 10-15 days interval to check further infestation. The total yield, damage, marketable yield, cost of insecticide, labour and hire charges were considered for obtaining the cost benefit ratio. The data was subjected to analysis of variance to draw conclusions.

Table 1. Evaluation of damage levels for fixing ETL of Stem girdler in soybean during *kharif* 2017

Treatments	No of Sprays	Stem girdler (No. of damaged plants/*mrl*)	Percent damage /*mrl*	Percent tunneling /*mrl*	Yield (Kg ha^{-1})
T1 (0%)	5	2.47	12.71(20.88)	12.50(3.54)	2266
T2 (5%)	4	3.55	16.55(24.01)	12.78(3.57)	2161
T3 (10%)	3	4.24	21.31(27.49)	13.48(3.67)	2156
T4 (15%)	2	4.69	23.75(29.17)	14.23(3.77)	1662
T5 (20%)	1	5.46	27.62(31.70)	14.48(3.81)	1380
T6 (25%)	1	5.86	28.91(32.53)	14.58(3.82)	1265
T7(PP)	3	3.00	14.96(22.75)	12.54(3.54)	2186
T8 (Un treated control)	0	6.49	32.62(34.83)	14.90(3.86)	1012
SE ± (M)	-	-	0.079	0.004	38.50
CD 1%	-	-	0.241	0.011	162.11
CD 5%	-	-	0.334	0.015	116.80
CV %	-	-	0.49	0.17	11.36

Figures in parenthesis are arc sin and square root transformation

Table 2. Evaluation of damage levels for fixing ETL of Stem girdler in soybean during *kharif* 2018

Treatments	No of Sprays	Stem girdler (No. of damaged plants/*mrl*)	Percent damage /*mrl*	Percent tunneling /*mrl* (%)	Yield (Kg ha^{-1})
T1 (0%)	5	2.11	10.68(3.27)	12.46(3.53)	2276
T2 (5%)	4	3.30	16.24(4.03)	12.77(3.57)	2033
T3 (10%)	3	3.53	17.74(4.21)	13.78(3.71)	2110
T4 (15%)	2	4.41	20.84(4.57)	14.35(3.79)	1546
T5 (20%)	1	4.45	22.59(4.75)	14.56(3.82)	1377
T6 (25%)	1	4.91	24.81(4.98)	14.70(3.83)	1255
T7(PP)	3	3.70	18.61(4.31)	12.55(3.54)	2150
T8 (Un treated control)	0	5.62	28.29(5.32)	14.91(3.86)	1002
SE±(M)	-	-	0.010	0.006	37.29
CD 1%	-	-	0.031	0.017	157.03
CD 5%	-	-	0.043	0.024	113.14
CV %	-	-	0.40	0.26	11.27

Figures in parenthesis are square root transformation

Table 3. Soybean yield and cost benefit ratio during *kharif* 2017

Treatments (Stem girdler percent damage/*mrl*)	CoC (Rs ha^{-1})	No. of Sprays	Gross returns (Rs ha^{-1})	BC Ratio	Yield (kg ha^{-1})
T1 (0%)	21250	5	69113	3.25	2266
T2 (5%)	20625	4	65910	3.19	2161
T3 (10%)	20000	3	65758	3.28	2156
T4 (15%)	19375	2	50691	2.61	1662
T5 (20%)	18750	1	42090	2.24	1380
T6 (25%)	18750	1	38582	2.05	1265
T7 (Pp)	20000	3	66673	3.33	2186
T8 (Untreated control)	18125	0	30866	1.70	1012

Table 4. Soybean yield and cost benefit ratio during *kharif* 2018.

Treatments (Stem girdler per cent damage/*mrl*)	CoC (Rs ha^{-1})	No of Sprays	Gross returns (Rs ha^{-1})	BC Ratio	Yield (kg ha^{-1})
T1(0%)	21250	5	69418	3.26	2276
T2(5%)	20625	4	62006	3.00	2033
T3(10%)	20000	3	64355	3.21	2110
T4(15%)	19375	2	47153	2.43	1546
T5(20%)	18750	1	41998	2.23	1377
T6(25%)	18750	1	38277	2.04	1255
T7(Pp)	20000	3	65575	3.27	2150
T8(Untreated control)	18125	0	30561	1.68	1002

RESULTS AND DISCUSSION

a) Percent damage

During 2017, significantly lowest damage of 12.71 percent was recorded in the treatment, T1 (0% damage) followed by treatments T7 (PP) *i.e.* 14.96 percent. The treatments T2 (5% damage), T3 (10% damage), T4 (15% damage), T5 (20% damage) and T6 (25% damage) recorded 16.55, 21.31, 23.75, 27.62, and 28.91 percent, respectively, whereas the highest damage of 32.62 percent was recorded in T8 (Untreated control).

During 2018, similar trend was observed where significantly lowest percent damage was recorded in treatment T1 i.e. 10.68 percent followed by the treatments T2, T3 and T7 (PP), which recorded 16.24, 17.74 and 18.61 percent respectively. However, the treatments T4, T5, T6 have recorded a damage of 20.84, 22.59, 24.81 percent respectively compared to 18.61 percent when plant protection measures were adopted, whereas highest damage was recorded in T8 (Untreated control) *i.e.* 28.29 percent.(Tables 1 & 2)

b) Percent tunneling

During 2017, the percent tunneling due to stem girdler infestation in the treatments T1, T2, T3, T4, T5, T6, T7 and T8 revealed significantly lowest tunneling in the treatment T1 i.e. 12.50 percent that was found at par with the treatment, T7 (PP) i.e. 12.54 percent. Other treatments i.e T2, T3 and T4 have recorded 12.78, 13.48 and 14.23 percent tunneling, respectively. The treatment T5 and T6 recorded 14.48 and 14.58 percent tunneling and were found to be at par with each other, whereas highest tunneling was recorded in T8 (Untreated control) i.e. 14.90 per cent.

During 2018, treatment T1 recorded significantly lowest tunneling *i.e.* 12.46 percent that was at par with the treatment T7 (PP) *i.e.* 12.55 percent. T2, T3 and T4 have recorded 12.77, 13.78 and 14.35 percent tunneling in the treatments, respectively. The treatment T5 and T6 recorded 14.56 and 14.7 percent tunneling and were found at par with each other, though highest tunneling was recorded in T8 (Untreated control) *i.e.* 14.91 percent.(Tables 1 & 2)

c) Yield (Kg ha^{-1})

During 2017, yield obtained from different plants from different treatments *viz.*, T1, T2, T3, T4, T5, T6 damage, T7 and T8 (Untreated control) resulted in (Table 25) significantly higher total and marketable yields at low level of infestation. The highest amount of yield was obtained in the treatment T1 *i.e.* 2266 kg ha^{-1} followed by the treatments T7 (PP), T2 and T3 with 2186, 2161 and 2156 kg ha^{-1} respectively that were at par with each other. The former treatment was followed by T4, T5 and T6 with 1662, 1380 and 1265 kg ha^{-1} yield, respectively. Lowest yield of 1012 kg ha^{-1} was recorded in treatment T8 (Untreated control). During 2018, maximum yield of 2270 kg ha^{-1} was obtained in treatment T1 followed by treatments, T7 (PP), T3 and T2 with 2150, 2110 and 2033 kg ha^{-1} respectively and were on par with each other. The treatments, T4, T5 and T6 have recorded 1546, 1377 and 1255 kg ha^{-1} respectively, while minimum yield was recorded in the treatment T8 (Control) *i.e.* 1002 kg ha^{-1} (Tables 1 & 2).

Economics

During 2017, the maximum cost benefit ratio was recorded in the treatment T7 (Plant protection schedule) i.e. (1:3.33) followed by treatments T3, T1, T2, T4, T5 and T6 with 1:3.28, 1:3.25, 1:3.19, 1:2.61, 1:2.24 and 1:2.05 respectively. Minimum cost benefit ratio was recorded in T8 (control) with no sprays i.e. (1:1.70). During *kharif* 2018, highest cost benefit ratio was observed in the treatment T7 (Plant protection schedule) i.e. (1:3.27) followed by treatments T1, T3, T2, T4, T5 and T6 with 1:3.26, 1:3.21, 1:3.00, 1:2.43, 1:2.23 and 1:2.04 of B:C ratio, respectively though minimum cost benefit ratio was recorded in T8 (Untreated control) with no sprays *i.e.* (1: 1.68). (Tables 3 & 4)

The present results are in line with the findings of Singh and Singh (1991), Saha (1982) who reported ETLs for *Earias* spp. as 2.67 and 4.94% respectively during the year 1980 and 1981. Sreelatha and Divakar (1998) who described the ETL of *Earias* spp. as 5.3% fruit infestation. The present findings are also in line with Kaur *et al.* (2015) who reported that lower number of sprays, higher marketable yield and economic returns were obtained in two ETLs, 2 and 4% fruit infestation level. Singh and Singh. (1991) studied on the economic threshold level for the green semilooper on soybean cultivar JS 72-44 during 1986 in Madhya Pradesh and opined that control measures should be adopted at economic threshold level of three larvae and two larvae/ mrl(meter row length) at flower initiation and pod filling stage of the crop, respectively. Ahirwar *et al.,* (2017) reported that economic threshold level of the soybean semilooper was 2 larvae and less than 2 larvae/mrl at 60 day and 80 day old crop, respectively, whereas the economic injury level was 4 larvae/mrl. Abhilash and Patil (2008) computed EIL for soybean pod borer, *Cydia ptychora* (Meyrick) as 0.45 larva/plant based on the gain threshold, ratio of cost of pest control to the market price of produce.

During *kharif* 2017 and 2018, significantly minimum damage and tunneling by girdle beetle was recorded in treatments of low infestation level T1 *i.e.* (12.71 and 12.50; 10.68 and 12.46 percent, respectively) followed by T7 (PP), T2 , T3, T4 , T5 and T6 and maximum was recorded in untreated control T8 (Control) *i.e.* (32.62 and 14.90; 28.29 and 14.91 percent, respectively). Although significantly higher total and marketable yields were obtained under lower level of infestation, maximum cost benefit ratio was recorded in treatment T7 (PP) during 2017 and 2018 *i.e.* (1 : 3.33 and 1 : 3.27 respectively followed by T3 with three number of sprays, T1 with five number of sprays and T2 with four number of sprays. Therefore it is desirable to spray at 10 % infestation level which will provide sufficient protection against the pest and reduce the unnecessary insecticide load on the crop.

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Research Article
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POLYMORPHIC SSR MARKERS AMONG *ORYZA SATIVA* CV. SWARNA AND ITS DERIVED ADVANCED BACKCROSS LINES WITH WILD INTROGRESSIONS FROM *O. NIVARA*

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ABSTRACT

Wild species derived introgression lines are good source of novel genes for improving complex traits like yield. Identification of molecular markers revealing genotypic polymorphism is a prerequisite for mapping QTLs and genes for target traits. Polymorphism between parental lines of mapping populations involving Swarna, 166s and 148s was identified in this study. Swarna is a high yielding mega variety, while, 166s and 148s are advanced backcross introgression lines (BILs) developed from a cross between Swarna x *O. nivara.* A total of 530 randomly selected SSR markers were used to identify the polymorphism between Swarna and BILs 166s and 148s. Eighty eight markers (16.66%) which showed distinct alleles between Swarna and 166s were again used to study the polymorphism between Swarna/148s and 166s/148s. Out of 88 markers, 50 were (56.81%) polymorphic between Swarna/148s and 54 markers (61.36%) were polymorphic between 166s /148s. Some of these polymorphic SSR markers were already reported as linked to yield traits in previous studies. These identified markers will be useful in further QTL mapping of the populations derived from the parental lines used in this study.

Rice (*Oryza sativa* L.) is one of the most important food crops in the world and to meet the growing demand from the increasing human population, rice varieties with higher yield potential and greater yield stability need to be developed. To meet the demand of estimated 8.8 billion population in 2035 and raising the rice productivity from the current 10 to 12 tons ha^{-1} are posing a major challenge to rice scientists (Kaur *et al*., 2018). In the domestication process, the strong directional selection reduced the genetic variability in existing cultivated rice genotypes. Due to a great loss of allelic variability or "genetic erosion", the improvement of rice yield became a challenging part in rice breeding programmes.

As a primary gene pool, wild relatives of rice contain unexploited genes which can help in improving rice yield, through broadening the genetic variation in modern rice breeding. Introgression lines (ILs) having genomic fragments from wild rice can be used to develop improved cultivars. The wild relatives of rice have been utilized extensively for introgression of major genes for disease and insect resistance, but their utilization in enhancing yield and yield-related traits has remained limited (Neelam *et al*., 2016). There are several studies to improve the rice yield using high yielding varieties of cultivated rice (Sharma *et al*., 2011; Marathi *et al*., 2012; Okada *et al*., 2018; Yu *et al*., 2018; Ma *et al*., 2019) by improving plant architecture (San *et al*., 2018) or increasing photosynthesis rate (Takai *et al*., 2013). As well, there are records on increasing rice yield by introgression of QTLs or genes of wild rice into cultivated rice (Rangell, 2008; Fu *et al.*, 2010; Srividhya *et al*., 2011; Thalapati *et al*., 2012; Luo *et al*., 2013; Yun *et al.,* 2016; Nassirou *et al*., 2017; Kaur *et al.*, 2018; Kemparaju *et al.*, 2018).

Grain size is a major determinant for domestication and one of the important components determining grain yield in rice. Grain size is considered as the main breeding target due to its effect on both yield and quality. Therefore, it is important to study the traits *viz*., grain size and grain weight for simultaneous improvement of yield and quality (Yu *et al*., 2018; Feng *et al*., 2020).

Genetic polymorphism is defined as the occurrence of a various allelic forms of specific

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chromosomal regions in the germplasm, as two or more discontinuous genotypic variants. Many researchers preferred SSRs or microsatellites for genotyping due to their advantages in molecular breeding (Varshney *et al*., 2005). SSRs remained as the most popular and preferred marker for a wide array of plant genetic analysis in past few decades. SSRs are the most widely used markers for genotyping plants because they are abundant, co-dominant, efficient, highly reproducible, requiring less quantity of DNA, robust amplification, polymorphic potential, multi-allelic in nature, wide genomic distribution and cost-effective (Li *et al.,* 2004; Varshney *et al*., 2005; Parida *et al*., 2006; Miah *et al*., 2013; Daware *et al*., 2016; Usman *et al*., 2018; Chukwu *et al*., 2019). The microsatellites are found in both coding and non-coding regions and have a lower level of mutation rate (10^{-2} and 10^{-4}) per generation (Chandu *et al*., 2020). The studies on population structure, genotype finger printing, genetic mapping, MAS, genetic diversity studies and evolutionary processes in crop plants are conducted with SSR markers. They have great potential to help breeders by linking genotypic and phenotypic variations and speed up the process of developing improved cultivars (Edwards and Batley, 2010; Gonzaga *et al*., 2015). This study aimed to identify informative polymorphic markers between the parental lines of mapping populations as the primary step for QTL mapping.

MATERIAL AND METHODS

The experimental material consisted of Swarna, 166s and 148s rice lines. Swarna is a semi-dwarf, low-land, high yielding, *indica* rice variety, which matures between 140-145 days with an average yield of 6.5 t ha^{-1}. 166s and 148s are advanced backcross introgression lines (BC_2F_8 lines) derived from a cross between Swarna and *Oryza nivara* and are early (148s) and late (166s) duration genotypes. 166s has strong culm strength, high grain number and panicle weight and 148s with high grain weight were obtained from crop improvement section, IIRR, Hyderabad.

The genomic DNA of Swarna, 166s and 148s was extracted from the young leaves of the plants by CTAB method (Doyle and Doyle, 1987). In summary, 0.1g of leaves was weighed and DNA was extracted with DNA extraction buffer (2% CTAB, 100 mM Tris HCl, 20 mM EDTA, 1.4 M NaCl, 2 % PVP) pre-heated at 60^0C. The extracted DNA was estimated by measuring the OD values at 260 nm/280 nm and 260 nm/230 nm for quality and quantity using a Nano Drop, ND1000 spectrophotometer. The estimated DNA quantity ranged between 88 to 964.4 ng/µl with 1.75-2.38 OD at 260 nm/280 nm. Five hundred and thirty randomly selected SSR markers were used to identify polymorphism between Swarna and 166s. Out of them, 88 SSRs markers showed polymorphism between Swarna and 166s and were used to screen the alleles between Swarna/148s and 166s/148s. PCR was carried out in thermal cycler (Veriti Thermal cycler, Applied Biosystems, Singapore) with a final reaction volume of 10 µl containing 50ng of genomic DNA (2µl), 10X assay buffer (1µl), 10 mM dNTPs (0.1µl), 5µM forward and reverse primers (0.5µl), 1 unit of Taq DNA polymerase (Thermo Scientific) (0.1µl) and MQ water (6.3µl). PCR cycles were programmed as follows: initial denaturation at 94° C for 5 min followed by 35 cycles of 94° C for 30 sec, 55° C for 30 sec, 72° C for 1 min, and a final extension of 10 min at 72°C. Amplified products were resolved in 1% agarose gel prepared in 1X TBE buffer and electrophoresed at 150 V for 10 minutes to fasten the DNA movement from the wells, followed by 120 V for 1-2 hrs until the bands are clearly separated. Gels were stained with Ethidium bromide and documented using a gel documentation system (Syngene, Ingenious 3, USA).

RESULTS AND DISCUSSION

The genomic DNA of the two parents Swarna and 166s was screened using 530 rice microsatellites (RM markers) distributed over the twelve chromosomes of rice. Out of 530 RM markers, 88 were identified as polymorphic between Swarna and 166s. These 88 markers were further used to confirm the polymorphism among the Swarna and its derived BILs 166s and 148s, and identified 50 and 54 polymorphic markers for Swarna/148s and 166s/148s respectively (**Table 1**) and the list of polymorphic markers between these three sets of parents with their respective chromosome numbers are presented in **Table 2**.

The per cent of polymorphism was 16.66% between Swarna/166s and the markers were distributed across all the twelve chromosomes. Among these, the highest number (18) of polymorphic markers were identified on chromosome 2 and the lowest number (3) of polymorphic markers were identified on

Table 1. Polymorphic markers identified on each chromosome among the parents Swarna, 166s and 148s

S.No.	Chromosome	Number of polymorphic markers identified		
		Swarna/166s	Swarna/148s	166s/148s
1	1	9	9	10
2	2	18	13	12
3	3	6	3	4
4	4	6	-	-
5	5	10	4	7
6	6	6	6	5
7	7	3	2	5
8	8	6	3	3
9	9	6	-	-
10	10	7	4	2
11	11	7	4	5
12	12	4	2	1
	Total	**88**	**50**	**54**

Table 2. List of polymorphic markers identified between Swarna /166s, Swarna /148s and 166s /148s crosses

S.No.	Chr.number	Polymorphic SSRs identified between		
		Swarna × 166s	Swarna ×148s	166s × 148s
1	**1**	RM495	RM 140	RM 495
		RM140	RM 490	RM 488
		RM8004	RM 488	RM 8004
		RM5638	RM 495	RM 6738
		RM2318	RM 5638	RM 140
		RM6738	RM 8004	RM 5638
		RM237	RM 6738	RM 490
		RM5310	RM 237	RM 1287
		RM 488	RM 1	RM 237
				RM 1
2	**2**	RM279	RM 279	RM 13599
		RM13599	RM 6375	RM 13616
		RM13616	RM 14001	RM 13630
		RM13630	RM 13599	RM 3774
		RM13641	RM 13616	RM 250
		RM14102	RM 13641	RM 106
		RM12729	RM 3774	RM13641
		RM6375	RM 250	RM 279
		RM424	RM106	RM6375
		RM2634	RM424	RM7485
		RM 5430	RM 13630	RM424

S.No.	Chr.number	Polymorphic SSRs identified between		
		Swarna × 166s	Swarna ×148s	166s × 148s
		RM3515	RM 13452	RM2634
		RM106	RM 2634	
		RM14001		
		RM250		
		RM3774		
		RM7485		
		RM154		
3	3	RM3372	RM14303	RM231
		RM7197	RM489	RM7197
		RM231	RM 231	RM232
		RM232		RM14303
		RM426		
		RM489		
4	4	RM7585	-	-
		RM16335		
		RM6314		
		RM3708		
		RM17377		
		RM6909		
5	5	RM17962	RM 3170	RM 17962
		RM5874	RM 3437	RM 3170
		RM18614	RM 164	RM 5874
		RM164	RM 334	RM 164
		RM3437		RM 3437
		RM430		RM 169
		RM3664		RM 334
		RM5907		
		RM169		
		RM3170		
6	6	RM6467	RM 7583	RM 1369
		RM1369	RM 20377	RM 6467
		RM253	RM 1369	RM 253
		RM19620	RM 19620	RM 19620
		RM30	RM 253	RM 20377
		RM 7583	RM 6467	
7	7	RM3859	RM 11	RM 11
		RM346	RM 346	RM 21975
		RM 21975		RM 346
				RM 3859
				RM 21975
8	8	RM337	RM 23182	RM 23182
		RM152	RM 337	RM 152
		RM22837	RM 3480	RM 3480

S.No.	Chr.number	Polymorphic SSRs identified between		
		Swarna × 166s	Swarna ×148s	166s × 148s
		RM149		
		RM3452		
		RM3480		
9	9	RM23861	-	-
		RM23736		
		RM24372		
		RM24382		
		RM24430		
		RM5526		
10	10	RM216	RM 258	RM 25262
		RM6737	RM 25262	RM 258
		RM258	RM6100	
		RM304	RM228	
		RM6100		
		RM228		
		RM 25262		
11	11	RM286	RM 206	RM 27154
		RM26249	RM 27154	RM 286
		RM26513	RM 26652	RM 26652
		RM26652	RM 26998	RM 26998
		RM206		RM 206
		RM26998		
		RM27154		
12	12	RM3747	RM 19	RM3747
		RM27564	RM 3747	
		RM247		
		RM 19		

chromosome 7. The polymorphism between Swarna and 148s was 56.81% and the highest number (13) of polymorphic markers were on chromosome 2 and the lowest number (2) of polymorphic markers were identified on chromosome 7 and 12. The per cent of polymorphism between 166s and 148s was 61.36% and the highest number (12) of polymorphic markers was on chromosome 2 and the lowest number (1) of polymorphic markers were identified on chromosome 12.

Frequency distribution of markers explained that a greater number of polymorphic markers were

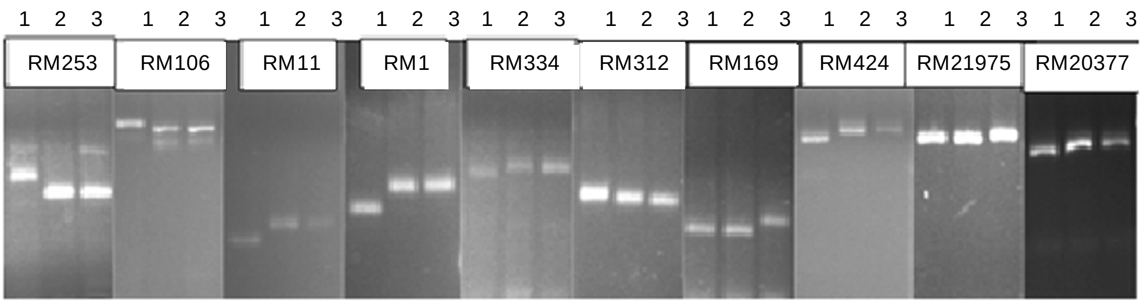

Figure 1. 10SSR markers showing polymorphism between 148s (1) Swarna (2) and 166s (3) on 1% agarose gel

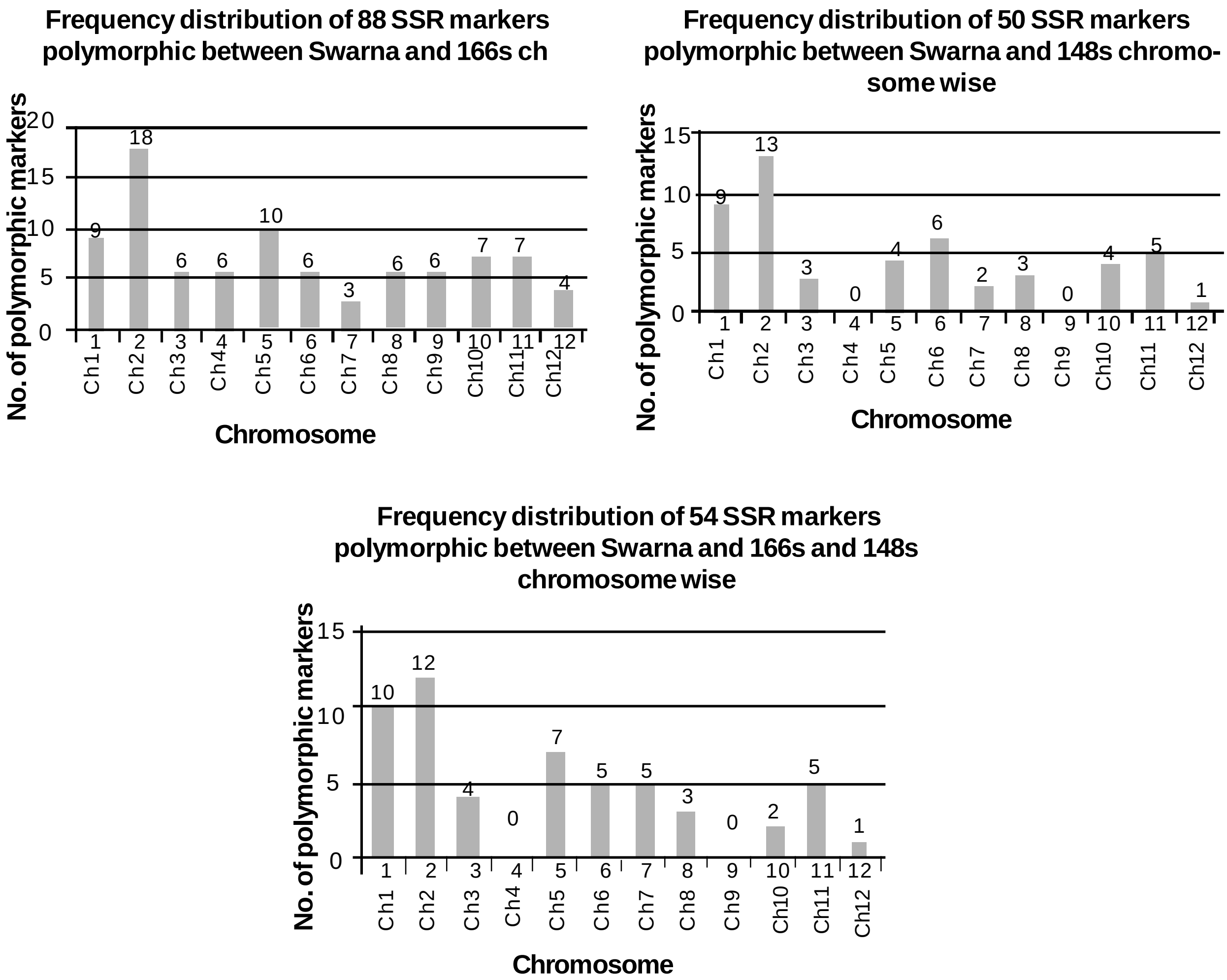

Figure 2. Frequency distribution of polymorphic markers chromosome wise in Swarna/166s, Swarna/148s and 166s/148s cosses

observed on chromosome 2 followed by chromosome 1 in all three parental combinations viz., Swarna /166s, Swarna x 148s and 166s x 148s (**Figure 2**). In case of Swarna /166s, among 88 polymorphic SSRs higher number of markers were distributed on chromosome 2 with 18 SSRs followed by 10 SSRs on chromosome 5 and 9 SSRs on chromosome 1. Chromosome 10 and 11 were observed to have 7 of polymorphic markers and chromosome 3, 4, 6, 8, 9 showed 6 polymorphic markers. Chromosome 12 was with 4 polymorphic markers followed by 3 polymorphic markers identified on chromosome 7.

Among the 50 polymorphic markers in Swarna/148s identified, 13 polymorphic markers were on chromosome 2 followed by 9 SSRs on chromosome 1, 6 SSRs on chromosome 6, 5 SSRs in chromosome 11 and chromosome 5 and 10 had 4 SSRs each, chromosome 3 and chromosome 8 with 3 SSRs, chromosome 7 with two polymorphic SSR, chromosome 12 with one SSR were found in this study. In the other set of parents 166s/148s, among all the 54 polymorphic SSRs higher number was distributed on chromosome 2 with 12 SSRs followed by chromosome 1 with 10 SSRs, chromosome 5 with 7 SSRs, chromosome 6, 7, 11 with 5 SSRs each, chromosome 3 with 4 SSRs and chromosome 8, 10, 12 distributed with polymorphic 3, 2, 1 SSRs respectively. In case of Swarna/148s and 166s/148s there was no polymorphic markers identified on chromosome 4 and 9.

Same markers were observed as polymorphic between Swarna and 148s and between 166s and 148s on chromosome 1 except RM1287 on 166s/148s. Except for RM14001 and RM13452, all the other markers showed polymorphism between Swarna and 148s on chromosome 2, along with polymorphism with 166s/148s. All the primers

Table 3. Details of polymorphic markers identified in previous studies

S.No.	Parental lines	Total no. of polymorphic markers (SSRs) identified	Polymorphic markers linked with yield traits reported previously and found polymorphic in this study	References
1.	Samba Mahsuri (BPT5204) × *Oryza rufipogon*.	149	RM5638, RM424, RM2634, RM13630, RM14303, RM232, RM206, RM11, RM3747, RM24382	Chandu *et al*., 2020
2.	Swarna × *Oryza nivara* (IRGC81832)	140	RM206, RM19, RM247, RM11, RM279, RM231, RM237, RM495	Balakrishnan *et al.,* 2020
3.	60 Rice genotypes, including 48 NPTs	66	RM154, RM489, RM6100	Donde *et al*., 2020
4.	Ali-Kazemi × Kadous	65	RM490, RM2318, RM6314, RM19	Khatibani *et al*., 2019
5.	Swarna × *O. nivara* (IRGC81832)	100	RM337, RM247	Swamy *et al*., 2018
6.	MAS25 (Aerobic rice) × IB370 (Lowland Basmati)	70	RM 154, RM424	Meena *et al*., 2018
7.	177 rice varieties	261	RM140	Liu *et al*., 2017
8.	Swarna × *O. nivara* ILs, KMR3 × *O. rufipogon* ILs, mutants of Nagina 22	49	RM489	Prasanth *et al*., 2017
9.	196 $F_{2:4}$ lines Sepidrood × Gharib (*Indica* varieties)	105	RM1, RM237, RM154	Rabiei *et al*., 2015
10.	176 RILs of Azucena × Moromutant (*O. sativa*)	26	RM152	Bekele *et al*., 2013
11.	Madhukar and Swarna	101	RM152, RM231, RM279, RM488, RM490	Anuradha *et al*., 2012

polymorphic on chromosome 5, 7 and 11 between Swarna and 148s were polymorphic between 166s and 148s also except, RM7583 on chromosome 6, RM337 on chromosome 8, RM6100 and RM228 on chromosome 10 and RM19 on chromosome 12. All other markers were polymorphic between Swarna and 148s showed polymorphism between 166s and 148s also.

Out of the nine markers on chromosome 1, showing polymorphism between Swarna and 148s, seven markers were also polymorphic between Swarna and 166s. Twelve markers on chromosome 2 and five markers on chromosome 6 were common for Swarna/148s and Swarna/166s parents. RM258, RM6100, RM228 and RM25262 on chromosome 10 and RM26652, RM206, RM26998 and RM27154 on chromosome 11, between Swarna/148s were polymorphic between Swarna/166s also.

Swamy *et al.,* 2018 identified 100 polymorphic markers between Swarna and the wild rice *O. nivara* (IRGC81832) and mapped QTLs for grain iron and zinc. They reported that RM517, RM223, RM 81A, RM256, RM264, RM287 and RM209 were polymorphic between Swarna and *O. nivara* and were also associated with grain iron and zinc QTLs. Balakrishnan *et al*., 2020 identified 140 SSRs as polymorphic among 165 SSRs for a set of 90 back cross lines at BC_2F_8 generation derived from Swarna x *Oryza nivara* (IRGC81832) and screened for yield traits and identified a set of 70 CSSLs covering 94.4% of *O. nivara* genome. Chandu *et al*., 2020 reported the SSR markers for grain iron, zinc and yield-related traits polymorphic between Samba Mahsuri (BPT5204) and a wild rice *Oryza rufipogon*. 149 SSR markers out of 750 showed polymorphism (19%). Prasanth *et al*., 2017 reported that, nine markers (RM243, RM517, RM225, RM518, RM525, RM195, RM282, RM489, and RM570) on chromosomes 1, 2, 3, 4, 6, and 8 showed associations with six yield traits under heat stress conditions.

Surapaneni *et al*., 2017 using 94 BILs of Swarna/ *Oryza nivara* (IRGC81848) mapped QTLs associated with yield and related traits and identified fifteen QTLs. BILs were genotyped using 111 polymorphic SSRs distributed across the genome. Rabiei *et al*., 2015 constructed a linkage map using 105 SSRs and 107 AFLP markers. A total of 28 QTLs were mapped for 11 traits of yield, yield component and plant morphology. Bekele *et al*., 2013 identified SSR markers associated with grain zinc concentration and other yield-related traits using 176 RIL population and reported that RM 152 was associated with days to 50 % flowering and grain yield other than grain zinc concentration. In other study in 2012 Anuradha *et al*. identified 22% polymorphism by using 101 SSRs between parents, Madhukar and Swarna.

Among the polymorphic markers identified in present study; RM1, RM11, RM19, RM140, RM152, RM154, RM206, RM231, RM232, RM237, RM247, RM279, RM337, RM424, RM488, RM489, RM490, RM495, RM2318, RM2634, RM3747, RM5638, RM6100, RM6314, RM13630, RM14303 and RM24382 were significantly associated with QTLs for grain yield and yield-related traits (Balakrishnan *et al*., 2020; Chandu *et al*., 2020; Donde *et al*., 2020; Khatibani *et al*., 2019; Swamy *et al*., 2018; Meena *et al*., 2018; Liu *et al*., 2017; Prasanth *et al*., 2017; Rabiei *et al*., 2015; Bekele *et al*., 2013; Anuradha *et al*., 2012). The previous studies in which these SSRs were polymorphic are presented in Table 3.

Daware *et al*., 2016 validated 4048 amplified SSR markers, identified 3819 (94.3%) markers to be polymorphic and generated a high-density genetic linkage map in rice using a population of IR 64 × Sonasal *ie.,* high and low grain weight accessions respectively. Donde *et al*., 2020 reported that, out of 85 SSRs screened from a study to identify QTLs associated with grain yield and related traits 66 were polymorphic (77.65%). They identified fifteen SSRs were associated with grain yield and reported RM154 and RM489 amplified more than two alleles. In the present study RM154 showed polymorphism between Swarna/166s, RM489 was polymorphic between Swarna/148s and RM6100 showed polymorphism in both Swarna/166s and Swarna/148s parents. Meena *et al*., 2018 identified QTLs related to grain yield, *qGYP2.1* was on chromosome 2 flanked between RM154 and RM424. Khatibani *et al*., 2019 evaluated 157 RILs derived from a cross between two Iranian rice cultivars Ali-Kazemi and Kadous and constructed a linkage map and out of seven QTLs, four QTLs for two traits were consistently flanked by RM23904 and RM24432 on chromosome 9. This is confirming that polymorphic markers identified in this study will be useful to tag associated QTLs for yield and related traits in the mapping populations.

CONCLUSION

The 88, 50 and 54 polymorphic markers identified between Swarna/166s, Swarna/148s and 166s/148s on the 12 chromosomes of rice are useful in mapping QTLs for yield and any related traits in the mapping populations derived from these cross combinations.

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Research Article
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EVALUATION OF BC_1F_1 PLANTS DEVELOPED BY MAS FOR BLB RESISTANCE IN RICE

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ABSTRACT

Bacterial leaf blight of rice caused by *Xanthomonas oryzae* pv. *oryzae (Xoo)* is the most destructive disease affecting the rice production worldwide. RP 5933-1-19-2 R is a high yielding genotype but susceptible to rice bacterial leaf blight. In this study, two major bacterial leaf blight (BLB) resistance genes *Xa21* and *xa13* were introgressed into RP 5933-1-19-2 R through marker-assisted backcross breeding BC_1F_1 generation during *Kharif*, 2018 to *Rabi,* 2019-20 at ICAR-IIRR, Rajendranagar. Improved Samba Mahsuri (possessing *Xa21* and *xa13*) was used as donor parent. Two PCR based functional markers pTA248 and xa13 prom were used for foreground selection to derive the improved lines for BLB. Fifteen out of the 76 BC_1F_1 plants were identified with both genes (*Xa21* and *xa13*) in heterozygous condition. On the basis of agronomic traits and resistance to BLB, three promising plants, BC_1F_1-11, BC_1F_1-16 and BC_1F_1-25 were selected for further generations.

Rice (*Oryza sativa* L.) is the most important primary source of food providing nutritional support for more than half of the world's population, of which major consumers are from tropical and subtropical Asia. It is a major cereal crop occupying second prominent position in global agriculture and its cultivation remains as a major source of employment and income in the Indian subcontinent as well as in Asian continent, especially in the rural areas (Hossain, 1997). Rice is grown in an area of 161.62 million hectares with a production of 728.06 million tones of paddy, in the world. India ranks first in the area under rice cultivation with 43.5 million hectares and stands second in production after china with an annual production of 163.52 million tonnes of paddy during 2018 (*http://ricestat.irri.org*).

However, the rice production is constrained by considerable number of diseases *i.e.,* fungal, bacterial and viral origin. Of which, bacterial leaf blight (BLB) caused by gram-negative proteo-bacterium *Xanthomonas oryzae* pv. *oryzae* (*Xoo*) which infects at maximum tillering stage results in blighting of leaves. Eventually in severely infected fields, it causes significant yield losses ranging from 20 to 30%, but this can reach as high as 80% to 100% (Baliyan *et al*., 2016; Sombunjitt *et al*., 2017) and affects photosynthetic area and reduces the yield drastically and produce partial grain filling and low quality fodder.

Chemical control for the management of BLB is not effective . Therefore, host-plant resistance offers the most effective, economical and environmentally safe option for management of BLB (Sombunjitt *et al*., 2017), several researcher have developed resistant cultivars using available resistance genes against bacterial leaf blight disease. To date, approximately 45 resistance (R) genes conferring resistance against BLB have been identified using diverse rice sources (Neelam *et al*., 2020).

Pyramiding entails stacking multiple genes leading to the simultaneous expression of more than one gene in a variety to develop durable resistance expression. Gene pyramiding is difficult using conventional breeding methods due to the dominance and epistasis effects of genes governing disease resistance, particularly in the case of recessively inherited resistance genes such as *xa5* and *xa13*. These limitations can be overcomed by marker assisted selection (MAS) which enables the evaluation of the expression status of resistance genes.

However, the availability of molecular markers closely linked with each of the resistance genes makes

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the identification of plants with several disease resistance genes.

MATERIAL AND METHODS

Plant material and breeding procedure

RP 5933-1-19-2 R derived from the cross Swarna*1/IBL57 (Samba Mahsuri/SC5 126-3-2-4) is a high yielding genotype with medium duration and short bold grain but susceptible to bacterial blight. It was used as a recurrent parent and Improved Samba Mahsuri carrying *Xa21* and *xa13* genes was used as a donor parent. The recurrent parent as female was crossed with the donor parent as male to generate F_1 at ICAR-Indian Institute of Rice Research (IIRR), Hyderabad during *Kharif*, 2018. After confirming the hybridity of the plants, true heterozygous plants were backcrossed with the recurrent parent, RP 5933-1-19-2 R and the BC_1F_1 seeds were produced during *Kharif*, 2019. After carrying out the foreground selection and strict phenotypic selection for recurrent parent type, plants with the target allele and desirable phenotype were selected. BC_1F_1 plants with both gene combination (*Xa21* and *xa13*) along with morphological similarity to recurrent parent were selected. The superior introgressed plants were evaluated for agronomic performance along with RP 5933-1-19-2 R during *Rabi,* 2019-20.

In this study, for BLB resistance genes, a functional marker *xa13* prom in case of *xa13* gene and a closely linked marker pTA248 in case of *Xa21* gene were used. The functional marker *xa13* prom was designed from promoter region of *xa13* gene (Zhang *et al*., 1996) and it was more accurate than earlier RG136, a CAPS marker which was reported to be ~1.5 cM away from *xa13* gene (Aruna Kumari *and* Durga Rani 2015). Ronald *et al*., 1992 had reported the tagging and mapping of the major and dominant BLB resistance gene *Xa21* with tightly linked PCR based marker pTA248 with a genetic distance of ~0.1cM.The details of the gene based marker, its linkage group and the allele size of the marker that was observed during the validation process are presented in the Table 1.

The fresh, healthy and young leaf tissue from 50-60 days old seedlings was collected and stored at -80ºC until used for DNA extraction. The extraction of plant genomic DNA was carried out by using CTAB (Cetyl-Tri Methyl Ammonium Bromide) method as described by Murray and Thompson (1980). The genomic DNA was extracted from individual plants in F_1 and BC_1F_1 generations along with the recurrent and donor parents..

PCR assay was performed for foreground selection using gene based marker. The 2 µl of diluted template DNA of each genotype was dispensed at the bottom of 96 well PCR plates (AXYGEN/TARSON) to which 8 µl of PCR master mix was added. Separately cocktails were prepared in an eppendorf tubes.

PCR reaction mixture contained 40 ng template DNA , 10× PCR buffer (10 mM Tris-HCl pH 8.3, 50 mM KCl), 1.5 mM MgCl2, 0.2 mM each dNTPs, 5 pmol of each forward and reverse primer, 1 U *Taq* DNA polymerase in a reaction volume of 10 µL (Table 2). PCR profile starts with initial denaturation at 94ºC for 5 min followed by 35 cycles of following parameters: 30 seconds at 94ºC denaturation, 30 seconds of annealing at 55ºC and 1 min extension at 72ºC, final extension of 7 min at 72ºC. The amplified products of pTA 248 and *xa13* prom (*Xa21* and *xa13*genes) markers were electrophoretically resolved on 1.5 % agarose gel (Lonza, Rockland, USA).

BC_1F_1 plants possessing two gene combinations coupled with bacterial leaf blight resistance were selected for agro- morphological evaluation along with recipient parent RP 5933-1-19-2-R. The phenotypic data was recorded during *Rabi*, 2019-20 at ICAR- IIRR, Rajendranagar (Table.2). Agronomic traits days to flowering, plant height (cm), number of productive tillers per plant, panicle length (cm), number of filled grains per panicle, grain yield per plant (g) and 1000-grain weight (g) were recorded.

RESULTS AND DISCUSSION

Marker-assisted introgression of *Xa21* and *xa13* into RP 5933-1-19-2 R

Out of 40 F_1 plants obtained from the cross RP 5933-1-19-2 R x Improved Samba Mahsuri, a total of 10 plants were identified to possess *Xa21* and *xa13* genes in heterozygous condition using the molecular markers *viz*., pTA248 and *xa13* prom. Hence, these plants were considered as true heterozygotes and were tagged before flowering and ten plants were back crossed with the recurrent parent, RP 5933-1-

19-2 R to generate BC_1F_1 seeds. The backcross was attempted using F_1 plants as a male parent and the recurrent parent, RP 5933-1-19-2 R as female parent. Fifteen out of the 76 BC_1F_1 plants were identified to posses both genes (*Xa 21*, *xa13*) in heterozygous condition (Figure 1 and 2) with morphological similarity to recurrent parent RP 5933-1-19-2 R. These 15 plants were tagged in the field for further agronomic evaluation.

In the previous studies, Pradhan *et al*. (2015) reported that only 14 plants showed the presence of three BLB resistance genes *Xa21, xa13* and *xa5* out of 360 BC_1F_1 plants. Sundaram *et al*. (2008) reported that 11 out of 145 BC_1F_1 plants were found to be triple heterozygotes for the 'R' (Resistance) gene linked markers.

Table 1. Molecular markers used for foreground selection of genes governing bacterial leaf blight resistance

S.No	Gene	Marker	Chr	Amplicon size (bp)	Reference
1	*Xa21*	pTA248	11	950	Huang *et al.*, (1997)
2	*xa13*	Xa13prom	8	490	Hajira *et al.*, 2016

Table 2. PCR mix for one reaction (Volume 10µl)

Reagent	Concentration	Quantity
Template DNA	40 ng/ µl	2.0 µl
PCR Master mix (Taq DNA polymerase, dNTPs, $MgCl_2$, optimized buffer, gel loading dye (green), and a density reagent)	-	5.0 µl
Forward primer	10 µM	0.5 µl
Reverse primer	10 µM	0.5 µl
Sterile water	-	2.0 µl
Total volume		**10 µl**

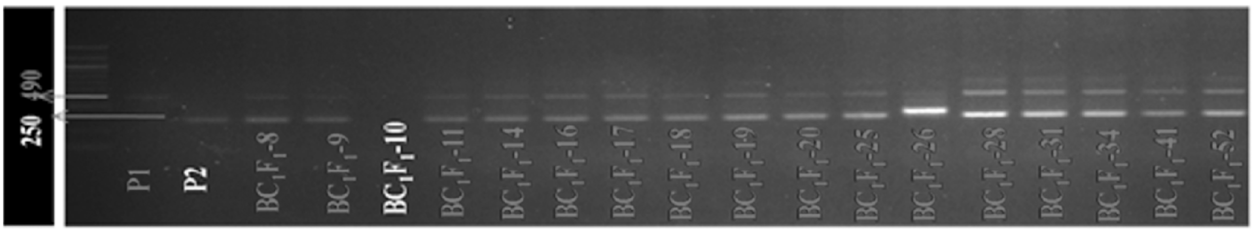

Fig 1: Screening of the BC_1F_1 plants for *xa13* gene by using xa13 prom marker (L: 100bp ladder; P1: Improved Samba Mahsuri; P2: RP 5933-1-19-2 R; BC_1F_1s)

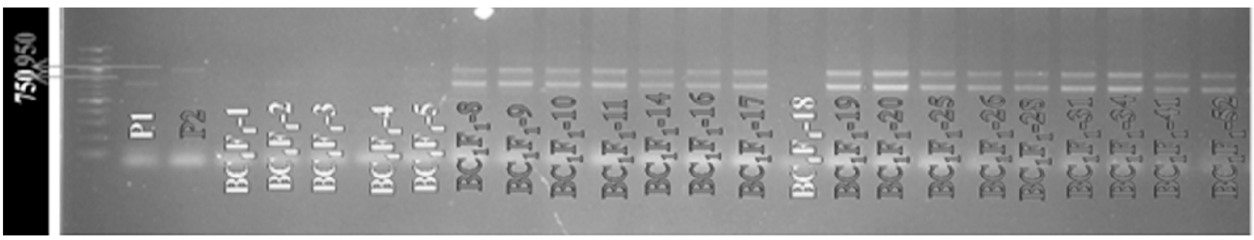

Fig 2: Screening of the BC_1F_1 plants for *Xa21* gene by using pTA248 marker (L: 100bp ladder; P1: RP 5933-1-19-2 R; P2: Improved Samba Mahsuri; BC_1F_1s)

Since, the markers used for foreground selection in the present study viz., *Xa21* and *xa13* were based on genes itself, there was hardly any chance of recombination between gene and marker. Therefore, the efficacy of foreground selection was very high.

Evaluation of the Introgressed Plants for Yield and Agro-Morphological Characters

All the BC_1F_1 plants along with the recurrent parent, RP 5933-1-19-2 R were raised in the field during *rabi* 2019-20. After carrying out foreground selection in the BC_1F_1 population, the Bacterial leaf blight resistant plants were selected for evaluation of yield and agro-morphological characters along with recipient parent RP 5933-1-19-2-R (Table 3).

The plant BC_1F_1-28 flowered early (94 days) followed by BC_1F_1-31 (95 days), BC_1F_1-14 (95 days) and BC_1F_1-26 (97 days). The plant *viz*., BC_1F_1- 8, (112 days), BC_1F_1-34, BC_1F_1-45 (110 days) and BC_1F_1-16 (107 days) were found flowering late compared to the recurrent parent RP 5933-1-19-2 R which flowered in 104 days. The height of plants BC_1F_1-45 (85 cm), BC_1F_1-26 (87 cm), BC_1F_1-19 (87.5 cm) and BC_1F_1-31(88 cm) were dwarf while the genotypes BC_1F_1-14 (99.50 cm) and BC_1F_1-8 (96.50 cm) and BC_1F_1-28 (96.30 cm) were found tall among fifteen plants as compared to the recurrent parent. The BC_1F_1 -11, BC_1F_1-25, BC_1F_1-34 and BC_1F_1-17 genotypes were similar to the recurrent parent.

Productive tillers of plants BC_1F_1-26 (7), BC_1F_1-14 (8), BC_1F_1-45 (9), BC_1F_1-9 (10) and BC_1F_1-31(10) were lower to the recurrent parent. The plant BC_1F_1-25 showed high number of productive tillers (16) followed by BC_1F_1-17 with 15 productive tillers. The plants BC_1F_1-28 (25.50 cm) and BC_1F_1-45 (24.50 cm) were found to be exhibiting high values for the panicle length whereas BC_1F_1-20 (21.50 cm) followed by BC_1F_1-16 (21.80 cm), BC_1F_1-25 (22.30 cm) and BC_1F_1-14 (22.30 cm) showed lowest value for panicle length. The parental line RP 5933-1-19-2 R exhibited the value of 23.5 cm for panicle length.

The parental line RP 5933-1-19-2 R exhibited the average value of 165 filled grains per panicle. The plants BC_1F_1-41 (213), BC_1F_1-34 (205), BC_1F_1-8 (202) and BC_1F_1-17 (187) exhibited high values, whereas BC_1F_1-20 (140), BC_1F_1-26 (145), BC_1F_1-19 (150) and BC_1F_1-31 (157) recorded low number of filled grains. The genotypes BC_1F_1-41 (49.98 g), BC_1F_1-34 (44.29 g), BC_1F_1-17 (39.2 g) and BC_1F_1-28 (35.55 g) have recorded high grain yield per plant, while BC_1F_1-20 showed low grain yield of 17.67 g followed by BC_1F_1-26 (19.86), BC_1F_1-45 (21.33 g), and BC_1F_1-31 (23.83 g). The parental line RP 5933-1-19-2 R exhibited 30.30 g of grain yield per plant. The genotypes BC_1F_1-41 (22.98 g), BC_1F_1-34 (23.72 g) and BC_1F_1 -17 (21.8) recorded high values for the seed weight while BC_1F_1-45 (12.33g) followed by BC_1F_1-20 (15.67 g) and BC_1F_1-14 (15.69 g) showed low 1000 seed weight. The 1000 seed weight recorded for the recurrent parent RP 5933-1-19-2 R was (1.96g).

From the above results, it was observed that five backcross derived BC_1F_1 plants *viz*., BC_1F_1-11, BC_1F_1-28, BC_1F_1-16, BC_1F_1-17 and BC_1F_1-25 showed improved performance over the recurrent parent with respect to yield per plant (g). Among these, two genotypes viz., BC_1F_1-41 (49.98 g) and BC_1F_1-34 (44.29 g) exhibited significant yield increase over the recurrent parent RP 5933-1-19-2 R (30.3 g). It has been also observed that in addition to the grain yield per plant, these genotypes showed improvement in other major yield attributing traits also like number of filled grains per panicle and 1000 seed weight. The increase in yield performance was brought about by the increase in panicle length, number of filled grains per panicle and 1000 seed weight.

The backcross derived lines performing better than and on par with the recurrent parent, implying that these lines could significantly give better yields under natural disease stress also. These lines can be further backcrossed with the recurrent parent coupled with selfing to recover its maximum genome background and attain homozygosity, which could be used as improved version of RP 5933-1-19-2 R for Bacterial leaf blight.

Sundaram *et al*., (2008) reported that the yield levels of the three-gene pyramid lines were not significantly different from those of Samba Mahsuri indicating that there is no apparent yield penalty associated with presence of the resistance genes.

Pradhan *et al*., (2015) revealed that yield and agro-morphologic data of 20 pyramided two parental lines that pyramided lines possessed excellent features of recurrent parent and also yielding ability with tolerance to bacterial blight resistance. Few of the pyramid lines are very close to the recurrent parent and some are even better than the recurrent parent with respect to yield.

Table 3. Mean agronomic performance of BC_1F_1 plants with *Xa21* and *xa13* genes

S.NO.	DF	PH (cm)	PL (cm)	No TPP	NGPP	1000 (g)	GYP (g)
RP-5933-1-19-2R	104	93.40	23.50	14.00	165.0	19.6	30.3
BC_1F_1-8	112	96.50	23.80	12.00	202.0	16.82	26.92
BC_1F_1-9	99	94.50	22.50	10.00	178.0	19.07	30.05
BC_1F_1-11	105	93.50	22.50	14.00	185.0	20.58	32.58
BC_1F_1-14	95	99.50	22.30	8.00	165.0	15.69	27.19
BC_1F1-16	107	92.50	21.80	13.00	177.0	19.14	32.24
BC_1F_1-17	106	93.70	23.50	15.00	187.0	21.8	39.2
BC_1F_1-19	102	87.50	22.50	11.00	150.0	16.66	27.62
BC_1F_1-20	103	89.00	21.50	13.00	140.0	15.67	17.67
BC_1F_1-25	104	94.00	22.30	16.00	175.0	21.07	31.69
BC_1F_1-26	97	87.00	23.60	7.00	145.0	17.86	19.86
BC_1F_1-28	94	96.30	25.50	14.00	185.0	20.5	35.55
BC_1F_1-31	95	88.00	22.50	10.00	157.0	18.83	23.83
BC_1F_1-34	110	93.50	23.50	13.00	205.0	23.75	44.29
BC_1F_1-41	102	92.50	22.50	14.00	213.0	24.98	49.98
BC_1F_1-45	110	85.00	24.50	9.00	164.0	12.33	21.33
Mean	102.73	92.09	22.99	11.93	175.20	18.98	30.67
Minimum	94	85.00	21.50	7.00	145.0	12.33	17.67
Maximum	112	96.50	24.50	16.00	213	24.98	49.98

Note: DF=Days to flowering**, PH=**Plant height**, PL=**Panicle length**, No TPP =**No of tillers per plant**, NGPP=**No of grains per panicle**, 1000g=** 1000 seed weight**, GYP=**Grain yield per plant.

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Research Article
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PROFILE OF THE FARMERS UNDER MISSION KAKATIYA PROGRAMME IN TELANGANA STATE

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ABSTRACT

A study was conducted to know the profile of the farmers under Mission Kakatiya programme. Telangana state was selected purposively, two districts (Karimnagar and Kamareddy) from Northern Telangana zone, Mahabubnagar and Nalgonda from Southern Telangana zone and Siddipet and Badradri Kotthagudem from Central Telanganaa zone) were selected purposively from each zone. From each district two tanks (one from beneficiary village and one from non-beneficiary village) were selected. A total of 360 (180 beneficiary farmers and 180 non-beneficiary farmers) farmers from 12 tanks were considered as sample for the study. Profile characteristics *viz.* age, education, farm size, farming experience, extension contact, information seeking behavior, mass media exposure, empathy, socio – politico participation, scientific orientation, economic motivation, achievement motivation and extent of participation in tank irrigation management were selected for the study. Experimental research design was followed. Majority of the beneficiary farmers belonged to categories of middle age (55.00%), primary school education (40.56%), Small farm size (38.34%), medium level of farming experience (50.00%), extension contact (45.56%), information seeking behaviour (51.67%), mass media exposure (48.33%), empathy (42.78%), socio-politico-participation(49.44%), scientific orientation (54.44%), economic orientation(47.78%), achievement motivation (43.89%) and Extent of participation in tank irrigation management(53.33%). With respect to non – beneficiaries, majority of the farmers belonged to categories of middle age (52.78%), primary school education (35.56%), small farm size (43.89%), medium level of farming experience (44.44%), extension contact (50.00%), information seeking behaviour (44.45%), mass media exposure (45.56%), socio-politico-participation (45.56%), scientific orientation (43.89%), economic orientation (43.33%) and achievement motivation(38.88%) and low level of empathy (45.00%) and extent of participation in tank irrigation management(43.33%).

The Government of Telangana has initiated restoration of Minor Irrigation Tanks, which have been the life line of Telangana people, since ages and are now becoming extinct slowly mainly due to neglect of their maintenance and partly due to rapid urbanization. In the state, every village has a tank and tanks from ages are still functioning. Tanks, apart from irrigation, also serve recharging of ground water, meeting the requirement of domestic water needs and livestock and for rearing fish. Tanks are helpful in maintaining ecological balance apart from being centres for socio-economic and religious activities of the village communities. Tanks play an important role in providing assured water supply and prevent to a greater extent the adverse effects on agriculture on account of vagaries of nature and ensure food security in drought prone areas. The Minor Irrigation tanks in the state have lost their original capacity due to ageing and siltation. The Government of Telangana realising the importance of reclamation of tanks for growth in the state, decided to take up restoration of these tanks under "Mission Kakatiya" programme as a peoples movement in a decentralised manner through community involvement in a sustainable manner. All the 46,531 tanks are proposed to be restorated, at the rate of 9350 per year, in a span of 5 years starting from 2014 – 15 onwards.

The objective of Mission Kakatiya is to enhance the development of agriculture based income for small and marginal farmers, by accelerating the development of minor irrigation infrastructure, strengthening community based irrigation management and adopting a comprehensive programme for restoration of tanks. Mission Kakatiya would have the benefits like increase in water retention capacity of the soil, capacity of the tank, yield and productivity of farms through suitable cropping pattern and increased cropping intensity. No study has been conducted to know the profile characteristics of farmers under Misssion Kakatiya programme. The profile characteristics of respondents will influence the impact of Mission Kakatiya programme interms of benefits

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accrued to the respondent farmers. Hence, the present study was conducted with an objective to know the profile characteristics of farmers under Mission Kakatiya Programme.

MATERIAL AND METHODS

An experimental research design was adopted for the study. Telangana was selected purposely for the study, as the Mission kakatiya programme is being implemented in the state. From each region, two districts were selected based on the highest number of tanks covered in the first phase of Mission Kakatiya programme. Accordingly, Karimanagar and Kamareddy from Northern Telangana Zone; Mahabubnagar and Nalgonda from Southern Telangana Zone and Siddipet and Badradri Kothagudem from Central Telangana Zone were selected. From each district one mandal was selected, from each mandal one beneficiary village and one non-beneficiary village was selected and from each village thirty farmers were randomly selected. Thus, a total of, six districts, six mandals, twelve villages (6 – beneficiary and 6 – non-beneficiary villages) and three hundred and sixty farmers (180 beneficiary and 180 non – beneficiary farmers) were considered as the sample for the study. The profile characteristics *viz* age, education, farm size, farming experience, extension contact, information seeking behavior, mass media exposure, empathy, socio – politico participation, scientific orientation, economic orientation, achievement motivation and extent of participation in tank irrigation management were selected for the study.

RESULTS AND DISCUSSION

Profile characteristics of farmers under Mission Kakatiya programme

It was found that majority (55.00%) of the beneficiary group respondents belonged to middle age followed by young (31.67%) and old (13.33%) age. Whereas, majority (52.78%) of the non-beneficiary group respondents were middle aged followed by young (36.11%) and old (11.11%) aged. Usually, farmers of middle aged are enthusiastic having more responsibility and are more efficient than the younger and older ones. This might be the important reason to find that majority of the respondents belonged to middle age group, are active in performing agricultural practices. This result was in accordance with the results of Sharma *et al.* (2012) Prashanth *et al.* (2016).

Table : Distribution of respondents according to their profile characteristics

S.No.	Profile character	Category	Beneficiaries group (n=180)		Non-beneficiaries group (n=180)	
			Frequency	Percentage	Frequency	Percentage
1.	Age	Young age (up to 35)	57	31.67	65	36.11
		Middle age (36-55)	99	55.00	95	52.78
		Old age (>55)	24	13.33	20	11.11
2.	Education	Illiterate	24	13.33	43	23.89
		Primary School	73	40.56	64	35.56
		High school	43	23.89	34	18.89
		Intermediate	19	10.56	15	8.33
		Under graduate	13	7.22	18	10.00
		Post graduation and above	8	4.44	6	3.33
3.	Farm size	Marginal	41	22.78	76	42.22
		Small	69	38.34	79	43.89
		Semi-medium	53	29.45	19	10.56
		Medium	16	8.88	6	3.33
		Large	1	0.55	0	0

S.No.	Profile character	Category	Beneficiaries group (n=180)		Non-beneficiaries group (n=180)	
			Frequency	Percentage	Frequency	Percentage
4.	Farming Experience	High	33	18.33	27	15.00
		Medium	90	50.00	80	44.44
		Low	57	31.67	73	40.56
5.	Extension contact	High	52	28.89	11	6.11
		Medium	82	45.56	90	50.00
		Low	46	25.55	79	43.89
6.	Information seeking behavior	High	48	26.67	29	16.11
		Medium	93	51.67	80	44.45
		Low	39	21.66	71	39.44
7.	Mass media exposure	High	50	27.78	39	21.66
		Medium	87	48.33	82	45.56
		Low	43	23.89	59	32.78
8.	Empathy	High	56	31.11	46	25.56
		Medium	77	42.78	53	29.44
		Low	47	26.11	81	45.00
9.	Socio-Political Participation	High	36	20.00	49	27.22
		Medium	89	49.44	82	45.56
		Low	55	30.56	49	27.22
10.	Scientific Orientation	High	50	27.78	32	17.78
		Medium	98	54.44	79	43.89
		Low	32	17.78	69	38.33
11.	Economic Orientation	High	52	28.89	38	21.11
		Medium	86	47.78	78	43.33
		Low	42	23.33	64	35.56
12.	Achievement Motivation	High	48	26.67	55	30.56
		Medium	79	43.89	70	38.88
		Low	53	29.44	55	30.56
13.	Extent of participation in tank irrigation management	High	43	23.89	27	15.00
		Medium	96	53.33	75	41.67
		Low	41	22.78	78	43.33

Majority of the beneficiary group respondents were educated up to primary school level (40.56%) followed by high school (23.89%), illiterate (13.33%), intermediate (10.56%), under graduate (7.22%) and post graduation (4.44%) whereas, majority of the non-beneficiary group respondents were educated upto primary school level (35.56%) followed by illiterate (23.89%), high school (18.89%), under graduate (10.00%), intermediate (8.33%) and post graduation (3.33%).The probable reasons might be due to the facilities available for education in the study areas were up to primary school only and might be the illiteracy of their parents and non – realization of importance of formal education. This result was in accordance with the results of Swetha (2010) and Prashanth *et al.* (2016).

Majority (38.34%) of the beneficiary farmers had small farm size followed by semi medium (29.45%), marginal (22.78%), medium (8.88%) and large farmers (0.55%). Whereas, majority (43.89%) of the non-beneficiary farmers had small farm size followed by marginal (42.22%), semi medium (10.56%), medium (3.33%) and zero percent of large farmers. The probable reason for this may be due to the fact that the division of joint families kept on occurring from time to time resulting in the fragmentation of land. This result was in accordance with the results of Swetha (2010) Vinaya Kumar *et al.* (2015).

Majority (50.00%) of the beneficiary group respondents had medium farming experience followed by low (31.67%) and high farming experience (18.33%). On the other hand, majority of the non-beneficiary group respondents (44.44%) had medium farming experience followed by low (40.56%) and high farming experience (15.00%). The probable reason might be that as majority of the farmers belong to middle age group and also there was less awareness among the farming community about the education which made them to enter into farming after completing their education. This result was in accordance with the results of Prashanth *et al.* (2016).

Majority (45.56%) of the beneficiary group respondents had medium level of extension contact followed by high (28.89%) and low level of extension contact (25.55%) whereas, majority of the non-beneficiary group respondents had (50.00%) medium level of extension contact followed by low (43.89%) and high level of extension contact (6.11%). The probable reason for the above trend might be that, respondents had regular contact with officials of department of agriculture and line departments for information. This finding was in accordance with the findings Vinaya Kumar *et al.* (2015).

Majority (51.67%) of the beneficiary group respondents had medium information seeking behaviour followed by high (26.67%) and low (21.66%). Whereas, majority (44.45%) of the non-beneficiary group respondents had medium level of information seeking behaviour followed by low (39.44%) and high (16.11%). The probable reason might be due to majority of respondents high dependence on informal sources followed by formal sources. This finding was in accordance with the findings of Neelima (2005).

Majority (48.33%) of the beneficiary group respondents had medium mass media exposure followed by high (27.78%) and low (23.89%). Whereas, majority (45.56%) of the non-beneficiary group respondents had medium level of mass media exposure followed by low (32.78%) and high (21.66%). The probable reason for this trend might be due to the fact that, majority of farmers are middle aged and were educated up to primary school and had inclination towards better utilization of different mass media such as Television and news papers. This finding was in accordance with the findings of Swetha (2010) and Mohan and Reddy (2012).

Majority (42.78%) of the beneficiary group respondents fell under medium empathy category followed by high (31.11%) and low (26.11%) empathy category. Whereas, majority (45.00%) of the non-beneficiary group respondents had low empathy followed by medium (29.44) and low (25.56%) empathy. This trend might be due to the reason that all the villagers who are coming under tank irrigation had small size land holdings under the jurisdiction of one tank ayacut. Farmers co-operating each other in all the aspects as a community and helping each other equally sharing the available water. This result was in accordance with the results of Mohan and Reddy (2012) and Prashanth *et al.* (2016). The low level of empathy among the non-beneficiary respondents could be attributed to the absence common sharing of resources and lack of team spirit among the farmers.

Majority (49.44%) of the beneficiary group respondents had medium socio-political participation followed by low (30.56%) and high participation (20.00%). Whereas, majority (45.56%) of the non-beneficiary group respondents had medium level of socio-political participation followed by an equal percentage (27.22%) of low and high level of socio-political participation. This might be because of limited number of social organizations in the villages and lack of awareness about the advantages of becoming member. This result was in accordance with the results of Swetha (2010) and Mohan and Reddy (2012).

Majority (54.44%) of the beneficiary group respondents had medium scientific orientation followed by high (27.78%) and low (17.78%). Incase of non-beneficiary group, majority of the respondents had medium (43.89%) scientific orientation followed by low (38.33%) and high (17.78%). The probable reason for this trend was remoteness of the villages, lack of higher education, medium level of socio-political participation, extension contact and information seeking behaviour. This result was in accordance with the results of Vinaya kumar (2012) and Prashanth *et al.* (2016).

Majority (47.78%) of the beneficiary group respondents had medium economic orientation followed by high (28.89%) and low (23.33%). In case of non-beneficiary group, majority of the respondents had medium (43.33%) scientific orientation followed by low (35.56%) and high (21.11%). The probable reason for this trend could be majority of the farmers were small and marginal with limited land holding. Another reason attributed was lack of proper attention towards economic goals and most of the farmers usually were satisfied with whatever income they get. This result was in accordance with the results of Roy (2005) and Mohan and Reddy (2012).

Majority (43.89%) of the beneficiary group respondents had medium achievement motivation followed by low (29.44%) and high (26.67%). Whereas, majority of the non-beneficiary respondents had medium (38.88%) achievement motivation followed by an equal percentage (30.56%) of high and low level of achievement motivation. Motivating the inner drive of farmers would be helpful in reaching the goals set by themselves. This result was in accordance with the results of Ashoka (2012).

Majority (53.33%) of the beneficiary group respondents had medium level of extent of participation in tank irrigation management followed by high (23.89%) and low (22.78%). This might be due to the restoration of irrigation tanks improved the water level in tanks and it motivates the farmers for cultivation. Whereas, majority (43.33%) of the non-beneficiary group respondents had low level of extent of participation in tank irrigation management followed by medium (41.67%) and high (15.00%). This result was in accordance with the results of Goudappa *et al.* (2012).

CONCLUSION

Majority of the beneficiary farmers were of middle aged, had primary school education, small land holdings, medium experienced in farming and possessed medium level of extension contact, information seeking behaviour, mass media exposure, empathy, socio-politico-participation, scientific orientation, economic orientation, achievement motivation and extent of participation in tank irrigation management. With respect to non – beneficiaries, majority of them were also middle aged, had primary school education, small land holdings, medium experienced in farming and possessed medium level of extension contact, information seeking behaviour, mass media exposure, socio-politico-participation, scientific orientation, economic orientation and achievement motivation and low level of empathy and extent of participation in tank irrigation management. This shows there is a greater need to increase the literacy levels by providing functional literacy programmes along with developing awareness among the farmers on importance of extension contact and mass media exposure in transfer of technology. There is every need to improve the profile of the respondents to make them to understand completely the intricacies of Mission Kakatiya programme to get benefited by it.

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Research Article
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INTEGRATED FARMING SYSTEM – FARMERS PERCEPTION IN TELANGANA

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ABSTRACT

The present study was conducted to find out and analyze the benefits of IFS obtained by the farmers. An exploratory research design was adopted for the study during 2017-19. The total sample size was 180 IFS farmers. Data was collected through well-structured interview schedule. The results of the study revealed that increased input use efficiency (100.00%) and maintenance of soil fertility (96.67%) ranked top among the farm benefits while increased productivity of agriculture and allied enterprises (86.67) and year round income generation (83.33 %) ranked top among the personal benefits. Increased productivity of agriculture and allied enterprises (86.67 %), year round income generation (86.67 %) and decreased cost of cultivation (80%) topped among the economic benefits. Reduction in waste material from different farm outputs (83.33 %) topped among environmental benefits and less risk of failure of crops and allied enterprises (80 %) topped among the complimentary benefits.

Indian agriculture is affected directly by the vagaries of monsoon and majority of small and marginal farmers are dependent on agriculture as a major source of livelihood. The population of the country is estimated to go up to 1530 million by 2030 (Census of India, 2011) with food grains requirement of 345 million tonnes (GOI, 2009; Jahagirdar and Subrat Kumar Nanda, 2017). The imbalanced use of fertilizer, nutrient deficiency and deterioration of soil health resulted in low agricultural productivity and demanded a paradigm shift to diversified farming.

The fragmentation of operational farm holding, marginal decline in family size of small holders would further reduce availability of manpower in agriculture (Gangwar *et al.,* 2014). The sustainability and profitability of existing farming systems especially in marginal and small households now has a paramount importance with a new technology generation without deteriorating resources. This can be accomplished only through Integrated Farming System which is a reliable way of obtaining high productivity by way of effective recycling of organic residues/wastes etc. obtained through the integration of various land-based enterprises (Vision, 2050). IFS also generates employment, maintains ecological balance and optimizes utilization of all resources resulting in maximization of productivity and doubling farmers income. Therefore considering the importance of Integrated Farming System, the study was undertaken with the objective "to enlist the perceived benefits of farmers obtained through IFS in Telangana State".

MATERIAL AND METHODS

An exploratory research design was used in the present investigation. The districts Mahaboobnagar, Nalgonda, Warangal, Karimnagar, Nizamabad and Khammam were selected based on highest gross sown area and livestock population of the district (Directorate of Economics and Statistics, 2016). Three (3) mandals were selected from each selected district thus making a total of 18 mandals. Two (2) villages were selected from each selected mandal thus making a total of 36 villages. From each selected village five (5) IFS farmers were chosen thus making a total sample of 180 respondents. Purposive sampling method was followed while selection of respondents. Data was collected using a pre-tested interview schedule and percentage analysis was performed for interpreting data. The data was analysed using appropriate statistical tools like frequency and percentage.

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RESULTS AND DISCUSSION

Perceived benefits of Integrated Farming System as expressed by the farmers

Farmers are availing many benefits while practicing IFS. The benefits obtained by IFS farmers were categorized into 5 divisions *viz.,* farm benefits, personal benefits, economic benefits, environmental benefits and complimentary benefits. Distribution of respondents according to benefits obtained through IFS is shown in Table 1.

Table 1. Distribution of IFS farmers according to their perceived benefits

(n=180)

S.No.	Perceived benefits	Frequency	Percent	Rank
I.	**Farm benefits**			
1.	Increased input use efficiency	180	100.00	I
2.	Weed control by optimum utilization of land	126	70.00	IV
3.	High rate of farm resource recycling	90	50.00	V
4.	Solves fuel and timber crisis	72	40.00	VI
5.	Meeting fodder crisis	132	73.33	III
6.	Efficient utilization of Crop residues through resource recycling	132	73.33	III
7.	Maintenance of Soil fertility	174	96.67	II
II.	**Personal benefits**			
8.	Knowledge gain on different farm enterprises	156	86.67	I
9.	Maintenance of multiple enterprises through timely information from officials on different farm enterprises	96	53.33	IV
10.	Provision for balanced food	102	56.67	III
11.	Achieving nutritional security	150	83.33	II
III.	**Economic benefits**			
12.	Increased productivity of agriculture and allied enterprises	156	86.67	I
13.	Better economic condition of farmers	108	60.00	VI
14.	Year round income generation	156	86.67	I
15.	Increased returns over a period of time	132	73.33	III
16.	Decreased cost of cultivation	144	80.00	II
17.	Energy saving	96	53.33	VIII
18.	Increase in economic yield per unit area	120	66.67	V
19.	Higher net returns	120	66.67	V
20.	High B:C ratio	102	56.67	VII
21.	Reduction of inputs purchase from outside agency	126	70.00	IV
22.	Reduced input cost through Government subsidy	96	53.33	VIII

S.No.	Perceived benefits	Frequency	Percent	Rank
IV.	**Environmental benefits**			
23.	Reduction in waste material from different farm outputs	150	83.33	I
24.	Low usage of pesticides helps to protect the environment	144	80.00	II
V.	**Complimentary benefits**			
25.	Reduction in unemployment and poverty	126	70.00	III
26.	Increased employment opportunities in rural areas	138	76.67	II
27.	Less risk of failure of crops and allied enterprises	144	80.00	I

Farm benefits

It is evident from the table 1 that, farm benefits obtained by the respondents with adoption of IFS is increased input use efficiency (Rank I) followed by maintenance of soil fertility (Rank II), meets fodder crisis (Rank III), efficient utilization of crop residues through resource recycling (Rank III), weed control by optimum utilization of land (Rank IV), high rate of farm resource recycling (Rank V) and solves fuel and timber crisis (Rank VI).

Increased input use efficiency ranked first among the farm benefits and the probable reason associated is utilisation of farm waste from one enterprise as an input to other enterprise, which leads to increased input use efficiency.

Second rank was given to maintenance of soil fertility. The possible reason was IFS farmers used organic inputs such as cow dung, FYM, vermi-compost and biofertilizer for maintaining soil fertility. In addition, practices like growing green manure crops, adoption of crop rotation, recycling the animal wastes also helped the respondents in reducing the external input usage and increasing the value of nutrient content thereby maintaining the soil fertility.

Meeting fodder crisis ranked third, as IFS farmers cultivated fodder crops along the farm bunds and used it along with available straw in the field as input recycling to meet fodder crisis.

Fourth rank was given to efficient utilisation of crop residues through resource recycling by incorporation of previous crop residues into soil while ploughing and utilisation of the crop residue as mulch to control weeds, as feed to animals and for other household purposes.

Personal benefits

The personal benefits obtained by respondents were knowledge gain on different farm enterprises (Rank I) followed by achieving nutritional security (Rank II), provision for balanced food (Rank III) and maintenance of multiple enterprises through timely information from officials on different farm enterprises (Rank IV).

First rank was given to knowledge gain on different farm enterprises. The possible reason was respondents were provided information on different enterprises through frequent contact with extension officials and participating in training programmes and demonstrations.

Achieving nutritional security ranked second. The probable reason was that the bi-products obtained from multiple enterprises added in their daily diet has helped them to enhance the nutrition levels of the respondent family members. The decreased application of chemicals and fertilizers also helped in increasing the nutrient content and there by the quality of food consumed.

Third rank was given to provision of balanced food. The balanced food could be obtained from multiple enterprises maintained by the respondents which helped them to gain different nutrients *viz.*, carbohydrates, proteins, starch, minerals, vitamins.

Fourth rank was given to maintenance of multiple enterprises through timely information from officials on different farm enterprises. The possible reason might be that respondents had frequently contacted Agriculture Officers and KVK scientists to gain necessary information on different enterprises.

Economic benefits

Economic benefits obtained by respondents were increased productivity of agriculture and allied enterprises (Rank I) year round income generation (Rank I), followed by decreased cost of cultivation (Rank II), increased returns over a period of time (Rank III), reduction of inputs purchase from outside agency (Rank IV), increased economic yield per unit area (Rank V), higher net returns (Rank V), better economic condition of the farmers (Rank VI), higher B:C ratio (Rank VII), Energy saving (Rank VIII) and reduced input cost through government subsidy (Rank VIII).

The first rank was given to increased productivity of agriculture and allied enterprises and year round income generation. The increased productivity can be attributed to reduced weed intensity by adoption of cropping systems resulting in increased productivity of crops. Further respondents followed INM and IPM practices which has helped in increasing the productivity of different enterprises.

The second rank was given to decreased cost of cultivation. The complementary combinations of farm enterprises and mutual use of the products and by-products of farm enterprises as inputs helped in reduced cost of cultivation.

Increased returns over a period of time ranked third as efficient utilization of resources reduced the cost of cultivation and input recycling from one enterprise to another enterprise provided flow of money among the respondent throughout the year.

The fourth rank was given to reduction of inputs purchase from outside agency. The possible reason might be that the respondents were able to reduce external input usage by following resource recycling with their own material at farm level which enabled them to increase the net income of the farm as a whole.

Findings are inline with results of channabasavanna *et.al* (2009) and Ugwumba *et.al* (2010) and Tarai *et.al* (2016).

Environmental benefits

Environmental benefits obtained by respondents were reduction in waste material from different farm outputs (Rank I) and low usage of pesticides helped to protect the environment (Rank II).

Reduction in waste material from different farm outputs ranked first among the environmental benefits which can be attributed to input recycling which inturn reduced the waste material from different farm outputs. It is considered as an environmentally safe practice as recycling of on-farm inputs reduced contamination of soil, water and environment.

Complementary benefits

Complementary benefits obtained by IFS farmers were less risk of failure of crops and allied enterprises (Rank I), increased employment opportunities in rural areas (Rank II) and reduction in unemployment and poverty (Rank III).

The first rank was given to less risk of failure of crops and allied enterprises. The possible reason might be that respondents were fully aware of new technologies in farming and gained income from one or the other enterprises by maintaining multiple enterprises thereby risk from failure of crops reduced.

Increased employment opportunities in rural areas ranked second. The possible reason might be that small and marginal farmers by adopting different enterprises could increase employment opportunities. Combining crop enterprises with livestock increased the labour requirement hence providing employment to rural people.

Third rank was given to reduction in unemployment and poverty. The may be due to the engagement of more labour in multiple enterprises by adoption of IFS by small, marginal and large farmers.

Findings are inline with results of Sanjeev kumar *et.al* (2012).

CONCLUSION

The farmers realized personal, economic, environmental and complementary benefits through Integrated Farming System, hence it is one of the best approach to resolve the problems of small and marginal farmers of Telangana state. Therefore, there is a need to reduce technological gap at field level by creating awareness on IFS among farming community through strong linkage between Extension officials from the department of agriculture and allied sectors.

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STATUS AND PROSPECTS OF *KRISHI VIGYAN KENDRA* ACTIVITIES IN SOUTHERN INDIA

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Krishi Vigyan Kendra's (KVKs) are established at district level in each state of India under Indian Council of Agricultural Research (ICAR), New Delhi with a vision of KVKs vital role in transfer of the scientific technologies to the farming community. Technology assessment and demonstration for its application, out scaling of farm innovations through On Farm Testing (OFTs), Front Line Demonstrations (FLDs) and Capacity building are the main mandate of the KVKs and they also act as 'Knowledge and Resource center' with the allied activities like Kisan Mobile Advisory Service (KMAS), Laboratory Service, Farm literature and multimedia content development, Production of quality technological inputs and other value added products for the benefit of the farmers. Understanding the importance and need of these activities in present days, the study was conducted from the year 2011-12 to 2018-19 with an objective to analyze the status and prospects of KVK activities which render timely and need based services to the farmers.

Bimal (2016) reported that KVKs conducted a total of 549 OFTs, 546 FLDs and 4,793 trainings for farmers from the year 2007-2008 to 2011-2012. Along with the mandated activities, due to advancement of technologies, the farmers were reached timely with need based situation specific information. Stephane (2017) rightly pointed that the mobile phones have the potential to deliver the timely advisories to farmers and bring change in the farming sector of rural areas. The KVKs also update farmers about their activities in the social media platforms like WhatsApp, Facebook and KVK websites. The multimedia content developed and shared among the farmers can be revisited by farmers and get contact with KVKs for detailed information on the technologies. In recent years, to sustain agriculture and to obtain quality oriented higher production, the Ministry of Agriculture and Farmers' Welfare, Government of India emphasized the importance of soil testing through "Soil Health Card" scheme nationwide (PIB, 2020). This was based on the national project on 'Management of Soil health and Fertility' launched in the year 2008-2009 (Reddy, 2017). The extension functionaries at the grass root were given the responsibility to create awareness among farmers about the importance of soil testing and make sure that each farmer have tested the soil to know the status of soil for suitable crop cultivation. Being, grass root extension institute, KVKs also provide service of soil and water testing and this helps the farmers to get the soil and water sample tests conducted along with the expert advice on suitable crop and nutrient management practices. In addition to lab services, the KVKs are also involved in income generating activities with the production of quality technological inputs and value added products needed by farmers. The generated income from the sale of these products considered as revolving fund will be further used for the development of KVK and help them to sustain their activities and manage their expenses independently. Kumar (2018) mentioned that a revolving fund of Rs.8.0 lakh was earned by KVK through sale of inputs like planting materials, bio fertilizers and also with the development of publications. These activities drive the KVKs for being a knowledge and resource center along with their transfer of technology activities in the district.

The study was conducted with a sample of 13 KVKs in Southern India covering five states (Andhra Pradesh, Karnataka, Kerala, Tamil Nadu, and Telangana and one Union Territory (Puducherry) under ATARI Zone X (Hyderabad) and ATARI Zone XI

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(Bengaluru) with the pre consent of ATARI Directors, Host Organizations and KVKs. The study was conducted during 2017-2018 to 2019-2020 and the data on activities were collected from KVKs for a period of last eight years (2011-2012 to 2018-2019). This helped the researcher to analyze the trend of selected activities of KVKs and comprehend its status and prospects of service for the farming community. The results were analyzed based on frequency and percentage and the trend of the selected activities was assessed using growth rate formula:

$$\text{Growth rate} = \frac{(R - B)}{B} \times 100$$

Where, R: the value of recent year; B: the value of base year.

The Growth rate indicates the contribution of the selected activities of KVK from 2011-2012 to 2018-2019 for the farmers in the jurisdiction of sampled KVKs in Southern India.

The results of mandated activities presented in table 1 revealed that the sampled KVKs have conducted a total of 744 OFTs, 1,395 FLDs and 12,487 number of trainings from the year 2011-12 to 2018-19. It was observed that the OFTs has increased by 35.87 percent but the growth rate of FLDs and trainings over the years reduced by 2.09 percent and 16.40 percent. The FLDs and training activities decreased compared to 2011-2012 till the year 2014-15 but later years the number of FLD and training activities found to have increased. The variation in number of activities over the years may be due to several changes in the policy reforms, diversification in activities at institutional level and increased workload of activities other than mandated activities on KVKs.

Table 1. Cumulative number of mandated activities of KVK from 2011-2012 to 2018-2019

n=13

Year	No. of OFTs	Percent (%)	No. of FLDs	Percent (%)	No. of trainings	Percent (%)
2011-2012	92	12.37	191	13.69	1543	12.36
2012-2013	78	10.48	178	12.76	1889	15.13
2013-2014	85	11.42	169	12.11	1728	13.84
2014-2015	81	10.89	172	12.33	1215	9.73
2015-2016	96	12.90	162	11.61	1453	11.64
2016-2017	85	11.42	168	12.04	2085	16.70
2017-2018	102	13.71	168	12.04	1284	10.28
2018-2019	125	16.80	187	13.41	1290	10.33
Total	744	100	1395	100.00	12487	100.00
Growth rate	35.87 percent		-2.09 percent		-16.40 percent	

Table 2. Cumulative number of Kisan Mobile Advisory Services by KVKs (2011-2012 to 2018-2019)

n=13

Year	Number of SMS sent	Percent (%)	Number of farmers covered	Percent (%)
2011-12	1328	8.47	137501	1.84
2012-13	1220	7.78	69593	0.93
2013-14	1645	10.50	122668	1.64
2014-15	3199	20.41	166685	2.23
2015-16	2367	15.10	1070951	14.31
2016-17	1969	12.56	1791305	23.94
2017-18	1865	11.90	2064459	27.59
2018-19	2080	13.27	2059843	27.53
Total	15673	100.00	7483005	100.00
Growth rate (%)	56.63 percent			

The results of Kisan mobile advisory service provided by KVKs presented in table 2. The KVKs provide specific advisory services to farmers through voice and text messages in local language. It was observed that the growth rate of advisory service activities has increased by 56.53 percent and the trend of farmers covered under Kisan mobile advisory during last eight years found to be increased from 1.84 percent (2011-2012) to 27.53 percent (2018-2019). There was tremendous increase in the service provided and farmers covered by the KVKs compared to base year (2011-2012). But, the utility of these advisory services at the field level is still a matter of concern as it is a one way communication from KVK. There is a need for the follow up of the information sent via advisory services by conducting studies on effectiveness and extent of utilization of the advisories given by KVKs.

In addition to advisory service, the KVK also develop farm literatures and multimedia content for precise reach of technological information to the farmers. The results in table 3 indicate that the KVKs develop farm literatures in the form of research papers, technical reports, popular articles (English and local language), training manual, extension literatures, books, and posters.

Table 3. Growth rate in Farm Literature developed by KVKs from 2011-2012 to 2018-2019

n=13

Farm Literature	**2018-19**	**2017-18**	**2016-17**	**2015-16**	**2014-15**	**2013-14**	**2012-13**	**2011-12**
Research papers	69	56	53	10	25	42	32	30
Technical reports	16	00	09	15	17	15	20	44
Technical bulletins	25	12	13	13	10	08	08	08
Popular articles (English)	19	01	35	04	05	48	50	09
Popular articles (Regional)	73	60	64	32	54	78	34	95
Training manual	19	11	10	13	01	04	08	03
Extension literature (leaflets, folders, booklets)	41	39	53	90	57	103	91	76
Book	19	14	19	04	03	05	03	10
Others (Posters)	32	32	27	24	09	53	23	49
Total	313	225	283	205	181	356	269	324
Growth rate (%)	**-3.40**							

In the year 2018-2019, an increase in publication of the farm literatures was observed but when it is considered for last eight years (2011-2012 to 2018-2019), the farm literatures have reduced by 3.40 percent. This might be due to the time constraint, work load and more reporting works of KVKs. The decline in the printed form of extension literatures for farmers might be due to the increased usage of social media by farmers and extension personnel where the information is provided in the form of voice and text messages, videos and information related to extension activities, technologies, inputs availability are pre intimated to farmers in WhatsApp groups, Facebook page and their websites.

The outreach of KVK activities were also available to farmers in the form of multimedia access (figure 1) where it was found that all the sampled KVKs had Facebook accounts (100%) and they were active in updating their activities in the home page. The technological information was also observed to reach the farmers in the form of radio and TV programmes in collaboration with TV/Radio channels from experts of sampled KVKs. With advancement of social media applications like WhatsApp, more than 90 percent of KVKs have encashed this opportunity to reach the farmers by forming groups in WhatsApp as KVK being the administrator. In addition to these, more than half of the KVKs maintained functional websites to timely communication and showcase their activities. The successful technological information were posted in the websites in the form of videos and around 54 percent of KVKs also developed CD/DVDs about the technologies like 'Process of mushroom cultivation', 'Value addition from Minor Millets', etc., for detailed

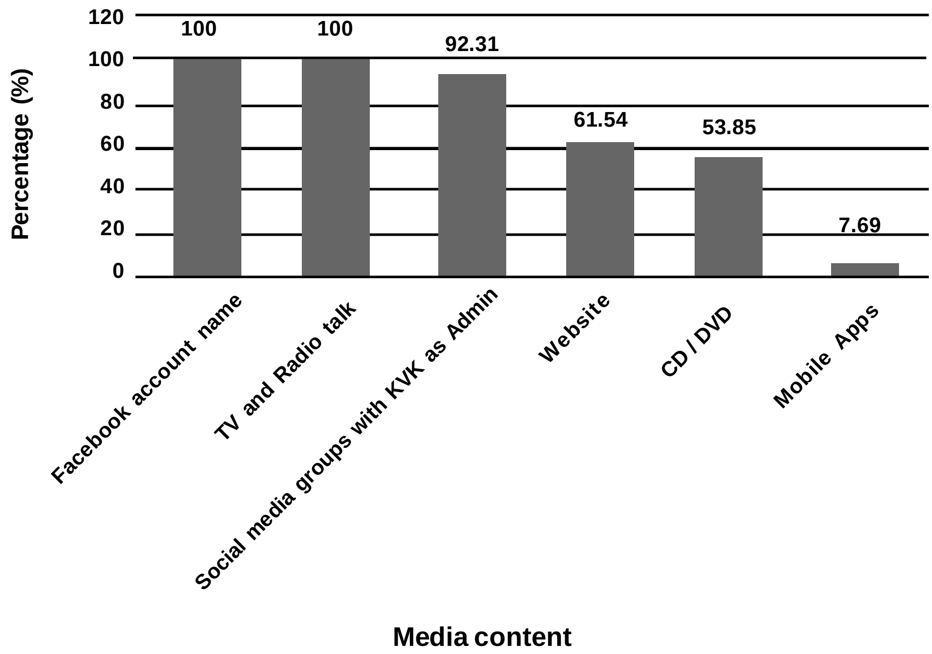

Fig 1. Distribution of KVKs based on Multi-media content development (n=13)

reference by the farmers from KVKs. To make the advisory services easily accessible by KVK clients (Farmers/rural youth/farm women/extension functionaries and other stakeholders), certain KVKs like KVK Amadalavalasa of Andhra Pradesh state, has taken initiative in development of mobile app called '*Krishi Vigyan'* for the farmers to take timely decision in agriculture and horticulture crop cultivation.

The KVKs also found to provide laboratory services to the farmers to know the status and quality of soil and water of their farm/fields by conducting soil and water testing in their well-established Soil water testing laboratory or using mini soil testing kit. This helps the farmers to grow suitable crops based on the soil and water test reports.

The results in table 4 inform us that, the sample testing at KVKs conducted in three different modes where 61.54 percent of sample test conducted in soil water testing laboratory followed by 23.08 percent conducted using mini-soil testing kit (who has no laboratory/ has non-functional laboratory) and 15.38 percent conducted in both the modes. It was also found that nearly one quarter of soil testing laboratory facilities at KVKs were found to be non-functional.

Table 4. Mode of sample testing conducted by KVKs in the year 2018-2019

n=13

Mode of sample testing	Frequency (F)	Percent (%)	Status of mode of sample testing			
			Functional	Percent (%)	Non-functional	Percent (%)
Soil water testing laboratory (SWTL)	08	61.54	07	87.50	01	12.5
Mini soil testing kit	03	23.08	02	66.67	01	33.33
SWTL + Mini soil testing kit	02	15.38	01	50.00	01	50.00
Total	13	100.00	10	76.92	03	23.08

Table 5. Cumulative number of sample testing conducted by KVKs

n=13

Year	No. of samples* analyzed	Percent (%)	No. of farmers benefitted	Percent (%)	No. of villages	Percent (%)
2011-12	11674	15.70	9607	14.76	1676	9.42
2012-13	8265	11.12	7172	11.02	2018	11.32
2013-14	10061	13.53	9199	14.14	2442	13.70
2014-15	10143	13.64	8699	13.37	3397	19.06
2015-16	9599	12.91	8412	12.93	2329	13.07
2016-17	9659	12.99	8502	13.07	2454	13.77
2017-18	8343	11.22	7997	12.29	2046	11.48
2018-19	6599	8.88	5485	8.43	1457	8.18
Total	74343	100.00	65073	100.00	17819	100.00
Growth rate (%)	-43.47 percent		-42.91 percent		-13.07 percent	

* Note: Samples include soil, water, and plant testing conducted by KVKs

Results in table 5 represent that, the sample testing service at KVKs was reduced by 43.47 percentage over the last eight years. Therefore, the number of farmers benefitted and villages covered also reduced over a period of time. The status of non-functional labs, dependence on only mini soil testing kits could be one of the reasons for the KVKs to have decreased status of sample testing from the base year (2011-2012). In this fast growing competitive era, it is highly needed for the KVKs to sustain the effectiveness of its services in the district. For sustenance, it is need for the KVKs to think of income generating activities to address their minor problems experienced in day to day activities in addition to the hardcore support from the ICAR and host organizations. So, they have to generate revenue with the efficient utilization of resources with them.

The results in table 6 provide information on income generating activities by KVKs in the year 2018-2019. The names of the KVKs were not revealed due to anonymity reason. The results revealed that the KVKs have involved in production of need based inputs and value added products for the benefit of farmers in their respective region. The income generated from the sale of those products were effectively utilized for the development of KVK. It was observed that the sampled KVKs supported farmers with the total production of 9,871.27 quintal seed, 20,32,788 number of planting material, 1,49,234 kg of bio products like azolla, trichoderma, banana special, mango special and others, 8,320 litres of milk 2,20,135 number of fingerlings and fishes and 6,338.82 kg of value added products like cookies, papads, pickles, cakes, malt powders etc.,.

In addition, the other activities like apiary, mushroom cultivation, handicrafts were also started in few KVKs. The gross returns generated is given in table 7 where the amount adds upto a total of Rs. 359 lakhs. The KVKs were ranked based on the gross income generated in rupees in lakhs, and it depends mainly on the demand and market price of the products they developed. The income generated depends on the location of KVK, demand for the product and also based on the quantity produced. It also depends on the resources available with KVKs. But, this activity has good contribution towards the revolving fund concept of KVKs to make them financially self-reliant. The results are in line with ICAR (2019) and Kumar (2018).

Table 6. Production of inputs and value added products from KVK n=13

KVK	Seed production (q)	Planting material (No.)	Bio-Products (kg)	Livestock Production (No.)	Fishery production (No.)	Value added products (kg)
KVK 1	91.08	24805	54.00	1998	30	Nil
KVK 2	2.14	156864	7956.00	5954	Nil	Nil
KVK 3	Nil	Nil	4000.00	Nil	Nil	Nil
KVK 4	164.45	Nil	339.00	Nil	Nil	Nil
KVK 5	6830.00	204473	51904.80	Nil	Nil	Nil
KVK 6	338.95	3135	3293.50	04	Nil	258.00
KVK 7	512.64	175675	2400.00	Nil	Nil	Nil
KVK 8	243.76	6000	1524.39	Nil	Nil	Nil
KVK 9	349.00	29381	153.39	Nil	Nil	Nil
KVK 10	721.25	8000	58967.00	12	175000	Nil
KVK 11	73.55	8910	Nil	227	Nil	Nil
KVK 12	2.65	1245337	132.18	Nil	Nil	2933.00
KVK 13	541.80	170208	18509.50	125	45105	3147.82
Total	**9871.27**	**2032788**	**149234.00**	**8320**	**220135**	**6338.82**

Table 7. Gross returns from income generating activities of sampled KVKs n=13

KVK	SP	PM	BP	LP	FP	VAP	Others	Gross income (Rs. in lakhs)	Rank
KVK 1	3.07	0.73	0.05	2.00	0.03	Nil	Nil	5.88	X
KVK 2	0.71	9.16	3.09	7.88	Nil	Nil	Nil	20.84	VII
KVK 3	Nil	Nil	0.20	Nil	Nil	Nil	0.41	0.61	XIII
KVK 4	2.91	Nil	1.22	Nil	Nil	Nil	Nil	4.12	XI
KVK 5	2.73	24.99	38.56	Nil	Nil	Nil	1.60	67.88	II
KVK 6	33.21	1.41	0.67	0.21	Nil	0.11	Nil	35.60	IV
KVK 7	59.25	0.69	0.05	Nil	Nil	Nil	Nil	59.98	III
KVK 8	4.07	0.03	14.36	Nil	Nil	1.50	0.81	16.70	VIII
KVK 9	7.33	0.91	24.46	Nil	Nil	Nil	0.10	32.80	V
KVK 10	14.65	2.40	4.25	.92	2.01	Nil	Nil	24.23	VI
KVK 11	0.90	1.80	.00	.18	Nil	Nil	Nil	2.89	XII
KVK 12	0.30	12.45	1.70	Nil	Nil	.30	Nil	14.74	IX
KVK 13	17.10	15.33	28.49	3.42	.75	7.57	Nil	72.66	I
Total	142.15	69.90	117.09	14.60	2.79	9.47	2.92	358.92	

SP: Seed production, PM: Plant materials, BP: Bio products, LP: Livestock production, FP: Fisheries production, VAP: Value Added Products. The values in table measured in lakhs.

The results and discussion above indicate that the activities of KVK has contribution towards agriculture and allied sectors with significant supply of technology and scientific information to the farmers through OFT, FLD, training, advisory services, farm literatures, social media and other activities. In addition, they are also in line to bring change in the farmers with the recommended practices of cultivation based on the soil, water sample test reports.

They are also taking up income generating activities which support the farmers with supply of suitable location specific need based inputs and value added products and inturn helping the KVK to generate income for its development. These activities can be made unique, efficient and appealing than the already prevailing one in the region with the collaboration of other extension functionaries in the district.

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EFFECT OF PLANT GEOMETRIES ON YIELD AND QUALITY COMPONENTS OF QUINOA LEAVES (*Chenopodium quinoa*) UNDER SOUTHERN TELANGANA

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Quinoa (*Chenopodium quinoa* Willd.) belongs to the group of crops known as pseudo cereals (Cusack, 1984; Kozoil, 1993) and to the Amaranthaceae family Quinoa is one of the oldest crops in the Andean region, with approximately 7000 years of cultivation, and great cultures such as the Incas and Tiahuanaco have participated in its domestication and conservation (Jacobsen, 2003). Quinoa was first botanically described in 1778 as a species native to South America, whose center of origin is in the Andean of Bolivia and Peru. Recently, it has been introduced in Europe, North America, Asia and Africa (FAO, 2011). The year 2013 has been declared "The International Year of the Quinoa" (IYQ) by the United Nations. This crop is a natural food resource with high nutritive value and is becoming a high quality food for health and food security, for present and future human generations.

Quinoa leaves contain a high amount of ash (3.3%), fibre (1.9%), vitamin E (2.9 mg ±-TE/100 g), Na (289 mg/100 g), nitrates (0.4%), vitamin C (1.2–2.3 g kg^{-1}) and 27–30 g kg^{-1} of proteins (Bhargava *et al.* 2006). The total amount of phenolic acids in leaves varied from 16.80 to 59.70 mg per 100 g and the proportion of soluble phenolic acids varied from 7% to 61%; which was low compared with cereals like wheat and rye, but was similar to levels found in oat, barley, corn and rice (Repo Carrasco *et al.* 2010).

There is no research work on adaptability and standardization of package of practices of Quinoa as a leafy vegetable under Southern Telangana conditions. Hence, an experiment is proposed to standardize the plant geometries to asses yield of quinoa as a leafy vegetable .

The experiment was conducted at Horticulture garden, Rajendranagar, Hyderabad during *rabi* 2016-17 laid out in Randomized Block Design (RBD) with four treatments and five replications. The gross plot area is 2.56 m^2 and net plot area is one m^2 Fertilizers are applied in the form of urea, single super phosphate and murate of potash at required doses i.e. 50:50:50 kg NPK ha^{-1}. Urea was applied @ 50 kg ha^{-1} in 3 dose after first, second and third cuttings respectively. Phosphorous and potassium were applied initially at the time of sowing. Quinoa seed was sown in lines at different row spacings. Irrigation was given immediately after sowing and then at 4 days interval. Weeding was done manually at 30 DAS to keep the crop free from weeds. Harvesting was started at 30 DAS and subsequent cuttings were done at 15 days interval.

The weekly mean, maximum and minimum temperature during crop growth period was 29.5 ºC and 11.8 ºC respectively with an average temperature of 20.65 ºC. The average sunshine hours recorded was 8.0 hrs day^{-1} during crop growth period. In the present study, the crop was harvested at 30, 45, 60 and 75 days after sowing. The crude protein and crude fiber content was calculated using AOAC (2005) and AOAC (1990) whereas vitamin C and carotenoid content were analyzed using Sadasivam (1987) and Zakaria (1979) respectively. Statistical analysis was done (Panse and Sukhatame,1978) according to Randomized Block Design using Indostat software program.

The effect of crop geometries on total yield per hectare was found to be significant. The highest leaf yield was recorded in closer spacing S_1 (64.70 t ha^{-1}) and lowest was recorded in S_4 (22.94 t ha^{-1}) at all plant growth stages respectively (Table 1). Earlier, Jamriska *et al.* (2002) and Parvin *et al.* (2009) reported maximum green leaf yield at closer spacing at all stages

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of harvest due to accommodation of more number of plants per unit area. Decreased plant population due to increase in spacing resulted in highest yield per plant but it did not compensate total yield which was further supported by Peiretti *et al.* (1998) in amaranthus.

Vitamin C content was significantly influenced by different crop geometries. Highest vitamin C content (93.05 and 97.86 mg 100 g^{-1}) was recorded at closer spacing S_1 (15×10 cm) and lowest was recorded in S_4 (45×10 cm) (86.93 and 92.53 mg 100 g^{-1}). Significantly highest carotenoid content (442.3 and 630.8 mg kg^{-1}) was recorded in closer spacing S_1 (15×10 cm) and lowest (346 and 396.6 mg kg^{-1}) was recorded in wider spacing of S_4 (45×10 cm) at 30 and 60 days after sowing respectively (Table-2). Shukla *et al*. (2006) reported that ascorbic acid increased with successive cuttings and then showed decline in Amaranthus. Bhargava *et al.* (2007) reported a decrease in the carotenoid content as the row-to-row spacing was increased. Rapid increase in carotenoid content was recorded after first harvest (45 DAS) followed by second (60 DAS) and third harvest (75 DAS) and decreased in fourth cutting in Quinoa at Lucknow.

Highest crude protein (21.44 and 29.66 percent) was recorded in wider spacing and lowest (13.78 and 24.5 percent) in closer spacing at 30 and 60 DAS respectively(Table-3). Yasin *et al.* (2003) reported that higher protein content was recorded in closer spacing in Amaranthus but found contradictory to findings of Bhargava et al. (2007) that closer spacing results in more protein content than wider spacing whereas Modhvadia et al.(2007) reported that there was no significant effect of spacing on protein content in Amaranthus.

Crude fiber content was highest (7.86 and 14.22 percent) in wider spacing and lowest in closer spacing (4.98 and 11.64 percent) at 30 and 60 DAS respectively (Table-3). Shukla *et al.* (2006) reported that fibre content increased with successive cuttings and then showed decline in amaranthus.

Table 1. Effect of crop geometries on Yield and Total yield of quinoa at different stages of crop growth

Treatments	Yield (kg m^{-2})				Total Yield (t ha^{-1})
Crop geometry	**30 DAS**	**45 DAS**	**60 DAS**	**75 DAS**	
S_1(15×10 cm)	7.54	6.41	6.44	5.47	64.70
S_2(25×10 cm)	5.41	4.65	4.64	3.63	45.91
S_3(35×10 cm)	3.58	3.25	2.84	1.93	29.07
S_4(45×10 cm)	2.90	2.65	2.19	1.42	22.94
Mean	4.86	4.24	4.03	3.11	40.65
S.E±	0.11	0.12	0.12	0.16	1.16
C.D at 5%	0.36	0.39	0.37	0.50	3.597

Table 2. Effect of crop geometries on Vitamin 'C' and Carotenoid content of quinoa at different stages of crop growth

Treatments	Vitamin 'C' (mg 100 g^{-1})		Total carotenoids (mg kg^{-1})	
Crop geometry	**30 DAS**	**60 DAS**	**30 DAS**	**60 DAS**
S_1 (15×10 cm)	93.05	97.86	442.30	630.80
S_2 (25×10 cm)	90.93	97.33	392.80	558.30
S_3 (35×10 cm)	89.20	93.06	376.20	465.50
S_4 (45×10 cm)	86.93	92.53	346.00	396.60
Mean	91.02	95.19	389.39	512.84
S.E±	0.55	0.41	0.41	1.07
C.D at 5%	1.72	1.28	1.26	3.30

Table 3. Effect of crop geometries on Crude protein and Crude fiber content of quinoa at different stages of crop growth

Treatments	Crude Protein content (%)		Crude Fiber content (%)	
Crop geometry	30 DAS	60 DAS	30 DAS	60 DAS
S_1 (15×10 cm)	13.78	24.50	4.98	11.64
S_2 (25×10 cm)	15.40	26.38	6.28	11.96
S_3 (35×10 cm)	18.00	29.38	7.46	12.48
S_4 (45×10 cm)	21.44	29.66	7.86	14.22
Mean	17.15	27.48	6.64	12.57
S.E±	0.22	0.42	0.06	0.11
C.D at 5%	0.69	1.32	0.20	0.36

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CAPSICUM (*Capsicum annuum var. grossum L.*) RESPONSE TO DIFFERENT N AND K FERTIGATION LEVELS ON YIELD, YIELD ATTRIBUTES AND WATER PRODUCTIVITY UNDER POLY HOUSE

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Capsicum (*Capsicum annuum* var.*grossum* L.) also referred to as sweet or bell pepper is a highly priced vegetable crop both in the domestic and international market. It is a cool season crop occupying an area of 32 thousand hectares, producing 493 thousand metric tonnes in India. In Telangana it occupies an area of 150.2 ha, with 2873 metric tonnes production (Telangana State Horticulture Mission, 2018-19). The major capsicum producing states in India are Himachal Pradesh, Karnataka, Madhya Pradesh, Haryana, Jharkhand, Uttarakhand and Orissa. Capsicum is a member of Solanaceae family, native to tropical South America and was introduced in India by the Portuguese in the middle of sixteenth century.

Fertigation is an essential component of pressurized irrigation. It is a process in which fertilizers are applied with water directly into the root zone of the crop in which leaching and percolation losses are less with efficient use of fertilizers and water. Fertilizers can be applied as and when necessary and with every rotation of water depending upon crop need. The past research conducted shows that by means of fertigation it is possible to save fertilizers up to 25 percent (Kale, 1995).

The poly house is a system of controlled environment agriculture (CEA), with a precise control of air, temperature, humidity, light, carbon dioxide, water and plant nutrition. The inside environment (microclimate) of a poly house is controlled by growth factors such as light, temperature, humidity and carbon dioxide concentration. They are scientifically controlled to an optimum level throughout the cultivation period, thereby increasing the productivity by several folds. Poly house also permits to cultivate four to five crops in a year with efficient use of various inputs like water, fertilizer, seeds and plant protection chemicals. In addition, automation of irrigation, precise application of other inputs and environmental controls by using computers and artificial intelligence is possible for acclimatization of tissue culture plants and high value crops in poly house. The use of drip-fertigation in the poly house, not only saves water and fertilizer, but also gives better yield and quality by precise application of inputs in the root zone (Papadopoulos, 1992).

A field experiment was conducted at Horticultural Farm, College of Agriculture, Rajendranagar, Hyderabad during *rabi* season of 2019-20. The study was initiated on response of capsicum (*Capsicum annuum* var. *grossum* L.) to different nitrogen and potassium fertigation levels under poly house.The soil of the experimental site was sandy loam in texture with a pH of 7.6, electrical conductivity of 0.75 dS m^{-1}, medium in organic carbon (0.7%), low in available nitrogen (166.5 kg ha^{-1}), medium in available phosphorus (81.1 kg P_2O_5 ha^{-1}) and low in available potassium (245.4 kg K_2O ha^{-1}).

Capsicum (pasarella) seeds were sown in pro trays on 5th August 2019 and 35 days old seedlings were transplanted on 10th September 2019 in a zig zag manner in a paired row pattern on raised beds. The experiment comprised of three replications in Factorial Randomized Block Design (FRBD) with two factors {*i.e.* N levels (4), K levels (3) } with twelve treatments *viz*; T_1- Control (No N, K_2O), T_2 - N_0 (No fertilizer) + 80% RD of K_2O, T_3 - N_0 (No fertilizer) + 100% RD of K_2O, T_4 -120% RD of N + K_0 (No fertilizer), T_5 - 120% RD of N + 80% RD of K_2O, T_6 - 120% RD of N + 100% RD of K_2O, T_7 - 150% RD of N + K_0 (No fertilizer), T_8 -150% RD of N + 80% RD of K2O, T_9 - 150% RD of N + 100% RD of K_2O, T_{10} - 180% RD of

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N + K_0 (No fertilizer), T_{11} - 180% RD of N + 80% RD of K_2O, T_{12}- 180% RD of N + 100% RD of K_2O. {The 100 % (RDF) was 180, 90 and 120 kg N, P_2O_5 and K_2O ha^{-1}}The source of N is urea, P was single super phosphate (SSP) and K was white muriate of potash (MOP). A common dose of phosphorous was applied uniformly to all the treatments at basal.

The nitrogen and potassium were applied through fertigation by ventury (Table no.1) which was carried out at three day interval i.e., on every fourth day. In the fertigation programme during crop establishment stage (10 DAT to 14 DAT), 10 % of N and K_2O were applied in two splits. During vegetative stage, (15 to 46 DAT) 30 % of N and 20 % of K_2O were applied in eight splits. During flower initiation to fruit development (47 DAT to 74 DAT) 20 % of N and K_2O were applied in seven splits. From fruit development and colour formation stage onwards till final stage (75 DAT – 154 DAT) 40 % of N and 50 % K_2O were applied in 20 splits. Then the fertigation schedule was completed in a total of 37 splits. In addition, the crop had received a common dose of 12.5 t ha^{-1} vermicompost and 1.5 t ha^{-1} neem cake and 90 kg P_2O_5 ha and also waste decomposer, vermi wash sprays at every 15 days interval. Irrigation was scheduled based on 0.8 E pan and the total water applied through drip at 0.8 E pan (common to all the treatments) was 384.8 mm, water applied for nursery including special operations (bed preparation, wetting before transplanting) was 30.4 mm.The total water applied was 414.8 mm.The weight of mature fruits harvested from each picking was recorded till final harvest and total yield of fruits per hectare was computed and expressed in kg and tons per hectare.

The data regarding yield attributes *viz.*, mean fruit length (cm), mean fruit width (cm), total number of fruits $plant^{-1}$ and average fruit weight (g) are presented in Table 2. Fruit length, fruit width and average fruit weight is a mean data of first, third and fifth picking.

Among the different nitrogen doses the highest mean fruit length was recorded with N_{180} (10.08 cm) which was on par with N_{150} (9.99 cm) and superior over N_{120} (9.09 cm), N_0 (8.51 cm). However N_0 (8.51 cm) recorded the lowest mean fruit length. With regard to different potassium doses significantly highest mean fruit length was recorded with K_{100} (10.13 cm) compared to K_{80} and K_0. However K_{80} (9.16 cm) and K_0 (8.96 cm) were on par with each other.There was 18.4, 17.4, 6.8 % increase in mean fruit length in $N_{180,}$ N_{150} and N_{120} over N_0, While 13, 2.3 % increase was observed in K_{100} and K_{80} respectively over K_0.

The increase in length of the fruit in poly house condition was higher, this may be due to better microclimatic condition favouring deposition of more assimilates and thereby resulting in increse a fruit lenth. This finding is in conformity with the findings of Nanda and Mahapatra (2004) in tomato, Jaya laxmi *et al.* (2002) in brinjal and Mavengahama *et al*.(2006) in paprika.

Among the different nitrogen doses the highest mean fruit width was recorded with N_{180} (7.84 cm) which was on par with N_{150} (7.63 cm) but significantly superior over N_{120} (7.19 cm), N_0 (6.67 cm). However N_{150}, N_{120}, N_0 were on par with each other. The lowest fruit width was recorded with $N_{0,}$ which recorded 17.5% decrease in mean fruit width over N_{180}. Among potassium doses significantly highest mean fruit width was recorded with K_{100} (7.87 cm) while the lowest was recorded with K_0 increased mean fruit width (cm) was observed (7.01 cm), *i.e.,* 12.3% decrease over $K_{100.}$ Increase mean fruit width (cmd) was observed. With the increase in fertigation levels of N and K. This may be attributed to nitrogen and potassium elements favouring rapid cell division and widening intracellular spaces by regulating the osmotic adjustments. These results might be due to the role of potassium in fruit quality, as it is known as the quality nutrient because of its influence on fruit quality parameters (Imas and Bansal, 1999 and Lester *et al.* (2006). The results were also in accordance with those obtained by Ni-Wu *et al.* (2001).

The total number of fruits $plant^{-1}$ varied from 9.70 to 11.67. Among varying doses of nitrogen significantly higher number of fruits $plant^{-1}$ in capsicum was obtained with N_{180} (11.20) which was significantly superior over N_{120} and N_0 but statistically on par with N_{150} (10.68). However N_{150} was on par with N_{120} it was followed by N_0. There was 12.7, 7.4 and 4.3 % increase in total number of fruits $plant^{-1}$ in $N_{180,}$ N_{150} and N_{120} over N_0. With regard to potassium doses the highest number of fruits plant $^{-1}$ was noticed with K_{100}

(10.78) which was on par with K_{80} and $K_{0.}$ While the lowest was no. of fruits plant^{-1} was recorded with K_{80} (10.35). K_{100} recorded 2.6 % increase in fruit number over K_0.

With an increase in N and K fertigation levels there was increase in number of fruits plant^{-1} in poly house condition. Higher doses of nitrogen, potassium and their combination with better micro climate has resulted in an increased allocation of photosynthates towards the economic parts *i.e.* formation of more flowers, hormonal balance and there by more number of fruits. Similar finding were also reported by Pradeep *et al*. (2004) in tomato and Nanda and Mahapatra (2004) in tomato, Jaya laxmi *et al.* (2002) in brinjal, Mohanty *et al*. (2001) in chilli, Das *et al.* (1972) in capsicum, Nazeer *et al.* (1991) in chilli, Mavengahama *et al.* (2006) in paprika and Jan *et al*.(2006) in capsicum.

With regard to mean average fruit weight N_{180} (102.30 g) recorded the highest value followed by N_{150} (98.73 g) while the lowest was recorded with N_0 (87.50 g). Among potassium fertigation levels significantly highest mean average fruit weight was recorded with K_{100} (102.29 g). However the lowest was recorded with K_0 (89.89 g). There was an increase in fruit weight with increased doses of nitrogen, potash and their combination which can be attributed to the formation of more assimilates and their proper distribution to the storage organs. The results are in confirmation with the findings of Gupta and Sengar (2000) in tomato, Jaya laxmi *et al.* (2002) in brinjal, Sahoo *et al.* (2002) in tomato, Ravanappa *et al.* (1998) in chilli, and Jan *et al.* (2006) in capsicum.

Fresh fruit yield of capsicum (sum of six pickings) was significantly influenced by different N and K fertigation levels. Fruit yield varied from 30.83 t ha^{-1} to 52.12 t ha^{-1}. The highest fruit yield was recorded with N_{180} (43570 kg ha^{-1}) which was significantly superior over other levels except N_{150} (40550 kg ha^{-1}), However N_{150} and N_{120} were on par with each other. It was observed that all the nitrogen fertigation levels N_{180}, N_{150} and N_{120} recorded higher fruit yield over N_0 (33130 kg ha^{-1}) Increase of an 31.5, 22.4 & 16.9 % in total fresh fruit yield (kg ha^{-1}) was observed in $N_{180,}$ N_{150} and N_{120} over N_0. By the application of different potassium doses a significant difference was noticed. K_{100} (43790 kg ha^{-1}) recorded significantly the highest fresh fruit yield compared to K_{80} and K_0. While the lowest was recorded by K_0 (34780 kg ha^{-1}). There was 25.9 & 10.5 % increase in fruit yield with K_{100} and K_{80} over K_0. Interaction was found to be non significant.

Protected condition provides a better environment, weed free situation and somewhat less incidence of insect pest and diseases there by leading to higher yields, while increased, yield plant^{-1} and ha^{-1} is a net result of balanced nutrition. Continuous supply of nutrients through drip fertigation favours the mobilization of food materials from vegetative parts to the productive part of the plant resulting in higher yield. Total fruit yield increased gradually with increase in N and K fertigation levels. However a slight increase in yield was noticed in control plot, due to application of organic manures (neem cake and vermicompost) basally and at every 15 days interval which improves the availability of nutrients to the crop. The similar results were reported by Channappa (1979) in tomato, who observed that tomato yield significantly improved by 40% with fertigation as compared to band placement. Shivanappan and Padmakumari (1980) also reported in chilli. (*Capsicum annuum*) that the availability of nutrients increased through drip irrigation which may be reflected in yield by 44% as compared to the conventional method. O Dell (1983) also observed that in tomato fertigation not only save the fertilizer but also increased the yield.

The effect of the differential amount of fertilizer added through the drip irrigation system showed significant improvement in irrigation water use efficiency (Table. 3). With regard to nitrogen fertigation the highest water productivity (10.50 kg m^{-3}) was observed with N_{180},which was significantly superior over N_{120} and N_0 and was statistically on par with N_{150} (9.78 kg m^{-3}).

Table 1. Details of N and K fertigation schedule for capsicum under poly house

S.No.	Crop growth stage	DAT	Number of fertigations	N%	K_2O %
1	Transplanting to establishment	1 to 14 DAT	2	5.00	5.00
2	Vegetative stage	15 to 46 DAT	8	3.75	2.50

Table 1. Contd.

S.No.	Crop growth stage	DAT	Number of fertigations	N %	K_2O %
3	Flower initiation to Fruit set	47 to 74 DAT	7	2.86	2.86
4	Harvesting stage	75 to 154 DAT	20	2.00	2.50
	Total		**37**	**100**	**100**

Table 2. Mean fruit length (cm), fruit width (cm), Total number of fruits plant^{-1} and Average fruit weight (g) of capsicum as influenced by different N and K fertigation levels under poly house during *rabi* 2019-2020

Treatments	Mean fruit length (cm)	Mean fruit width (cm)	Total number of fruits plant^{-1}	Average fruit weight (g)
RD Nitrogen (N)				
0%-N	8.51	6.67	9.94	87.50
120%-N	9.09	7.19	10.37	96.34
150%-N	9.99	7.63	10.68	98.73
180%-N	10.08	7.84	11.20	102.30
S.E±	0.17	0.22	0.21	2.26
C.D (P=0.05)	0.50	0.64	0.61	6.60
RD Potassium (K)				
0%-K	8.96	7.01	10.51	89.89
80%-K	9.16	7.12	10.35	96.47
100%-K	10.13	7.87	10.78	102.29
S.E±	0.15	0.19	0.18	1.95
C.D (P=0.05)	0.43	0.56	0.53	5.72
Interaction between RD N&K				
S.E±	0.30	0.38	0.36	3.91
C.D (P=0.05)	NS	NS	NS	NS

Note: Mean fruit length (cm), mean fruit width (cm), mean of first, third and fifth picking. and average fruit weight (g) is a mean of first to sixth pickings.

Table 3. Total fresh fruit yield (kg ha^{-1}) and water productivity (kg m^{-3}) of capsicum as influenced by different N and K fertigation levels under poly house during *rabi* 2019-2020

Treatments	Yield (kg ha^{-1})	Total water applied (mm)	Water productivity (kg m^{-3})
RD Nitrogen (N)			
0%-N	33,130	414.8	7.99
120%-N	38,730	414.8	9.34
150%-N	40,550	414.8	9.78

Table 3. Contd.

Treatments	Yield (kg ha^{-1})	Total water applied (mm)	Water productivity (kg m^{-3})
180%-N	43,570	414.8	10.50
S.E±	1280		-
C.D (P=0.05)	3740		-
RD Potassium (K)			
0%-K	34,780	414.8	8.38
80%-K	38,420	414.8	9.26
100%-K	43,790	414.8	10.56
S.E±	1110		**-**
C.D (P=0.05)	3240		**-**
Interaction between RD N&K			
S.E±	2220	-	-
C.D (P=0.05)	NS	-	-

Note: Total fruit yield is a sum of six pickings of capsicum

However N_{150} and N_{120} were on par with each other. The lowest water productivity was recorded with N_0 (7.99 kg m^{-3}). However a significant difference was noticed among potassium doses. Significantly highest water productivity was recorded in K_{100} (10.56 kg m^{-3}) compared to K_{80} and $K_{0,}$ while the lowest was recorded with K_0 (8.38 kg m^{-3}).

Similar results were reported by Tiwari *et al*. (1998)in poly house conditions which may be due to better utilization of water and fertilizers throughout the crop growth period. Moreover, it may also due to better availability of applied water, reduced loss of water due to lesser evaporation, percolation and lower weed density throughout the crop growth period in poly house.

Finally, in brief it can be concluded that, among different nitrogen fertigation levels application of 180% of recommended dose of N (324 kg N ha^{-1}) recorded the highest value in all crop growth parameters, yield attributes like fresh fruit yield, fruit quality, nutrient uptake, gross and net returns, B: C ratio followed by 150 % RD (270 kg N ha^{-1}) of N. Among different potassium doses, application of 100 % RD (120 kg K_2O ha^{-1}) of K_2O recorded significantly higher values.

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Research Note
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DIVERSITY AND ABUNDANCE OF INSECT AND SPIDER FAUNA IN SOLE AND SOYBEAN INTERCROPPED COTTON

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Cotton, popularly known as the "white gold" in India is one of the important cash crops. India is the second largest exporter of cotton in 2019 exporting 65 lakh bales of 170 kgs and contributing 5% to agricultural GDP of our country and 11% to total export earnings. Insect pests constitute one of the major limiting factors in the production as the crop is vulnerable to attack by about 162 species of insects and mites (Sundarmurthy, 1985). In cotton, intercropping can provide resources such as food and shelter and enhance the abundance and effectiveness of natural enemies (Mensah, 1999). Plant diversification increases the population of various natural enemies, which subsequently enhances natural pest control. For many species, natural enemies are the primary regulating force in the dynamics of their populations (Pedigo and Rice, 2009). Diversity of a crop ecosystem can be increased by intercropping, trap cropping, presence of weeds or by crops grown in the adjacent fields. When interplanted crops or weeds in the crop are also suitable host plants for a particular pest, they may reduce feeding damage to the main crop by diverting the pest (Cromartrie Jr., 1993). The present study was taken up to quantify the abundance and diversity of insect fauna in the vegetative stage of cotton-soybean intercropped system and compare with the sole cropped system and to comprehend the impact of increased diversity of natural enemies on pests in cotton.

The experiment was laid out in a plot of 1200 sq. m. in College Farm, Rajendranagar during *kharif* 2019-20. The plot was divided into two modules *viz*., module M-I and module M-II of 600 sq.m each. In module M-II, cotton was intercropped with soybean in 1:2 ratio while module M-I was raised as sole crop. Spacing adopted was 90 cm X 60 cm for cotton and 30 cm X 10 cm for soybean. Cotton was sown in the second week of July and soybean was sown ten days after germination of cotton. Observations on insect and spider fauna were taken from 10 days after germination till the end of the vegetative stage *i.e.* from the last week of August to the last week of September using yellow pan traps, pitfall traps, sticky traps and visual observations. Five yellow pan traps and five pitfall traps were placed in each module and water mixed with little soap and salt was poured into them. One sticky trap was placed in each module. Twenty-four hours after placing traps in the field, insects trapped were collected, separated into orders and their abundance was worked out. Using BIODIVERSITY PRO 2.0 software, the following indices were calibrated to study the diversity parameters of pests and natural enemies in the modules *viz*., Shannon-Wiener index of diversity or species diversity (H'), Margelef's species richness index (S), The Pielou's Evenness Index (E) and Simpson's Diversity Index (D).

Results revealed that apart from Araneae, insects belonging to 13 orders were recorded during the study in intercropped cotton module and those of 12 orders in sole cotton module. Destructive sucking pests of cotton belonging to families of Cicadellidae, Aleyrodidae and Aphididae and beneficial predators belonging to families Anthocoridae, Lygaeidae and Nabidae in order Hemiptera were collected in yellow pan, pitfall, sticky traps and visual count method in both the modules. Overall mean population of Hemiptera in intercropped and sole cotton module was 25.84 and 26.78 per count respectively. Thysanoptera (Family: Thripidae) was numerically the most abundant pest order recorded during the study with overall mean population of 29.10 and 30.41 thrips per count respectively in intercropped and sole cotton module (Table.1).

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The overall mean population of insects belonging to order diptera, hymenoptra and coleoptera were 7.10, 3.68 and 3.57 respectively in the intercropped module whereas in sole cotton, it was 5.81, 2.29 and 4.41 respectively. Order coleoptera contained predators of the pests essentially belonging to the families of Coccinellidae and Staphylinidae. Collembolans recorded in this study during the vegetative stage of crop were designated as neutral insects, which served as prey for the predators in the absence of the regular prey. The overall mean population of springtails in the family Entomobryidae was 0.79 and 1.12 per count, respectively in intercropped cotton and sole cotton module. Odonata, Neuroptera and Mantodea were the minor predatory orders observed during the study. Their overall mean populations were 0.03, 0.03 and 0.01 per count respectively in intercropped module while 0.00,0.03 and 0.01 per count respectively in sole cotton module (Table.1).

Araneae was the other important predatory order observed during the experiment. Nine spider families were recorded, among which Lycosidae and Araneidae were most abundant. Mean population of Lycosidae was 15.75 and 7.75 per count in intercropped and sole cotton respectively, while that of Araneidae was 10.00 and 8.50 per count in intercropped and sole cotton respectively (Table.2). Abundance of other spider families was less. However, overall abundance of the spider families was also higher in intercropped module (1.42 per count) than sole cotton module (0.76 per count) (Table.1).

Diversity indices clearly indicated that intercropped module had higher diversity and density of insect and spider fauna than sole cotton module. Shannon Wiener (H') diversity index and Simpson diversity (D) values for intercropped module were 1.31 and 0.36 respectively, whereas they were 1.19 and 0.40 for sole cotton respectively, indicating higher diversity of insect and spider fauna in the intercropped module than in the sole cotton module. Similarly, Margelef's species richness index value also higher for intercropped module (1.51) than sole cotton module (1.38). Pielou's evenness index (E) was 0.50 for intercropped module and 0.46 for sole cotton indicating that though insects and spiders were more evenly spread in intercropped module, the general distribution of insects in the field was not very uniform. Jaccard's

Table 1. Insect and spider abundance in intercropped and sole cotton module during vegetative stage

S.No	Orders	Overall mean in Intercropped Module	Overall mean in Sole cotton Module
1	Diptera	7.10	5.81
2	Hymenoptera	3.68	2.29
3	Hemiptera	25.84	26.78
4	Thysanoptera	29.10	30.41
5	Lepidoptera	0.01	0.05
6	Coleoptera	3.57	4.41
7	Orthoptera	0.26	0.14
8	Collembola	0.79	1.12
9	Odonata	0.03	0.00
10	Ephemeroptera	0.13	0.13
11	Dermaptera	0.08	0.13
12	Neuroptera	0.03	0.03
13	Mantodea	0.01	0.01
14	Araneae	1.42	0.76

Table 2. Abundance of spider families in intercropped and sole cotton during vegetative stage

S.No.	Family	Mean of four observations	
		Intercropped cotton	Sole cotton
1	Lycosidae	15.75	7.75
2	Araneidae	10.00	8.50
3	Thomisidae	2.00	1.25
4	Theridiidae	2.00	1.25
5	Oxyopidae	1.50	1.50
6	Pisauridae	1.00	0.00
7	Salticidae	0.75	0.25
8	Clubionidae	0.25	0.25
9	Gnaphosidae	0.00	0.25

Table 3. Diversity indices and density of insect orders in intercropped cotton and sole cotton in vegetative stage

S.No.	Diversity indices	Intercropped cotton	Sole cotton
1	Shannon Wiener (H')	1.31	1.19
2	Margelef's species richness index	1.51	1.38
3	Pielou's evenness index (E)	0.50	0.46
4	Simpson diversity (D)	0.36	0.40
5	Jaccard index of similarity	92%	
6	Density	11.16	10.00

index of similarity was 92% showing that the modules recorded 92% similarity in the insect and spider fauna present. Though the abundance differed between the modules, diversity was not very different between them (Table.3). Insect density in the intercropped module was 11.16 per sq.m., while in the sole cotton module was 10.00 per sq.m. highlighting the role of intercrops in enhancing diversity of insects in the field, thereby contributing to good natural control.

From the study it was evident that overall abundance of major pest orders *viz*., Hemiptera and Thysanoptera stood higher in sole cotton than the intercropped cotton. Lower incidence of pests and higher occurrence of natural enemies is the sole requisite of any agricultural module for better crop protection and enhanced yields. From the results it was clear that intercropped module was superior than the sole cropped module with respect to numbers of natural enemies and neutral insects.

Similar results were reported by Godhani (2006) who quantified the population of aphids 3.33,3.53, 3.98 and 5.29 per plant in cotton intercropped with maize, sesamum, soybean and pure cotton plots, respectively and reported the population of leaf hoppers to be 1.37, 1.43, 1.58 and 1.70 per plant in the above treatments. Same trend was seen in the population of whitefly with 1.26, 1.30, 1.36 and1.50 whitefly per plant. Population of thrips was 1.28, 1.33, 1.13 and 1.55 thrips per plant in above treatments.

Rao (2011) recorded highest population of *Cheilomenes sexmaculata,* in cotton + soybean (1.94 grubs and 3.39 adults per plant) followed by cotton + red gram (1.45 grubs and 1.62 adults per plant), cotton + black gram (1.14 grubs and 1.82 adults per plant), cotton + green gram (0.85 grubs and 1.44 adults per plant) and sole cotton (0.59 grubs and 1.34 adults per plant). Occurrence of *Chrysoperla* spp was highest in cotton + soybean (2.63 grubs per plant) followed by cotton + black gram (1.70 grubs per plant), cotton + red gram (1.68 grubs per plant), sole cotton (1.59 grubs per plant) and cotton + green gram (1.37 grubs per plant). Population of spiders was highest in cotton + soybean (2.49 spiders per plant) followed by cotton + black gram (1.96 spiders per plant), cotton + green gram (1.73 spiders per plant) and sole cotton (1.23 spiders per plant) in his study.

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Research Note
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EFFECT OF DIFFERENT LEVELS OF DRIP IRRIGATION REGIMES AND FERTIGATION ON YIELD AND YIELD ATTRIBUTES OF *RABI* SUNFLOWER (*Helianthus annuus.* L)

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Sunflower (*Helianthus annuus* L.) is an important oilseed crop in India. It contains sufficient amount of calcium, iron and vitamins A, D, E and B complex. Because of high linoleic acid content (64%) it has got anti cholesterol property as a result of which it has been used by heart patients. It is being cultivated over an area of about 2.8 lakh hectares with a production of 2.2 lakh tones and productivity of 643 kg ha^{-1} (IIOR, 2018). In india total area under drip irrigation was 4.77 M ha. Karnataka occupies first position in India with respect to area (1.7 lakh hectares) and production (1.06 lakh tones) followed by Andhra Pradesh, Maharashtra, Bihar, Orissa and Tamil Nadu. In Telangana, sunflower is being grown in an area of 4000 hectare, producing 8000 tonnes with the productivity of 1154 kg ha^{-1} (IIOR, 2018). The global challenge for the coming decades is to increase the food production with utilization of less water. It can be partially achieved by increasing crop water use efficiency (WUE). Improving the water and nutrient use efficiency has become imperative in present day's Agriculture. Drip irrigation with proper irrigation schedule and application of fertilizers through drip with right quantity and right time will enhance the crop growth which leads to increased yield.

The field experiment was conducted during *rabi* 2019-2020 at Water Technology Center, College farm, College of Agriculture, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Rajendranagar, Hyderabad. The soils are sandy clay loam alkaline in reaction and non-saline, low in available nitrogen, high in available phosphorous and available potassium, medium in organic carbon content, with total available soil moisture of 60.91 mm in 45 cm depth of soil. Irrigation water was neutral (7.22 pH) and was classified as C3 class suggesting that it is suitable for irrigation by following good management practices. The experiment was laid out in a split plot design consisting of three main irrigation regimes *viz.,* drip irrigation scheduled at 0.8, 1.0 and 1.2 Epan and four fertigation levels of 60% RD N& K_2O, 80% RD N& K_2O,100% RD N& K_2O and 120% RD N& K_2O, replicated thrice. The recommended dose of (RD) nutrients were 75:90:30 kg NPK $ha^{-1}$and entire dose of P_2O_5 was applied as basal, N and K_2O was applied as fertigation in 18 splits in the form of urea and sulphate of potash (SoP) based on crop requirement at each stage with 4 days interval from 10 days after sowing onwards. The data of Epan was collected from agro meteorological observatory located 500 away from the location at Agricultural Research Institute, Rajendranagar and accordingly application rate and drip system operation time was calculated. The crop was irrigated once in 2 days. Need based plant protection measures were taken up and kept weedfree to avoid crop weed competition by weeding at 30 days after sowing. Net plot yield was taken and computed to kg per hectare when crop reached harvest maturity stage. The data collected was statistically analysed as suggested by Gomez and Gomez (1984).

Significantly superior capitulum diameter of sunflower was recorded in drip irrigation scheduled at 1.0 Epan (16.0 cm) compared with 0.8 Epan (14.1 cm) and was on par with drip irrigation scheduled at 1.2 Epan (15.6 cm). Irrigation at 0.8 Epan produced significantly lower capitulum diameter than rest of the irrigation levels (Table1). Among fertigation levels 100% RD N & K_2O recorded significantly higher capitulum diameter of *rabi* sunflower (16.2 cm) than 80% RD N & K_2O (14.9 cm) and 60% RD N & K_2O (13.7 cm) and was not significantly different from 120% RD N & K_2O (16.0 cm). Fertigation with 120% RD N & K_2O was

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next to 100% RD N & K_2O and was on par with 80% RD N & K_2O. Significantly lower capitulum diameter was found in fertigation with 60% RD N & K_2O than 80%, 100% and 120%. Interaction effect due to irrigation and fertigation levels was not significant.

The increase in sunflower capitulum size with drip irrigation scheduled at 1.0 Epan and 1.2 Epan might be due to maintenance of optimum soil moisture status in the effective root zone throughout the crop growth period which helped in maintaining a higher leaf water potential, photosynthetic efficiency and translocation of photosynthates leading to production of higher biomass and increased capitulum diameter. These results validate findings of Kadasiddappa *et al.* (2015) and Kaviya *et al.* (2013). These may be due to increases in fertigation level from 60% to 120% RD N & K_2O and water level from 0.8 to 1.0 Epan which increases the nutrient and moisture availability to the plants resulting in increased nutrient uptake and better growth parameters leading to increased capitulum size.

Among the irrigation regimes, drip irrigation scheduled at 1.0 Epan recorded significantly superior capitulum weight (59.5 g) than 0.8 Epan (43.2 g) and was on par with 1.2 Epan (57.7 g). Drip irrigation scheduled at 1.2 Epan was next to 1.0 Epan and significantly higher than 0.8 Epan. Significantly lower capitulum weight was realized with irrigation scheduled at 0.8 Epan than 1.0 and 1.2 Epan. On the other hand, significantly higher capitulum weight was recorded under fertigation with 100% RD N & K_2O (63.8 g) and 120% RD N & K_2O (58.9 g) compared with 80% RD N & K_2O (51.6 g) and 60% RD N & K_2O (39.5 g). Fertigation with 100% RD N & K_2O and 120% RD N & K_2O were on par with each other. Significantly lower capitulum weight was observed with fertigation of 60% RD N & K_2O than rest of the fertigation levels and interaction effect between irrigation regimes and fertigation levels was not significant. These results are in similar trend with the findings reported by Preethika *et al*. (2018) and Akanksha, (2015).

Table 1. Yield attributes and yield of *rabi* sunflower as influenced by different levels of drip irrigation regimes and fertigation

Treatments	Capitulum diameter (cm)	Capitulum weight (g)	No of seeds/ Capitulum	Seed weight/ Capitulum	Threshing (%)	Test weight (g)	Seed yield (kg ha^{-1})
Main plot – (Irrigation regimes)							
I_1: Drip irrigation at 0.8 Epan	14.1	43.2	578.5	29.4	68.9	54.2	1781
I_2: Drip irrigation at 1.0 Epan	16.0	59.5	687.6	40.4	70.2	56.1	2082
I_3: Drip irrigation at 1.2 Epan	15.6	57.7	677.4	37.8	66.0	56.4	2028
SEm ±	0.3	1.5	17.8	0.7	2.7	0.9	51
C.D (P=0.05)	1.4	5.9	70.0	3.0	NS	NS	200
Sub plot – (Fertigation levels)							
F_1 – 60 % RD N & K_2O	13.7	39.5	540.1	29.0	73.7	53.7	1688
F_2 – 80 % RD N & K_2O	14.9	51.6	586.5	34.5	67.9	55.6	1872
F_3 – 100 % RD N & K_2O	16.2	63.8	737.2	40.3	63.9	56.1	2162
F_4 – 120 % RD N & K_2O	16.0	58.9	727.6	39.7	67.9	56.8	2133
SEm ±	0.3	2.2	25.7	1.0	2.7	1.0	73
C.D (P=0.05)	1.1	6.5	76.5	3.0	NS	NS	219
Interaction							
Fertigation levels at same level of irrigation regimes							
SEm ±	0.6	3.8	44.6	1.7	4.7	1.8	127
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS

Table 1. Contd.

Treatments	Capitulum diameter (cm)	Capitulum weight (g)	No of seeds/ Capitulum	Seed weight/ Capitulum	Threshing (%)	Test weight (g)	Seed yield (kg ha^{-1})
Irrigation regimes at same or different levels of fertigation							
SEm ±	0.6	3.6	42.5	1.7	4.9	1.8	121
C.D (P=0.05)	NS	NS	NS	NS	NS	NS	NS

Number of seeds capitulum^{-1} was not significantly influenced by the interaction effect between irrigation regimes and fertigation levels of *rabi* sunflower. Data of number of seeds capitulum^{-1} presented in Table.1 indicated that significantly maximum number of seeds were observed with irrigation scheduled at 1.0 Epan (687.6) than 0.8 Epan (578.5) and was on par with 1.2 Epan (677.4). Significantly lower seed number capitulum^{-1} was recorded with drip irrigation scheduled at 0.8 Epan owing to moisture stress experienced by crop at flowering, seed formation and seed filling stages. Thus, water deficit during later crop growth period have shown significant reduction in number of seeds capitulum^{-1} (Human *et al*., 1990; Venkanna *et al*., 1994). Results reported by Kadasiddappa *et al.* (2015) and Kaviya *et al.* (2013) were in similar trend with the present investigation. Among the fertigation levels, 100% RD N & K_2O (737.2) and 120% RD N & K_2O (727.6) recorded significantly greater number of seeds capitulum^{-1} than 80% RD N & K_2O (586.5) and 60% RD N & K_2O (540.1). However, 100% and 120% RD N & K_2O did not differ significantly in seed number, while, 60% and 80% RD N & K_2O were on par each other.

With the increase in drip irrigation levels seed weight capitulum^{-1} increased enormously and significantly highest seed weight capitulum^{-1} was recorded with drip irrigation scheduled at 1.0 Epan (40.4 g) over 0.8 Epan (29.4 g). However, the seed weight per capitulum recorded with 1.0 Epan was found to be at par with 1.2 Epan (37.8 g). Significantly lower seed weight per Capitulum was obtained at 0.8 Epan than other irrigation treatments. Seed weight per capitulum in sunflower was significantly affected by different fertigation levels, with increase in fertigation levels it increased significantly with 100% RD N & K_2O (40.3 g) over 80% RD N & K_2O (34.5 g) and 60% RD N & K_2O (29.0 g) and was on par with 120% RD N & K_2O (39.7 g). Fertigation with 80% RD N & K_2O recorded significantly higher seed weight capitulum^{-1} than 60% RD N & K_2O and was significantly lower than 120% RD N & K_2O. Lowest seed weight capitulum^{-1} was achieved in 60% RD N & K_2O than other fertigation levels which differed significantly with rest of the treatments. The interaction effect between irrigation regimes and fertigation levels on seed weight capitulum^{-1} of *rabi* sunflower was not significant.

The results obtained from the present investigation showed that threshing percent is not significantly influenced by irrigation regimes and fertigation of RD N & K_2O levels as well by their interactions. However, numerically higher threshing percent was recorded with drip irrigation scheduled at 1.0 Epan (70.2 %) and fertigation with 60% RD N & K_2O (73.7 %) than rest of the treatments.

The irrigation regimes and fertigation levels and their interactions did not influence significantly test weight of the *rabi* sunflower. However, as the irrigation level increased from 0.8 to 1.2 Epan and fertigation level from 60% to 120%, there was increase in test weight which ranged from 54.2 g to 56.4 g with irrigation levels and from 53.7 g to 56.8 g with fertigation.

Significantly higher grain yield of *rabi* sunflower was recorded with drip irrigation scheduled at 1.0 Epan (2082 kg ha^{-1}) than irrigation at 0.8 Epan (1781 kg ha^{-1}) and was on par with 1.2 Epan (2028 kg ha^{-1}). However, significantly lower yield was obtained with irrigation scheduled at 0.8 Epan than rest of the irrigation levels.

Drip irrigation at frequent intervals with amount of water equivalent to pan evaporation helped in maintaining optimum soil moisture and nutrients in the root zone throughout the crop growth period which enabled production of higher leaf area index, growth parameters and dry matter (Badr and Taalab, 2007) in turn contributing higher yield components which ultimately led to higher sunflower seed yield (Kazemeini *et al*. 2009). Significantly lower yield with 0.8 Epan might be due to insufficient quantity of water applied resulting in lower yield attributes such as no of seeds capitulum^{-1} and seed weight capitulum^{-1} leading to lower seed yield. Similar findings of decreased yield with 0.8 Epan in grain weight were also reported by Kadasiddappa *et al.* (2015), Kaviya *et al.* (2013) and Kassab *et al.* (2012).

Significantly higher grain yield (2162 kg ha^{-1}) was recorded with fertigation of 100% RD N & K_2O over 80% (1872 kg ha^{-1}) and 60% (1688 kg ha^{-1}) but was on par with fertigation of 120%RD N & K_2O (2133 kg ha^{-1}) On the other hand 80% RD N & K_2O and 60% RD N & K_2O were on par with each other. This might be due to the fact that, with drip fertigation, the root zone is simultaneously supplied with more readily available form of N and K nutrients in the soil solution applied in multiple splits, which led to higher uptake resulting in higher yield.

Based on the above results obtained, it can be concluded that drip irrigation scheduled at 1.0 Epan in irrigation regimes and 100% RD N & K_2O in fertigation levels was found to be beneficial for *rabi* sunflower compared with other irrigation (0.8 and 1.2 Epan) and fertigation (60%, 80% and 120% RD N& K_2O) levels.

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Research Note
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ECONOMICS OF ORGANIC AND CONVENTIONAL PADDY FARMING IN MAHBUBNAGAR DISTRICT OF TELANGANA

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India is the second largest producer of rice in the world with 117.94 m.tons in 2019. In the past 50 years, rice production has nearly tripled following the introduction of semi dwarf modern varieties accompanied with usage of large quantities of fertilizers and pesticides. The demand for food grains is increasing day by day in order to meet the requirements of growing population. In order to meet the growing food demand, farmers started cultivating modern varieties using chemical fertilizers, pesticides, fungicides, herbicides etc.

Indiscriminate and excessive usage of high toxic synthetic chemicals contaminated the soil, water, and other vegetation. On the human health side continuous exposure to pesticides resulted in development of cancers, genotoxic, immunotoxic, neurotoxic, adverse reproductive effects. The alternative to mitigate the problems of health hazards and imbalance in environment and to protect the ecosystem is organic farming. It is an effective method which avoids dangerous chemicals and nourishes plants and animals in balanced fashion. Organic farming is well known to reduce greenhouse gas emissions especially in rice fields. The benefits in using organic amendments will have a long term improvement in soil quality, nutrient availability, increase in soil carbon and soil biological activities Growing awareness over health and environmental issues associated with the intensive use of chemical agriculture inputs has led to the interest in organic farming.

In India nearly 8.35 lakh farmers are engaged in organic farming with cultivable area of 1.49 m.ha and ranks 9th position globally in terms of cultivated area. In Telangana state also the concept of organic farming is gaining importance. Under the Paramparagat Krishi Vikas Yojana (PKVY) scheme, the state government has formed 584 farmer cluster groups and promoting organic cultivation. Apart from the state Government, many NGOs are actively involved in the promotion of organic farming and providing training to the farmers. As more number of farmers are cultivating paddy under organic farming in Mahaboobnagar district, the present study was conducted to analyse the costs and returns of paddy under organic and conventional farming.

1. Costs and returns of paddy in organic farming and conventional farming.

The details of cost and returns of paddy in organic and conventional farming are presented in Table:1.1.

1.1 Cost of cultivation of selected organic and conventional paddy farms

Production costs play an important role in the process of decision making. The details of various costs incurred on organic and conventional paddy cultivation were calculated and presented in Table1.1. Perusal of the table indicates that the total cost of paddy cultivation on organic farms was less than that of conventional farms. The average cost of cultivation per acre of paddy on organic farms was Rs.35, 473.26 as against Rs. 37,340.98 on conventional paddy farms.

In the total cost, variable cost accounted for a major share in both organic and conventional farms. The variable costs in organic and conventional farms were Rs. 23,112.77 and Rs. 24,635.44 accounting for 65.16 percent and 65.97 percent of total cost of cultivation respectively. The fixed costs were Rs. 12,360.49 (34.84%) and Rs. 12,705.54 (34.03%) on organic and conventional paddy farms respectively.

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The proportion of variable cost and fixed cost in total cost was almost similar in both farms.

Among the variable costs, the expenditure on labour costs was found to be higher than the material costs in both organic and conventional paddy farms. In case of organic farms, the expenditure incurred on human labour was Rs. 10,812.32 accounting for 30.48 per cent of total cost followed by machine power (Rs. 5,908.28), which accounted for 16.66 percent of total cost. Among the material cost, an amount of Rs. 1750.03 was spent on manures which accounted for 4.93 per cent of total cost followed by expenditure on seed Rs. 971.9 (2.74%), bullock labour Rs. 670.77 (1.89%), biopesticides Rs.450.92 (1.27%), biofertilisers Rs.344.63 (0.97%), poultry manure Rs. 273.79 (0.77%) and vermicompost Rs.219.03 (0.62%)

The other items of expenditure in organic paddy cultivation were miscellaneous costs and interest on working capital which accounted for 2.62 and 2.20 percent share in total cost.

Among the fixed costs, rental value of owned land was the main item amounting Rs. 11,000 per acre (31.01%). This was followed by interest on fixed capital and depreciation accounting for 1.97 and 1.86 percent of the total cost respectively.

Table 1.1. Cost of cultivation of selected paddy farms

S.No.	Particulars	Organic farms (Rs. acre^{-1})	Percent	Conventional farms (Rs. acre^{-1})	Percent
A	Variable costs				
1	Human labour	10,812.32	30.48	9,293.28	24.89
2	Bullock labour	670.77	1.89	506.49	1.36
3	Machine labour	5,908.28	16.66	5,724.27	15.33
4	Seed	971.91	2.74	1,004.69	2.69
5	Manures	1,750.03	4.93	1,851.58	4.96
6	Vermicompost	219.03	0.62	-	-
7	Poultry manure	273.79	0.77	-	-
8	Fertilizers	-	-	2,853.04	7.64
9	Biofertilisers	344.63	0.97	-	-
10	Plant protection chemicals	-	-	1,474.15	3.95
11	Bio pesticides	450.92	1.27	-	-
12	Miscellaneous costs	929.50	2.62	1,094.86	2.93
13	Interest on working capital @ 7%	781.59	2.20	833.08	2.23
	Total variable cost (A)	23,112.77	65.16	24,635.44	65.97
B	Fixed costs				
1	Rental value of owned land	11,000	31.01	11,000	29.46
2	Rent paid for leased land	0.00	0.00	0.00	0.00
3	Land revenue	0.00	0.00	0.00	0.00
4	Depreciation	660.84	1.86	986.36	2.64
5	Interest on fixed capital @ 10%	699.65	1.97	719.18	1.93
	Total fixed cost (B)	12,360.49	34.84	12,705.54	34.03
	Total cost (A+B)	35,473.26	100.00	37,340.98	100.00

Among the variable costs in the conventional paddy cultivation, cost of human labour was higher than all other inputs amounting Rs. 9293.28 per acre accounting for 24.89 percent of total cost. This was followed by expenditure on machine labour amounting Rs 5,724.27 (15.33%), fertilizers Rs.2,853.04 (7.64%), manures Rs.1,851.58 (4.96%), seed 1,004.69 (2.69%), plant protection chemicals Rs.1,474.15 (3.95%) and bullock labour Rs.506.49 (1.36%). The share of interest on working capital and miscellaneous costs were 2.23 percent and 2.93 percent of the total cost respectively.

The rental value of owned land formed the major item of fixed cost amounting Rs.11,000 per acre (29.46%). This was followed by interest on fixed capital and depreciation accounting for 2.64 percent and 1.93 percent of the total cost respectively.

The overall analysis of cost structure of organic and conventional paddy cultivation revealed that the average per acre cost of cultivation of conventional paddy was higher by Rs. 1,867.72 over organic paddy cultivation. This difference was mainly due to higher expenditure incurred on fertilizers and plant protection chemicals in conventional paddy farms compared to organic farms.The expenditure on human labour and machine labour found to be the most important items in the cost of cultivation of paddy on both organic and conventional farms.

The results observed in cost of cultivation of organic paddy farms and conventional paddy farms were in line with the study of Kondaguri *et al.* in Tungabadra command area of Karnataka (2014) and Jitendra (2006) *et al.* in Udham Singh nagar district of Uttaranchal state.

1.2 Yields and returns in organic cultivation of paddy and conventional cultivation of paddy.

The details of physical outputs of main product, by-product, gross income and net income from organic farms and conventional farms were analyzed and presented in Table 1.2. On an average, the yields of main product per acre were 21.10 and 24.56 quintals on organic and conventional paddy farms respectively. The yields of by-product in organic and conventional paddy farms were 2.33 tonnes per acre and 2.52 tonnes per acre. This indicate that the yields in organic farms were low compared to conventional farms.

On an average, the selected organic farmers and conventional farmers realized a gross income of Rs.60,907.60 and Rs.47,520.98 per acre respectively. The net income was Rs. 25,434.33 in organic farms and Rs. 10,180.00 in conventional farms. The gross and net income were more by Rs. 13386.6 and Rs.15254.33 on organic farms over conventional farms. The more gross income in organic farms was attributable to the premium price received for organic produce.The cost of production per quintal of paddy was Rs 1,681.27 on organic farms, as against Rs. 1,520.17 on conventional farms. Relatively higher cost of production on organic farms was mainly due to low yields compared to conventional paddy farms. The return per rupee spent was 1.72 on organic farms, while in conventional farms it was 1.27.

Thus the economic analysis of paddy in organic and conventional farms revealed low cost of cultivation and high net returns in organic farms compared to conventional farms.Though the yield levels are low in organic farming, because of high price

Table 1.2. Yields and returns of paddy in organic and conventional farms

S. No.	Particulars	Organic farms	Conventional farms
1	Yield of main product (q ac^{-1})	21.10	24.56
2	Yield of by- product (t ac^{-1})	2.33	2.52
3	Market price of main product (Rs. q^{-1})	2,826.00	1,879.00
4	By-product (Rs. t^{-1})	550.00	542.00
5	Gross income (Rs. ac^{-1})	60,907.60	47,520.98
6	Net income (Rs. ac^{-1})	25,434.33	10,180.00
7	Cost of production (Rs. q^{-1})	1,681.27	1,520.17
8	Return per rupee spent	1.72	1.27

received for the organic produce, net returns were high under organic farms. In view of growing demand for organic produce, the farmers should be encouraged to cultivate paddy under organic farming and government should support the farmers by providing the fertilisers and biopesctides at reasonable price**.**

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SURVEY FOR FUSARIUM WILT INCIDENCE OF TOMATO IN MAJOR CROP GROWING AREAS OF TELANGANA STATE

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Tomato (*Lycopersicum esculantum* Mill.), a "fruity vegetable", native of Peru, South America, is a popular and widely grown vegetable crop cultivated throughout the world. It is also known as poor man's apple due to the availability of vitamin C, minerals (Fe and Cu) and antioxidants in moderate quantities with generally low dietary nutrients. It is an annual vegetable crop growing to a height of 1-3 m, with weak woody stem (Naika *et al*., 2005), bearing edible fruits belonging to the family *Solanaceae* having more than 3000 species. Tomato crop is affected by several diseases incited by organisms like fungi, bacteria and viruses etc., which affects plant growth and yield. Among the fungal diseases that affect tomato, Fusarium wilt caused by *Fusarium oxysporum* f. sp. *lycopersici* (Sacc.), Snyder and Hans, is one of the most serious and destructive diseases across the world (Sheu and Wang, 2006) with severe economic loss wherever tomato is grown (Sudhamoy *et. al*., 2009).

In India, Fusarium wilt of tomato recorded an incidence of 19 to 45 % (Manikandan and Raguchander, 2012) causing an approximate yield loss of 45 % in Northern India (Kalaivani, 2005), 30 to 40 % in south India (Kiran kumar *et al., 2008*) and 10 to 90 % in temperate regions (Singh and Singh, 2004). In view of this, a random survey was conducted in major tomato growing districts of Telangana State to record the incidence of Fusarium wilt and its characteristic symptoms so as to formulate the necessary management practices in advance against this dreadful disease.

Multiple roving surveys were conducted in major tomato growing areas of Telangana state covering three districts *viz*., Adilabad, Sangareddy and Ranga Reddy during the years 2017 and 2018, from July to October and January to March and percent disease incidence of Fusarium wilt was recorded. In each district, three mandals and in each mandal three villages with 2 to 3 km apart from each other were selected to represent the overall mean disease incidence of that particular geographical area. Further, from each village, three tomato fields were selected to record the disease incidence. The mandals surveyed for Fusarium wilt disease incidence in Adilabad district include Gudihatnoor, Indervelley, and Echoda, while in Ranga Reddy district they were Ibrahimpatnam, Yacharam and Shabad and in Sangareddy district Gummadidala, Jharasangam and Zaheerabad mandals were surveyed.

Tomato fields were identified based on external symptoms *i.e*., leaves drooping, yellowing, stunted in growth, initial yellowing on one side of the plant on lower leaves and branches, browning and death of entire plant at advanced stage of infection. Internal vascular discolouration of stem region was also noticed which is a chief characteristic symptom of Fusarium wilt. Affected tomato plants were noticed with less number of fruits or with no fruits if affected during flower initiation stage. Based on the symptoms observed, percent disease incidence was estimated.

During survey, five micro areas with an area of $1m^2$ in each field were observed randomly duly covering both healthy and infected plants to assess the incidence of Fusarium wilt. At every micro area, the total number of plants and number of affected plants were recorded. Percent disease incidence of each tomato field was calculated as per the formula given below and further mean percent disease incidence of each village was also calculated.

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Initial symptom of Fusarium wilt on tomato plant

Vascular discolouration on stem

Vascular discolouration initiated from basal portion of the stem

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

Tomato was grown in an area of 4,145 ha during *kharif* and *rabi,* 2017-18 in Adilabad district. The survey results revealed that, the crop was effected by Fusarium wilt in both the seasons and the overall percent disease incidence in *kharif* 2017-18 ranged from a minimum of 2.53 % at Muthunuru village of Indervelli Mandal to a maximum of 21.33 % at Gudihatnoor village of Gudihatnoor mandal, with the overall mean percent disease incidence of 11.49 %. During *rabi* 2017-18, the percent wilt incidence recorded ranged from 22.71 % at Tosham village, Gudihatnoor mandal to 33.80 % at Tejpur village of Indervelli mandal, with a mean incidence of 27.19 % (Table 1).

Table 1. Percent disease incidence of Fusraium wilt in Adilabad district

S.No	Name of the mandal	Name of village	PDI(%) of Fusarium wilt disease			
			Kharif, 2017-18		*Rabi*, 2017-18	
			PDI	Crop stage	PDI	Crop stage
1	Gudihatnoor	Gudihatnoor	21.33	Fi & Fs	25.86	Fi & Fs
		Tosham	13.60	Fi & Fs	22.71	Fi & Fs
		Kolhari	9.73	Vg	26.90	Fi & Fs
2	Indervelly	Indervelly	5.53	Vg	25.73	Fi & Fs
		Muthunur	2.53	Vg	26.80	Fi & Fs
		Tejpur	14.73	Fi &Fs	33.80	Fi & Fs
3	Ichoda	Ichoda	10.06	Fi & Fs	28.43	Fi & Fs
		Salewada	11.00	Fi & Fs	24.90	Fi & Fs
		Boregoan	15.40	Fi & Fs	29.60	Fi & Fs
Mean percent disease incidence		**11.49**		**27.19**		
		S.E(m) ±	**0.30**		**0.43**	
		C.D	**1.20**		**1.38**	
		CV	**17.13**		**14.41**	
(Fi- Flower initiation, Fs- Fruit set , Vg- vegetative growth stage)						

Sangareddy was found to be the important tomato growing district of Telangana state, with an acerage of 2,110 ha, growing majorly during *rabi* season. The major tomato growing mandals in Sangareddy district were Gummadidala (282 ha), Jharasangam (104 ha) and Zaheerabad (419 ha) with local and hybrid varieties *viz.* US 440, PHS 448 and Laxmi under cultivation. The results revealed that, Fusarium wilt disease incidence in Sangareddy district during *kharif,* 2017-18 ranged from 2.40% at Edulapally village in Jharasangam mandal to 11.40 % at Jharasanagam village cum mandal with its mean percent disease incidence of 6.17%. During *rabi* 2017-18 the percent disease incidence ranged from minimum of 8.76 % at Raipalle village of Zaheerabad mandal to its maximum of 25.73 % at Nallavelli village, Gummadidala mandal with a mean per cent disease incidence of 15.29 % (Table.2).

Table 2. Percent disease incidence of Fusraium wilt disease in Sangareddy district

S.No	Name of the mandal	Name of village	PDI(%) of Fusarium wilt disease			
			***Kharif,* 2017-18**		***Rabi,* 2017-18**	
			PDI	**Crop stage**	**PDI**	**Crop stage**
1	Gummadidala	Gummadidala	5.80	Vg	17.73	Fi &Fs
		Kankunta	4.43	Vg	25.16	Fi &Fs
		Nallavelli	9.73	Vg	25.73	Fi &Fs
2	Jharasangam	Jharasangam	11.40	Fi & Fs	9.63	Fi &Fs
		Edulapally	2.40	Vg	12.36	Fi &Fs
		Medpally	5.70	Vg	10.63	Fi &Fs
3	Zaheerabad	Zaheerabad	3.56	Vg	14.53	Fi &Fs
		Chinna hyderabd	3.73	Vg	13.16	Fi &Fs
		Raipalle	8.80	Vg	8.76	Vg
Mean percent disease incidence			6.17	Vg	15.29	Fi &Fs
S.E(m)±			0.38		0.63	
C.D			1.16		1.9	
CV			15.6		13.8	
(Fi- Flower initiation, Fs- Fuit set , Vg-Vegetative Growth)						

Ranga Reddy district was found to be the largest tomato growing district of Telangana State, with an area of 6,593 ha, majorly in Mandals of Ibrahimpatnam (1800 ac), Yacharam (1100 ac) and Shabad (2680 ac). Due to marketing conveyance and availability of drip irrigation system, the crop was grown in all seasons *i.e*., *kharif* , *rabi* and summer.

Survey results indicated that the incidence of Fusarium wilt in *kharif*, 2017-18 ranged from a minimum of 9.80 % at Raipole village of Ibrahimpatnam mandal to the maximum of 18.33 % at Tadlapally village of Shabad mandal with a mean PDI of 13.02 %. During *rabi,* 2017-18, the disese incidence ranged from minimum of 26.0 % at Raipole village, Ibrahimpatnam mandal to 32.60 % at Manchal village of Yacharam mandal with a mean disease incidence of 28.62 % (Table 3).

Across the areas surveyed, it was evident from the results that , the incidence of wilt in tomato was more during *rabi* season than in *kharif*, 2017-18. Further, the results also evinced that , the highest maen percent disease incidence was observed in Ranga Reddy district (28.62%), followed by Adilabad (27.19%), while the lowest was noticed during *kharif* in Sangareddy district (6.17%).

A study conducted by Amutha and Darwin Christdhas Henry, (2017) indicated that the

Table 3. Percent disease incidence of Fusraium wilt disease in Ranga Reddy district

S.No	Name of the mandal	Name of village	PDI(%) of Fusarium wilt disease			
			***Kharif,* 2017-18**		***Rabi,* 2017-18**	
			PDI	**Crop stage**	**PDI**	**Crop stage**
1	Ibrahimpatnam	Dandumailaram	16.20	Fi & Fs	26.33	Fi & Fs
		Mangalpally	11.10	Vg	32.55	Fi & Fs
		Raipole	9.80	Vg	26.00	Fi & Fs
2	Yacharam	Yacharam	15.30	Fi & Fs	27.50	Fi & Fs
		Gungal	12.50	Fi & Fs	26.90	Fi & Fs
		Manchal	12.65	Fi & Fs	32.60	Fi & Fs
3	Shabad	Damergidda	10.40	Vg	29.30	Fi & Fs
		Ragadidoswada	11.00	Vg	27.80	Fi & Fs
		Thadlapally	18.33	Fi & Fs	28.60	Fi & Fs
Mean percent disease incidence			13.02	—	28.62	—
		S.E.(m)±	0.91		0.61	
		C.D	1.31		1.85	
		CV	15.73		15.89	
(Fi- Flower initiation, Fs- Fruit set , Vg-Vegetative growth)						

occurrence of Fusarium wilt of tomato ranged from 12 % to 59 % in almost all tomato growing areas of Tamil Nadu state. Anitha and Rebeeth (2009) also reported a maximum of 75% wilt incidence at Nachipalayam village of Coimbatore District and 19% to 45% (Manikandan and Raguchander , 2012) in major tomato growing areas of Tamil Nadu. An incidence of 20 – 90% was reported from Sirmour district of Himachal Pradesh. Similar findings were reported by Khan *et al*. (2016) who stated that, the Fusarium wilt incidence of tomato was 80.34 % at Masauli block of Barabanki district, followed by 74.5 % at Arniya block, Bulandshah district, with a mean percent disease incidence ranging between 10.67 % to 80.34 % among all surveyed districts of Uttar Pradesh. According to Sahu *et al*. (2013) 26 % of wilt incidence was recorded from Raipur district of Chhattisgarh, with its initial incidence in the month of October progressing further in later months.

Bawa (2016) noticed the incidence of Fusarium wilt disease both under protected and field conditions wherever tomato was grown and especially with more incidence during warm climatic conditions *i.e.*, at 28 ^{0}C.

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CORRELATION AND PATH ANALYSIS IN RICE (*Oryza sativa* L.) FOR GRAIN YIELD AND ITS COMPONENTS

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Rice (*Oryza sativa* L.) is the major staple food crop for more than half of the world's population and plays a pivotal role in food and nutritional security by providing 43 percent of the calorie requirement. In the coming decades, demand for rice is expected to keep intensifying along with the growing population. India is the second-most densely populated country and hence the prime objective of plant breeders would always be an improvement in the productivity of the economic product. In rice, grain yield is the ultimate criterion for developing a high yielding variety. However, straight selection for grain yield alone remains ineffective since it is a complex trait and influenced by many component characters. The rapid improvement in grain yield is possible only when selection is practiced for component traits also for which knowledge on inter relationship of plant characters with yield and among them is essential. Therefore, in the current study correlation analysis was carried out for understanding the nature of association between grain yield and its component traits.

In addition to correlation, path-coefficient analysis which partitions the correlation into direct and indirect effects provides better elucidation of cause and effect relationship (Babu *et al*., 2012). Thus, it enables the plant breeders in selection of the traits with a major contribution towards the grain yield. Therefore, in this study, an attempt was made to estimate the nature of relationship between the yield components and grain yield and their direct and indirect role in accomplishing high grain yield.

The present experiment was carried out during *Kharif,* 2020 at the research farm, Indian Institute of Rice Research (ICAR-IIRR), Hyderabad using fifty one ICF_3 rice genotypes derived from the Marker assisted backcross breeding programme. Seeds of the fifty one rice genotypes were sown on nursery beds and thirty days old seedlings were planted with a spacing of 20X15 cm in randomized block design with three replications. All the recommended package of practices were followed to raise a good crop. Data was recorded for grain yield per plant and various yield component characters *viz*., days to 50% flowering, plant height (cm), panicle length (cm), number of productive tillers, number of filled grains per panicle and 1000 grain weight (g) and was subjected to statistical analysis following Singh and Chaudhary (1995) for correlation coefficient and Dewey and Lu (1959) for path analysis.

Grain yield being the complex character is the interactive effect of various yield attributing traits. The detailed knowledge of magnitude and direction of association between yield and its attributes is very important in identifying the key characters, which can be exploited in the selection criteria for crop improvement through a suitable breeding programme. Correlation between yield and yield components *viz*., days to 50% flowering, plant height (cm), panicle length (cm), number of productive tillers, number of filled grains per panicle and 1000 grain weight (g) was computed and the magnitude and nature of association of characters at the genotypic level are furnished in Table 1.

Grain yield per plant showed a significant positive association with number of productive tillers per plant (0.597) and number of filled grains per panicle (0.525). This indicated that these characters are essential for yield improvement. Similarly, Lakshmi *et al.* (2017), Kalyan *et al.* (2017), Srijan *et al.,* (2016), Babu *et al.* (2012), Basavaraja *et al.,* (2011), Fiyaz *et al.* (2011) and Shanthi *et al.,* (2011) also observed the significant positive association of number of productive tillers per plant with grain yield where as

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Table 1. Correlation coefficient of yield and its component traits in rice

Characters	Days to flowering	Plant height (cm)	No. of Productive tillers per plant	Panicle length (cm)	No. of filled grains per panicle	1000 Seed weight (g)	Grain yield per plant (g)
Days to flowering	1.000	-0.323*	0.378**	-0.425**	0.015	-0.181	0.022
Plant height (cm)		1.000	-0.211	0.603***	0. 152	0.297*	0.139
No. of Productive tillers per plant			1.000	-0.255	0.311 *	0.086	0.597***
Panicle length (cm)				1.000	0.129	0.304*	0.094
No. of filled grains per panicle					1.000	0.050	0.525***
1000 Seed weight (g)						1.000	0.241
Grain yield per plant (g)							1.000

* and ** indicate significance of values at P=0.05 and 0.01, respectively;

Haider *et al*. (2012), Padmaja *et al.* (2011) and Shanthi *et al.,* (2011) observed strong inherent association between number of filled grains per panicle and the grain yield. Therefore, selection of such characters will indirectly enhance the grain yield. Hence, these characters could be considered as criteria for selection for higher yield as these were strongly coupled with grain yield.

However, with the rest of the characters *viz*., days to 50 per cent flowering, plant height, panicle length, grain yield per plant exhibited non-significant but positive association. These reports are in consonance with the findings of Ratna *et al*. (2015) and Yadav *et al.,* (2010) for days to 50 per cent flowering, Srijan *et al.,* (2016) for plant height and panicle length.

Days to 50 percent flowering had significant positive correlation with the number of productive tillers per plant (0.378) while significant negative association with panicle length (-0.425) and plant height (-0.323) Ramesh *et al*. (2018) and Priyanka *et al*. (2016) also reported negative association with panicle length (-0.425) and plant height (-0.323). Plant height had significant positive correlation with panicle length (0.603) and 1000 seed weight (0.297) while negative and non-significant association with number of productive tillers per plant (-0.211). Similar results were reported by Priyanka *et al*. (2016) for panicle length. Number of productive tillers per plant had significant positive correlation with number of filled grains per panicle (0.311) and grain yield per plant (0.597) which is identical to the reports of Seyoum *et al.,* (2012), Sabesan *et al.,* (2009), Patel *et al.,* (2014) and Moosavi *et al.,* (2015). Panicle length had significant positive correlation with 1000 seed weight (0.304) which is in consonance with the report of Srijan *et al.* (2018).

In the current investigation, character association studies revealed a significant influence of component characters on grain yield but could not specify the association with yield either due to their direct effect on yield or is a consequence of their indirect effect *via* some other traits. In such a case partitioning the total correlation into direct and indirect effects of cause as devised by wright (1921) would give more meaningful interpretation to the cause of the association between the dependent variable like yield and independent variables like yield components (Madhukar *et al.* 2017).

In the present study, path coefficient analysis was done using correlation coefficients for distinguishing the direct and indirect contribution of component characters on grain yield (Table 2). It was revealed from the study that a high direct contribution to grain yield was displayed by the number of productive tillers per plant (0.597) followed by the number of filled grains per panicle (0. 352). These findings are in conformity with the results reported by Lakshmi *et al.* (2017), Premkumar (2015), Rathod *et al.* (2017).

The number of productive tillers per plant exhibited the highest indirect effect on yield *via* days to 50 per cent flowering (0.22) and number of filled grains per panicle (0.191), followed by the number of filled

Table 2. Estimates of direct and indirect effects of yield attributing characters on grain yield

Characters	Days to flowering	Plant height (cm)	No. of Productive tillers per plant	Panicle length (cm)	No. of filled grains per panicle	1000 Seed weight (g)	Grain yield per plant (g)
Days to flowering	**-0.147**	0.046	-0.055	0.065	-0.002	0.025	0.016
Plant height (cm)	-0.033	**0.105**	-0.021	0.069	0.015	0.031	0.139
No. of Productive tillers per plant	0.227	-0.121	**0.597**	-0.159	0.191	0.083	0.627
Panicle length (cm)	-0.024	0.036	-0.014	**0.055**	0.006	0.017	0.094
No. of filled grains per panicle	0.005	0.051	0.112	0.041	**0.352**	0.019	0.567
1000 Seed weight (g)	-0.012	0.021	0.009	0.022	0.004	**0.071**	0.248

grains per panicle which exhibited the indirect effect on yield via the number of productive tillers per plant (0.112). This indicates that selection for the yield related traits like number of filled grains per panicle and the number of productive tillers per plant would indirectly help in increasing the crop yield.

Days to 50 per cent flowering had a negative direct effect (-0.147) on grain yield but had positive indirect effect through plant height (0.046), panicle length (0.065) and thousand grain weight (0.025). Similar results were reported by Muthuramu and Sakthivel, 2016 and Bagudam *et al*. (2018) for negative direct effect on grain yield whereas Priya *et al*. (2017) for positive indirect effect via plant height, thousand grain weight. On the other hand, Srijan *et al*. (2018), Islam *et al*. (2019), Katiyar *et al*. (2019) and Saha *et al*. (2019) reported positive direct effects of days to 50 % flowering on grain yield. Plant height had shown positive direct effect (0.105) on grain yield and registered negative indirect effects *via* days to 50 % flowering (-0.033) and number of productive tillers (-0.021). Kalyan *et al*. (2017) and Sudeepthi *et al*. (2017) also observed positive direct effect on grain yield whereas Srijan *et al*. (2018) observed negative direct effect on grain yield.

Panicle length exhibited a genotypic positive direct effect (0.055) on grain yield but it had shown negative indirect effects on grain yield through days to 50 % flowering (-0.024) and number of productive tillers per plant (-0.014). Similar results were reported by Bagudam *et al*. (2018), Dhavaleshvar *et al*. (2019) and Saha *et al*. (2019) for positive direct effect on grain yield whereas negative direct effect of panicle length on grain yield was reported by Sudeepthi *et al*. (2017), Srijan *et al*. (2018). Thousand grain weight had shown positive effect on grain yield both directly (0.071) and indirectly through plant height (0.021), panicle length (0.022), number of productive tillers per plant (0.009) and number of filled grains per panicle (0.004).

In the present study among the traits studied, number of productive tillers per plant and number of filled grains per panicle were found to be the major contributors to grain yield both directly and indirectly and were also holding a strong inherent positive association with the grain yield. Since the selection of grain yield alone is not effectual as it is much influenced by several other factors, indirect selection through component characters plays a significant role in breeding for yield improvement. This revealed that selection based on the characters like number of productive tillers per plant and the number of filled grains per panicle would effectively result in higher yield.

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Research Note
The J. Res. PJTSAU 48 (3&4) 93-95, 2020

ANALYSIS OF RESISTANCE TO YELLOW MOSAIC VIRUS IN GREEN GRAM (*Vigna radiata* (L.) Wilczek)

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Greengram (*Vigna radiata* (L.) R. Wilczek var. radiata), also known as Mung bean or moong, is an important legume crop in Asia, Africa and latin America. Green gram protein is easily digested, comparatively rich in lysine, an amino acid that is deficient in cereal grains.Green gram is a self- pollinated diploid grain legume (2n=2x=22) crop with a small genome size of 579 Mb/1C (Arumuganathan *et al*., 1991). This crop plays an important role in crop rotation due to its ability to fix biological nitrogen and improving soil fertility. In India, MYMV (Mungbean yellow mosaic virus) was found to affect greengram in all the major growing regions.The disease is transmitted by whitefly (*Bemisia tabaci*) persistently and can infect green gram at all growth stages. White fly adapts easily to new host plants in any geographical region, as a result it has now been reported from all the continents except Antarctica (Rishi, 2004).It is polyphagus and was found on more than 600 plant species transmitting more than 60 plant viruses (Oliveira *et al*., 2001). MYMV produces typical yellow mosaic symptoms. The symptoms are in the form of small irregular yellow specks and spots along the veins, which enlarge until leaves become completely yellow.

Management of MYMV is often linked with control of the *Bemisia tabaci* population by spraying insecticides, which is sometimes ineffective because of high population pressure. The chemical management of the vector is expensive since numerous sprays of the insecticides are required to control the whitefly. Spraying often also lead to health hazards and ecological effluence. On the contrary, use of virus resistant varieties is the most economical, efficient and environment friendly approach to alleviate occurrences of MYMV in areas where the infection is a major constraint.

F_6(RIL)population developed at the Institute of Biotechnology, PJTSAU, Rjendranagar, Hyderabad, from a cross between the susceptible variety MGG 295 as female parent and resistant variety WGG 42 as pollen parent by single seed descent method was used for determining the mode of inheritance. A total of 128 RILs (F_6) along with parents were screened in *Rabi*, 2019 under hot spot condition at Agriculture Research station (ARS), Madhira, Khammam using infector-row technique in RBD experimental design. Generally, one row of a most susceptible spreader genotype of that area is sown after every two (Habib *et al*., 2007), or 10 rows of the genotypes (Sai *et al*., 2017). 10 rows of susceptible genotypes were sown in the field. Recommended cultural practices were followed with no insecticide spray so as to encourage the whitefly population for sufficient infection and spread of YMV. For screening of RILs against MYMV infection, the disease-rating scale (0–5) was used to score the infection according to Bashir *et al*. (2005).

RILs obtained from a cross WGG 42 x MGG 295 were phenotyped as resistant and susceptible based on the field evaluation by using MYMY scoring according to Bashir *et al*. (2005). The green gram (RIL's) were divided into six categories i.e., highly resistant (HR), Resistant (R), moderately resistant (MR), moderately susceptible (MS), susceptible (S) and highly susceptible (HS). Plants that are moderately susceptible (MS), Susceptible (S) and Highly Susceptible (HS) were included in susceptible group and highly resistant (HR), resistant (R), moderately resistant (MR) plants were included in resistant group (KR *et al.,* 2020) (Table 1). The chi-square test was performed to determine the goodness of fit of observed segregation for MYMV disease reaction in F_6

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Table 1. Grouping of 128 F6 RILs of the cross MGG-295 x WGG-42 based on MYMV reaction under field condition (Bashir *et al*., 2005)

Scale	Percent plants infected	Infection Category	Disease reaction	No of lines	Final classification of F_6 RILs on the basis of YMV infection
0	All plants free of virus symptoms	Highly resistant	H R	28	73
1	1-10%	Resistant	R	7	
2	11-20%	Moderately resistant	M R	38	
3	21-30%	Moderately susceptible	M S	15	55
4	30-50%	Susceptible	S	23	
5	More than 50 %	Highly susceptible	HS	17	

Table 2. Chi-square test for segregation of disease resistant reaction in F_6 RIL population

RILs (F_6)	Total plants	Disease Resistant Reaction				RatioR:S	$\chi 2$
		Observed		Expected			
		Resistant	Susceptible	Resistant	Susceptible		
MGG 295 X WGG 42	128	73	55	64	64	1:1	2.53^NS

generation.Chi-square test performed to check goodness of fit for ascertaining the numberof genes governing the MYMV resistance,The RIL population showed goodness of fit to ratio of 1:1 for disease resistance and susceptible reaction (Table 2) revealing monogenic inheritance of MYMV resistance. Monogenic inheritance for MYMV resistance has also been reported in green gram by previous researchers (Patel *et al*., 2018 and Anusha *et al*., 2014) while recessive monogenic resistance in case of black gram was reported by Gupta *et al*., (2005).

Field evaluation of F_6 RILs for YMV resistant and susceptible genotypes indicated that YMV resistance in green gram is controlled by single gene. The information would pave the way for YMV resistance breeding and mapping of the gene with linked molecular marker.

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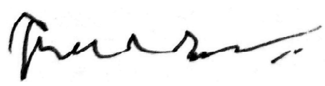

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