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# ASSESSMENT OF YIELD LOSS CAUSED BY SPOTTED STEM BORER, *Chilo partellus* (SWINHOE) TO MAIZE (*Zea mays* L.)

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**ABSTRACT**

The study was conducted during the *rabi* season of 2014-15 and 2015-16 at Agricultural Research Station, Darsi, Prakasam district with an objective of assessing the yield loss by *C. partellus* in maize. Popular maize hybrid 30V92 is used in this study. Yield loss by this pest was estimated by obtaining the yield difference between the chemically protected and unprotected maize plants across five dates of maize sowings taken up at weekly interval in a Factorial Randomized Block Design. Unprotected plots (31.55 q ha$^{-1}$) harvested less yield over protected ones (70.00 q ha$^{-1}$). Reduction in plant stand due to dead heart damage was more pronounced with delay in sowings with an average of 21.44 per cent across five sowing weeks. The stem borer population was more in late sown crop (1.66 plant$^{-1}$) as compared to early sown crop (0.84 plant$^{-1}$). Similarly, unprotected plots harboured more larval population of stem borer (1.89 plant$^{-1}$) over protected ones (0.65 plant$^{-1}$). The crop sown during December IV week under natural infestation recorded more dead heart incidence (11.82%) as compared to protected ones (1.06%) as the stem borer population was more in delayed sowings manifested in higher dead heart incidence in delayed sowings. The per cent stem tunnelling (16.26), per cent foliage damage (52.06) and number of exit holes per plant (3.25) were also more in late sown crop under unprotected conditions as compared to early sown crop and protected ones (1.24%, 15.09% and 0.56/ plant, respectively).

## INTRODUCTION

Maize (*Zea mays* L.) is the most important crop in the world after wheat and rice. India is the fifth largest producer of maize in the world contributing 3 per cent of the global production. In India, maize is grown in all the seasons *i.e*., *kharif, rabi* and *summer*. Of these three seasons, nearly 90 per cent of the production is from *kharif* season, 7-8 per cent during *rabi* and remaining 1-2 per cent in *summer* season. India registered a production of 24.35 mt with an average productivity of 2583 kg ha$^{-1}$ from an area of 92.46 m ha (Yadav, 2015). Among the major maize producing states in India, Andhra Pradesh tops the list with the contribution of 17 per cent to the total Indian maize production (Manjunath, 2013).

In spite of increase in the area under this crop, the productivity is still considerably low which may be undoubtedly due to the attack of various insect pests particularly the stem borers which have gained major importance in the state by inflicting greater loss to the crop. The spotted stem borer, *Chilo partellus* (Swinhoe) is a major predominant production constraint in both *kharif* and *rabi* tracts of Andhra Pradesh by causing direct economic damage to the crop. The losses due to this pest have been reported to vary from 24 to 75 per cent (Karimullah *et al*., 1986); 12.9 per cent (De Groote, 2002); 45 per cent and more (Birader, 2010) and 7 to 35.7 per cent (Ravinder and Jindal, 2015), which may even rise up to 81 per cent (Moyal, 1998). In certain cases ravages of maize borer resulted in total failure of the crop (Singh and Sharma, 1984). Grain yield losses were reported to be 0.4 to 35.4 per cent in various maize cultivars under borer infestation (Panwar *et al*., 2001). Stem borer damage ultimately affects food security and the agricultural economy (Mugo, 2001).

The insect is considered as a pest only based on the damage or loss it causes to the crop. Depending upon this the plant protection measures have to be tailored for getting higher economic returns. Therefore assessment of yield loss due to insect pest becomes essential for any planned crop protection against a particular pest in a particular crop. Yield loss assessment data are the primary tool to design a module for insect pest management. These data are very important and considered for

**E-mail:** suneelkumar.gonam@gmail.com; *Part of Ph.D thesis submitted to Acharya N.G. Ranga Agricultural University determining the status of the pest. Even then very few attempts have been made in the major maize growing areas. Hence, the present study was aimed to estimate the yield loss caused by stem borer, *C. partellus* in maize ecosystem and elucidates the effect of its damage on various yield affecting factors.

## MATERIAL AND METHODS

The experiment was conducted with five dates of sowing taken up at weekly intervals commencing from the fourth week of November to fourth week of December (28th November, 5th December, 12th December, 19th December and 26th December) during *rabi* 2014-15 and again during *rabi* 2015-16 in a Factorial Randomized Block Design having protected and unprotected plots with four replications, using 30V92 maize hybrid in a plot size of 3.0 m x 5.0 m (5 rows each of 5.0 m length). The crop was raised with a spacing of 60 cm x 20 cm by following all regular cultural practices as per recommended package practices of ANGRAU except the plant protection schedule. In the case of protected plots the stem borer was kept under check by whorl application of carbofuran 3G @ 10 kg $ha^{-1}$ applied twice at 20 and 35 DAE, while in the unprotected plots, it was allowed for natural infestation of stem borer. The carbofuran application was the main treatment plot which formed the protected and unprotected plots; while the dates of sowing of maize were the sub-plots. The ear head caterpillars and other pests, if any during the growing season, were hand-picked and destroyed.

The incidence of stem borer was regularly recorded both in protected and un-protected plots *viz.,* per cent foliage damage at 35, 45, 55 and 65 days after crop emergence (DAE), per cent dead heart at 45 DAE and observations on per cent stem tunnelling and yield was made at harvest. A random sample of 10 stems per subplot was taken to record number bored from which number of borer cavities was derived. Thereafter, bored stems were split to recover borer larvae and the average population per plant was worked out. Total number of plants, number of cobs harvested and number of poor cobs in each net subplot was recorded as the yield affecting factors during and after the harvesting.

The yield of maize grains were assessed based on the weight obtained from the un-protected and protected plots. The productive cobs in both un-protected and protected plots were harvested, shelled and cleaned. Grain yield from the net plot of each treatment was taken, dried, weighed and was converted to q $ha^{-1}$ for statistical interpretations. The direct method of estimating crop loss from insect pests was used, defined as the difference between the potential yield (yield that would have been obtained in the absence of the pest under study that is treated with insecticide) and the actual yield of the plots naturally infested with stem borer. The loss in the quality of maize grains from the field experiment for estimation of yield loss was also determined in terms of seed weight. Weight of 100 grains from each treatment was recorded when the moisture level in the grains was below 14 per cent after sun drying. Weight of three such grain samples from four replications was taken and average was worked out. Data were summarized separately for *rabi* 2014-15 and *rabi* 2015-16 and the combined data of both the years were analyzed statistically and subjected to ANOVA technique in Factorial Randomized Block Design after suitable transformations. Differences between datasets were determined using least significant difference at P=0.05.

## RESULTS AND DISCUSSION

### Foliage damage caused by *C. partellus* larvae

At all the intervals of observation significantly higher foliage damage was recorded in unprotected plots as compared to protected ones with a mean damage of 43.08 and 22.24 per cent, respectively. Sowing at November IV and December I week were found to record least foliage damage and were comparable with each other and so also with mean foliage damage of 24.94 and 27.69 per cent, respectively at all the intervals of observation. December II and III week sown crops were significantly different from one another by recording the foliage damage of 32.35 and 37.34 per cent, respectively. December IV week sown crop was found to have significantly highest foliage damage of 41.00

per cent. Among the treatment combinations of protection levels and different sowing weeks, maize sown on November IV week under protected conditions was significantly superior with lowest foliage damage of 15.09 per cent and was statistically on par with December I week sown crop (17.53%). With delay in sowing, foliage damage was significantly increased in December II week sown maize crop (21.99%). This was significantly followed by December III (26.65%) and IV week (29.93%) sown crops and both were at par. The increase in foliage damage in the unprotected condition over protected maize in November IV, December I, II, III and IV week was to an extent of 56.61, 53.67, 48.51, 44.51 and 42.51 per cent, respectively thus accounted for 49.16 per cent over all increased foliage damage across five sowing weeks (Table 1).

**Per cent dead heart incidence**

Pooled data revealed significantly higher dead heart incidence in unprotected plots as compared to protected ones with 9.30 and 2.38 per cent, respectively. The overall influence of different sowing dates irrespective of protection levels on dead heart incidence was found to be highest with December IV week sowing (7.75%) which was significantly followed by sowing at December III week (6.73%). The next highest dead heart damage was recorded with December II week (5.56%) which was on par with December I week (5.05%). The least dead heart percentage was recorded with November IV (4.12%) sowing week which was significantly different from other sowing weeks. Among the different treatment combinations of protection levels and sowing weeks, significant differences were observed in per cent of dead hearts with highest during December IV week sowing under unprotected conditions (11.82%) followed by December III (10.30%) and II (8.83%) sowing week. The latter sowing week was on par with December I (8.39%). The least per cent of dead hearts was recorded with November IV (7.18%) sowing week which differed significantly from other treatment combinations. Overall, increased incidences in unprotected plot over protected ones across five dates of sowing are accounting for 75.43 per cent (Table 1).

**Per cent stem tunnelling**

Pooled data on per cent stem tunnelling in maize as influenced by different dates of sowing in the protected and unprotected plots revealed significantly higher stem tunnelling was recorded in unprotected plots as compared to protected ones with 11.72 and 3.30 per cent, respectively. Among all five sowing weeks irrespective of protection levels, the highest per cent stem tunnelling of 10.76 was recorded when the crop was sown during IV week of December and it was significantly followed by December III, II, I and November IV week sown crop (9.05, 6.93, 6.03 and 4.77%, respectively) and differed significantly from each other. Among the different treatment combinations, the crop sown on December IV week under unprotected conditions recorded significantly highest stem tunnelling of 16.26 per cent and was on par with crop sown during December III week (13.53%). Among the remaining treatment combinations, December II week sown crop recorded 10.98 per cent stem tunnelling and was significantly different from December I week (9.51%) and November IV week (8.30%) sown crops and both were at par. The per cent increase in stem tunnelling in the unprotected condition over protected maize was to the tune of 85.09, 73.19, 73.69, 66.17 and 67.64 per cent in November IV, December I, II, III and IV week with an average of 73.16 per cent across five sowing weeks (Table 1).

**Larval population of *C. partellus***

The data for *rabi* 2014-15 and 2015-16 were combined and analyzed indicated significant differences between protection levels, sowing dates and their interaction. The protected plot recorded significantly lower *C. partellus* larval population (0.65 larvae plant$^{-1}$) as against 1.89 larvae plant$^{-1}$in unprotected conditions. Among the different maize crop sowing weeks, sowing taken up during November IV week was significantly superior over all other treatments by recording the lowest mean larval population of 0.84 plant$^{-1}$ followed by December I week sown crop (1.12 larvae plant$^{-1}$) which was at par with December II week sown crop (1.27 larvae plant$^{-1}$). The crop sown during December IV week significantly recorded highest larval population of *C. partellus* (1.66 plant$^{-1}$) and at par with December III week sown crop (1.47 larvae plant$^{-1}$) and the latter treatment in turn was on par with December II week sown crop. Among the different treatment combinations, the crop sown on November IV week under protected conditions recorded significantly lower population of 0.29 larvae plant$^{-1}$ as compared to the remaining treatment combinations and it was followed by December I week sown crop (0.54 larvae plant$^{-1}$). Among the remaining treatment combinations under protected conditions December II week (0.64 larvae plant$^{-1}$) sown crop was on par with December I and also with III week (0.81 larvae plant$^{-1}$) sown crop and the latter treatment in turn was on par with December IV week sown crop (0.95 larvae plant$^{-1}$). The increase in larval population of *C. partellus* in the unprotected condition over protected condition was to an extent of 78.99, 68.24, 66.14, 61.97 and 59.75 per cent when the crop was sown during November IV week, December I, II, III, and IV weeks, respectively with an overall increase in population of 67.02 per cent (Table 2).

### Exit holes caused by *C. partellus* larvae

Pooled data on exit holes made by *C. partellus* in maize as influenced by different dates of sowing in the protected and unprotected plots revealed significantly higher number of exit holes was recorded in unprotected plots as compared to protected ones with 2.55 and 0.84 plant$^{-1}$, respectively. Among all five sowing weeks, the lowest number of 1.19 exit holes plant$^{-1}$ was counted when the crop was sown during IV week of November and it was significantly followed by December I (1.58 plant$^{-1}$) week sown crop. The latter sowing week was on par with December II (1.65 plant$^{-1}$) which in turn was on par with December III (1.89 plant$^{-1}$) week sown crop. The crop sown on December IV week recorded highest number of 2.16 exit holes plant$^{-1}$ and it was on par with December III week sown maize crop. Among the different treatment combinations, the crop sown on November IV week under protected conditions recorded significantly least number of exit holes (0.56 plant$^{-1}$) and was significantly followed by crops sown during December I (0.75 plant$^{-1}$) and II week (0.81 plant$^{-1}$) which were at par with each other. The latter treatment combination was on par with December III week (1.00 plant$^{-1}$) which in turn was on par with December IV week sown crop (1.06 plant$^{-1}$). The per cent increase in number of exit holes per plant in the unprotected condition over protected maize was accounted for 69.06, 68.88, 67.47, 64.03 and 67.38 per cent in November IV, December I, II, III and IV weeks with an average of 67.36 per cent across five sowing weeks (Table 2).

### Plant population

Plant population per unit area differed with different weeks of sowing irrespective of protection levels and highest mean number of plants ha$^{-1}$ (76389) was recorded in the crop sown during IV week of November and was at par with December I week sown crop which had 74722 plants ha$^{-1}$. The plant population gradually decreased in latter weeks of sowing *viz*., December II week (71979 ha$^{-1}$) which was on par with December I week and also on par with III week (70069 ha$^{-1}$) sowing. Significantly lowest plant population (66840 ha$^{-1}$) was measured in December IV week sown crop which was on par with December III week sown crop. The interaction between protection level and sowing weeks differed significantly and highest number of plants ha$^{-1}$ (83958) was recorded in November IV week under protected conditions followed by December I (83055), II (80416), III week (79097) and were at par with each other. The latter treatment was on par with crop sown on December IV week with 76805 plants ha$^{-1}$. The reduction in number of plants ha$^{-1}$ in the unprotected condition over protected maize in different dates of sowing varied from 18.03 per cent in November IV week to 25.95 per cent in December IV week with an average of 21.44 per cent across five sowing weeks (Table 2).

### Number of poor cobs

The results of pooled analysis of *rabi* 2014-15 and 2015-16 revealed the superiority of protected plot having the lowest number of poor cobs (13833.33 ha$^{-1}$) which was significantly different to unprotected plot with 28638.89 poor cobs ha$^{-1}$. Number of poor

**Table 1. Influence of different dates of sowing on stem borer, *C. partellus,* damage in chemically protected and unprotected maize crop**

| Sowing week | Pooled Mean (*Rabi* 2014-15 & 2015-16) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | % Foliage damage (Leaf scraping + pinholes) | | | | Dead hearts (%) | | | | Stem tunneling (%) | | | |
| | Protected | Un-protected | Mean | % increase | Protected | Un-protected | Mean | % increase | Protected | Un-protected | Mean | % increase |
| November IV | 15.09 (22.81)[a] | 34.78 (36.14)[d] | 24.94 (29.48)[a] | 56.61 | 1.06 (5.85)[a] | 7.18 (15.52)[d] | 4.12 (10.69)[a] | 85.27 | 1.24 (6.33)[a] | 8.30 (16.72)[d] | 4.77 (11.53)[a] | 85.09 |
| December I | 17.53 (24.68)[a] | 37.84 (37.97)[d] | 27.69 (31.33)[a] | 53.67 | 1.71 (7.50)[b] | 8.39 (16.84)[e] | 5.05 (12.16)[b] | 79.59 | 2.55 (9.11)[b] | 9.51 (17.96)[d] | 6.03 (13.53)[b] | 73.19 |
| December II | 21.99 (27.98)[b] | 42.71 (40.81)[e] | 32.35 (34.40)[b] | 48.51 | 2.29 (8.68)[b] | 8.83 (17.27)[e] | 5.56 (12.98)[b] | 74.07 | 2.89 (9.78)[b] | 10.98 (19.35)[e] | 6.93 (14.57)[c] | 73.69 |
| December III | 26.65 (31.08)[c] | 48.03 (43.89)[f] | 37.34 (37.49)[c] | 44.51 | 3.17 (10.24)[c] | 10.30 (18.72)[f] | 6.73 (14.49)[c] | 69.22 | 4.58 (12.34)[c] | 13.53 (21.57)[f] | 9.05 (16.96)[d] | 66.17 |
| December IV | 29.93 (33.16)[c] | 52.06 (46.21)[f] | 41.00 (39.69)[d] | 42.51 | 3.67 (10.98)[c] | 1.82 1(20.12)[g] | 7.75 (15.55)[d] | 68.99 | 5.26 (13.24)[c] | 16.26 (23.77)[f] | 10.76 (18.51)[e] | 67.64 |
| Mean | 22.24 (27.94)[a] | 43.08 (41.00)[b] | 32.66 | 49.16 | 2.38 (8.65)[a] | 9.30 (17.69)[b] | 5.84 | 75.43 | 3.30 (10.16)[a] | 11.72 (19.88)[b] | 7.51 | 73.16 |
| CV (%) | 5.58 | | | | 6.43 | | | | 5.76 | | | |

| For comparing | SEm± | CD @5% | SEm± | CD @5% | SEm± | CD @5% |
|---|---|---|---|---|---|---|
| Plant Protection (P) | 0.43 | 1.25 | 0.19 | 0.55 | 0.19 | 0.57 |
| Sowing dates (S) | 0.68 | 1.98 | 0.30 | 0.86 | 0.30 | 0.88 |
| Interaction (PXS) | 0.96 | 2.79 | 0.42 | 1.22 | 0.43 | 1.26 |

Figures in the parentheses are arc sine transformed values

Means followed by similar letters in columns or rows are not significantly different ($P < 0.05$) as per DMRT

November IV – 27.11.14 & 26.11.15; December I – 4.12.14 & 3.12.15; December II – 11.12.14 & 10.12.15; December III – 18.12.14 & 17.12.15; December IV – 26.12.14 & 24.12.15

**Table 2. Influence of different dates of sowing on stem borer, *C. partellus* larval density, exit holes and plant population in chemically protected and unprotected maize crop**

| Sowing week | Pooled Mean (*Rabi* 2014-15 & 2015-16) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Chilo partellus* larvae plant$^{-1}$ | | | | Exit holes plant$^{-1}$ | | | | Plant stand ha$^{-1}$ | | | |
| | Protected | Un-protected | Mean | % increase | Protected | Un-protected | Mean | % increase | Protected | Un-protected | Mean | % decrease |
| November IV | 0.29 (0.53)$^{a}$ | 1.38 (1.17)$^{e}$ | 0.84 (0.84)$^{a}$ | 78.99 | 0.63 (0.78)$^{a}$ | 1.95 (1.39)$^{d}$ | 1.29 (1.08)$^{a}$ | 67.69 | 83958.33 (289.75)$^{e}$ | 68819.44 (262.24)$^{c}$ | 76388.89 (276.00)$^{d}$ | 18.03 |
| December I | 0.54 (0.73)$^{b}$ | 1.70 (1.30)$^{f}$ | 1.12 (1.02)$^{b}$ | 68.24 | 0.73 (0.85)$^{ab}$ | 2.50 (1.58)$^{e}$ | 1.62 (1.21)$^{ab}$ | 70.80 | 83055.56 (288.20)$^{de}$ | 66388.89 (257.49)$^{bc}$ | 74722.22 (272.85)$^{cd}$ | 20.07 |
| December II | 0.64 (0.79)$^{bc}$ | 1.89 (1.38)$^{fg}$ | 1.27 (1.09)$^{bc}$ | 66.14 | 0.78 (0.88)$^{abc}$ | 2.48 (1.58)$^{e}$ | 1.63 (1.22)$^{b}$ | 68.55 | 80416.67 (283.54)$^{de}$ | 63541.67 (251.95)$^{bc}$ | 71979.17 (267.75)$^{bc}$ | 20.98 |
| December III | 0.81 (0.89)$^{cd}$ | 2.13 (1.45)$^{gh}$ | 1.47 (1.17)$^{cd}$ | 61.97 | 1.05 (1.01)$^{bc}$ | 2.98 (1.72)$^{ef}$ | 2.02 (1.37)$^{c}$ | 64.77 | 79097.22 (281.23)$^{de}$ | 61041.67 (246.83)$^{ab}$ | 70069.44 (264.02)$^{ab}$ | 22.83 |
| December IV | 0.95 (0.97)$^{d}$ | 2.36 (1.54)$^{h}$ | 1.66 (1.26)$^{d}$ | 59.75 | 1.08 (1.03)$^{c}$ | 3.38 (1.84)$^{f}$ | 2.23 (1.43)$^{c}$ | 68.05 | 76805.56 (277.10)$^{d}$ | 56875.00 (238.19)$^{a}$ | 66840.28 (257.65)$^{a}$ | 25.95 |
| Mean | 0.65 (0.78)$^{a}$ | 1.89 (1.37)$^{b}$ | 1.27 | 67.02 | 0.85 (0.90)$^{a}$ | 2.66 (1.62)$^{b}$ | 1.76 | 67.97 | 80527.78 (283.97)$^{b}$ | 63333.33 (251.33)$^{a}$ | 71930.56 | 21.44 |
| CV (%) | 8.14 | | | | 9.71 | | | | 2.88 | | | |

| For comparing | SEm± | CD @5% | SEm± | CD @5% | SEm± | CD @5% |
|---|---|---|---|---|---|---|
| Plant Protection (P) | 0.43 | 1.25 | 0.19 | 0.55 | 0.19 | 0.57 |
| Sowing dates (S) | 0.68 | 1.98 | 0.30 | 0.86 | 0.30 | 0.88 |
| Interaction (PXS) | 0.96 | 2.79 | 0.42 | 1.22 | 0.43 | 1.26 |

Figures in the parentheses are square root transformed values

Means followed by similar letters in columns or rows are not significantly different ($P < 0.05$) as per DMRT

Nov. IV – 27.11.14 & 26.11.15; Dec. I – 4.12.14 & 3.12.15; Dec. II – 11.12.14 & 10.12.15; Dec. III – 18.12.14 & 17.12.15; Dec. IV – 26.12.14 & 24.12.15

cobs per unit area differed with different weeks of sowing irrespective of protection levels and lowest mean number of poor cobs $ha^{-1}$ (13785) was recorded with November IV week sown crop and was on par with December I week sown crop which had 16076 poor cobs $ha^{-1}$. The number of poor cobs significantly increased in December II week sowing (22083 $ha^{-1}$) which was statistically superior from December III (25937 $ha^{-1}$) and IV week sown crop (28299 $ha^{-1}$) and the latter two sowing weeks were at par with each other. The interaction between protection level and sowing weeks differed significantly and among the different treatment combinations, lowest number of poor cobs $ha^{-1}$ (7569) was recorded in November IV week under protected conditions followed by December I week (10347) and were at par with each other. The latter treatment was significantly different from crop sown on December II week with 14097 poor cobs $ha^{-1}$ which was on par with December III (17708 $hectare^{-1}$) and it in turn was on par with December IV week sown crop (19444 $ha^{-1}$).The number of poor cobs $ha^{-1}$ in the unprotected condition over protected maize was increased to the tune of 62.15, 52.55, 53.12, 48.17 and 47.66 in five dates of sowing from November IV week to December IV week with an average of 52.73 per cent (Table 3).

**Estimation of loss in grain yield**

Pooled analysis of *rabi* 2014-15 and 2015-16 data revealed significant difference between protected and unprotected plots with a mean grain yield of 70.00 and 31.55 q $ha^{-1}$, respectively. Significantly highest mean grain yield of 65.91 q $ha^{-1}$ was obtained when the crop was sown during IV week of November and it was on par with December I week sown crop (63.39 q $ha^{-1}$). December II week sown crop recorded 54.19 q $ha^{-1}$ and was on par with December I week sown crop. The latter two sowings *viz*., December III and IV week were statistically identical with 39.18 and 31.19 q $ha^{-1}$, respectively. Significant differences were observed in interaction between protection level and sowing time and significantly higher grain yield of 86.69 q $ha^{-1}$ was recorded in November IV week sown crop under protected conditions and it was statistically on par with December I (85.07 q $ha^{-1}$) and December II (73.65 q $ha^{-1}$) week sown crop. With delay in sowings, December III and IV week's sown crops differed significantly by recording maize grain yield of 55.19 and 49.40 q $ha^{-1}$, respectively. The loss in grain yield in the unprotected condition over protected in different dates of sowing varied from 47.93 per cent in November IV week to73.70 per cent in December IV week with an average of 56.69 per cent across five sowing weeks (Table 3).

**Test weight**

Combined result indicated significant difference between protected and unprotected plots with a mean 100-grain weight of 29.74 and 28.77 g, respectively. November IV week sown crop was significantly superior over all other dates of sowing irrespective of protection levels by recording mean highest 100-grain weight of 32.08 g and was followed by December I week sowing which recorded mean 100-grain weight of 29.83 g which in turn was on par with December II week sowing (28.73 g). December III week sowing maintains its similarity with December II week in recording 100-grain weight of 28.11 g and was significantly unaffected by the sowing week of December IV with 27.53 g. Among the interaction between protection level and dates of sowing combinations, 100-grain weight ranged in protected plots from 28.03 to 33.01 g, where November IV week sown maize crop had significantly highest 100-grain weight (33.01 g) followed by December I (30.08 g). The latter three treatment combinations of December II, III and IV weeks under protection recorded 28.91, 28.65 and 28.03 g, respectively which were at par. Sowing of maize crop at November IV week, December I, II, III and IV weeks reflected in 100-grain weight loss of 5.62, 1.70, 1.25, 3.80 and 3.60 per cent, respectively with an overall loss of 3.19 per cent (Table 3).

The crop that was sown late produced lower biomass (foliage area) and stunting of growth at the time when the stem borer population became high. Consequently, the increased dead heart incidence, early leaf senescence, reduced translocation, lodging and direct damage to the cobs in later dates of sowing manifested in lowering the grain yield. On the other

**Table 3. Influence of different dates of sowing on poor cobs, grain yield and test weight in chemically protected and unprotected maize crop**

| Sowing week | Pooled Mean (*Rabi* 2014-15 & 2015-16) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. of poor cobs $ha^{-1}$ | | | | Grain yield (q $ha^{-1}$) | | | | 100 grain weight (g) | | | |
| | Protected | Un-protected | Mean | % increase | Protected | Un-protected | Mean | % Loss | Protected | Un-protected | Mean | % Loss |
| November IV | 7569.44 (86.32)$^{a}$ | 20000.00 (140.89)$^{c}$ | 13784.72 (113.60)$^{a}$ | 62.15 | 86.69$^{f}$ | 45.14$^{cde}$ | 65.91$^{c}$ | 47.93 | 33.01$^{f}$ | 31.15$^{e}$ | 32.08$^{d}$ | 5.62 |
| December I | 10347.22 (101.61)$^{a}$ | 21805.56 (147.48)$^{c}$ | 16076.39 (124.55)$^{a}$ | 52.55 | 85.07$^{f}$ | 41.70$^{cd}$ | 63.39$^{bc}$ | 50.98 | 30.08$^{de}$ | 29.57$^{cde}$ | 29.83$^{c}$ | 1.70 |
| December II | 14097.22 (118.45)$^{b}$ | 30069.44 (173.32)$^{d}$ | 22083.33 (145.88)$^{b}$ | 53.12 | 73.65$^{f}$ | 34.74$^{bc}$ | 54.19$^{b}$ | 52.82 | 28.91$^{bcd}$ | 28.55$^{abcd}$ | 28.73$^{bc}$ | 1.25 |
| December III | 17708.33 (132.39)$^{bc}$ | 34166.67 (184.42)$^{de}$ | 25937.50 (158.41)$^{c}$ | 48.17 | 55.19$^{e}$ | 23.16$^{ab}$ | 39.18$^{a}$ | 58.04 | 28.65$^{abcd}$ | 27.56$^{ab}$ | 28.11$^{ab}$ | 3.80 |
| December IV | 19444.44 (139.12)$^{c}$ | 37152.78 (192.47)$^{e}$ | 28298.61 (165.80)$^{c}$ | 47.66 | 49.40$^{de}$ | 12.99$^{a}$ | 31.19$^{a}$ | 73.70 | 28.03$^{abc}$ | 27.02$^{a}$ | 27.53$^{a}$ | 3.60 |
| Mean | 13833.33 (115.57)$^{a}$ | 28638.89 (167.71)$^{b}$ | 21236.11 | 52.73 | 70.00$^{b}$ | 31.55$^{a}$ | 50.77 | 56.69 | 29.74$^{b}$ | 28.77$^{a}$ | 29.25 | 3.19 |
| CV (%) | 7.98 | | | | 18.17 | | | | 3.85 | | | |

| For comparing | **SEm±** | **CD @5%** | **SEm±** | **CD @5%** | **SEm±** | **CD @5%** |
|---|---|---|---|---|---|---|
| Plant Protection (P) | 2.53 | 7.34 | 2.06 | 5.98 | 0.25 | 0.72 |
| Sowing dates (S) | 4.00 | 11.61 | 3.27 | 9.46 | 0.40 | 1.15 |
| Interaction (PXS) | 5.65 | 16.41 | 4.61 | 13.39 | 0.56 | 1.63 |

Figures in the parentheses are square root transformed values

Means followed by similar letters in columns or rows are not significantly different ($P< 0.05$) as per DMRT

Nov. IV – 27.11.14 & 26.11.15; Dec. I – 4.12.14 & 3.12.15; Dec. II – 11.12.14 & 10.12.15; Dec. III – 18.12.14 & 17.12.15; Dec. IV – 26.12.14 & 24.12.15

hand, the lower population of stem borer in early sown crop resulted in less loss in grain yield. A positive correlation between crop loss and late planting was demonstrated by Gebre-Amlak *et al*. (1989). Up to 80 per cent maize yield loss has been attributed to stem borer damage in Pakistan (Rahman *et al*., 1986), 27 per cent loss in Ghana (Gounou *et al*., 1994), over 50 per cent in Mozambique (Cugala, 2002), 13.5 per cent loss in Kenya (De-Groote *et al*., 2003), up to 80 per cent loss in Africa (Vanden Berg, 2009), 30 to 70 per cent loss in Israel (Ben-Yakir *et al*., 2012) and 20 to 40 per cent loss in Nigeria (IITA, 2013). Maize stem borer alone has been attributed for 10 to 30 per cent loss in maize grain yield in Sikkim (Gupta *et al*., 1994) and 26.7 to 80.4 per cent yield losses in different agro-climatic regions of India (Panwar, 2005). Data from natural infestation indicates that early infestation by stem borer in late sown crop is the most damaging and results in greatest reduction of yield. Though recommendations on dates appropriate for sowing exist across all agro-ecological zones where maize is cultivated in India, staggered dates of sowing are prevalent in many areas thereby making maize crop available to stem borer at different phenological stages for completion of several generations (1-4). As previously observed by Polaszek (1998), the early- planted maize crop was less severely infested and damaged compared with the late sown crop. In Mozambique, larvae of third-generation *C. partellus*, was reported to infest 87 per cent of cobs of late-planted maize and to severely damage 70 per cent of grain (Berger, 1981).

Reliable information on yield losses due to insect pests to establish the increased yield is practicable when the insect pests are controlled at acceptable economic cost. Yield loss estimates are thus regarded as the best way to indicate to the farmer that the opportunities are gained when sound plant protection measures are applied (Duraimurugan and Tyagi, 2014). Protection level also determined the final yield. Unprotected plots (31.55 q $ha^{-1}$) harvested to some extent less yield over protected ones (70.00 q $ha^{-1}$). Hence, the protections against stem borer in maize are very much needed in order to prevent the yield loss. Stem borer infestations in maize range from 30 to 70 per cent in fields of resource–poor farmers but are less than 30 per cent in commercial farms where insecticides are used (Sithole, 1987). The significant reductions in infestation and damage accompanied by yield increases with application of carbofuran against stem borers agreed with the findings of Khan and Amjad (2000).

## CONCLUSION

This experiment is important in providing a good base for assessing the level of damage by stem borer to maize. Damage on the treated plots was significantly lower than the untreated plots. Treated plots gave higher yields than untreated ones significantly. Thus, insecticide control gave a better yield. This could be used in IPM to improve the quantity and quality of maize.

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# RESPONSE OF NEWLY RELEASED *hirsutum* HYBRID NHH-715 TO PLANT GEOMETRY AND FERTILIZER LEVELS UNDER RAINFED CONDITIONS OF SCARCE RAINFALL ZONE OF ANDHRA PRADESH

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**ABSTRACT**

A field experiment was conducted during 2016 at Regional Agricultural Research Station, Nandyal in Kurnool district in black soils to study the response of NHH hybrid to spacings and fertilizer levels. The experiment was conducted with two spacings ($S_1$-90 cm X 60 cm and $S_2$- 90 cm X 45 cm), three fertilizer levels *viz.,* $F_1$: 100 % RDF (120-60-60 NPK kg ha$^{-1}$), $F_2$: 125 % RDF (150-75-75 NPK kg ha$^{-1}$) and $F_3$: 150 % RDF (180-90-90 NPK kg ha$^{-1}$) and two cotton hybrids ($V_1$: NHH-715 and $V_2$: RCH-138). Between the spacings tested 90 cm x 60 cm recorded higher seed cotton yield (2966 kg ha$^{-1}$) than 90 cm x 45 cm (2746 kg ha$^{-1}$). Significantly higher seed cotton yield was recorded with 150 % RDF (3080 kg ha$^{-1}$) than 125 % (2813 kg ha$^{-1}$) and 100 % RDF (2675 kg ha$^{-1}$). Between the hybrids tested, NHH-715(2967 kg ha$^{-1}$) recorded higher seed cotton yield than RCH-138 (2745 kg ha$^{-1}$).

## INTRODUCTION

Cotton (*Gossypium hirsutum* L.), is a predominant cash crop in India. Cotton is an important raw material for the Indian textile industry contributing about 65 per cent of its requirements. The Indian textile industry occupies a significant place in the Indian economy with over 1500 mills, 1.7 million power looms, and thousands of garments, hosiery and processing units, providing an employment directly or indirectly to around 35 million people (Ashok *et al.*, 2004). In recent years, cotton apparels are being preferred to the synthetic ones due to the increasing health consciousness among the people. In India, textile industry has prime importance next to the sugar industries which provide livelihood by way of support in agriculture, processing and use of cotton in textiles. Nearly one-third of India's export earnings are from textile sector, of which cotton alone constitute approximately 70 per cent of raw materials and also contributes 29.8 per cent of the national GDP. In India, cotton occupied 118.7 lakh hectare with production of 338 lakh bales and productivity is 484 kg lint per ha. Among the states, Andhra Pradesh occupied with 6.6 lakh ha with production of 24 lakh bales and productivity is 613 kg ha$^{-1}$ (CAB,2016). Cotton can be grown with different crop geometry and fertilizers levels. However, hybrids of cotton require tailored crop geometry and fertilizers for yield maximization under rainfed condition. The precise knowledge on adequate crop geometry and fertilizers not only saves the investment of costly input, but also enhance the production through adequate plant stand and efficient utilization of inputs. Further, monopodia, sympodia, lint yield, number of functional leaf, dry-matter per plant are also influenced by type of cotton hybrids under different levels of fertilizer and crop geometry. It is substantially required to fully exploit the production potential of the hybrids by standardizing some of the agronomic practices particularly optimum crop geometry with efficient and balanced fertilization of NPK which influence the growth, development and quality parameter of cotton. Optimum crop geometry prevents inter plant competition for resources. However, balanced application of NPK fertilizers is required for higher productivity and maintains physiological, bio-chemical and metabolic processes of plant to produce good quality fiber and sustained productivity. Hence, there is a need to work on crop geometry with different levels of NPK under rain fed conditions for the new hybrids. The present investigation was, therefore, conducted to study the effect of plant

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geometry and fertilizer levels on yield of NHH-715 hybrid under rain fed conditions.

## MATERIAL AND METHODS

A field experiment was conducted at Regional Agricultural Research Station, Nandyal, during *kharif* 2016-2017 to study the response of NHH-715 hybrid to plant geometry, fertilizer levels under rainfed condition. The soil of experimental field was deep black having clayey textural class with low organic carbon (0.39%) and available nitrogen (188.6 kg ha$^{-1}$), medium in available phosphorus (23.6 kg ha$^{-1}$) and high in potassium (480 kg ha$^{-1}$). The pH and EC (dS/m) of soil was 8.3 and 0.09, respectively. A total 810 mm rainfall was received in 40 rainy days during the crop period.

The experiment was conducted in split-plot design and replicated thrice. The main plots assigned with two crop geometry ($S_1$-90 cm x 60 cm and $S_2$-90 cm x 45 cm) , sub plots are assigned with three NPK levels($F_1$: 100 % RDF (120-60-60 kg ha$^{-1}$), $F_2$: 125 % RDF (150-75-75 kg ha$^{-1}$), $F_3$: 150 % RDF (180-90-90 kg ha$^{-1}$) and two cotton hybrids ($V_1$: NHH-715, $V_2$: RCH-138 as check). The entire dose of phosphorus and potassium as per the treatments were applied as basal dose through Single Super Phosphate and Muriate of Potash. Nitrogen was applied in the form of urea as per the treatments in three equal splits at 30,60 and 90 days after sowing by pocketing method. The sowing was done by dibbling of 2-3 seeds at each hill as per the treatments. The plant population was maintained by gap filling and subsequent thinning keeping single plant per hill. All the data was statistically analysed with standard procedure. Ginning out-turn is a useful indicator of the performance of a genotype. Ginning out-turn can be described as the percentage of lint obtained from a sample of seed cotton. Genotypes with high ginning out-turn values are thus preferable, because they yield more lint

$$\text{Ginning out-turn} = \frac{\text{Weight of lint in the sample}}{\text{Weight of seed cotton in the sample}} \times 100$$

## RESULTS AND DISCUSSION

The plant population per net plot varied significantly with different spacings tested. Higher population being recorded in 90 cm x 45 cm (24691 plants ha$^{-1}$) and was lower in 90 cm x60 cm (18518 plants ha$^{-1}$). Plant height did not differ significantly among the spacings and fertilizers levels tested with pre release hirsutum hybrids. The number of monopodia and sympodia plant$^{-1}$ recorded with two hybrids tested were not affected by spacings and fertilizer levels.

Number of bolls per sq m differed significantly between the two spacings tested. Higher number of bolls per sq m (51.9) was recorded at 90 cm × 60 cm than with 90 cm × 45 cm(47.3).There was significant effect of different fertilizer levels on number of bolls per sq m. Maximum number of bolls per sq m (54.8) was recorded with 150% RDF and was significantly superior to other two fertilizer levels. Lower number of bolls per sq m (46.4) was observed in 100 % RDF. Higher number of bolls per sq m (52.2) was recorded in NHH-715 than RCH-138(47.0).

Boll weight did not differ significantly due to the spacings and hybrids tested, however there was significant effect of different fertilizer levels on boll weight. Maximum boll weight (4.40g) was recorded with 150% RDF than 125 % and 100 % RDF and lower boll weight (3.82g) was observed with 100% RDF. The macronutrient (NPK) play important role during vegetative as well as reproductive growth stages of cotton and also increase the sympodial branches, number of bolls and boll weight by encouraging the process of photosynthesis. Ultimately, product of photosynthesis accumulated in economic part of cotton *i.e.* bolls and hence, increased final yield of cotton (Solanke *et al.*, 2001 and Wankhade *et al.*, 2001).

Between the two spacings tested higher seed cotton yield (2966 kg ha$^{-1}$) and lint yield (1123 kg ha$^{-1}$) were recorded with spacing of 90 cm x 60 cm where as 2746 kg ha$^{-1}$ of seed cotton yield and 1011 kg ha$^{-1}$ lint yield were recorded with 90 cm x

**Table 1. Effect of spacing and fertilizer levels on growth parameters of *hirsutum* hybrids**

| Treatments | Final plant population (No/net plot) | Plant height (cm) | No of monopodia plant$^{-1}$ | No of sympodia plant$^{-1}$ | No of Bolls m$^{-2}$ | Boll weight (g) |
|---|---|---|---|---|---|---|
| **Spacing(cm)** | | | | | | |
| $S_1$ - 90 x 60 | 17 | 100.6 | 2.0 | 15.6 | 51.9 | 4.14 |
| $S_2$ - 90 x 45 | 28 | 106.7 | 1.8 | 15.0 | 47.3 | 4.06 |
| SEm ± | 0.6 | 2.0 | 0.03 | 0.9 | 0.5 | 0.05 |
| CD @5 % | 3.8 | NS | NS | NS | 3.3 | NS |
| **Fertilizer levels** | | | | | | |
| $F_1$-100 %RDF (120-60-60 NPK kg ha$^{-1}$) | 22 | 104.3 | 2.1 | 15.0 | 46.4 | 3.82 |
| $F_2$- 125% RDF (150-75-75 NPK kg ha$^{-1}$) | 23 | 99.8 | 1.9 | 15.4 | 47.5 | 4.09 |
| $F_3$- 150% RDF (180-90-90 NPK kg ha$^{-1}$) | 23 | 106.7 | 1.8 | 15.5 | 54.8 | 4.40 |
| SEm ± | 0.6 | 2.0 | 0.09 | 0.4 | 1.6 | 0.07 |
| CD @ 5 % | NS | NS | NS | NS | 5.3 | 0.2 |
| **Hybrids** | | | | | | |
| $V_1$-NHH-715 | 23 | 104.0 | 2.0 | 15.7 | 52.2 | 4.13 |
| $V_2$- RCH-138 | 22 | 103.3 | 1.9 | 14.9 | 47.0 | 4.07 |
| SEm ± | 0.5 | 1.7 | 0.04 | 0.3 | 1.3 | 0.1 |
| CD @5 % | NS | NS | NS | NS | 4.2 | NS |
| Interaction | NS | NS | NS | NS | NS | NS |
| CV (%) | 10 | 7 | 10 | 9 | 12 | 11 |

45 cm . Similar results were also reported by Uma Nath *et al.*(2013). This might be due to better aeration and adequate interception of light as well as lesser competition for nutrients due to low plant population per unit area in wider spacing of 90 cm x 60 cm. Beneficial effects of wider spacing in cotton was also reported by Narkhede *et al.*(2000). Higher seed cotton yield (3080 kg ha$^{-1}$) and lint yield ( 1203 kg ha-$^{1}$ ) was recorded with 150 % RDF and was on par with 125 % RDF (2813 kg ha$^{-1}$ and 1069 kg ha$^{-1,}$ respectively). Lower seed cotton and lint yield (2675 kg ha$^{-1}$ and 950 kg ha$^{-1}$ respectively) was recorded with 100 % RDF. The increase in seed cotton yield with higher fertilizer doses might be due to more number of sympodial branches, number of bolls and yield plant$^{-1}$. All these characters are positively correlated with the seed cotton yield.

Between the two hybrids tested, NHH-715 recorded superior seed cotton yield (2967 kg ha$^{-1}$) and lint yield (1132 kg ha$^{-1}$) over RCH-138. The increase in seed cotton yield might be due to the better production of yield attributing characters of

**Table 2. Effect of spacing and fertilizer levels on yield parameters of *hirsutum* hybrids**

| Treatments | Seed cotton yield (kg ha$^{-1}$) | Lint yield (kg ha$^{-1}$) | Ginning out turn (%) | Test weight (g) | Seed index (g) |
|---|---|---|---|---|---|
| **Spacing(cm)** | | | | | |
| $S_1$- 90 x 60 | 2966 | 1123 | 38 | 13.3 | 8.7 |
| $S_2$- 90 X 45 | 2746 | 1011 | 36 | 13.7 | 8.8 |
| SEm ± | 26 | 11.2 | 0.17 | 0.15 | 0.05 |
| CD @ 5 % | 160 | 68 | 1.0 | NS | NS |
| **Fertilizer levles** | | | | | |
| $F_1$-100 %RDF (120-60-60 NPK kg ha$^{-1}$) | 2675 | 950 | 35 | 12.7 | 7.9 |
| $F_2$-125 % RDF(150-75-75 NPK kg ha$^{-1}$ ) | 2813 | 1069 | 37 | 13.5 | 8.8 |
| $F_3$-150 % RDF(180-90-90 NPK kg ha$^{-1}$) | 3080 | 1203 | 39 | 14.3 | 9.6 |
| SEm ± | 95 | 34 | 0.7 | 0.55 | 0.27 |
| CD @5 % | 311 | 110 | 2.2 | NS | 0.9 |
| **Hybrids** | | | | | |
| $V_1$-NHH-715 | 2967 | 1132 | 38 | 13.2 | 8.5 |
| $V_2$- RCH-138 | 2745 | 1002 | 36 | 13.8 | 9.0 |
| SEm ± | 67 | 26.8 | 0.6 | 0.34 | 0.25 |
| CD @5 % | 206 | 82 | 1.9 | NS | NS |
| Interaction | NS | NS | NS | NS | NS |
| CV (%) | 10 | 11 | 10 | 11 | 12 |

NHH-715 such as fruiting branches (sympodia), number bolls and boll weight etc. which are directly co-related with increase in yield in context of lint yield and seed cotton yield. Higher ginning out turn (38%) was recorded with 90 cm x 60 cm over 90 cm x 45 cm. Among the fertilizer levels ginning out turn was increased with increasing fertilizer levels from 100 % RDF to 150 % RDF. Higher ginning out turn (39 %) was recorded with 150 % RDF where as lower ginning out turn (35 %) was recorded with 100% RDF. Between the hybrids tested, NHH-715 hybrid recorded higher ginning out turn (38%) over RCH-138 hybrid. Spacings and fertilizer levels did not show any significant effect on 100 seed weight of hybrids.

Seed index increased with increasing fertilizer levels from 100 % RDF to 150 % RDF. Maximum seed index (9.6) was recorded with 150 % RDF and was on par with 125 % RDF and lowest seed index (7.9) was recorded with 100 % RDF. The yield parameters and yield recorded with two hybrids tested were not influenced by spacings, fertilizer levels.

## CONCLUSION

It can be concluded that the *hirsutum* hybrid NHH-715 recorded higher seed cotton yield at a spacing of 90 cm x 60 cm with 150% RDF (180-90-90 NPK kg ha$^{-1}$) in black soils in scarce rainfall zone of Andhra Pradesh under rainfed conditions.

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# CORRELATION STUDIES FOR YIELD ATTRIBUTING TRAITS AND TRAITS RELATED TO MECHANICAL HARVESTING IN CHICKPEA (*Cicer arietinum* L.)

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**ABSTRACT**

An experiment with 30 chickpea genotypes (with erect to semi erect growth habit) was conducted under rainfed and irrigated conditions with three replications at Regional Agricultural Research Station, Nandyal during *rabi* 2016-17. Correlations were studied to find out relationship between fourteen plant characters with respect to genetic improvement in yield and amenability to mechanical harvesting. Yield attributes *viz*., number of secondary branches plant$^{-1}$, number of pods plant$^{-1}$, shoot biomass, harvest index and 100 seed weight exhibited positive and highly significant association with seed yield and also among themselves under rainfed as well as irrigated conditions while phenological traits (days to 50% flowering and days to maturity) were negatively correlated with seed yield. It is suggested that breeding for high yield should consider optimum crop growth period depending on water availability. Though, angle of the primary branch, one of the traits related to mechanical harvest was positively correlated with seed yield under irrigated condition, height of the first pod has shown significant negative correlation with seed yield. Hence, it is inferred that the traits suitable for mechanical harvesting cannot be developed concurrently as they were negatively correlated. Breeding programmes should aim at breaking undesirable linkages between traits by crossing desirable genotypes for different traits.

## INTRODUCTION

Globally chickpea (*Cicer arietinum* L.) is the second most important pulse crop occupying 14.80 million ha of area with 14.23 million tons of production (FAO STAT, 2016). Chickpea is one of the major pulses cultivated in India. It has high nutritional value and can be a best supplement for meat. India is the largest producer and consumer of chickpeas in the world with cultivable area of 8.84 million ha and 8.29 million tons of production (Source website:http://dpd.dacnet.nic.in/). The scenario of chickpea cultivation in India has drastically changed during last four to five decades. There has been impressive growth in area, production and productivity of chickpea in South India. Andhra Pradesh is also an important chickpea growing state with 6 per cent chickpea area of the country and has witnessed 'chickpea revolution' with fast increase in chickpea area from 71,000 ha in 1992-93 to 6.3 lakh ha during 2007-08 and registering the highest productivity in India (1448 kg ha$^{-1}$). This is because of the introduction and adaptation of short duration, wilt resistant varieties such as JG 11, JAKI 9218 and KAK 2 and mechanization of farming operations.

Shortage of labour necessitated seed to seed mechanization in chickpea. Farmers adapted farm mechanization and custom hiring of farm machines and implements to cultivate chickpea. However, most of the existing popular chickpea varieties grown in India have inadequate plant height (35-45 cm) and semi-spreading growth habit and thus not suitable for mechanical harvesting. Therefore, especially in South India, there is a requirement to develop chickpea cultivars with 30 to 40 per cent more height than the existing cultivars and semi-erect to erect growth habit having fruiting zone starting at about 30 cm from the ground. During *rabi*, chickpea crop is grown under receding soil moisture conditions and rarely one or two rains are received during crop growth period. Chickpea is usually subjected to moisture stress due to low rainfall in growing areas and it responds favourably to supplemental irrigation (Singh *et al.*, 1980; Raghu and Choubey, 1983). Chickpea is being cultivated under protective irrigation in some areas of Andhra Pradesh even as alternative to commercial crops like cotton and tobacco as the realised yield under protective irrigation is very high yield (2.5 to 3.0 t ha$^{-1}$). In this context, the study of

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**Table 1. Phenotypic ($r_p$) and genotypic ($r_g$) correlation coefficients among 14 characters in 30 chickpea genotypes under rainfed condition during *rabi* 2016-17**

| Character | | HFP | DF | DM | PH | NPB | NSB | SCMR | NPP | SHB | HI | 100 SW | Protein | SY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| APB | $r_p$ | 0.2716** | -0.1023 | -0.1657 | 0.2591* | 0.0324 | -0.3468** | -0.2794** | -0.1175 | -0.0771 | -0.1305 | -0.0971 | 0.3373** | -0.1741 |
| | $r_g$ | 0.3723 | -0.1721 | -0.2538 | 0.4622 | 0.1768 | -0.4814 | -0.7722 | 0.0723 | -0.1309 | -0.1266 | -0.1018 | 0.6593 | -0.2277 |
| HFP | $r_p$ | | 0.5638** | 0.5283** | 0.7048** | 0.5064** | -0.3260** | -0.4747** | -0.3558** | -0.0753 | -0.4208** | -0.2169* | 0.5784** | -0.2708** |
| | $r_g$ | | 0.5880 | 0.5541 | 0.7446 | 0.5660 | -0.3997 | -0.6855 | -0.4686 | -0.0973 | -0.4724 | -0.2176 | 0.7661 | -0.3029 |
| DF | $r_p$ | | | 0.7840** | 0.2782** | 0.7355** | -0.4117** | -0.4385** | -0.1132 | -0.3387** | -0.4898** | -0.6762** | 0.1964 | -0.5496** |
| | $r_g$ | | | 0.7992 | 0.2936 | 0.7994 | -0.4710 | -0.6207 | -0.1402 | -0.3504 | -0.5551 | -0.6865 | 0.2394 | -0.5798 |
| DM | $r_p$ | | | | 0.3017** | 0.4707** | -0.4305** | -0.4249** | -0.2808** | -0.3863** | -0.4365** | -0.5451** | 0.2038 | -0.5647** |
| | $r_g$ | | | | 0.3158 | 0.5321 | -0.4976 | -0.5777 | -0.3432 | -0.3991 | -0.5023 | -0.5565 | 0.2510 | -0.5998 |
| PH | $r_p$ | | | | | 0.2115* | -0.2653* | -0.0821 | -0.3816** | 0.1303 | -0.3663** | 0.0194 | 0.5802** | -0.0574 |
| | $r_g$ | | | | | 0.2161 | -0.3434 | -0.1058 | -0.5426 | 0.1314 | -0.4301 | 0.0191 | 0.7165 | -0.0773 |
| NPB | $r_p$ | | | | | | -0.3091** | -0.3556** | 0.1968 | 0.1109 | -0.4742** | -0.4548** | 0.0966 | -0.1875 |
| | $r_g$ | | | | | | -0.4189 | -0.4893 | 0.2218 | 0.1133 | -0.5552 | -0.5053 | 0.1370 | -0.2020 |
| NSB | $r_p$ | | | | | | | 0.3139** | 0.2949** | 0.3143** | 0.2421* | 0.4266 | -0.2011 | 0.4537** |
| | $r_g$ | | | | | | | 0.6224 | 0.1581 | 0.3322 | 0.2965 | 0.5159 | -0.2769 | 0.4973 |
| SCMR | $r_p$ | | | | | | | | 0.2826** | 0.2934** | 0.4130** | 0.4764** | -0.3435** | 0.5083** |
| | $r_g$ | | | | | | | | 0.5473 | 0.4223 | 0.5794 | 0.6575 | -0.4319 | 0.7071 |
| NPP | $r_p$ | | | | | | | | | 0.4238** | 0.1996 | 0.0706 | -0.3160** | 0.4958** |
| | $r_g$ | | | | | | | | | 0.4998 | 0.2193 | 0.0961 | -0.5134 | 0.5595 |
| SHB | $r_p$ | | | | | | | | | | -0.1672 | 0.6153** | 0.1825 | 0.7666** |
| | $r_g$ | | | | | | | | | | -0.1357 | 0.6512 | 0.2940 | 0.8039 |
| HI | $r_p$ | | | | | | | | | | | 0.3634** | -0.4172** | 0.4780** |
| | $r_g$ | | | | | | | | | | | 0.3945 | -0.6260 | 0.4532 |
| 100 SW | $r_p$ | | | | | | | | | | | | 0.0131 | 0.7793** |
| | $r_g$ | | | | | | | | | | | | 0.0185 | 0.8235 |
| Protein | $r_p$ | | | | | | | | | | | | | -0.0465 |
| | $r_g$ | | | | | | | | | | | | | -0.0283 |

$r_p$= Phenotypic correlation; $r_g$ = Genotypic correlation; *, ** Significant at $P \leq 0.05$ and $P \leq 0.01$, respectively.

APB=Angle of primary branch, HFP=Height of the first pod, DF=Days to 50% flowering, DM=Days to maturity, PH=Plant height, NPB=Number of primary branches, NSB=Number of secondary branches, SCMR=SPAD Chlorophyll meter readings, NPP=Number of pods plant$^{-1}$, SHB=Shoot biomass, HI=Harvest Index, 100SW=100 seed weight, Protein=Protein content chickpea varieties for the traits suitable for mechanical harvesting under irrigated condition (supplemental irrigation) has also gained importance. Different components of seed yield very often exhibit varying degree of associations with seed yield as well as among themselves. In order to accumulate optimum combination of seed yield contributing characters in a single genotype, it is essential to know the relationships among themselves. Correlation analysis would provide reliable information in nature, extent and direction of the selection especially when the breeder needs to combine high yield potential with desirable traits and seed quality characters. Therefore, the study was planned with 30 chickpea genotypes under rainfed and irrigated conditions during *rabi* 2016-17 at Regional Agricultural Research Station, Nandyal, Andhra Pradesh to find out relationship between fourteen plant characters with respect to genetic improvement in yield and amenability to mechanical harvesting.

## MATERIAL AND METHODS

The experiment was carried out at Regional Agricultural Research Station, Nandyal, Andhra Pradesh during *rabi* 2016-17 with 30 chickpea genotypes characterised by erect to semi erect growth habit in a Randomized Block Design (RBD) with three replications. Two separate experiments in adjacent blocks were conducted for evaluating the genotypes under rainfed conditions and also with two supplemental irrigations and designated as 'rainfed' and 'irrigated' experiments, respectively. Each genotype was grown in single row plot of 4 m length by adopting a spacing of 30 cm x 10 cm. Standard crop management practices were followed. The observations on various yield attributing traits *viz.,* days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of secondary branches plant$^{-1}$, SPAD Chlorophyll meter reading (SCMR), number of pods plant$^{-1}$, shoot biomass plant$^{-1}$, seed yield, 100 seed weight, protein content of grain including traits related to mechanical harvesting *viz*., angle of the primary branch, height of the first pod and plant height were recorded.

## RESULTS AND DISCUSSION

### Analysis of variance

The analysis of variance (ANOVA) was carried out for 14 characters. ANOVA revealed the existence of significant differences among 30 genotypes for 14 characters under rainfed condition and 13 out of 14 characters under irrigated condition. The differences among the genotypes for harvest index under 'irrigated' were not significant. Dahiya *et al*. (1990), Sindhu *et al*. (2006), Lather (2000) and Gaur *et al*. (2008) studied genetics of traits suited to mechanical harvesting in chickpea and identified mutants with upright growth habit and utilised them in chickpea breeding programs.

### Correlation studies

The genotypic and phenotypic correlation coefficient of different characters with seed yield and their relationship among themselves under both rainfed and irrigated conditions were presented in Table 1 and 2. Heritable association between traits and their magnitude was decreased due to influence of environment which was reflected in magnitude of genotypic correlations which were higher than the corresponding phenotypic correlation values.

### 1. Traits related to seed yield

Shoot biomass (rainfed: $r_p$ = 0.7666, $r_g$ = 0.8039 ; irrigated: $r_p$ = 0.8432, $r_g$ = 0.9734), 100 seed weight (rainfed: $r_p$ = 0.7793, $r_g$ = 0.8235 ; irrigated: $r_p$ = 0.4002, $r_g$ = 0.4657), number of pods plant$^{-1}$ (rainfed: $r_p$ = 0.4958, $r_g$ = 0.5595 ; irrigated: $r_p$ = 0.6507, $r_g$ = 0.7491), harvest index (rainfed: $r_p$ = 0.4780, $r_g$ = 0.4532 ; irrigated: $r_p$ = 0.4176, $r_g$ = 0.5692) and number of secondary branches plant$^{-1}$ (rainfed: $r_p$ = 0.4537, $r_g$ = 0.4973 ; irrigated: $r_p$ = 0.2713, $r_g$ = 0.3522) exhibited highly significant and positive correlation with seed yield under both the studied situations. Shoot biomass was the most important trait among all the traits studied due to its close relationship with seed yield (Toker and Cagrgan, 2004 and Shiva Prakash Singh, 2006). Specifically SCMR ($r_p$ = 0.5083, $r_g$ = 0.7071) under rainfed condition and angle of the primary branch ($r_p$ =

**Table 2. Phenotypic ($r_p$) and genotypic ($r_g$) correlation coefficients among 14 characters in 30 chickpea genotypes under irrigated condition during *rabi* 2016-17**

| Character | | HFP | DF | DM | PH | NPB | NSB | SCMR | NPP | SHB | HI | 100 SW | Protein | SY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **APB** | $r_p$ | 0.0162 | -0.4399** | -0.2249* | -0.0093 | -0.4842** | -0.0672 | -0.0901 | 0.0629 | 0.2122* | 0.2268* | 0.1462 | 0.1389 | 0.3126** |
| | $r_g$ | 0.0151 | -0.4869 | -0.2482 | -0.0355 | -0.5802 | -0.0963 | -0.1393 | 0.0459 | 0.2382 | 0.5950 | 0.1685 | 0.1596 | 0.3441 |
| **HFP** | $r_p$ | | 0.4817** | 0.4361** | 0.6461** | 0.3964** | 0.1384 | -0.4993** | -0.0741 | -0.2323* | -0.0332 | -0.2802** | -0.1709 | -0.2269* |
| | $r_g$ | | 0.4914 | 0.4515 | 0.6603 | 0.4681 | 0.1426 | -0.5829 | -0.0772 | -0.2821 | -0.0454 | -0.2820 | -0.1765 | -0.2567 |
| **DF** | $r_p$ | | | 0.7533** | 0.0629 | 0.7848** | 0.1445 | -0.5568** | -0.0135 | -0.4798** | -0.0684 | -0.6197** | -0.1110 | -0.4606** |
| | $r_g$ | | | 0.7729 | 0.0650 | 0.9054 | 0.1692 | -0.6552 | -0.0148 | -0.5647 | -0.1730 | -0.6274 | -0.1113 | -0.5277 |
| **DM** | $r_p$ | | | | 0.2480* | 0.5201** | 0.3455** | -0.3819** | 0.0350 | -0.3325** | -0.1060 | -0.5086** | -0.0604 | -0.3588** |
| | $r_g$ | | | | 0.2532 | 0.6026 | 0.3921 | -0.4860 | 0.0441 | -0.4199 | -0.2268 | -0.5241 | -0.0656 | -0.4230 |
| **PH** | $r_p$ | | | | | -0.0420 | 0.0409 | -0.0388 | -0.1207 | 0.1719 | -0.3161** | 0.1021 | -0.0153 | -0.0281 |
| | $r_g$ | | | | | -0.0323 | 0.0292 | -0.0521 | -0.1362 | 0.2178 | -0.8360 | 0.1125 | -0.0106 | -0.0319 |
| **NPB** | $r_p$ | | | | | | 0.1188 | -0.5146** | 0.1828 | -0.2517* | -0.0040 | -0.4181** | -0.2657* | -0.2079* |
| | $r_g$ | | | | | | 0.0652 | -0.6230 | 0.1875 | -0.3263 | -0.2114 | -0.4857 | -0.3172 | -0.3054 |
| **NSB** | $r_p$ | | | | | | | -0.3303** | 0.5539** | 0.2852** | 0.0288 | 0.0017 | 0.0877 | 0.2713** |
| | $r_g$ | | | | | | | -0.3479 | 0.5797 | 0.3932 | 0.0836 | 0.0026 | 0.0941 | 0.3522 |
| **SCMR** | $r_p$ | | | | | | | | -0.0973 | 0.2955** | -0.1671 | 0.3930** | -0.0542 | 0.1654 |
| | $r_g$ | | | | | | | | -0.0982 | 0.3644 | -0.3330 | 0.4809 | -0.0656 | 0.2346 |
| **NPP** | $r_p$ | | | | | | | | | 0.5918** | 0.1752 | -0.1400 | -0.2908** | 0.6507** |
| | $r_g$ | | | | | | | | | 0.7020 | 0.4645 | -0.1471 | -0.3071 | 0.7491 |
| **SHB** | $r_p$ | | | | | | | | | | -0.1286 | 0.4507** | -0.1119 | 0.8432** |
| | $r_g$ | | | | | | | | | | 0.3603 | 0.5415 | -0.1340 | 0.9734 |
| **HI** | $r_p$ | | | | | | | | | | | 0.0140 | 0.0216 | 0.4176** |
| | $r_g$ | | | | | | | | | | | 0.0345 | 0.0805 | 0.5692 |
| **100 SW** | $r_p$ | | | | | | | | | | | | 0.2915** | 0.4002** |
| | $r_g$ | | | | | | | | | | | | 0.3057 | 0.4657 |
| **Protein** | $r_p$ | | | | | | | | | | | | | -0.1313 |
| | $r_g$ | | | | | | | | | | | | | -0.1445 |

$r_p$= Phenotypic correlation; $r_g$ = Genotypic correlation; *, ** Significant at P≤ 0.05 and P ≤ 0.01, respectively.

APB=Angle of primary branch, HFP=Height of the first pod, DF=Days to 50% flowering, DM=Days to maturity, PH=Plant height, NPB=Number of primary branches, NSB=Number of secondary branches, SCMR=SPAD Chlorophyll meter readings, NPP=Number of pods plant$^{-1}$, SHB=Shoot biomass, HI=Harvest Index, 100SW=100 seed weight, Protein=Protein content.

0.3126, $r_g$ = 0.3441) under irrigated conditions were positively correlated with seed yield. The important *inter se* associations were observed between days to 50 per cent flowering and days to maturity; number of primary branches plant$^{-1}$, days to maturity and also between number of primary branches plant$^{-1}$, SCMR and 100 seed weight. *Inter se* associations between shoot biomass, number of pods plant$^{-1}$; shoot biomass and 100 seed weight under both the tested environments were significant. Protein content under rainfed condition was significant and negatively correlated with SCMR. Therefore, these five characters *viz.,* shoot biomass, harvest index, 100 seed weight, number of pods plant$^{-1}$ and number of secondary branches plant$^{-1}$ can effectively be utilised for improving yield under rainfed as well as irrigated conditions in chickpea.

Negative correlation between seed yield and days to 50 per cent flowering, days to maturity clearly indicated increase in duration of the crop results in yield losses. Terminal drought stress in chickpea, as in many other crops, is known to reduce the growth duration, especially the reproductive phase (Krishnamurthy *et al*., 2013). Chickpea growing environments in Southern India experience a ceiling to the reproductive growth duration due to progressively increasing terminal moisture stress at the final stages of reproductive growth, requiring an increased partitioning (HI), thereby providing the plants to escape the later stress stages with less adverse effects on the yield formation (Krishnamurthy *et al*., 2013). Therefore, success in selecting for high yield under drought requires a simultaneous selection for both crop duration and high HI (Krishnamurthy *et al.,* 1999).

### 2. Traits related to mechanical harvest

An ideal genotype of chickpea suitable for mechanical harvesting should have erect to semi erect growth habit which is reflected in its angle of the primary branch measured from the horizontal. The angle should be $70^0$ and above. Moreover, the fruiting zone of genotypes should be about 30 cm from the base (Lather, 2000). Though angle of the primary branch ($r_p$ = 0.3126, $r_g$ = 0.3441) was positively correlated with seed yield under irrigated condition, height of the first pod (rainfed: $r_p$ = -0.2708, $r_g$ = -0.3029; irrigated: $r_p$ = -0.2269, $r_g$ = -0.2567) has shown significant negative correlation with seed yield. Hence, it can be stated that the traits suitable for mechanical harvesting cannot be developed concurrently as they were negatively correlated. Breeding programmes should aim at breaking undesirable linkages between traits by crossing desirable genotypes for different traits.

## CONCLUSIONS

Traits related to mechanical harvesting *viz*., angle of the primary branch, height of the first pod and plant height were positively associated among themselves under rainfed condition. Whereas, under irrigated condition, positive correlation existed between height of the first pod and plant height. Height of the first pod was negatively correlated with seed yield under both conditions. However, highly significant positive association for seed yield was seen with angle of the primary branch under irrigated condition while no association was noticed with plant height under both conditions. Therefore, it necessitates separate breeding programmes for improvement of traits related to mechanical harvesting with seed yield.

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# EVALUATION OF PIGEONPEA GENOTYPES AGAINST POD FLY, *Melanagromyza obtusa*

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**ABSTRACT**

Fourteen pigeonpea genotypes were screened to know their influence on pod fly infestation during 2016-17 at Regional Agricultural Research Station, Guntur, Andhra Pradesh. Among fourteen pigeonpea genotypes, WRP 1, ICPHaRL 4985-11, ICPHaRL 4985-10, ICPHaRL 4989-7, LRG 52, CO 6, ICP 11957 and BRG 10-2 were found to be resistant as they have recorded lowest mean pod and seed damage ranging from 9.33 to 23.67 per cent and 4.78 to 13.00 per cent, respectively with pest susceptibility rating ranging from 1 to 5. The mean number of maggots and pupae pod$^{-1}$ ranged from 0.04 (WRP 1) to 0.51 (GRG 2013) and 0.10 (LRG 52) to 0.54 (GRG 2013), respectively. The genotype, ICPHaRL 4985-10 has recorded maximum yield (1761.34 kg ha$^{-1}$), followed by BRG 10-2 (1640.74 kg ha$^{-1}$), ICPHaRL 4989-7 (1638.66 kg ha$^{-1}$), WRP 1 (1533.56 kg ha$^{-1}$), ICPHaRL 4985-11 (1475.23 kg ha$^{-1}$) and LRG 41 (1459.33 kg ha$^{-1}$).

## INTRODUCTION

Pigeonpea is an important legume crop of rainfed agriculture and occupies the second largest area among various pulse crops grown in India. It is predominantly grown in semi-arid tropics under wide range of agro-ecological situations contributing greater than 80 per cent of the total world's production (FAO, 2005). The crop is highly sensitive to attack by a wide range of insect pests both in the field (at various stages of crop growth) and storage. Most of the pests attack the crop at reproductive stage causing direct losses. Among the borers, the pod fly *Melanagromyza obtusa* (Malloch) appears to be the most noxious pest causing maximum damage which accounts for 70-80 per cent of the total pod damage caused by pod borer complex. There are no obvious external symptoms of pod fly attack till the fully grown maggot chew holes in the pod walls leaving a "window" through which the flies emerge after pupation in the pod.

The concealed mode of life within the pod makes it difficult to control with chemical insecticides (Subharani and Singh, 2010).Host plant resistance plays a very important role in governing the pest infestation level in pigeonpea and screening is an appropriate method to identify resistant genotypes. Identification and cultivation of cultivars which are less preferred by pod fly have number of advantages, particularly for an eco-friendly management of this insect pest on pigeonpea. As levels of resistance to this pest in the cultivated pigeonpea cultivars are low to moderate, thus it is important to identify pigeonpea cultivars that permit slow growth or lesser population buildup of pod fly. However, Singh and Singh (1990) reported that no definite conclusions could be drawn about the relative susceptibility of pigeonpea genotypes to pod fly damage because of staggered flowering and variation in pod fly abundance over time. Thus, keeping these views in mind, the present study was conducted to identify resistant sources so as to evolve cultivars less susceptible to pod fly in pigeonpea.

## MATERIAL AND METHODS

Field experiment was conducted at Regional Agricultural Research Station (RARS), Lam, Guntur during *kharif,* 2016 to evaluate the resistance/ tolerance levels against pod fly in a randomized block design (RBD) with 14 genotypes including the local check variety (LRG 41). Each genotype was replicated thrice and accommodated in two rows each of 4 m length with 1.8 m x 0.2 m spacing between rows and plants, respectively. No insecticidal spray was taken up throughout the crop season. Observations on the following parametres were recorded.

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**Pod damage (%):** To assess the degree of infestation caused by pod fly, two hundred pods were picked out randomly from each replication at the time of harvest and the per cent pod damage was calculated.

$$\text{Per cent pod damage} = \frac{\text{Number of damaged pods}}{\text{Total number of pods}} \times 100$$

**Seed damage (%):** At the time of harvest two hundred pods per replication were collected at random and were split open to count the healthy and damaged seeds and the per cent seed damage was calculated. The seeds damaged by pod fly have a characteristic streak on seeds.

$$\text{Per cent seed damage} = \frac{\text{Number of damaged seeds}}{\text{Total number of seeds}} \times 100$$

**Grouping of genotypes based on pest susceptibility:** In order to group the genotypes, the pest susceptibility was calculated using the following formula and then converted to 1 to 9 rating scale as given by Abbott (1925).

$$\text{Pest susceptibility (\%)} = \frac{\text{P.D. of check} - \text{P.D. of test entry}}{\text{P.D. of check}} \text{ X } 100$$

Where, P.D. = mean of per cent pods or seeds damaged

A rating of scale 1-5 was considered as resistant, 6 was equal to check and from 7-9 as susceptible.

| Pest Susceptibility Rating | Pest Susceptibility (%) |
|---|---|
| 1 | 100 |
| 2 | 75 to 99.9 |
| 3 | 50 to 74.9 |
| 4 | 25 to 49.9 |
| 5 | 10 to 24.9 |
| 6 | –10 to 9.9 |
| 7 | –25 to – 9.9 |
| 8 | –50 to –24.9 |
| 9 | –50 or less |

**Number of maggots and pupae per pod:** The fully matured green pods were collected and the sampled pods (50 pods per plot) were split open to count the number of maggots and pupae and the average number per pod was calculated and subjected to statistical analysis. Seed yield per plot was recorded for each genotype and converted to kg ha$^{-1}$.

## RESULTS AND DISCUSSION

Fourteen pigeonpea genotypes tested for their reaction to the infestation of pod fly showed a great deal of variation in respect of per cent pod and seed damage. None of the genotypes were completely free from infestation due to pod fly.

**Pod damage (%):** The data on per cent pod damage by *M. obtusa* in different pigeonpea genotypes differed significantly (Table 1). Out of 14 genotypes screened for resistance/tolerance against pod fly, based on per cent pod damage, eight genotypes *viz*., WRP 1 (9.33%), ICPHaRL 4985-11 (12.17%), ICPHaRL 4985-10 (13.50%), ICPHaRL 4989-7 (14.17%), LRG 52 (17.67%), CO 6 (18.33%), ICP 11957 (18.75%) and BRG 10-2 (23.67%) were grouped under resistant category as they recorded the pest susceptibility rating ranging from 1 to 5 and five genotypes *viz*., ICPL 87119 (32.67%), ICPL 332-WR (33.83%), Guliyal Local (Red) (34.33%), ICP 8863 (41.44%) and GRG 2013 (52.67%) were grouped under susceptible category as they showed the pest susceptibility rating ranging from 7 to 9. Whereas, local check variety LRG 41 recorded 26.50 per cent pod damage.

The pod damage in different genotypes ranged from 9.33% to 52.67 per cent. The present findings were in agreement with Parsai (1996), Malathi and Rao (2011) and Revathi *et al.* (2015) who reported that the pod damage due to pod fly was in the range of 8.3% to 52.5 per cent, 8.31% to 50.88 per cent and 16.5% to 57.8 per cent respectively among different genotypes. However, higher degree of pod damage (24.67% to 88.67%) by this pest was reported by Kumar *et al.* (2015), which might be due to the differences in genotypes, pest population pressure as well as the agro-climatic conditions.

**Table 1. Comparative performance of pigeonpea genotypes against pod fly, *M. obtusa* during *Kharif*, 2016-17**

| S. No | Name of the genotype | Pod damage | | | Seed damage | | | No. of maggots per pod** | No. of pupae per pod** | Seed yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Pod damage*(%) | Pest suscep-tibility(%) | PSR | Seed damage*(%) | Pest suscep-tibility(%) | PSR | | | |
| 1 | ICPHaRL 4989-7 | 14.17 (21.50) | 46.54 | 4 | 7.28 (15.17) | 51.47 | 3 | 0.10 (0.30) | 0.12 (0.34) | 1638.66 |
| 2 | ICPHaRL 4985-10 | 13.50 (21.43) | 49.06 | 4 | 6.94 (14.98) | 53.71 | 3 | 0.09 (0.30) | 0.12 (0.33) | 1761.34 |
| 3 | ICPHaRL 4985-11 | 12.17 (20.18) | 54.09 | 3 | 7.72 (15.90) | 48.51 | 4 | 0.13 (0.35) | 0.14 (0.37) | 1475.23 |
| 4 | Guliyal Local (Red) | 34.33 (35.87) | -29.56 | 8 | 22.39 (28.24) | -49.24 | 8 | 0.34 (0.59) | 0.29 (0.53) | 1379.63 |
| 5 | BRG 10-2 | 23.67 (29.02) | 10.69 | 5 | 13.00 (21.04) | 13.36 | 5 | 0.16 (0.39) | 0.25 (0.50) | 1640.74 |
| 6 | ICP 11957 | 18.75 (25.66) | 29.25 | 4 | 10.28 (18.63) | 31.47 | 4 | 0.17 (0.40) | 0.16 (0.39) | 982.64 |
| 7 | LRG 52 | 17.67 (24.83) | 33.33 | 4 | 7.28 (15.65) | 51.49 | 3 | 0.11 (0.32) | 0.10 (0.32) | 1116.67 |
| 8 | GRG 2013 | 52.67 (46.55) | -98.74 | 9 | 36.83 (37.38) | -145.56 | 9 | 0.51 (0.71) | 0.54 (0.73) | 1180.09 |
| 9 | ICP 8863 | 41.44 (40.09) | -56.39 | 9 | 23.22 (28.81) | -54.80 | 9 | 0.33 (0.57) | 0.43 (0.66) | 1120.37 |
| 10 | CO 6 | 18.33 (24.86) | 30.82 | 4 | 9.67 (17.53) | 35.56 | 4 | 0.10 (0.31) | 0.16 (0.40) | 1097.92 |
| 11 | WRP 1 | 9.33 (17.79) | 64.78 | 3 | 4.78 (12.55) | 68.16 | 3 | 0.04 (0.21) | 0.11 (0.34) | 1533.56 |
| 12 | ICPL 87119 | 32.67 (34.75) | -23.27 | 7 | 18.06 (25.05) | -20.38 | 7 | 0.23 (0.48) | 0.31 (0.56) | 1087.27 |
| 13 | ICPL 332-WR | 33.83 (35.40) | -27.67 | 8 | 19.78 (26.12) | -31.84 | 8 | 0.30 (0.54) | 0.33 (0.57) | 1410.88 |
| 14 | LRG 41 (Check) | 26.50 (30.98) | - | - | 15.00 (22.71) | - | - | 0.20 (0.45) | 0.22 (0.47) | 1459.33 |
| | Mean | 24.93 | - | - | 14.44 | - | - | 0.20 | 0.23 | 1348.88 |
| | F-Test | Significant | - | - | Significant | - | - | Significant | Significant | Significant |
| | SEm± | 2.17 | - | - | 1.78 | - | - | 0.04 | 0.03 | 58.55 |
| | CD @ 5 % | 6.31 | - | - | 5.17 | - | - | 0.11 | 0.09 | 170.21 |
| | CV (%) | 12.87 | - | - | 14.37 | - | - | 15.54 | 11.79 | 7.52 |

PSR – Pest Susceptibility Rating

*Values in parentheses are arc sine transformed values; **Values in parentheses are square root transformed value

**Seed damage (%):** The per cent seed damage due to *M. obtusa* among different genotypes varied significantly (Table 1). The data pertaining to seed damage also recorded that eight genotypes *viz*., WRP 1 (4.78%), ICPHaRL 4985-10 (6.94%), ICPHaRL 4989-7 (7.28%), LRG 52 (7.28%), ICPHaRL 4985-11 (7.72%), CO 6 (9.67%), ICP 11957 (10.28%) and BRG 10-2 (13.00%) were grouped under resistant category as they recorded the pest susceptibility rating ranging from 1 to 5 and five genotypes *viz*., ICPL 87119 (18.06%), ICPL 332-WR (19.78%), Guliyal Local (Red) (22.39%), ICP 8863 (23.22%) and GRG 2013 (36.83%) were grouped under susceptible category as they showed the pest susceptibility rating ranging from 7 to 9. Whereas, local check variety LRG 41 recorded 15.00 per cent seed damage.

The seed damage in different genotypes varied from 4.78 to 36.83 per cent. The present studies were in accordance with the results of Devi *et al.* (2014) and Revathi *et al.* (2015) who reported that seed damage due to pod fly was in the range of 4.3 to 40.7 per cent and 6.0 to 34.2 per cent, respectively. Out of 14 genotypes screened for resistance against pod fly, none could secure pest susceptibility rating of 1 and 2. The present findings showed that the per cent seed damage was low compared to pod damage in different genotypes and also observed that the genotypes with higher rate of pod infestation by *M. obtusa* also showed higher rate of seed infestation which were in consonance with findings of Revathi *et al.* (2015).

**Number of maggots and pupae per pod:** Observations showed that there exists a significant variation among different pigeonpea genotypes with respect to number of maggots and pupae per pod (Table 1). The genotype, GRG 2013 recorded highest number of maggots and pupae *i.e*., 0.51 and 0.54, respectively whereas, the genotype WRP 1 recorded least number of maggots (0.04) while, the genotype LRG 52 recorded least number of pupae (0.10) per pod.

These findings were more or less similar with the findings of Revathi *et al.* (2015) who reported that the genotype 2011-5 recorded highest number of maggots (1.5) and pupae (1.7) per pod. Whereas, the genotype ENT 11 and WRG 51 has recorded least number of maggots (0.5) and pupae (0.5) per pod, respectively.

**Yield (kg ha$^{-1}$):** The yield of different pigeonpea genotypes ranged from 982.64 to 1761.34 kg ha$^{-1}$ with an average of 1348.88 kg ha$^{-1}$ and the yield in different genotypes was significant (Table 1). The genotype ICPHaRL 4985-10 (1761.34 kg ha$^{-1}$) recorded highest seed yield, followed by BRG 10-2 (1640.74 kg ha$^{-1}$), ICPHaRL 4989-7 (1638.66 kg ha$^{-1}$), WRP 1 (1533.56 kg ha$^{-1}$), ICPHaRL 4985-11 (1475.23 kg ha$^{-1}$), LRG 41(1459.33 kg ha$^{-1}$), ICPL 332-WR (1410.88 kg ha$^{-1}$) and Guliyal Local (Red) (1379.63 kg ha$^{-1}$). The lowest seed yield was observed in ICP 11957 (982.64 kg ha$^{-1}$), followed by ICPL 87119 (1087.27 kg ha$^{-1}$), CO 6 (1097.92 kg ha$^{-1}$), LRG 52 (1116.67 kg ha$^{-1}$), ICP 8863 (1120.37 kg ha$^{-1}$) and GRG 2013 (1180.09 kg ha$^{-1}$).

The genotypes *viz.,* ICPL 332-WR and Guliyal Local (Red) recorded higher seed yield irrespective of high infestation of pod fly, which may be due to presence of higher number of branches, pods and test weight. It was in conformity with Patel and Patel (1990) who reported that the seed yield of GAUT 82-90 and GAUT 83-17 was significantly higher even though they had relatively high infestation of pod fly.

## CONCLUSION

It can be concluded that the genotypes *viz*., WRP 1, ICPHaRL 4985-11, ICPHaRL 4985-10, ICPHaRL 4989-7, LRG 52, CO 6, ICP 11957 and BRG 10-2 were found to be resistant against pod fly with less pod damage and seed damage. These findings certainly would go a long way in developing desirable redgram varieties resistant to pod fly, *Melanagromyza obtusa* eventually in providing most efficient and economic control strategy to the farmer.

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# YIELDING ABILITY OF GROUNDNUT VARIETIES IN RAINFED ALFISOLS OF ANDHRA PRADESH

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**ABSTRACT**

A field experiment was conducted to study the under rainfed conditions for three consecutive years during *kharif*, 2012, 2013 and 2014 at Agricultural Research Station, yielding ability of groundnut varieties in dryland regions of scarce rainfall zone Ananthapuramu of Andhra Pradesh. Experiment results revealed that Harithandhra followed by Narayani and Abhaya varieties produced higher number of filled pods plant$^{-1}$ compared to other varieties while less number of filled pods plant$^{-1}$ was produced by TMV 2. Pod and haulm yields were remarkably influenced by the tested varieties. Among the varieties tested, K 6 produced significantly higher pod yield which in turn comparable with K 9, Narayani, TMV 2, Abhaya and significantly superior to other tested varieties. K 9 have produced significantly higher haulm yield however, which is on par with Narayani, K6, ICGV-0030, Anantha, Abhaya, Harithandhra and significantly superior to other tested varieties. TMV 2 recorded higher harvest index followed by K 6 and Vemana.

## INTRODUCTION

Groundnut also known as peanut, is a legume crop and is important in human nutrition, due to its high protein and energy content and its seeds contain high amounts of edible oil (43%–55%) and protein (25%–28%). In addition to the seed, peanut plants produce high-protein forage that has long been used as ruminant feed (Sharma *et al.,* 2010). In India, around 90% of groundnut production was concentrated in states of Gujarat, Andhra Pradesh, Tamilnadu, Karnataka and Maharashtra, mainly grown during the *kharif* season. The rain-dependent cultivation is one of the most important reasons for very low productivity (937 kg ha$^{-1}$) compared to the world average of 1332 kg ha$^{-1}$ (Lal *et al.,* 2006; Chenault *et al.,* 2008). Low rainfall and prolonged dry spells during the crop growth period are the main reason that cripples the groundnut productivity.

Ananthapuramu is the southern-most district of the Rayalaseema region of Andhra Pradesh. While agriculture remains the most important economic activity of the district, it is characterized by high levels of instability and uncertainty. During early 1960s, minor millets dominated the cropping pattern of the district. Millet area has declined sharply since the late 1970s, and the area under groundnut has increased. Around this period, the spread variety of groundnut was getting replaced by bunch variety in the district. While the duration of the bunch variety was 90–110 days, that is, about forty to fifty days lower than spreading variety, the drudgery involved in harvesting the bunch variety was also lower.

*Kharif* is the major crop season in Ananthapuramu District. Of the 9.75 lakh ha of gross cropped area in the district, 7.94 lakh hectares, *i.e.,* 81 percent of gross cropped area gets cultivated with groundnut during the kharif season. The soil-moisture stress condition under different stages of crop growth would result in inadequate plant population, higher percentage of flower drop, poor seed filling, etc., and thereby have implications for crop yields. Dryspell during harvesting which results in difficulty in retrieving all the pods from the hard soil (Gadgil,1999). Only two varieties of groundnut seeds, TMV 2 and JL 24, were distributed by the Department of Agriculture till 2006. The popular variety TMV 2 is a variety that was released six decades ago and is in use in Ananthapuramu district for more than three decades, when this variety is used continuously over many years the viability of seeds gets eroded as the genetic and physical purity of the seed wears down over the years. Later, Red Pollachi, Narayani, and K6 are being distributed by the department only since 2007. Hence, by keeping all the above points in view, the

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present study was carried out to study yielding ability of groundnut varieties in dryland regions of scarce rainfall zone.

## MATERIAL AND METHODS

A field experiment was conducted to study yielding ability of groundnut varieties in dryland region of scarce rainfall zone under rainfed conditions for three consecutive years during *kharif*, 2012, 2013 and 2014 at Agricultural Research Station, Ananthapuramu of Andhra Pradesh. The soil of the experimental site was red sandy loam with shallow depth, low in organic carbon (0.37%) and low in available nitrogen (131 kg $ha^{-1}$), medium in available phosphorous (36 kg $ha^{-1}$) and potassium (234 kg $ha^{-1}$). The experiment was laid out in randomized block design with three replications. The treatments consisted of nine varieties *viz.,* $T_1$: K-6, $T_2$: K-9, $T_3$: Vemana, $T_4$: Narayani, $T_5$: ICGV-00308, $T_6$: Ananta, $T_7$: Abhaya, $T_8$: TMV-2 and $T_9$: Harithandhra. The experimental field was prepared by working with a tractor drawn disc plough and then tractor drawn cultivator was drawn along the field. Healthy seeds of groundnut varieties with good germination per cent (95%) used for sowing purpose. Sowing was taken up as per the treatments. The seeds were sown by dibbling in furrows at a depth of 5 cm. The furrows were covered immediately after sowing and compacted sufficiently for better germination. Thinning was done at 15 DAS by retaining one healthy seedling $hill^{-1}$. The recommended dose of 20, 40 and 40 kg N, $P_2O_5$ and $K_2O$ $ha^{-1}$ was applied through urea, single super phosphate and muriate of potash, respectively. Thinning and gap filling was done wherever necessary, weeding and hoeing were taken up depending on the intensity of weeds at critical stages of crop weed competition. Two hand weedings were done with the help of star weeder in interrows and with hand hoes in the intrarows and all other cultural practices were kept normal and uniform for all treatments. At harvest, in each treatment pod and haulm yield from the net plot (5 m x 4.8 m) was recorded and expressed in kg $ha^{-1}$.

## RESULTS AND DISCUSSION

### Rainfall and crop performance

In 2012, annual rainfall received (445.8 mm in 34 rainy days) was -21.3 % of normal annual rainfall (567 mm). All varieties were sown on 29.6.2012. Tested varieties were harvested at different dates depending on maturity with varying crop duration. Crop duration of varieties was ranged from 105 to 115 days, rainfall during crop period was 302.8 mm in 22 rainy days. In 2013, annual rainfall received (431.8 mm in 23 rainy days) was-24.6 % of normal annual rainfall (573 mm). All varieties were sown on 08.6.2013. Tested varieties harvested at different dates depending on maturity with varying crop duration. Crop duration of varieties was ranged from 107 to 121 days, rainfall during crop period ranged from 352.4 mm to 356.6 mm in 13 rainy days. In 2014, annual rainfall received (375.2 mm in 26 rainy days) was-34.2 % of normal annual rainfall (570 mm). All varieties were sown on 04.6.2014. Tested varieties harvested at different dates depending on maturity with varying crop duration. Crop duration of varieties was ranged from 105 to 120 days, rainfall during crop period ranged from 216.2 mm to 229.2 mm in 13 rainy days (Fig.1).

### Yield attributes

Number of filled pods was not significantly influenced by the tested varieties. However, among nine varieties evaluated, Harithandhra followed by Narayani and Abhaya varieties produced higher number of filled pods $plant^{-1}$ compared to other varieties while less number of filled pods $plant^{-1}$ was produced by TMV2 (Table 2). Bhagavatha Priya (2014) reported that highest number of filled pods $plant^{-1}$ was produced with Dharani. The lowest number of filled pods $plant^{-1}$ was obtained with Abhaya, which was on par with Kadiri-6 due to poor source and sink relationship in these varieties.

Different tested varieties have exerted significant influence on shelling percent and 100 kernel weight (g). Among tested varieties ICGV-0030 variety recorded higher shelling percent which in turn on par with K9, TMV 2, K6, Abhaya, Narayani and significantly superior to remaining varieties. Jadhav *et al*. (2000) noticed that shelling percentage computed with Dharani was significantly higher than the rest of the varieties. This might be due to better channelization of more photosynthates from vegetative parts to developing kernels resulting in complete filling of the pods. The second best variety in producing higher shelling percentage was the TAG-24, followed by Abhaya and Kadiri-6, with a significant disparity between any two of them. Statistically higher 100 kernel weight was produced with ICGV-0030 variety which in turn comparable with K 6, K 9 and significantly superior to other tested varieties. Ramesh (2002) observed that highest 100 kernel weight was produced with Dharani, which was significantly higher than rest of the varieties tried due to its bold size and better partitioning ability of photosynthates from source to developing kernels. The next best variety in producing higher hundred kernel weight was the Kadiri-6 followed by Abhaya and TAG-24, with a significant disparity between any two of them. This might be due to the size of the groundnut kernel which is mainly a genetic character and influence of the management practices on hundred kernel weight is negligible.

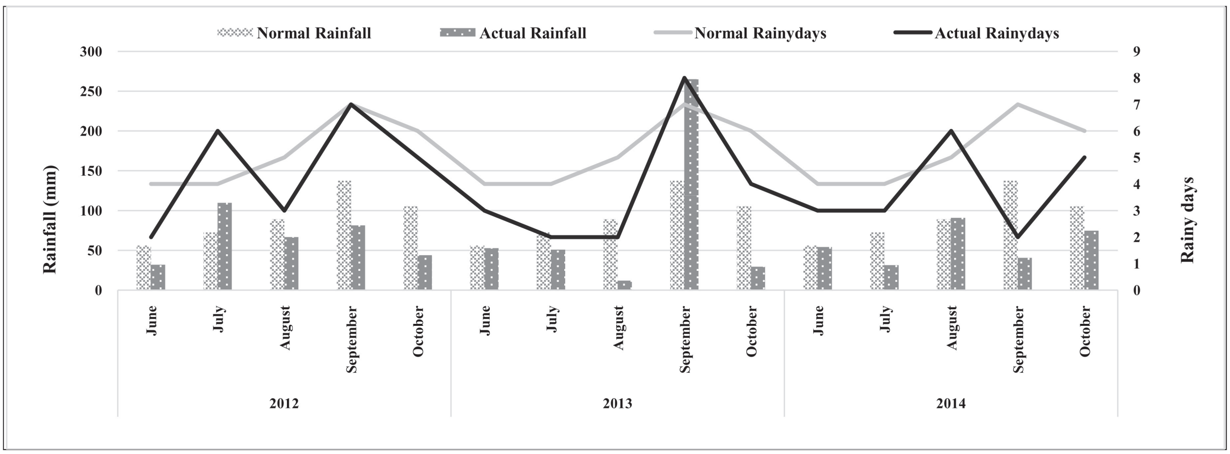


**Fig.1. Rainfall and rainy days during crop growth period of 2012, 2013 and 2014**

The lowest hundred kernel weight was obtained with TAG-24, which was significantly lower than rest of the varieties tried. Arunachalam and Kannan (2012) reported that the stress during pod development stage reduced the number of matured pods from 37.4 to 25.1 (32.8%). As the experimental soil was alfisols, even small amount of rainfall after dryspell led to surface sealing of iron and aluminum oxide clay, which resulted in rapid surface crusting problem (Palaniappan *et al.,* 2009). Peg elongation, which is turgor dependent, is delayed due to drought stress; pegs fail to penetrate effectively into air-dry soil, especially crusted soils (Boote and Ketring, 1990). The number of pods plant$^{-1}$ is reduced due to increase in soil resistance caused by prolonged drought (Sharma and Sivakumar, 1991).

## Pod and haulm yield

Pod and haulm yields were remarkably influenced by the tested varieties (Table 2). Among the varieties tested K 6 produced significantly higher pod yield which in turn comparable with K 9, Narayani, TMV 2, Abhaya and significantly superior to other tested varieties. Krishna Reddy *et al*. (2013) recorded that Dharani recorded 20.5 %, 47.6 % and 73.6 per cent higher pod yield compared to TAG-24, Kadiri-6 and Abhaya, respectively. Difference in yields among the varieties can be attributed to their genetic potentiality to utilize and translocate photosynthates from source to sink. The pod yield of groundnut mainly depends on partitioning ability of photosynthates from growth parameters to

**Table 1. Rainfall (mm) and rainy days during crop growth period of 2012, 2013 and 2014**

| Particulars | K-6 | K-9 | Vemana | Narayani | ICGV - 00308 | Ananta | Abhaya | TMV-2 | Harithan -dhra |
|---|---|---|---|---|---|---|---|---|---|
| **2012** | | | | | | | | | |
| Date of sowing | 29.6.12 | 29.6.12 | 29.6.12 | 29.6.12 | 29.6.12 | 29.6.12 | 29.6.12 | 29.6.12 | 29.6.12 |
| Date of harvesting | 15.10.12 | 21.10.12 | 11.10.12 | 16.10.12 | 17.10.12 | 15.10.12 | 15.10.12 | 11.10.12 | 17.10.12 |
| Crop duration (days) | 109 | 115 | 105 | 110 | 111 | 109 | 109 | 105 | 111 |
| Rainfall during crop period (mm) | 302.8 | 302.8 | 302.8 | 302.8 | 302.8 | 302.8 | 302.8 | 302.8 | 302.8 |
| Number of rainy days during crop period | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 | 22 |
| **2013** | | | | | | | | | |
| Date of sowing | 8.6.13 | 8.6.13 | 8.6.13 | 8.6.13 | 8.6.13 | 8.6.13 | 8.6.13 | 8.6.13 | 8.6.13 |
| Date of harvesting | 25.9.13 | 30.9.13 | 28.9.13 | 25.9.13 | 25.9.13 | 8.10.13 | 27.9.13 | 31.9.13 | 6.10.13 |
| Crop duration (days) | 107 | 112 | 110 | 107 | 107 | 121 | 109 | 113 | 119 |
| Rainfall during crop period (mm) | 352.4 | 352.4 | 352.4 | 352.4 | 352.4 | 356.6 | 352.4 | 352.4 | 356.6 |
| Number of rainy days during crop period | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 | 13 |
| **2014** | | | | | | | | | |
| Date of sowing | 4.6.14 | 4.6.14 | 4.6.14 | 4.6.14 | 4.6.14 | 4.6.14 | 4.6.14 | 4.6.14 | 4.6.14 |
| Date of harvesting | 21.9.14 | 29.9.14 | 20.9.14 | 26.9.14 | 24.9.14 | 1.10.14 | 23.9.14 | 17.9.14 | 24.9.14 |
| Crop duration (days) | 109 | 117 | 108 | 114 | 112 | 120 | 111 | 105 | 112 |
| Rainfall during crop period (mm) | 216.2 | 216.2 | 216.2 | 216.2 | 216.2 | 229.2 | 216.2 | 216.2 | 216.2 |
| Number of rainy days during crop period | 13 | 13 | 13 | 13 | 13 | 14 | 13 | 13 | 13 |

**Table 2. Yield attributes and yield of groundnut varieties in rainfed alfisols (mean of 2012, 2013 and 2014 data)**

| Varieties | No. filled pods plant$^{-1}$ | Shelling percentage | 100 kernel weight(g) | Pod yield (kg ha$^{-1}$) | Haulm yield (kg ha$^{-1}$) | Harvest Index |
|---|---|---|---|---|---|---|
| K-6 | 9.8 | 64.4 | 34.0 | 664 | 1498 | 0.31 |
| K-9 | 10.1 | 65.1 | 32.1 | 592 | 1585 | 0.28 |
| Vemana | 11.6 | 62.5 | 30.2 | 536 | 1260 | 0.30 |
| Narayani | 11.9 | 63.6 | 30.3 | 590 | 15430.28 | |
| ICGV-0030 | 11.5 | 68.1 | 35.5 | 520 | 1401 | 0.26 |
| Anantha | 11.2 | 58.6 | 26.6 | 539 | 1396 | 0.28 |
| Abhaya | 11.8 | 64.2 | 29.0 | 562 | 1370 | 0.29 |
| TMV2 | 9.0 | 64.9 | 29.5 | 570 | 1188 | 0.34 |
| Harithandhra | 12.4 | 59.1 | 29.9 | 378 | 1363 | 0.23 |
| S.Em ± | 2.1 | 1.6 | 1.2 | 41.6 | 83.4 | - |
| CD at 5 % | NS | 4.7 | 3.6 | 117.7 | 233.5 | |

**Table 3. Correlation coefficient between yield attributes and yield of groundnut varieties in rainfed alfisols during 2012-13**

| Varieties | No.of filled pods plant$^{-1}$ | Shelling percentage | 100 kernel weight(g) | Pod yield (kg ha$^{-1}$) | Haulm yield (kg ha$^{-1}$) | Harvest Index |
|---|---|---|---|---|---|---|
| No.of filled pods plant$^{-1}$ | 1 | | | | | |
| Shelling percentage | -0.457 | 1 | | | | |
| 100 kernel weight (g) | -0.016 | 0.639 | 1 | | | |
| Pod yield (kg ha$^{-1}$) | -0.390 | 0.593 | 0.125 | 1 | | |
| Haulm yield (kg ha$^{-1}$) | -0.447 | 0.350 | 0.020 | 0.908* | 1 | |
| Harvest Index | 0.237 | 0.441 | 0.170 | 0.052 | -0.368 | 1 |

*Significant at 5 % level

**Table 4. Correlation coefficient between yield attributes and yield of groundnut varieties in rainfed alfisols during 2013-14**

| Varieties | No.of filled pods plant$^{-1}$ | Shelling percentage | 100 kernel weight(g) | Pod yield (kg ha$^{-1}$) | Haulm yield (kg ha$^{-1}$) | Harvest Index |
|---|---|---|---|---|---|---|
| No. of filled pods plant$^{-1}$ | 1 | | | | | |
| Shelling percentage | 0.161 | 1 | | | | |
| 100 kernel weight (g) | -0.192 | 0.443 | 1 | | | |
| Pod yield (kg ha$^{-1}$) | -0.336 | 0.585 | 0.235 | 1 | | |
| Haulm yield (kg ha$^{-1}$) | -0.523 | 0.516 | 0.481 | 0.840* | 1 | |
| Harvest Index | -0.023 | 0.430 | -0.151 | 0.810* | 0.364 | 1 |

*Significant at 5 % level

**Table 5. Correlation coefficient between yield attributes and yield of groundnut varieties in rainfed alfisols during 2014-15**

| Varieties | No.of filled pods plant$^{-1}$ | Shelling percentage | 100 kernel weight(g) | Pod yield (kg ha$^{-1}$) | Haulm yield (kg ha$^{-1}$) | Harvest Index |
|---|---|---|---|---|---|---|
| No. of filled pods plant$^{-1}$ | 1 | | | | | |
| Shelling percentage | -0.448 | 1 | | | | |
| 100 kernel weight (g) | -0.162 | 0.836* | 1 | | | |
| Pod yield (kg ha$^{-1}$) | 0.659 | 0.069 | 0.185 | 1 | | |
| Haulm yield (kg ha$^{-1}$) | 0.058 | -0.238 | -0.084 | -0.149 | 1 | |
| Harvest Index | 0.212 | 0.250 | 0.173 | 0.499 | -0.892 | 1 |

*Significant at 5 % level

**Table 6. Correlation coefficient between yield attributes and yield of groundnut varieties in rainfed alfisols (mean of 2012, 2013 and 2014 data)**

| Varieties | No.of filled pods plant$^{-1}$ | Shelling percentage | 100 kernel weight(g) | Pod yield (kg ha$^{-1}$) | Haulm yield (kg ha$^{-1}$) | Harvest Index |
|---|---|---|---|---|---|---|
| No.of filled pods plant$^{-1}$ | 1 | | | | | |
| Shelling percentage | -0.332 | 1 | | | | |
| 100 kernel weight (g) | -0.091 | 0.539 | 1 | | | |
| Pod yield (kg ha$^{-1}$) | 0.236 | -0.372 | -0.008 | 1 | | |
| Haulm yield (kg ha$^{-1}$) | -0.098 | -0.478 | -0.072 | 0.721* | 1 | |
| Harvest Index | 0.405 | 0.168 | 0.064 | 0.337 | -0.384 | 1 |

*Significant at 5 % level

developing pods for producing more number of filled pods plant$^{-1}$ and hundred kernel weight which in turn led to increased pod yield (Labana *et al*., 1980). The lowest pod yield was obtained with Harithandhra, which was significantly lesser than other varieties tried. This might be due to poor partitioning ability of photosynthates from vegetative parts to developing pods. These findings are quite contradictory to Bhagavatha Priya (2014) who reported that lowest pod yield was obtained with Abhaya, which was significantly lesser than other varieties tried in her study. Arunachalam and Kannan (2012) reported that TMV 7 was stable in pod yield under moisture stress with less DSI (Drought Susceptibility Index) and high DTE (Drought Tolerance Efficiency). Hence, the four-decade old Spanish bunch variety TMV 7 is widely preferred by the rain-fed farmers. However, this genotype was not having significant yield advantage over drought tolerant and recently released varieties. K-9 produced significantly higher haulm yield however which is on par with Narayani, K 6, ICGV-0030, Anantha, Abhaya, Harithandhra and significantly superior to other tested varieties. These results were in conformity with Soumya *et al*. (2011). TMV 2 recorded higher harvest index followed by K 6 and Vemana. Sahadeva Reddy *et al.* (2014) reported that haulm yield from different varieties of groundnut suggested that the Harithandra variety is less productive, whereas, Ananta variety is highly productive. However, Veeramani and Subramaniyan

(2011) reported slightly higher yield of the latter than the former.

### Correlation between yield attributes and yield of groundnut varieties

During 2012, shelling percentage was negatively correlated to number of filled pods plant$^{-1}$. 100 kernel weight was negatively correlated to number of filled pods plant$^{-1}$ but positively correlated with shelling percentage (Table 3). Pod yield was negatively correlated to number of filled pods plant$^{-1}$ but positively correlated with shelling percentage and 100 kernel weight. Haulm yield was negatively correlated to number of filled pods plant$^{-1}$ but positively correlated with shelling percent and 100 kernel weight. Haulm yield has significant and positive relation with pod yield. During 2013, shelling percentage was positively correlated to number of filled pods plant$^{-1}$. 100 kernel weight was negatively correlated to number of filled pods plant$^{-1}$ but positively correlated with shelling percent. Pod yield was negatively correlated to number of filled pods plant$^{-1}$ but positively correlated with shelling percentage and 100 kernel weight. Haulm yield was negatively correlated to number of filled pods plant$^{-1}$ but positively correlated with shelling percentage and 100 kernel weight (Table 4). Haulm yield and harvest index has significant and positive relation with pod yield. During 2014, shelling percentage was negatively correlated to number of filled pods plant$^{-1}$. 100 kernel weight was negatively correlated to number of filled pods plant$^{-1}$ but has significant and positive relation with shelling percent (Table 5). Pod yield was positively correlated to number of filled pods plant$^{-1}$, shelling percent and 100 kernel weight. Haulm yield was positively correlated to number of filled pods plant$^{-}$1 but negatively correlated with shelling percentage, 100 kernel weight and pod yield. Haulm yield and harvest index has significant and positive relation with pod yield. Harvest has positive relation with number of filled pods$^{-1}$ plant, shelling percentage, 100 kernel weight and pod yield.

The pooled analysis showed that there was negative correlation between shelling percentage and number of filled pods per plant$^{-1}$ (Table 6). 100 kernel weight has negative correlation with number of filled pods per plant$^{-}$1 but positively correlated with shelling percentage. Pod yield was positively related with number of filled pods per plant$^{-1}$ but has negative correlation with shelling percent and 100 kernel weight. Haulm yield has significant and positive relation with pod yield. Harvest has positive relation with number of filled pods$^{-1}$ plant$^{-1}$, shelling percentage, 100 kernel weight and pod yield.

## CONCLUSION

The varieties K6, K9, Narayani, TMV 2 and Abhaya produced higher pod yield, whereas, K 9, Narayani, K 6, ICGV-0030, Anantha, Abhaya, Harithandhra have produced higher haulm yield. Keeping in view, the demand for pod and haulm, the varieties, K 6, K 9, Narayani, TMV 2 and Abhaya can be recommended for rainfed alfisols of scarce rainfall zone of Andhra Pradesh.

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# SURVEY ON INSECT PESTS OF CAPSICUM (*Capsicum annuum* L. var. grossum Sendt.) AND MANAGEMENT OF THRIPS UNDER POLYHOUSE CONDITIONS

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**ABSTRACT**

The roving survey on the occurrence of major insect pests of capsicum in Guntur district revealed that thrips, *Scirtothrips dorsalis* Hood, mites, *Polyphagotarsonemus latus* Banks, aphids, *Myzus persicae* (Sulz.), whitefly, *Bemisia tabaci*(Gennadius), cut worm, *Agrotis ipsilon* (Hufn.), blossom midge, *Asphondylia capsici* Barnes and fruit borer, *Spodoptera litura* Fab were recorded under shade net conditions. Bio-efficacy of insecticides against thrips of capsicum, under poly house conditions in the years 2013-14 and 2014-15, revealed that mean thrips population in pre count ranged from 1.07 to 4.34 thrips/leaf and post count population was lower with spinosad(0.06 thrips/leaf) followed by diafenthiuron (0.50 thrips/leaf) and thiomethoxam (1.30 thrips/ leaf).The mean LCI of two years revealed that Leaf Curl Index (LCI) at one Days Before Spray (DBS) (1.25) was significantly reduced to 0.51 in spinosad treated plants followed by diafenthiuron (1.69 to 0.90) and thiomethoxam (1.82 to 1.16). Whereas, LCI was significantly increased from one DBS to 10 DAS in chlorantraniliprole (2.41 to 2.51), flubendiamide (2.43 to 2.55), spiromesifen (2.51 to 2.64) and triazophos (2.53 to 2.72) and untreated check (2.71 to 2.96). Among the insecticides,spinosad found to be effective insecticide to reduce thrips population and LCI on capsicum.

## INTRODUCTION

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

Among the biotic factors, insect pests reduces the quality of produce and even a small blemish on the fruit will drastically reduce its market value. Butani (1976) reported over 20 insect species on chillies (*Capsicum* spp.) from India of which thrips, *Scirtothrips dorsalis* Hood is the most damaging pest under field and polyhouse conditions (Kaur *et al*., 2010). Estimated crop loss of 40 to 60 tons per ha of capsicum when the crop was not subjected to insecticidal control (Reddy and Kumar, 2006). In order to control the thrips and get higher market price, farmers are indiscriminately using insecticides. As capsicum is consumed fresh there is a need to minimize the pesticide residues in marketable capsicum. Hence, the present study was conducted to find effective insecticide to manage the thrips on capsicum.

## MATERIAL AND METHODS

### Survey on insect pests of capsicum

In Guntur district, roving survey was conducted in nine villages *viz.,* Nadendla, Yedlapadu, Thimmapuram, Chilakaluripeta, Sathuluru villages in Chilakaluripeta mandal, Sathenapalli, Thubadu villages of Sathenapalli mandal and Narakoduru of Tenali mandal, respectively. In Guntur district, capsicum is cultivated under shade net (SN) conditions (Table 1). A questionnaire was prepared to collect the data scientifically for statistical analysis on various parameters such as type of insect pests at different crop growth stages, per cent damage of each pest, insecticide usage pattern and yield losses due to insect pests. During the survey, data on insect population and per cent damage was recorded in

**E-mail:** vijji.edward6@gmail.com; * Part of PhD thesis submitted to Professor Jayashankar Telangana State Agricultural University each location at three crop stages, *viz.,* nursery, vegetative and reproductive stages of the crop. At each stage of the crop, five spots (each 2 $m^2$) were selected randomly in each location of shade net (one from centre and four from four corners) and in each spot ten plants were randomly selected, insect population per leaf (sucking pests) and per cent damage per plant ( non-sucking pests) was recorded and means were calculated. At each stage (seedling, vegetative and reproductive) mean population was calculated from nine shade nets and cumulative mean of each pest was discussed. Expected yield loss and insecticide usage pattern were recorded as percentage and cumulative means are reported and discussed.The pooled data was analysed by simple statistical tools such as mean and standard deviation (SD).

**Bio-efficacy of new insecticide molecules against thrips in capsicum**

Polyhouse experiments were conducted in 2013-14 and 2014 -15 at Horticultural Garden, College of Agriculture, Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad to evaluate the new insecticides for the management of thrips, with leading popular capsicum variety Royal Wonder of Seminis Pvt. Ltd. The experiments were conducted in Randomized Block Design (RBD) with three replications. Capsicum seedlings raised in the nursery were transplanted at age of 40 days in the main field by adopting a spacing of 45 cm X 30 cm and 30 cm X 30 cm in poly house conditions. Plot size maintained is 6 m X 6 m. All the recommended agronomical practices were implemented to raise crop except plant protection measures against pod borers.

The selected insecticides belonging to different groups *viz.,* Organophosphates (Triazophas), Neonicotinoids(Thiamethoxam), Microbialinsecticide (Spinosad,), Thiourea derivatives (Diafenthiuron), Diamides (Chlorantraniliprole), Pthalic acid diamides (Flubendiamide) and Ketones (Spiromesifen) along with untreated control were evaluated for two years. First spray was initiated when the population reached Economic Threshold levels (ETL) (thrips –1 no./leaf

**Table 1. Details of insecticides treatments used in the Bioefficacy studies**

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

) and second spray was given at seven days after first spray(Kumar *et al*., 2007). A total of three sprays were applied during the entire experimentation in both the seasons. Same procedure was followed in both the open field and polyhouse conditions.

was calculated by using the following formula (Flemming and Retnakaran, 1985).

Pre count (1 DBS) and post count (mean of 1,3,5 and 7 DAS) population and per cent reduction over control were calculated after each spray.

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

Observations on population of thrips were recorded in ten randomly tagged plants, from five terminal leaves (2 from top, 2 from middle and 1 from bottom) per plant. Pre count (one day before spray) and post count (1,3,5 and 7 days after spray) of the insects was recorded by using destructive sampling procedure. Per cent population reduction over control Cumulative mean of three sprays in 2013-14 and 2014-15 under polyhouse conditions and pooled mean of two years are represented in tables and discussed here under. Leaf Curl Index (LCI) was recorded one day before and 10 days after each spray following the methodology of Kumar *et al*. (1996) (Table 2).

**Table 2. Scoring procedure for thrips damage (Leaf Curl Index (LCI))**

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

## RESULTS AND DISCUSSION

Roving survey in the Guntur district of Andhra Pradesh revealed that at farmers level capsicum cultivation was done only under shade net conditions and there was no cultivation of capsicum in open field and polyhouse conditions. High day temperatures observed in the Guntur district, were not ideal for capsicum cultivation under open field conditions. During survey in 2013 - 14 crop season, population and damage levels recorded at three growth stages *viz*., seedling, vegetative and reproductive stages of the crop under shade net conditions are presented in Table 3.

At seedling stage, thrips, *S. dorsalis,* aphids, *M. persicae,* whitefly, *B. tabaci* and cut worm, *A. ipsilon* incidence was recorded, whereas, at vegetative stage, thrips, *S. dorsalis,* mite, *P.latus*, aphids, *M. persicae,* whiteflies,

**Table 3. Details of locations to conducted survey in Guntur (District) of Andhra Pradesh**

| S.No | Village | Mandal | Code | Open/poly house/Shade Net |
|---|---|---|---|---|
| 1 | Nadendla | Chilakaluripeta | SN-1 | Shade Net |
| | Edlapadu | | SN-2 | Shade Net |
| | Thimmapuram | | SN-3 | Shade Net |
| | Chilakaluripeta | | SN-4 | Shade Net |
| | Sathuluru | | SN-5 | Shade Net |
| 2 | Sathenapalli | Sathenapalli | SN-6 | Shade Net |
| | Thubadu | | SN-7 | Shade Net |
| 3 | Narsaraopeta | Narsaraopeta | SN-8 | Shade Net |
| 4 | Narakoduru | Tenali | SN-9 | Shade Net |

SN : Shade Net

*B. tabaci* were observed. At reproductive stage, thrips,*S. dorsalis,* mite, *P.latus*, blossom midge, *A. capsici* and fruit borer, *S. litura* incidence was recorded. The cumulative means of pest population and incidence recorded under nine shade nets are discussed in Table 3.

At seedling stage, the mean population (no. / leaf) of thrips, aphids and whiteflies ranged from 1.25 ±0.47 to 2.71 ± 0.59,0.56 ±0.49 to 1.89 ±0.77 and 1.24 ±0.19 to 2.36 ±0.23, respectively. There was no incidence of mite, *P. latus* at seedling stage in all the shade nets surveyed in Guntur district. Mean per cent damage caused by cut worm, *A. ipsilon* ranged from 1.35 ± 0.22 to and 2.91 ± 0.53. There was no incidence of blossom midge, *A. capsici* and fruit borer, *S. litura* at seedling stage. At vegetative stage, mean population (no. / leaf) of thrips, *S. Dorsalis* ranged from 2.06 ±0.07 to 5.29 ± 0.41,whereas, for other pests *viz.,* mite, *P. latus* 0.70 ±0.33 to 3.71 ± 0.75, aphids, *M. Persicae* 0.59 ± 0.45 to 2.23 ±0.26, whiteflies, *B.tabaci* 1.23±0.33 to 2.78 ±0.50, respectively. No incidence of cut worm, *A.ipsilon,* blossom midge, *A. capsici* and fruitborer, *S. litura* were observed at vegetative stage was reported.At reproductive stage, meanpopulation (no. of / leaf) of thrips, *S. dorsalis* ranged from 0.19 ± 0.15 to 0.76 ± 0.15, whereas for aphids, *M. persicae* 0.66 ± 0.04 to 0.36 ± 0.70,blossom midge, *A. capsici*1.14 ± 0.54 to 2.32 ± 0.34 and fruit borer, *S. litura* 2.58 ± 0.44 to 9.21 ±2.05 were reported. No incidence of mite, *P. latus,* whitefly, *B. tabaci*, cut worm, *A.ipsilon* was reported at reproductive stage.

Survey carried out at seedling stage of capsicum under shade net conditions at Guntur district revealed that the sucking pests, thrips, *S. dorsalis,* aphids, *M. persicae*, whitefly, *B. tabaci* were major sucking pests and cut worm, *A. ipsilon* was damaging the capsicum. Similar observations were reported by Sunitha *et al*. (2007) from Karnataka state. According to them of the 36 spp. of insects infesting the crop, among them, thrips and mites are debilitating the crop at seedling stage.

It is evident from the survey that farmers opined that without using any insecticides, the expected per cent yield loss caused by insect pests varied with the location and severity of insect pests. From the Table 4 thrips, *S. dorsalis* caused 47.38 ± 2.26, Mite, *P.latus* 25.46 ± 1.53, aphids, *M. persicae* 9.33± 0.79, whiteflies, *B. tabaci* 12.2 ± 0.91 cut worm, *A.ipsilon* 33.88 ±1.37,blossom midge, *A.capsici* 43.11 ± 2.01 and fruit borer, *S.litura* 52.05± 2.59 per cent yield loss, respectively.Insecticide usage pattern against insect pests in shade net conditions in Guntur district are presented in Table 5, based on questionnaire, farmers were using both new and conventional insecticides *viz.,* spinosad, flubendiamide, chlorantraniliprole, diafenthiuron,

**Table 4. Population and damage levels, Expected per cent yield loss of insect pests under shade net conditions of Guntur District**

| Name of the Insect Pest | Seedling Stage | | Vegetative Stage | | Reproductive stage | | Expected per cent yield loss |
|---|---|---|---|---|---|---|---|
| | Mean±SD | | Mean ±SD | | Mean ±SD | | |
| | Lower limit | Upper limit | Lower limit | Upper limit | Lower limit | Upper limit | Mean ±SD |
| Thrips* | 1.25±0.47 | 2.71±0.59 | 2.06+-0.07 | 5.29+-0.41 | 0.19±0.15 | 0.76±0.15 | 47.38 ± 2.26 |
| Mites * | 0.00 | 0.00 | 0.70+0.33 | 3.71+0.75 | 0.00 | 0.00 | 25.46± 1.53 |
| Aphids * | 0.56±0.49 | 1.89±0.77 | 0.59+-0.45 | 2.23+-0.26 | 0.66±0.04 | 0.70±3.06 | 9.33± 0.79 |
| Whiteflies * | 1.24±0.19 | 2.36±0.23 | 1.23+-0.33 | 2.78+-0.50 | 0.00 | 0.00 | 12.2 ± 0.91 |
| Cut worm# | 1.35±0.22 | 2.91±0.53 | 0.00 | 0.00 | 0.00 | 0.00 | 33.88± 1.37 |
| Blossom midge # | 0.00 | 0.00 | 0.00 | 0.00 | 1.14±0.54 | 2.32±0.34 | 43.11± 2.01 |
| Fruit Borer # | 0.00 | 0.00 | 0.00 | 0.00 | 2.58±0.44 | 9.21±2.05 | 52.05 ±2.59 |

*Mean population per leaf/plant, # Per cent damage per plant.

**Table 5. Insecticide usage pattern against insect pests of capsicum under shade net conditions of Guntur District**

| Name of the Insecticide | Telangana | | | | Andhra Pradesh | |
|---|---|---|---|---|---|---|
| | Open Field# | | Poly House $ | | Shade Net* | |
| | Per cent usage | Rank | Per cent usage | Rank | Per cent usage | Rank |
| Spinosad 45 SC | 100.00 | 1 | 66.66 | 2 | 100.00 | 1 |
| Flubendiamide 480 SC | 100.00 | 1 | 77.7 | 1 | 100.00 | 1 |
| Chlorantraniliprole 20 SC | 100.00 | 1 | 55.5 | 3 | 100.00 | 1 |
| Diafenthiuron 25 WP | 100.00 | 1 | 66.6 | 2 | 100.00 | 1 |
| Spiromesifen 22.9 SL | 50.00 | 3 | 0.00 | 5 | 100.00 | 1 |
| Thiamethoxam 25 WG | 75.00 | 2 | 0.00 | 5 | 66.6 | 3 |
| Triazophos 40 EC | 25.00 | 4 | 0.00 | 5 | 100.00 | 1 |
| Acephate 75 SP | 25.00 | 4 | 44.4 | 4 | 55.50 | 4 |
| Imidacloprid 200 SC | 25.00 | 4 | 66.6 | 2 | 66.60 | 3 |
| Chlorypyriphos 20 EC | 75.00 | 2 | 44.4 | 4 | 33.30 | 6 |
| Abamectin 0.15 EC | 50.00 | 3 | 44.4 | 4 | 77.70 | 2 |
| Propergite 720 EC | 50.00 | 3 | 0.00 | - | 33.30 | 6 |
| Dicofol 18.5 EC | 50.00 | 3 | 44.4 | 4 | 44.40 | 5 |
| Acetamiprid 20 SP | 0.00 | 5 | 44.4 | 4 | 33.30 | 6 |
| Monocrotophos 36 SL | 0.00 | 5 | 44.4 | 4 | 0.00 | 7 |
| Methomyl 40 SP | 100.00 | 1 | 77.7 | 1 | 0.00 | 7 |

# Mean of four open fields, $ Mean of nine poly houses, * Mean of nine shade nets

**Table 6. Cumulative efficacy of certain insecticide molecules against thrips, *S. dorsalis* and Leaf curl index (LCI) on capsicum under polyhouse conditions after three sprays during 2013-14 and 2014-15**

| T. No | Treatments | Dose (g or ml $ha^{-1}$) | Mean of 2013-14 and 2014-15 | | | LCI | |
|---|---|---|---|---|---|---|---|
| | | | Pre count (1 DBS)* | Post count (1,3,5,7 DAS mean)* | Per cent Reduction$ | 1 DBS | 10 DAS |
| $T_1$ | Spinosad 45 SC | 125 | 1.07(1.43)c | 0.06(1.03)c | 98.05(81.94)a | 1.25(1.50) | 0.51(1.22)b |
| $T_2$ | Flubendiamide 480 SC | 200 | 3.35(2.08)abc | 3.81(2.19)ab | 24.71(29.79)de | 2.43(1.85) | 2.55(1.88)a |
| $T_3$ | Chlorantraniliprole 20 SC | 200 | 3.20(2.04)abc | 3.55(2.13)ab | 27.56(31.65)d | 2.41(1.84) | 2.51(1.87)a |
| $T_4$ | Diafenthiuron 25 WP | 750 | 1.46(1.56)bc | 0.50(1.22)c | 87.52(69.28)b | 1.69(1.64) | 0.90(1.37)b |
| $T_5$ | Spiromesifen 22.9SL | 750 | 3.16(2.04)abc | 3.61(2.14)ab | 28.26(32.10)d | 2.51(1.87) | 2.64(1.90)a |
| $T_6$ | Thiomethoxam 25 WG | 150 | 2.01(1.73)abc | 1.30(1.51)bc | 72.98(58.66)c | 1.82(1.67) | 1.16(1.47)b |
| $T_7$ | Triazophos 40 EC | 1250 | 3.65(2.15)ab | 4.24(2.28)ab | 19.45(25.63)e | 2.53(1.87) | 2.72(1.92)a |
| $T_8$ | Untreated check | — | 4.34(2.28)a | 5.60(2.47)a | 0.00f | 2.71(1.87) | 2.96(1.94)a |
| | SEm± | 0.09 | 0.16 | 1.52 | 0.11 | 0.10 | |
| | CD @ 5 % | 0.27 | 0.51 | 4.68 | 0.35 | 0.32 | |
| | CV (%) | 13.82 | 15.55 | 16.44 | 12.60 | 13.73 | |

#No.ofthrips/leaf, mean of five leaves per plant, ten plants per replication, three replications per treatment.

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

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

DOS :$I^{st}$spray: 30-11-2013; $II^{nd}$ Spray:07-12-2013; $III^{rd}$ spray: 14-12-2013

DMRT : Means followed by a common letter are not significantly different (P= 0.05)

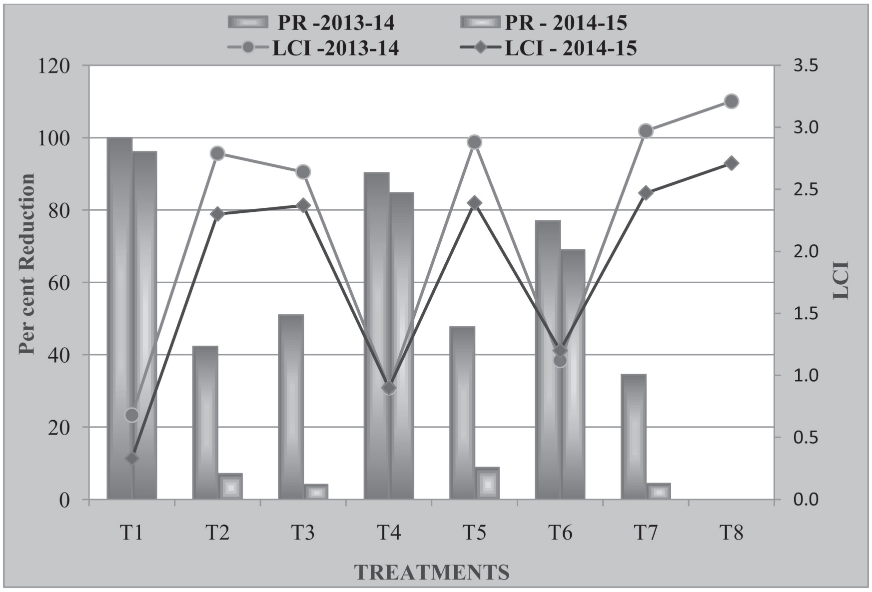


Figure 1. Bio-efficacy of certain insecticide molecules against thrips, *Scirtothrips dorsalis* Hood on capsicum under poly house conditions during 2013-14 and 2014-15 (Percent Reduction (PR) and LCI)

spiromesifen, thiamethoxam, triazophos, acephate, imidacloprid, chlorpyriphos, abamectin, propergite, dicofol and acetamiprid to manage the insect pests in shade net conditions.

Among the sixteen insecticides, the per cent usage of spinosad, flubendiamide, chlorantraniliprole, diafenthiuron, spiromesifen and triazophos were highest (100.00 %), *i.e.* all the nine shade nets surveyed in Guntur district the farmers used the above insecticides. These were followed by abamectin (77.70 %), thiamethoxamand imidacloprid (66.60%), acephate (55.50 %), dicofol (44.40 %), chlorpyriphos, propergite and acetamiprid (33.30 %), respectively. Monocrotophos and Methomyl are used in capsicum cultivation under shade net conditions in Telangana state but not used by the farmers in A.P.

**Efficacy of insecticides against thrips, *S.dorsalis* under poly house conditions**

**Pooled mean of 2013 -14 and 2014-15**

The results with regard to overall cumulative mean efficacy of the treatments against thrips, *S.dorsalis* during the two years under polyhouse conditions are presented in Table 6. Mean thrips population in pre count ranged from 1.07 thrips/leaf to 4.34 and post count population was lower with spinosad(0.06 thrips/leaf) followed by diafenthiuron (0.50 thrips/leaf) and thiomethoxam (1.30 thrips/leaf) which were significantly superior over untreated check (5.6 thrips/leaf) and at par with each other. The descending order of efficacy in the treatments was chlorantraniliprole(3.55 thrips/ leaf)> spiromesifen (3.61 thrips/leaf)> flubendiamide (3.81 thrips/leaf) >triazophos(4.24 thrips / leaf) which were found to beat par with untreated check (5.60 thrips/leaf).

The percent reduction over untreated check revealed that the highest per cent reduction of thrips population was in spinosad(98.05%) which was significantly superior over other treatments. Diafenthiuron(87.52 %) and thiomethoxam(72.98 %) were next best treatments. The other treatments in the descending order of efficacy were spiromesifen(28.26), chlorantraniliprole (27.56), flubendiamide(24.71) and triazophos (19.45) which were found to be significantly superior over untreated check.

The mean LCI of two years revealed that LCI at one DBS (1.25) was significantly reduced to 0.51 in spinosad treated plants followed by diafenthiuron (1.69 to 0.90) and thiomethoxam(1.82 to 1.16).

Whereas, LCI was significantly increased from one DBS to 10 DAS in chlorantraniliprole(2.41 to 2.51),flubendiamide (2.43 to 2.55), spiromesifen (2.51 to 2.64) and triazophos(2.53 to 2.72) and untreated check (2.71 to 2.96) (Table 6 & Fig. 1).

The results obtained from the both years of polyhouse experiment clearly showed that spinosad was significantly superior over rest of the treatments and showed lowest mean no. of thrips per leaf (0.06) and mean reduction of thrips population (98.05 %). Next best treatment was diafenthiuronin reducing mean thrips population (0.50) and increased mean per cent reduction of population (87.52 %) followed by thiomethoxam which showed significant superiority in reducing mean thrips population (1.30) and moderate mean per cent reduction of thrips population (72.98).

Spinosad, a naturally occurring mixture of spinosyn A and spinosyn D, is a secondary metabolite from the aerobic fermentation of *Saccharopolysporaspinosa* on nutrient media. The superior efficacy is due to the excitation of insect nervous system leading to involuntary muscle contraction, prostration with tremors and paralysis. These effects are consistent with the activation of nicotinic acetylcholine receptors by a mechanism that is clearly novel and unique. Spinosad also effects GABA receptor function that may contribute further to its insect activity(Sparks *et al*., 2001).The present results are in concurrence with Prasad and Ahmed (2009) who reported that spinosad was superior in reducing thrips, *S. dorsalis* population and increased fruit yield of chilli in Andhra Pradesh. Similar reports by Hossain *et al*. (2014) using spinosad @ 0.4ml $l^{-1}$ + white sticky trap@ 40 traps $ha^{-1}$ resulted in the lowest thrips (*T.tabaci)* population with highest marginal benefit cost ratio (1 :1.99) in garlic insect pest management. The efficacy of spinosad @ 75 g a.i.$ha^{-1}$ against S*. dorsalis* in cotton was also reported by Srinivas *et al*. (2002), Bheemanna *et al*. (2009).

In the study, the next best treatment was diafenthiuron in reducing mean thrips population (1.72) and increased mean per cent reduction of population (79.47). Next in priority was thiomethoxam 25 WG 150 g ml $ha^{-1}$, which showed significant superiority in reducing mean thrips population and moderate mean per cent reduction of thrips population. Similar findings were reported by Nandini *et al*. (2012) and Raj *et al*. (2012) on efficacy of thiomethoxam against thrips. It is interesting to note that spinosad, diafenthiuron and thiomethoxam reduced the incidence of the thrips population after the three sprays while the rest of the insecticides increased the incidence compared to before spraying. This observation indicated that these three insecticides effectively controlled thrips upto a week after spraying.

## CONCLUSION

In Guntur district of Andhra Pradesh, capsicum cultivation is done only under shade net conditions. Thrips, mites, aphid*,* whitefly, cut worm, blossom midge and fruit borer were reducing the crop yields. To reduce the pest damage spinosad, flubendiamide, chlorantraniliprole, diafenthiuron, spiromesifen and triazophos were used by farmers. To reduce the thrips population, spinosad@ 75 g a.i.$ha^{-1}$ was found to be effective.

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# CORRELATION AND PATH COEFFICIENT ANALYSIS FOR YIELD AND YIELD COMPONENT TRAITS IN UPLAND COTTON (*Gossypium hirsutum* L.)

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**ABSTRACT**

Correlation and path coefficient analysis were worked out for 14 characters in 54 genotypes of upland cotton. The association studies revealed that plant height, number of sympodia per plant, number of bolls per plant, boll weight, seed index, ginning out turn and micronaire value showed significant positive association with seed cotton yield per plant. Further partitioning of correlation coefficients into direct and indirect effects showed that traits *viz*., plant height, number of monopodia plant$^{-1}$, number of sympoida plant$^{-1}$, boll weight, seed index and lint index, had direct positive effect on seed cotton yield per plant. Thus, correlation and path analysis clearly indicated that direct selection based on number of bolls per plant, boll weight and seed index may be helpful in developing high yielding varieties in upland cotton.

## INTRODUCTION

Cotton (*Gossypium spp)* is one of the most important commercial cash crop and plays a key role in economic, political and social affairs of the world. Cotton enjoys a pre-eminent status among all the cash crops in the country, being the principal material for flourishing textile industries. The predominant species cultivated in India is *G. hirsutum* which covers about 90% of the total area.

The ultimate objective of any breeder is to increase the yield and is normally a complex trait governed by polygenes. Hence, it is desirable for plant breeder to know the extent of relationship between yield and yield components which would facilitate in selecting desirable characteristics for yield improvement. Correlation coefficient analysis measures the magnitude of relationship between various plant characters and determines the component character on which selection can be based for improvement of seed cotton yield.

Further, the true picture of correlation between seed cotton yield and other yield traits is reflected from direct and indirect effects in order to perceive the most influencing characters to be utilized as selection criteria in cotton breeding programme.

## MATERIAL AND METHODS

The present study was carried out with 54 genotypes of cotton in randomized complete block design (RCBD) with three replications at Regional Agricultural Research Station, Lam, Guntur during *kharif,* 2016-17. The inter-row and intra-row spacing adapted was 105 cm x 60 cm. Each plot consisted of one row of 6 m length and observations were recorded on five randomly selected plants from each genotype per replication for 14 characters *viz*., plant height (cm), number of monopodia plant$^{-1}$, number of sympodia plant$^{-1}$, number of bolls plant$^{-1}$, boll weight (g), seed index (g), lint index (g) and seed cotton yield plant$^{-1}$ (g). The characters *viz*., days to 50% flowering, ginning out turn (%), 2.5% span length (mm), micronaire ($10^{-6}$ g inch$^{-1}$), bundle strength (g/tex) and uniformity ratio were recorded on plot basis. The fibre quality characters were analysed at Central Institute for Research on Cotton Technology, Regional Unit, Coimbatore. The data collected from the experimental material was subjected to the correlation and path coefficient analysis.

## RESULTS AND DISCUSSION

The analysis of variance indicated significant differences among the genotypes for all the

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**Table 1. Phenotypic (above diagonal) and genotypic (below diagonal) correlation coefficients for 14 characters in intra-specific hybrids of cotton during *kharif*, 2016-17**

| Character | Plant height (cm) | Days to 50% flowe-ring | Number of mono-podia plant$^{-1}$ | Number of symp-odia plant$^{-1}$ | Number of bolls plant$^{-1}$ | Boll weight | Seed index | Lint index | Ginning outturn | 2.5% span length | Micro-naire value | Bundle strength | Unifo-rmity ratio | Seed cotton yield plant$^{-1}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plant height (cm) | 1.000 | -0.1366 | 0.0912 | 0.3143** | 0.3179** | 0.2487** | 0.1600* | 0.1084 | -0.0577 | 0.0636 | -0.1005 | 0.1688* | -0.0497 | 0.2119** |
| Days to 50% flowering | -0.2588** | 1.000 | -0.1362 | 0.0173 | -0.0253 | -0.1586* | -0.1855* | -0.2084** | -0.0777 | -0.0096 | 0.0020 | -0.0828 | 0.0435 | -0.1372 |
| Number of monopodia plant$^{1}$ | 0.2393** | -0.2146 | 1.000 | 0.1127 | 0.2315** | 0.0442 | 0.0481 | -0.0365 | -0.1660* | 0.0273 | 0.0387 | -0.0512 | -0.0475 | 0.1993* |
| Number of sympodia plant$^{1}$ | 0.4298** | -0.0288 | 0.2016* | 1.000 | 0.2572** | 0.0110 | 0.0707 | 0.0452 | -0.0374 | -0.0743 | -0.0384 | 0.0966 | 0.1417 | 0.1986* |
| Number of bolls plant$^{1}$ | 0.3082** | -0.0225 | 0.4121** | 0.4051** | 1.000 | 0.3116** | 0.2669** | 0.1817* | -0.0888 | -0.2099** | 0.1951* | -0.2106** | 0.2105** | 0.7488** |
| Boll weight | 0.3804** | -0.3016** | 0.0185 | 0.0364 | 0.4188** | 1.000 | 0.5484** | 0.5266** | 0.0669 | 0.0969 | 0.5297 | 0.1000 | -0.0805 | 0.5287** |
| Seed index | 0.2316** | -0.3041** | 0.0966 | 0.1900* | 0.3837** | 0.6773 | 1.000 | 0.8454** | -0.0333 | -0.1405 | 0.0178 | 0.0511 | 0.0456 | 0.4154** |
| Lint index | 0.1497 | -0.3315** | -0.0625 | 0.1290 | 0.2425** | 0.6350 | 0.8714 | 1.000 | 0.4712** | -0.1069 | 0.0154 | 0.0030 | 0.1153 | 0.3040** |
| Ginning outturn | -0.1441 | -0.1271 | -0.2856** | -0.0750 | -0.1863* | 0.0577 | -0.0695 | 0.4502 | 1.000 | 0.0205 | -0.0168 | -0.0977 | 0.1425 | -0.0936 |
| 2.5% span length | 0.0710 | -0.0364 | 0.0350 | -0.1825* | -0.2587** | 0.0885 | -0.1363 | -0.1213 | 0.0216 | 1.000 | -0.2275** | 0.5723** | -0.4756** | -0.2112* |
| Micronaire value($10^{-6}$ g/in) | -0.1670* | -0.1211 | 0.0729 | 0.3715** | 0.2355** | 0.1498 | 0.0524 | 0.0284 | -0.0295 | -0.3072** | 1.000 | -0.4109** | 0.0611 | 0.2915 |
| Bundle strength | 0.2169** | -0.1076 | -0.1158 | -0.1544 | -0.2653** | 0.0846 | 0.1247 | 0.0502 | -0.1124 | 0.6270** | -0.5393** | 1.000 | -0.3708* | -0.2195 |
| Uniformity ratio | -0.2071** | 0.3139** | -0.0818 | 0.1022 | 0.3707** | -0.0534 | 0.0811 | 0.1934* | 0.2647** | -0.9776 | 0.2984** | -0.7314 | 1.000 | 0.1586 |
| Seed cotton yield per plant (g) | 0.3118** | -0.2014* | 0.3285** | 0.3450** | 0.9692** | 0.6288** | 0.5010** | 0.4056** | -0.0859 | -0.2174* | 0.3616** | -0.2631** | 0.3294** | 1.000 |

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

**Table 2. Direct and indirect effects (phenotypic) of 14 characters on seed cotton yield in intra-specific hybrids of cotton**

| Character | Plant height (cm) | Days to 50% flowe-ring | Number of mono-podia plant$^{-1}$ | Number of symp-odia plant$^{-1}$ | Number of bolls plant$^{-1}$ | Boll weight | Seed index | Lint index | Ginning outturn | 2.5% span length | Micro-naire value | Bundle strength | Unifo-rmity ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plant height(cm) | **-0.0790** | 0.0108 | -0.0072 | -0.0248 | -0.0251 | -0.0196 | -0.0126 | -0.0086 | 0.0043 | -0.0050 | 0.0084 | -0.0133 | 0.0039 |
| Days to 50% flowering | 0.0115 | **-0.0844** | 0.0115 | -0.0015 | 0.0021 | 0.0134 | 0.0157 | 0.0176 | 0.0066 | 0.0008 | -0.002 | 0.0070 | -0.0037 |
| Number of monopodia plant$^{1}$ | 0.0017 | -0.0026 | **0.0180** | 0.0021 | 0.0044 | 0.0008 | 0.0009 | -0.0007 | -0.0031 | 0.0005 | 0.0007 | -0.0010 | -0.0009 |
| Number of sympodia plant$^{1}$ | 0.0224 | 0.0012 | 0.0080 | **0.0713** | 0.0183 | 0.0008 | 0.0050 | 0.0032 | -0.0027 | -0.0053 | -0.0027 | 0.0069 | 0.0101 |
| Number of bolls plant$^{1}$ | 0.1833 | -0.0146 | 0.1355 | 0.1483 | **0.5765** | 0.1796 | 0.1538 | 0.1048 | -0.0512 | -0.1210 | 0.1125 | -0.1214 | 0.1214 |
| Boll weight | 0.0820 | -0.0523 | 0.0146 | 0.0036 | 0.1027 | **0.3297** | 0.1808 | 0.1736 | 0.0221 | 0.0319 | 0.0411 | 0.0330 | -.0.0265 |
| Seed index | 0.0617 | -0.0716 | 0.0186 | 0.0273 | 0.1029 | 0.2114 | **0.3856** | 0.3260 | -0.0128 | -0.0542 | 0.0069 | 0.0197 | 0.0176 |
| Lint index | -0.0400 | 0.0770 | 0.0135 | -0.0167 | -0.0671 | -0.1945 | -0.3123 | **-0.3694** | -0.1741 | 0.0395 | -0.0057 | -0.0011 | -0.0426 |
| Ginning outturn | -0.0060 | -0.0085 | -0.0182 | -0.0041 | -0.0097 | 0.0073 | -0.0036 | 0.0516 | **0.1094** | 0.0022 | -0.0018 | -0.0107 | 0.0156 |
| 2.5% span length | -0.0017 | 0.0003 | -0.0007 | 0.0020 | 0.0056 | -0.0026 | 0.0037 | 0.0028 | -0.0005 | **-0.0265** | 0.0060 | -0.0152 | 0.0126 |
| Micronaire value | -0.0099 | 0.0022 | 0.0036 | -0.0036 | 0.0181 | 0.0116 | 0.0016 | 0.0014 | -0.0016 | -0.0211 | **0.0927** | -0.6381 | 0.0057 |
| Bundle strength | -0.0134 | 0.0066 | 0.0041 | -0.0077 | 0.0167 | -0.0079 | -0.0041 | -0.0002 | 0.0073 | -0.0454 | 0.0326 | **-0.0793** | 0.0294 |
| Uniformity ratio | -0.008 | 0.0007 | -0.0008 | 0.0023 | 0.0034 | -0.0013 | 0.0007 | 0.0019 | -0.0076 | -0.0076 | 0.0010 | -0.0060 | **0.0161** |
| Correlation with seed cotton yield plant$^{-1}$ (g) | **0.2119**** | **-0.1372** | **0.1993*** | **0.1986*** | **0.7488**** | **0.5287**** | **0.4154**** | **0.3040**** | **-0.0936** | **-0.2112** | **0.2915** | **-0.2195** | **0.1586** |

* Significant at 5% level, ** Significant at 1% level, Residual effect = 0.539, Bold and diagonal values indicate direct effects

**Table 3. Direct and indirect effects (genotypic) of 14 characters on seed cotton yield in intra-specific hybrids of cotton during *kharif*, 2016-17**

| Character | Plant height (cm) | Days to 50% flowe-ring | Number of mono-podia plant$^{-1}$ | Number of symp-odia plant$^{-1}$ | Number of bolls plant$^{-1}$ | Boll weight | Seed index | Lint index | Ginning outturn | 2.5% span length | Micro-naire value | Bundle strength | Unifo-rmity ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plant height (cm) | **-0.0490** | 0.0127 | -0.0117 | -0.0211 | -0.0151 | -0.0186 | -0.0113 | -0.0073 | 0.0071 | -0.0035 | 0.0082 | -0.0106 | 0.0101 |
| Days to 50% flowering | 0.0317 | **-0.1226** | 0.0263 | 0.0035 | 0.0028 | 0.0370 | 0.0373 | 0.0406 | 0.0156 | 0.0045 | 0.0149 | 0.0132 | -0.0385 |
| Number of monopodia plant$^{1}$ | -0.0169 | 0.0151 | **-0.0705** | -0.0142 | -0.0291 | -0.0013 | -0.0068 | 0.0044 | 0.0201 | -0.0025 | -0.0051 | 0.0082 | 0.0058 |
| Number of sympodia plant$^{1}$ | 0.0191 | -0.0013 | 0.0090 | **0.0445** | 0.0180 | 0.0016 | 0.0085 | 0.0057 | -0.0033 | -0.0081 | -0.0069 | 0.0045 | 0.0165 |
| Number of bolls plant$^{1}$ | 0.2723 | -0.0198 | 0.3642 | 0.3580 | **0.8837** | 0.3701 | 0.3385 | 0.2143 | -0.1646 | -0.2286 | 0.2081 | -0.2344 | 0.3276 |
| Boll weight | 0.0859 | -0.0682 | 0.0042 | 0.0082 | 0.0946 | **0.2260** | 0.1530 | 0.1435 | 0.0130 | 0.0200 | 0.0339 | 0.0191 | -0.0121 |
| Seed index | 0.0735 | -0.0965 | 0.0306 | 0.0603 | 0.1215 | 0.2149 | **0.3173** | 0.2765 | -0.0221 | -0.0432 | 0.0166 | 0.0396 | 0.0257 |
| Lint index | -0.0541 | 0.1198 | 0.0226 | -0.0466 | -0.0876 | -0.2294 | -0.3149 | **-0.3614** | -0.1627 | 0.0438 | -0.0103 | -0.0181 | -0.0701 |
| Ginning outturn | -0.0306 | -0.0269 | -0.0606 | -0.0159 | -0.0395 | 0.0122 | -0.0147 | 0.0954 | **0.2120** | 0.0046 | -0.0063 | -0.0238 | 0.0561 |
| 2.5% span length | 0.0028 | -0.0014 | 0.0014 | -0.0073 | -0.0103 | 0.0035 | -0.0054 | -0.0048 | 0.0009 | **0.0398** | -0.0122 | 0.0249 | -0.0389 |
| Micronaire value | -0.0173 | -0.0125 | 0.0075 | -0.0160 | 0.244 | 0.0155 | 0.0054 | 0.0029 | -0.0031 | -0.0318 | **0.1035** | -0.0558 | 0.0309 |
| Bundle strength | -0.0084 | 0.0042 | 0.0045 | -0.0040 | 0.0103 | -0.0033 | -0.0048 | -0.0019 | 0.0044 | -0.0243 | 0.0209 | **-0.0387** | 0.0283 |
| Uniformity ratio | 0.0025 | -0.0038 | 0.0010 | -0.0045 | -0.0045 | 0.0007 | -0.0010 | -0.0024 | -0.0032 | 0.0119 | -0.0036 | 0.0089 | **-0.0122** |
| Correlation with seed cotton yield plant$^{-1}$ (g) | **0.3118** | **-0.2014*** | **0.3285**** | **0.3450**** | **0.9692** | **0.6288** | **0.5010** | **0.4050** | **-0.0859** | **-0.2174*** | **0.3616** | **-0.2631**** | **0.3294**** |

***** = Significant at 5% level, ****** = Significant at 1% level, Residual effect = 0.1245, Bold and diagonal values indicate direct effect characters studied. The phenotypic and genotypic association pattern between seed cotton yield and other yield components and among themselves were estimated and presented in the Table 1. The genotypic correlations in general were higher than phenotypic correlations indicating that the apparent associations are largely due to genetic reasons.

Plant height recorded significant positive association with number of bolls plant$^{1}$ ,number of sympodia plant$^{-1}$, boll weight, seed index, bundle strength and seed cotton yield plant$^{-1}$ at both genotypic and phenotypic levels indicating their true association. Similar results were also reported earlier by Alkuddsi *et al.* (2013), Rajamani *et al*. (2013), Asha *et al*. (2015) and Bhailume *et al.* (2016). Days to 50% flowering showed significant negative association with boll weight, seed index and lint index both at phenotypic and genotypic levels. This is in accordance with the research findings of Kumar and Ravikesavan. (2010), Reddy *et al*.(2015) and Sirisha *et al*. (2016).

The traits, number of monopodia plant$^{1}$, number of sympodia plant$^{1}$, number of bolls plant$^{1}$, boll weight and seed index, also showed significant positive association with seed cotton yield per plant at both phenotypic and genotypic levels indicating the usefulness of these traits in selection programmes. Similar results were reported by Kishore *et al.* (2011) and Rajamani *et al.* (2013). Days to 50% flowering, ginning out turn and uniformity ratio showed non-significant negative association with seed cotton yield per plant at phenotypic level, whereas at genotypic level they showed significant negative association. This is in line with the reports of Pujer *et al.* (2014) and Sirisha *et al*. (2016).

The traits, plant height, number of monopodia plant$^{1}$, number of sympodia plant$^{1}$, boll weight and seed index were found to posses significant positive association in desirable direction with seed cotton yield per plant both at genotypic and phenotypic levels. The traits *viz*., plant height, days to 50% flowering, lint index, 2.5% span length and bundle strength, had negative association with seed cotton yield. But these traits showed indirect effects through other yield traits for their exploitation in the selection programme.

In any plant breeding programme, it is very difficult to have complete knowledge of all component traits of yield. The residual effect permits precise explanation about the pattern of interaction of other possible components of yield. In other words, residual effect measures the role of the possible independent variables which were not included in the study on the dependent variable. In the present study, the residual effect observed at phenotypic (0.539) and genotypic (0.125) levels explains that the characters chosen for path analysis were adequate and appropriate.

The path analysis indicated that number of monopodia plant$^{1}$, number of sympodia plant$^{1}$, number of bolls plant$^{-1}$, boll weight and seed index had direct positive effects and significant correlation with seed cotton yield per plant (Table 2 and 3). Thus, the study revealed that the major emphasis should be laid on selection process with these traits without sacrificing desirable fibre qualities by adopting restriction selection model. However, care should be exercised in developing varieties with desirable fiber quality matching the needs of textile industry since some of the important yield attributes were found negatively associated with important fiber quality parameters and also among themselves.

## CONCLUSIONS

The study indicated that number of monopodia plant$^{1}$, number of sympodia plant$^{1}$, number of bolls plant$^{1}$, boll weight and seed index emerged as the major contribution for seed cotton yield plant$^{1}$ as evidenced from their significant association. It is very clear through path analysis that the most important characters accounting for cause and effect relationships on seed cotton yield are number of number of monopodia plant$^{1}$, number of sympodia plant$^{1}$, number of bolls plant$^{1}$, boll weight and seed index as witnessed from their high direct effects as well as indirect contribution via other traits. Therefore, selection of number of monopodia plant$^{1}$, number of sympodia plant$^{1}$, number of bolls plant$^{1}$, boll weight and seed index would lead to high seed cotton yield.

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# CORRELATION STUDIES OF QUALITY, NUTRIENT UPTAKE AND YIELD OF CHILLI WITH THE APPLICATION OF ORGANIC MANURES AND FOLIAR SPRAY OF WATER SOLUBLE FERTILIZERS

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**ABSTRACT**

A field experiment was conducted during *kharif* 2013-14 and 2014-15 on Byadgi chilli by substituting fertilizer nitrogen with different sources of organic manures along with foliar application of water soluble fertilizers to study the relation between yield, quality, nutrient uptake and nutrient concentration of chilli crop. The experiment consists of four main treatments as organics, $M_1$- Recommended Package of Practices (RPP)- {Recommended Dose of Fertilizers (RDF) + 25 t $ha^{-1}$ FYM (Farm Yard Manure)}, $M_2$- 50 per cent N through FYM + 50 per cent inorganic N, $M_3$- 50 per cent N through VC(vermicompost) + 50 per cent inorganic N, $M_4$- 50 per cent N through FYM and VC + 50 per cent inorganic N and four sub treatments as water soluble fertilizers, $S_1$- $KNO_3$ @ 1 per cent, $S_2$- $K_2SO_4$ @ 1 per cent, $S_3$- 19:19:19 @ 1 per cent, $S_4$- $KNO_3$+ $K_2SO_4$+ 19:19:19 each @ 1% along with one control (RPP + water spray) with three replications. Split plot design was adopted. Results showed that highest correlation coefficient (r=0.96**) value was obtained between nitrogen concentration of whole red fruit and capsaicin content. Potassium content of whole red fruits shown significant and positive correlation with colour value (0.95**), per cent oleoresin (0.81**) and less correlated with per cent capsaicin (0.58). The correlation coefficient values for fruit yield, colour value, capsaicin and oleoresin contents versus nitrogen uptake were 0.96**, 0.90*, 0.94* and 0.95**, respectively.

## INTRODUCTION

Nitrogen plays a role in the formation of amide molecule present in the side chain of capsaicin structure that is responsible for pungency in chilli. Ananthakrishna and Govindarajan (1975) reported the synthesis of amide ($NH_2$) radical in capsaicin structure as closely related to nitrogen uptake. Plants should have adequate supply of nitrogen during fruit ripening to enhance capsaicin content responsible for pungency. However, the conventional nitrogen fertilizers applied to soil as basal dose during transplanting and top dressed after 45 DAT are subjected to leaching, volatilization and run off losses leaving very little nitrogen available during fruit development. This results in lesser pungency in chilli fruits.

Contrary to nitrogen, colour value in chilli fruits is closely related to potassium content and adequate potassium supply to plants during fruit maturity results in rapid transformation of green colour to pink and finally to red colour (Bidari, 2000). It is found that, potassium brings about equilibrium between acids and sugars in fruits, which results in good ripening and development of red colour. Cazi (1961) reported a direct relationship between colour value of fruits and potassium supply to plants. Hence, the role of potassium in the synthesis of red colour in chillies is quite evident. As chilli is a long duration and indeterminate plant, requires adequate supply of nitrogen and potassium particularly during fruit development and maturity for enhancing pungency and colour value. In this context foliar spray of water soluble grade fertilizers containing nitrogen and potassium appeared to play significant role in enhancing quality attributes of chillies. Potassium nitrate is a water soluble potassic fertilizer containing 44 per cent $K_2O$ and 13 per cent nitrogen suitable for foliar application (Yawalkar *et al.,* 1996). Potassium sulphate is another water soluble grade complete fertilizer containing 50 per cent potassium suitable for foliar application. 19:19:19 is another water soluble grade complete fertilizer containing four per cent $NO_3$-N, 4.50 per cent $NH_4$-N and 10.5 per cent $NH_2$-N including 19 per cent each of water soluble P and K. The foliar spray of these water soluble grade fertilizers at fruit development and maturity may significantly enhance the red colour, pungency and oleoresin in

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chillies provided optimum concentrations of nitrogen and potassium are supplied through foliar spray synchronizing with crop requirement. Hence, an attempt was made to correlate quality, nutrient uptake and yield of chilli with the application of organic manures and foliar spray of water soluble fertilizers.

## MATERIAL AND METHODS

An experiment was conducted during *kharif* 2013-14 and 2014-15 in farmer's field in Dharwad district situated in the northern transitional zone of Karnataka. The soil of the experimental site was *Typic Chromustert* and soil reaction was neutral (7.44). The organic carbon content of experimental soil was 6.10 g $kg^{-1}$, low in available nitrogen (171 kg $ha^{-1}$), medium in $P_2O_5$(25.8 kg $ha^{-1}$ ) and medium in $K_2O$ (235 kg $ha^{-1}$). The experiment consists of four main treatments as organics, $M_1$- Recommended Package of Practices (RPP)- {Recommended Dose of Fertilizers (RDF) + 25 t $ha^{-1}$ FYM}, $M_2$- 50 per cent N through FYM + 50 per cent inorganic N, $M_3$- 50 per cent N through VC + 50 per cent inorganic N, $M_4$- 50 per cent N through FYM and VC + 50 per cent inorganic N and four sub treatments as water soluble fertilizers, $S_1$- $KNO_3$ @ 1 per cent, $S_2$- $K_2SO_4$ @ 1 per cent, $S_3$- 19:19:19 @ 1 per cent, $S_4$- $KNO_3$+ $K_2SO_4$+ 19:19:19 each @ 1 per cent along with one control ( RPP + water spray) with three replications. Split plot design was adopted. The cultivar used for the experiment was Dyvanur with a spacing of 75 cm x 75 cm. Foliar sprays were given on 45$^{th}$ DAT (Days after Transplanting) and 90$^{th}$ DAT except for the sub plot treatment ($S_4$) which received combined spray of $KNO_3$, $K_2SO_4$, 19:19:19 given at 45$^{th}$ DAT (Days After Transplanting) with 10 days interval for each spray. RDF is 100 -50-50 N, $P_2O_5$ and $K_2O$ kg per ha.

## RESULTS AND DISCUSSION

### Yield and quality attributes of chilli fruits Vs nutrient uptake

Correlation coefficient values of yield and all the three quality attributes of chilli had significant and positive correlation with nitrogen uptake by the plant. The correlation coefficient values for fruit yield, colour value, capsaicin and oleoresin contents versus nitrogen uptake were 0.96**, 0.90*, 0.94* and 0.95**, respectively. Phosphorous and potassium uptake also had significant positive correlation with yield and quality attributes. The correlation values for fruit yield, colour value, capsaicin content and oleoresin content vs P uptake were 0.97**, 0.85*, 0.91* and 0.93**, respectively. Similarly, the values for K uptake were 0.97**, 0.96*, 0.91*, and 0.93* for fruit yield, colour value, capsaicin content and oleoresin content, respectively (Table 1).

Nitrogen absorbed by plant enhances chlorophyll content in leaves, leading to increased photosynthesis that contributed for increased fruit yield. Similar type of relationship existed between quality attributes of red chillies and phosphorus uptake at harvest. The absorbed phosphorus by crop canopy enhances cell division, leading to more number of branches, flowers which led to higher fruit yield. Potassium uptake had a significant positive correlation with dry fruit yield, oleoresin content, colour value and capsaicin. There is an established role of potassium in enhancing colour value of fruits as potassium balances acid: sugar ratio in fruits. There is enhanced potassium uptake by plants once chilli fruits start turning red (Bidari, 2000). Prabhavathi *et al.* (2009) reported a close relationship between potassium uptake by plants and red colour synthesis in chillies. Positive relationship between potassium uptake by plants and colour value of chilli fruits was also reported by Subhani *et al.* (1990) and Somimol (2012). Micronutrients have also shown positive correlation with yield and quality attributes because of their specific roles in chlorophyll synthesis and enzyme activation, which increased the yield and quality.

### Nutrient content of whole red fruit Vs quality attributes

All the three quality attributes *i.e*. capsaicin, colour value and oleoresin of red chillies bear significant and positive correlation with nitrogen, phosphorus, potassium and sulphur concentration in whole red fruits. Highest correlation coefficient (r

= 0.96**) value was obtained between nitrogen concentration of whole red fruit and capsaicin content. Similarly, nitrogen content of whole red fruits possessed significant positive correlation with per cent oleoresin (0.88*), and also positive correlation with colour value (0.67).Similarly, phosphorus content of red chilli fruit had a positive correlation with colour value (0.73*), per cent oleoresin (0.75*)per cent capsaicin (0.81**). Potassium content of whole red fruits had a significant and positive correlation with colour value (0.95**), per cent oleoresin (0.81**) and less correlated with per cent capsaicin (0.58). Sulphur content of whole red fruits showed significant positive correlation with colour value (0.73*), oleoresin content (0.87**) and capsaicin content (0.89**) (Table 2).

It is a well-known fact that pungency in chillies is due to an alkaloid *viz.*, capsaicin. Nitrogen content of whole red fruit bears significant positive relationship with capsaicin (0.96**). This is obvious, because the amide ($NH_2$) molecule present in side chain of capsaicin structure is an active ingredient of capsaicin. Hence, high nitrogen content in chilli fruits led to greater concentration of amide radical leading to increased pungency. Similar observations were reported by Ananthakrishna and Govindarajan (1975). Further, nitrogen content of fruits possessed positive relationship with colour value and oleoresin contents but in the second order. This might be due to the higher concentration of potassium in chilli fruits over nitrogen. This high concentration of potassium might have a masking effect on the role of nitrogen in colour

**Table 1. Relationship of yield and quality attributes of red chilli (cv. Dyavnur) fruits with nutrients uptake by chilli at 140 DAT**

| Nutrient uptake at 140 DAT | 'r' value | | | |
|---|---|---|---|---|
| | Dry fruit yield | Colour value | Capsaicin | Oleoresin |
| Nitrogen | 0.96** | 0.90* | 0.94* | 0.95** |
| Phosphorus | 0.97** | 0.85* | 0.91* | 0.93* |
| Potassium | 0.97** | 0.96** | 0.91* | 0.93* |
| Sulphur | 0.97* | 0.80 | 0.87 | 0.90* |
| Iron | 0.98** | 0.86* | 0.92* | 0.93* |
| Zinc | 0.96** | 0.81 | 0.87 | 0.91* |
| Manganese | 0.96** | 0.85* | 0.91* | 0.94* |
| Copper | 0.97** | 0.82 | 0.89* | 0.92* |

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

**Table 2. Relation between quality attributes of red chilli fruits [cv- Dyavnur] and nutrients concentration of chilli fruits**

| Nutrient concentration | 'r' value | | |
|---|---|---|---|
| | Capsaicin | Colour value | Oleoresin |
| Nitrogen | 0.96** | 0.67 | 0.88* |
| Phosphorus | 0.81** | 0.73* | 0.75* |
| Potassium | 0.58 | 0.95** | 0.81** |
| Sulphur | 0.89** | 0.73* | 0.87** |
| Iron | 0.77* | 0.82** | 0.78* |

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

synthesis as well as in oleoresin yield. Potassium content of whole red fruit bears significant positive relationship with colour value (r =0.95**). This is mainly because of the role of K in red colour synthesis. Potassium balances acid sugar ratio in fruits (Subhani *et al.*, 1990; Marcelle, 1995) and fruits having high potassium content exhibited deep blood red colour. Pankar and Magar (1978) highlighted that there was greater partitioning of K into pericarp than seed and 99 per cent of colour is concentrated in pericarp. Sulphur content of fruits also bears significant positive relationship with capsaicin (r=0.89**), colour value (r=0.73*) and oleoresin (r=0.87**). As chilli seeds contain volatile fatty acids *viz.,* linolenic, linoleic acids and capsaicin, the absorbed sulphur might play a role in the synthesis of capsaicin and oleoresin. Niranjana and Suseeladevi (1990) reported that sulphur and phosphorus influence the capsaicin content in chilli fruits particularly in laterite soil.

## CONCLUSION

Nitrogen content of whole red fruit bears significant positive relationship with capsaicin, while potassium content was significantly and positively related to colour value and oleoresin content.

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# STUDY ON THE DEVELOPMENT AND EVALUATION OF OAT (*Avena sativa* L.) FORTIFIED COOKIES

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**ABSTRACT**

The study was conducted in the year 2015 on formulation of nutritive cookies by incorporating oat flour. The oat flours were mixed in the conventional formulation for replacing refined wheat flours in quantity of 0, 10, 20, and 30 percent. The results of physical analysis such as diameter thickness and spread ratio were estimated. The result of physical analysis of cookies showed that oat decreases the diameter from 62.43±0.4 mm to 59.5±0.23 mm, increases thickness from 6.23±0.2 mm to 7.66±0.32 mm, decreases spread ratio from 10.33±0.38 to 8.15±0.15. The nutritional estimation of the oat fortified cookies was done for protein, fat, moisture, ash and fibre. The nutritional value of treatments with different percent of oat flour remarkably varied from the control sample. Fibre content of 30% oat flour incorporated sample was maximum with a value of 5.24±0.26 %. Results of sensory analysis revealed that the 20% incorporation of the oat flour was having higher overall acceptability (7.92±0.9). Thus, acceptable cookies can be obtained from 20% incorporation of oat flour having maximum overall acceptability and average nutritional values.

## INTRODUCTION

The word cookie originally derived from the Dutch word *'keokje'* meaning small cake. Cookies are also termed as biscuit in England and Australia. Cookies are normally a combination of all purpose flour baking powder, unsalted butter; sugar and flavoring. Cookies are affluent in fat and sugar content than whole bread. However, they are low in proteins. The lower content of vitamins, proteins (lysine) and dietary fibre and nutritional problems with many bakery products enrichment adds B complex, vitamins, Iron, and dietary fibres. Wheat is the major source of protein and calorie for large section of population, which is consumed as chapati but with the emergence of various baking technology and changing food habits, wheat is consumed in many forms of bakery products such as bread, biscuit, cookies, cakes, etc.

Bakery industry is booming at about 10 percent per year and the products are steadily consumed by different age groups (Indrani *et al.,* 1997). Lately in India, bakery products have become popular among different cross sections of population due to huge demand for convenience foods. Bread and Biscuit account for 80% of total bakery products produced in the country. Biscuit is a small baked product made up of basically refined wheat flour, sugar and shortening.

Dietary fibre has been defined as the plant cell polysaccharides and lignin not hydrolyzed by the digestive enzymes of animal and human. These dietary fibres are components of plants which are hard for digestion in the alimentary canal of human being. These dietary fibres may be soluble and insoluble. The diet rich in fibre controls weight in various ways. Generally, dietary fibre foods provide less calories but give a sense of fullness to stomach. They also slow down gastric emptying and sensation of hunger. Dietary fibres are not equivalent to crude fibres; it is the material remaining after rather rigorous treatment of a food sample with acid and alkali. The residue probably reflects the cellulose and lignin content of food dietary fibre as used in this discussion refers to the combined indigestive carbohydrates in food, and encompasses the cellulose and lignin found in crude fibre as well as hemicelluloses, pectin substances.

The major food sources of fibre are fruits, vegetables and whole grain cereals. Although foods sources of fibre are complex, they may be rich in specific type of fibre e.g. Oat bran is rich in water-soluble gums. Fibre is not digestible by the human digestive system. It performs two very important functions *i.e.* providing bulk to faecal matter and stimulating the large intestine for easy movements. Oat which is not of Indian origin but now a days it is gaining more and more importance in India due to

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its nutritive value. During first century A.D. it was Ferdinand Schumacher who developed oats into a commercial product by thermal processing introducing unique flavour to it. It is still considered as a forage crop and livestock feed. Oats for human consumption are limited to products like rolled oat flakes and oat flour blended with other confectionary products. It also has low market cost. Oats is used for quick energy yield. It contains soluble as well as insoluble dietary fibres, B vitamins, proteins, iron and zinc and low fats. Oats prevents the buildup of blood sugar level and lowering the demand for insulin production.

## MATERIAL AND METHODS

Oat flour was obtained from regional market of Parbhani. The wheat flour was of off white color, also free of foreign materials. Oat has great fibre content which is most important feature. Refined wheat flour, shortenings, baking powder, spray dried milk powder, sugar and salt were obtained from regional grocery of Parbhani.

**Table 1. Formulation table for preparation of oat fortified cookies**

| Ingredients | $T_0$ | $T_1$ | $T_2$ | $T_3$ |
|---|---|---|---|---|
| Refined wheat flour (g) | 100 | 90 | 80 | 70 |
| Shortening (g) | 70 | 70 | 70 | 70 |
| Sugar (g) | 65 | 65 | 65 | 65 |
| Baking powder (g) | 1.5 | 1.5 | 1.5 | 1.5 |
| Honey (ml) | 2 | 2 | 2 | 2 |
| Skim milk powder (g) | 5 | 5 | 5 | 5 |
| Oat flour (g) | —— | 10 | 20 | 30 |

Receiving of raw material

↓

Sieve together flour, baking powder

↓

Combine hydrogenated vegetable oil and sugar to form cream mixture

↓

Beat the whole egg to form foam

↓

Mix the cream mixture with beaten egg
(Add essence)

↓

Add the dry mixture of flour to above mixture slowly by constant mixing

↓

Transfer the mixture in greased mold

↓

Bake for 30-35 min. at185 °C

↓

Cool it for 15-20 min and pack it

**Fig. 1. Flowchart for preparation of oat flour fortified cookies**

**Preparation of cookies**

Oat flour was used at 10, 20, and 30 per cent (Table 1). It was incorporated in the standardized formula of cookies with slight modification of standardize process (Ranhotra, 1980). Dough was rolled and allowed to bake for 30 min at 185 $^0$C (Fig. 1).

**Physical analysis of oats**

Cookies were analysed for width, thickness and spread factor by applying standard procedures (AACC, 2000). Diameter- Six cookies were kept horizontally and turned at 90° angle for taking reading. Diameter was calculated by using vernier caliper. Thickness - thickness of cookies was measured by a vernier caliper in triplicate. Means were calculated. Spread factor - this was estimated by applying standard procedures (AACC, 2000) by using the formula below mentioned

SF=(W/TxCF)x10

Where; CF= Correction factor (1.0 in this case)

The prepared samples were analysed for moisture content by using standard AOAC (1995) method whereas ash, protein and fat content were analyzed by using Ranganna (1986) method**.** After preparing cookies were evaluated for colour, flavour, aroma, taste, after taste and also overall acceptability using 9-point hedonic scale by the panel comprising 25 members including professors and postgraduate students in the Department of Food Technology.

**RESULTS AND DISCUSSION**

**Physical analysis of oat cookies**

The physical analysis of oat cookies was carried out for diameter, thickness and spread ratio for the samples $T_1$, $T_2$, $T_3$, and $T_0$ as per (AACC, 2000**).** The values of different physical parameters analyzed are presented in Table 2. As per the data mentioned in Table 2 the average diameter of samples $T_0$, $T_1$, $T_2$ and $T_3$ of oat cookies was 62.43±0.43mm, 61.26±0.30mm, 60.2±0.26mm and 59.5±0.23mm, respectively. Thus, with increasing the proportion of oat flour there was gradual decrease in the diameter of the cookies. Further, the average thickness of samples $T_0$, $T_1$, $T_2$ and $T_3$ were 6.23±0.2mm, 6.7±0.35mm, 7.2±0.24mm and 7.66±0.32mm, respectively; which elucidates that thickness of oat cookies increased with increasing proportion of oat flour. The thicknesses of oat flour fortified cookies were greater than that of the control cookies. The average spread ratio of samples $T_0$, $T_1$, $T_2$ and $T_3$ of oat cookies was found to be 10.33±0.38, 9.38±0.12, 8.57±0.42 and 8.15±0.15, respectively, which shows there is inverse relation between spread ratio and proportion of oat flour incorporated in cookies.The better binding capacity of oat protein led to the decrease in the spread ratio of cookies which finally led to increase in the thickness of the cookies. Similar finding was reported by other researchers also; a reduction in spread ratio was observed when soy flour and fenugreek flours were substituted in the place of refined wheat flour **(**Singh *et al.,* 1996; Hooda and Jood, 2005**).** Similarly, the reduction in spread ratio can be due to aggregate formation from the combination of two flours *i.e.* refined wheat flour and oat flour which causes an increase in hydrophilic sites in the dough (McWatters, 1978**).** The lowering of spread ratio with increase in oat flour states that

**Table 2. Effect of different treatments on physical analysis of oat fortified cookies**

| Treatments | Diameter (mm) | Thickness (mm) | Spread ratio |
|---|---|---|---|
| No Oat flour ($T_0$) | 62.43±0.4 | 6.23±0.2 | 10.33±0.38 |
| 10% oat flour ($T_1$) | 61.26±0.30 | 6.7±0.35 | 9.38±0.12 |
| 20% oat flour ($T_2$) | 60.2±0.26 | 7.2±0.24 | 8.57±0.42 |
| 30% oat flour ($T_3$) | 59.5±0.23 | 7.66±0.32 | 8.15±0.15 |

Values are given in Mean ± SD of triplicate determinations starch molecules are held tightly with granules and thus swelling gets inhibited when cookies with refined wheat flour is heated. There is a formation of rigid gel when starch is cooled down which has features of large molecular aggregates. These results were similar to the work of Mridula *et al.* (2007) where the spread ratio gets lowered by increasing sorghum flour in wheat/sorghum composite biscuit. From the statistical data it is clear that there was significant difference at $p \leq 0.01$ in physical analysis of oat cookies which was done for diameter, thickness and spread ratio.

### Chemical analysis of oat cookies

The chemical analysis of oat cookies was done for the following parameters *i.e.* moisture, ash, fat, protein and fibre content. As per the data in Table 3 the average protein content of the samples $T_0$, $T_1$, $T_2$ and $T_3$ was found to be 7.62±0.58%, 8.50±0.25%, 10.80±0.13% and 12.47±0.15%, respectively. The incorporation of oat flour in the cookies shows improvement in the nutritional content with a maximum value of 12.47±0.15 % in 30 % oat based cookies, whereas, control sample contains 7.62±0.58 % of protein. The protein content of the oat based cookies is similar to the findings of researchers incorporating legumes in the cassava based composite flour (Padmaja and Jisha, 2005). Thus, protein content of cookies provides the evidence for its use in nutritionally enriched biscuits. Further, as per the data in Table 3 the average ash content of samples $T_0$, $T_1$, $T_2$, $T_3$ was 0.70±0.35 %, 1.05±0.23%, 1.47±0.3% and 1.86±0.33%, respectively. It shows that the ash content of 30% oat cookies is maximum with a value of 1.86±0.33%. The ash content of cookies increased significantly from $T_0$ to $T_3$ because of higher ash content of oat flour and also due to externally added fats. As both

**Table 3. Effect of different treatments on chemical analysis of oat fortified cookies**

| Treatments | Protein content (%) | Ash content (%) | Moisture content (%) | Fibre content (%) | Fat content (%) |
|---|---|---|---|---|---|
| No Oat flour ($T_0$) | 7.62±0.58 | 0.70±0.35 | 1.7±0.3 | 0.10±0.21 | 28.0±0.15 |
| 10% oat flour ($T_1$) | 8.50±0.25 | 1.05±0.23 | 1.87±0.41 | 1.55±0.33 | 27.9±0.25 |
| 20% oat flour ($T_2$) | 10.80±0.13 | 1.47±0.3 | 1.98±0.22 | 3.23±0.53 | 27.4±0.67 |
| 30% oat flour ($T_3$) | 12.47±0.15 | 1.86±0.33 | 2.12±0.38 | 5.24±0.26 | 27.1±0.41 |

Values are given in Mean ± SD of triplicate determinations

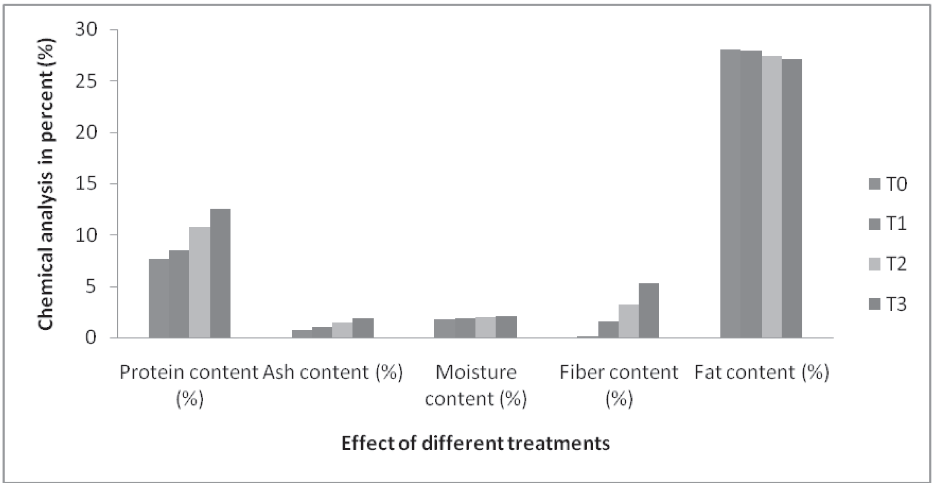


**Fig. 2. Effect of different treatments on chemical analysis of oat fortified cookies**

refined wheat flour and oat flour are having low fat content and hence total fats in samples were similar to control also there was slight reduction in fat content by increasing oat flour content. Similar findings were reported by Chauhan and Bains (1985**)** working on oat based cookies**.** Further, the average moisture content of samples $T_0$, $T_1$, $T_2$, and $T_3$ were 1.7±0.3%, 1.87±0.41%, 1.98±0.22% and 2.12±0.38%, respectively as presented in Table 3 which increases with increase in proportion of oat flour; this is because of high water binding capacity of oat flour. The results of moisture content were similar to the findings of researchers who incorporated potato flour in cookies (Mishra and Kalpana, 2003**).** Similarly, the data presented in Table 3 shows that the average fat content of different samples $T_0$, $T_1$, $T_2$, and $T_3$ of oat cookies were 28±0.15%, 27.9±0.25%, 27.4±0.67% and 27.1±0.41%, respectively. The fat content of cookies decreases because of lesser quantities of it in the oat flour so as the proportion of oat flour in the formulation increases, the amount of fat in the cookie decreases.

From the data given in Table 3 the average fibre content of the cookies $T_0$, $T_1$, $T_2$, and $T_3$ were 0.10±0.21%, 1.55±0.33%, 3.23±0.53% and 5.24±0.26%, respectively. The maximum fibre content was in 30% of oat flour incorporated cookies; so as the amount of oat flour in the formulations increases, the amount of fibre in the cookies also increases because of the presence of fibres in oat flour.

From the statistical data it is clear that there was significant difference at $p \leq 0.01$ in chemical analysis of oat cookies which was done for the following parameters *i.e.* moisture, ash, fat, protein and fibre content.

**Organoleptic study of oat fortified cookies**

The organoleptic study of the oats cookies was done on the following parameters- appearance, colour, taste, flavour, texture and overall acceptability which were analysed by a panel of judges using 9 point hedonic scale as per IS: 6273 (PART – II), 1971. As per the data in Table 4 the score for colour of samples $T_0$, $T_1$, $T_2$, and $T_3$ was 7.3±0.35, 7.8±0.87, 8±0.78 and 6.5±0.99, respectively. The highest colour score was for sample $T_2$ *i.e.* 8±0.78 followed by sample $T_1$ with score of 7.3±0.35. With increase in the proportion of oat flour the colour of cookies starts getting darker and maximum acceptability were for 20% incorporation of oat flour. Similar kinds of result were observed by other researchers too. Further, the values of appearance as presented in Table 4 for the samples $T_0$, $T_1$, $T_2$, and $T_3$ of oat cookies was 7.4±0.12, 7.5±0.76, 8±0.54 and 7±0.53, respectively. The highest value of appearance was for sample $T_2$ *i.e.* 8±0.54. The incorporation of oat flour to cookies resulted in a coarse and grainy appearance to the cookies which upto 20% was acceptable by the panelists but further increasing concentration to 30% resulted in excessive grainy appearance which was not acceptable by the panelists.Further, as per the data in Table 4 the scores of flavour for samples $T_0$, $T_1$, $T_2$ and $T_3$ was 7.63±1.07, 7.41±1.7, 7.85±0.95 and 6.40±0.68, respectively. The flavour score for sample $T_2$ was highest with a value of 7.85±0.95. Further, the values of taste for the samples $T_0$, $T_1$, $T_2$ and $T_3$ was 7.21±0.76, 7.34±0.98, 7.88±1.46 and

**Table 4. Effect of different treatments on sensory evaluation of oat cookies**

| Treatments | Colour | Appearance | Flavour | Texture | Taste | Over all acceptability |
|---|---|---|---|---|---|---|
| No Oat flour ($T_0$) | 7.3±0.35 | 7.4±0.12 | 7.63±1.07 | 7.07±0.76 | 7.21±0.76 | 7.32±1.09 |
| 10% oat flour ($T_1$) | 7.8±0.87 | 7.5±0.76 | 7.41±1.7 | 7.34±0.66 | 7.34±0.98 | 7.47±0.99 |
| 20% oat flour ($T_2$) | 8±0.78 | 8±0.54 | 7.85±0.95 | 7.88±0.44 | 7.88±1.46 | 7.92±0.9 |
| 30% oat flour ($T_3$) | 6.5±0.99 | 7±0.53 | 6.40±0.68 | 5.56±0.91 | 6.56±0.34 | 6.40±0.12 |

6.56±0.34, respectively; the highest value was found for sample $T_2$ with a score of 7.88±1.46. As per the data of Table 4 the values for texture for samples $T_0$, $T_1$, $T_2$, and $T_3$ was 7.07±0.76, 7.34±0.66, 7.88±0.44 and 5.56±0.91, respectively; the highest value was observed for sample $T_2$ with a score of 7.88±0.44 and was having proper crispiness of the cookies which was highly accepted by the panelists. Finally, the overall acceptability of the cookies was calculated by taking average of all the parameters *i.e*. colour, appearance, flavour, taste and texture of oats cookies. The highest score for overall acceptability was found in the sample $T_2$ (7.92±0.9) having 20% oat flour followed by $T_1$(7.47±0.99) and then control sample (7.32±1.09) while least was observed in sample $T_3$ with a value of 6.40±0.12. From the statistical data it is clear that, there was significant difference at $p \leq 0.01$ in all the sensory attributes *viz.,* colour, appearance, texture, aroma, taste and overall acceptability. Thus, on the basis of results obtained from sensory analysis it was concluded that 20% oat flour incorporation was better than other treatments and was highly accepted by the panel members.

## CONCLUSIONS

It can be concluded that oats can be used at the proportion of 20% and 30% without undesirable changes in organoleptic and physico-chemical characteristics of oat fortified cookies. Among all the treatments 20% oat flour incorporated cookies got maximum acceptability whereas the 30% oat flour incorporated cookies was best in terms of nutritional value. From this study it can be inferred that incorporation of oat flour in cookies helps enhance the nutritive value of bakery products. This product is economical and can be consumed by all social classes of people in the society. Also, there is a need for the food business operators to focus on this area so that the maximum population can have nutritive food products at lowest possible cost.

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# ASSESSMENT OF PHYSICAL PROPERTIES OF POPULAR AND PRE-RELEASED RICE VARIETIES OF NORTH COASTAL ZONE OF ANDHRA PRADESH

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**ABSTRACT**

The objective of the study(2014-15) was to determine the physical properties of rice varieties namely one popular variety Srikakulam sannalu (RGL-2537) and one pre-released variety (RGL-11226) rice variety. These rice varieties were procured from Agricultural Research Station(ARS), Amadalavalasa, Srikakulam district, Andhra Pradesh. Physical properties such as kernel length, breadth, L/B ratio, 1000 kernel weight, elongation ratio were assessed. Pre-released variety (RGL-11226) had kernel length of 6.06 mm, breadth of 1.63 mm and L/B ratio of 3.69 mm. Srikakulam sannalu (RGL-2537) had kernel length of 5.91 mm, breadth of 1.62 mm and L/B ratio of 3.64 mm. Physical properties of pre-released variety (RGL-11226) were good compared to Srikakulam sannalu (RGL-2537).

## INTRODUCTION

Rice (*Oryza sativa* L.) is one of the commonly consumed cereals and food staples for more than half of the world's population. Rice provides 20 percent of world's dietary energy supply. It is also a good source of thiamine, riboflavin, niacin and dietary fibre. Unmilled rice contains more nutrients than milled or polished white rice (Kanchana *et al*., 2012). It is the predominant dietary energy source for 17 countries in Asia and the Pacific, 9 countries in North and South Africa. In 59 countries, an average percapita availability of at least 75gms of rice is available (FAOSTAT, 2014). The total population of these countries is 4.1 billion which indicates that reaching the requirement of even half of that population would ensure a greater daily nutrient intake among 2 billion people (FFI, 2014).

Rice is the main constituent of life-saving oral rehydration solutions (ORS), and has been used for treatment of various ailments such as diarrhoea, vomiting, fever, haemorrhage, chest pain, wounds and burns. Recent studies recommend rice as a novel food due to its high mineral content, antioxidant properties and low glycemic index for lowering the incidence of lifestyle-related diseases such as heart attack, diabetes and cancer which have begun to assume epidemic form over the last two decades not only in urban India, but in rural India too (Rhoades, 2008).

Over 85 per cent of the calories contained in rice come from the energy providing carbohydrates whereas less than 1% come from fat (Attenburrow *et al*., 2003). Carbohydrates are the key energy supplying nutrient for the body. Without adequate carbohydrates, the body cannot supply the muscles, brain and virtually every living cell with the energy it needs. In addition, natural carbohydrate rich foods like rice are loaded with key nutrients that our bodies need, including folate and other B-vitamins, fibre, antioxidants and phytonutrients that have been shown to play a role in protecting the body from heart disease, certain cancers, osteoporosis and Alzheimer's disease (Freedman *et al*., 2001).The study was undertaken to assess the physical properties of selected popular and pre-released rice varieties.

## MATERIAL AND METHODS

The study was conducted in the Department of Foods and Nutrition, Post Graduate and Research Centre, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad (2014-15). The raw material required for study popular variety Srikakulam sannalu (RGL-2537) and Pre-released variety (RGL-11226) of rice varieties were

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procured from RARS (Regional Agricultural Research Station) of Amadalavasa of Srikakulam district, Andhra Pradesh.

Physical properties like grain hardness, volume expansion, 1000 kernel weight, elongation ratio, kernel length, breadth, L/B ratio and water uptake by the grains were assessed using standard procedures (Sahay and Singh, 2005). Cooking time, weight of cooked rice and loss of gruel were determined by standard procedure (AACC, 1995).Grain hardness of the samples was determined using grain hardness tester. Sample to be tested was placed on the sample table and the handle was turned to the left side. Gradually the handle was turned towards right side to compress the sample. Both needle pointers moved. When the sample was crushed the opening gap between the press and the sample table was measured before the pointer (black) returned back to zero. The mother pointer (red) remained in the same place. The mother pointer (red) showed press weights, which indicated the grain strength (rigidity). For each test the mother pointer (red) was set back to zero position. An average of ten readings was taken.

**Volume expansion**

Five grams of milled rice was taken in the big test tube in which 15 ml of water is added. Before adding the initial volume of water was noted. Volume after addition of rice (x-15) was read. The tubes were placed in boiling water bath and cooked for 20 minutes. Cooked rice was transferred into a measuring cylinder containing 50 ml of water. The final volume(y-50) was recorded. Volume expansion was calculated using the formula y-50/x-15. Average of 3 readings was taken.

**1000 kernel weight**

Materials required for measuring 1000 kernel weight are weighing balance and rice kernels. 1000 kernels were selected randomly. The samples were weighed. The procedures were repeated 3 times. An average of three readings was taken.

**Elongation ratio**

Materials required are rice varieties, micrometer, graph paper/scale. Length of the kernels were taken before and after cooking. Six readings were taken (for cooked kernel used milli meter scale).

$$\textbf{Elongation ratio} = \frac{\text{length of cooked kernel (mm)(y)}}{\text{Length of uncooked kernel (mm)(x)}}$$

**Kernel length, breadth, L/B ratio**

The length and width of rice kernels was measured using micrometer, by placing the kernels horizontally and vertically. An average of 10 readings was taken. The results were tabulated for further analysis. The rice samples were classified using the standard classification as shown in Table 1.

**Water uptake by the grains**

Two grams of sample was taken in a 50 ml graduated centrifuge tube and 100ml of water was added. Water was added to the sample and soaked for 30 minutes. The tubes were placed immediately for boiling in a beaker containing cold water and boiled for 45 minutes at 77-80ºc. The supernatant water was poured into a graduated cylinder after cooling and water level was noted. The water absorbed expressed as percent water uptake was calculated.

## RESULTS AND DISCUSSION

The physical parameters *viz.,* grain hardness, volume expansion, 1000 kernel weight, elongation ratio, kernel length, breadth, L/B ratio, water uptake by the grains, cooking time, weight of cooked rice were assessed and the results are presented in Table 2 and Table 3.

**Grain hardness**

Grain hardness of the samples was determined using grain hardness tester. Grain hardness values of popular variety Srikakulam sannalu (RGL - 2537) and Pre-released variety (RGL - 11226) ranged between 6.59±1.62 and 9.15±1.84, respectively.

**1000 Kernel weight**

1000 Kernel weights of Srikakulam sannalu (RGL - 2537) and Pre-released variety (RGL - 11226) ranged between 13.61 g and 16 g respectively. Diako *et al.* (2011) found that imported brands had low 1000 kernel weight. Values of 1000 kernel weight between 20 and 30g are considered good while those less than 20 g could be indicative of the presence of immature, damaged and unfilled grains.

**Kernel length, breadth, L/B ratio**

The length and breadth of the rice kernels were measured using digital vernier calliper (Yamayo, Digimatic caliper). Kernel length of Srikakulam sannalu (RGL – 2537) and Pre-released variety (RGL – 11226) were 5.91±0.63 mm and 6.06±0.43 mm, respectively. Meena *et al*. (2010) found that the grain length varied from 4.3 to 7.8 mm, breadth varied from 1.84 to 2.27 mm and Length/Breadth varied from 2.02 to 4.22 mm. Similar results were found by Sareepaung *et al*. (2008). The length and width of parboiled rice were ranged from 7.0 to 9.0 mm and 2.02 to 2.06 mm, respectively .Kernel breadth of Srikakulam sannalu (RGL – 2537) and Pre-released variety (RGL – 11226) were 1.62±0.06 mm and 1.63±0.10 mm, respectively. Length/ Breadth ratio of samples were 3.64±1.3 mm for Srikakulam sannalu (RGL – 2537) and 3.69±0.13 mm for Pre-released variety (RGL – 11226). It is clear that the kernel length, kernel breadth and L/B ratios of the varieties studied were in comparable range of above studies.

**Volume expansion**

Volume expansion values of Srikakulam sannalu (RGL - 2537) and Pre-released (RGL- 11226) varieties varied from 2.5 cm and 2.7 cm, respectively. Alaka *et al*. (2015) found that the volume expansion ratio of the rice samples ranged from 1.67 – 3.67 cm. It was found that the volume expansion of the varieties studied was within the range. of above study.

**Elongation ratio**

Linear elongation of rice on cooking is one of the major characteristics of good rice. Some varieties expand more in length than others upon cooking. Length-wise expansion without increase in girth is considered a desirable trait of high quality rice (Oko *et al*., 2012). Some varieties elongate more than others upon hydration and starch gelatinization without increase in girth, this is considered a desirable cooking quality trait in most high quality rice of the world (Singh *et al*., 2012). An elongation ratio less than 1.3 is not desirable (Dipti*et al*., 2002).The elongation ratios of Srikakulam sannalu (RGL - 2537) and Pre-released (RGL - 11226) rice varieties are 1.4 and 1.6, respectively, since the elongation ratio fall under the acceptable values, therefore, the samples have desirable elongation ratio. Highly polished rice tends to have higher elongation ratio due to less restriction by streaks of bran on the expansion of starch granules (Mohapatra and Bal, 2006).

**Water uptake by the grains**

The amount of water uptake during cooking process is associated with the appearance of cooked rice (Tan *et al*., 2000). The water uptake ratio of Srikakulam sannalu (RGL - 2537) and Pre-released (RGL - 11226) rice varieties ranged from 210 and 200. Shilpa (2010) reported that water uptake ratio in Basmati variety ranged from 280-335 and in aromatic traditional rice varieties 250-350.

**Table 1. Standard classification of rice (India)**

| Kernel size | Length (mm) | Ratio of length to breadth |
|---|---|---|
| Long slender | 6 and more | 3 and > 3 (super fine) |
| Round bold | <6 | <3 |
| Medium slender | <6 or 4.5 | 2.5 to 3 (fine) |
| Short slender | <6 | 3 and >3 |
| Short bold | <6 | < 3 (common) |

**Table 2. Mean score of physical properties of popular and pre-released rice varieties of North Coastal Zone**

| Variety name | Accession No. | Grain hardness | 1000 Kernel weight (g) | Kernel length (mm) | Kernel breadth (mm) | L/B ratio (mm) | Volume expansion (VE) (cm) | Elongation ratio (ER) | Water uptake by the grains(ml) |
|---|---|---|---|---|---|---|---|---|---|
| Srikak-ulam Sannalu | RGL-2537 | 6.59±1.62 | 13.61±0.1 | 5.91±0.63 | 1.62±0.06 | 3.64±1.3 | 2.5 | 1.4 | 210 |
| Pre-Released | RGL-11226 | 9.15±1.84 | 16±0.11 | 6.06±0.43 | 1.63±0.11 | 3.69±0.13 | 2.7 | 1.6 | 200 |

**Note**: Values are expressed as mean±standard deviation

### Cooking time and weight of cooked rice

Cooking time and weight of cooked rice were determined. 64 g of raw rice was weighed and cooked using 1:2 ratio of water. Same quantity was taken for both the rice varieties Srikakulam sannalu (RGL-2537) and Pre-released variety (RGL-11226). The popular variety RGL - 2537 took 17 minutes and pre-released variety RGL – 11226 took 19 minutes to cook. According to Dipti *et al*. (2002) cooking time varies from 14.5 to 20 minutes depending on the type of rice (starch gelatinization). The weight of cooked rice of both rice varieties were 194g for (RGL – 2537) variety and 197g for (RGL – 11226) variety(Table 3).

**Table 3. Standardized cooking time, cooked weight of rice varieties**

| Variety name | Accession No. | Weight of raw rice (g) | Cooked weight (g) | Cooking Time (minutes) |
|---|---|---|---|---|
| Srikakulam sannalu | RGL-2537 | 64 | 194 | 17 |
| Pre-released | RGL-11226 | 64 | 197 | 19 |

For each sample, six grains were immersed in a 1.7% KOH solution overnight at room temperature. Each grain was visually examined the next morning for its level of dispersion (chalkiness). The greater the amount of chalkiness in the grain, the more it is prone to grain breakage during milling, resulting in lower head rice yield (Khush *et al*., 1979). The rice variety Srikakulam sannalu (RGL – 2537) showed more chalkiness in the grain compared to pre-released rice variety (RGL – 11226), so Srikakulam sannalu (RGL – 2537) gave lesser head rice yield compared to pre-released (RGL – 11226) rice variety.

## CONCLUSION

The physical properties of selected rice varieties were assessed. Srikakulam sannalu (RGL-2537) had kernel length of 5.91mm, kernel breadth of 1.62mm and L/B ratio of 3.64mm. Pre-released variety (RGL-11226) had kernel length of 6.06mm, kernel breadth of 1.63mm and L/B ratio of 3.69mm. Thus, physical properties of Pre-released (RGL-11226) rice variety were good compared with Srikakulam sannalu (RGL-2537) rice variety.

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# KNOWLEDGE OF RURAL WOMEN IN BIHAR ABOUT HOMESTEAD TECHNOLOGIES OF RAJENDRA AGRICULTURAL UNIVERSITY (RAU)

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**ABSTRACT**

The present study was conducted in three districts of Bihar *viz.,* Samastipur, Muzaffarpur and Vaishali with 225 rural women from nine villages. A knowledge test was developed and standardized to assess the knowledge level of the respondents about homestead technologies of RAU (Presently Dr. Rajendra Prasad Central Agricultural University). Data was collected during April, 2013 to October, 2013 through the developed knowledge schedule to assess the overall knowledge level of the respondents with regard to the selected homestead technologies and also with respect to the individual homestead technology. Majority (65.78%) of the respondents possessed medium level of knowledge on homestead technologies of RAU. Majority of the respondents had low knowledge level with respect to fruit and vegetable preservation, value addition to garments, art and craft making and value added mushroom products, where as for rest of the technologies majority of them had medium knowledge level. None of them were found to possess high level of knowledge in any of these technologies.

## INTRODUCTION

Knowledge is the pre-requisite for acceptability and adoption of any technology. It is influenced by a number of socio-personal and economic, psychological and situational variables that impinge upon rural women. In the present study knowledge was operationalized as the awareness or familiarity gained by rural women on specific information about homestead technologies of RAU. The empirical studies showed that although women farmers play a vital role in agricultural development in a country, they are comparatively less informative than male farmers due to certain socio-economic and cultural constraints. Educating rural women and creating awareness about modern homestead technologies can go a long way in enhancing their knowledge and skill and ultimately, the productivity of the system and farm incomes. Rani and Reddy (2002) in their study on knowledge and adoption level of communicators of farm technology *(i.e.* rice production) and home technology (*i.e.* nutrition) in Warangal district indicated that though there were significant differences in knowledge and adoption levels, the women respondents of both villages were acquainted with rice production and nutrition technology through their own pattern of inter personal communication.

Homestead technologies have been generated through researches to improve the quality of life of urban and rural families. In the present era of scientific explosion, homestead knowledge is a must to bridge the gap between what is generated by the Home Science researchers and what is known and practiced by the rural women. There are a number of Home Science researchers engaged in generating new and appropriate homestead technologies and there are several agencies, institutions and programmes entrusted with the responsibility of delivering their useful knowledge and technology to the rural women. However, still the women folk remain less informed than their male counterparts. Thus, the present study was undertaken to assess the knowledge level of rural women about homestead technologies of RAU with the following specific objectives- to develop knowledge test on homestead technologies of RAU and to find out the knowledge level of rural women of Bihar about homestead technologies of RAU.

## MATERIAL AND METHODS

The study was conducted in Samastipur district of Bihar covering three blocks selected randomly, with a sample of 225 rural women from nine villages who were exposed to all the nine homestead technologies of RAU selected under

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study. A knowledge test was developed using standardised method. The developed schedule was administered to the final respondents and their response was recorded. A score of 'one' was given for each correct response and a score of 'zero' for each incorrect response for 37 objective questions. For remaining 10 open ended questions, a score of 1 was given for each correct response and as such the total score for that particular question was the sum of the total number of response or entries made by the respondent. Based on the total score of the respondents, Mean and S.D were calculated and respondents were grouped into the following three knowledge categories

| S. No. | Category | Score |
|---|---|---|
| 1 | Low | Mean- S.D |
| 2 | Medium | Mean ±S.D |
| 3 | High | Mean +S.D |

In addition to these, results were also presented on knowledge level of the respondents on the nine selected homestead technologies individually.

## RESULTS AND DISCUSSION

**1.0 The knowledge test of the respondents was measured using the test developed for the study as detailed below**

The purpose of construction of knowledge test was to identify the level of knowledge of rural women about homestead technologies of RAU. The items of knowledge test were administered in the non-sampled area *i.e.* Birauli Khurd village of Pusa block, Samastipur district to 60 respondents who were aware of all selected Homestead technologies.

**A. Collection of Items**

An item pool of knowledge test was prepared by thoroughly referring various published literature of the University and text books written by the Scientists on the subject matter. Additional information was also obtained through discussion and interaction with the experts of the concerned Homestead technologies. Finally a pool of items for all the ten selected Homestead technologies was prepared.

**B. Framing of test items**

The knowledge test comprised of objective/ closed ended questions in the form of true-false, multiple choice, fill up the blanks and open ended questions. The ten selected homestead technologies were- fruit and vegetable preservation, value added quality protein maize products, stitching and embroidery, value addition to garments, arts and craft making, value added products from cereals and pulses, mushroom production, value added mushroom products, vermicompost technology and apiculture. The knowledge test comprised of 72 closed and open ended questions from all the ten selected Homestead technologies.

C. **Selection of items for item analysis**

The criteria used for selection of items were- response to items should promote thinking rather than memorisation. They should differentiate the well informed respondents from the poorly informed respondents and should have some difficulty level. The items included should cover all areas of knowledge about Homestead technologies of RAU.

D. **Pre-testing**

Keeping in mind the criterion provided for selection of items, one of the homestead technology *i.e.* value added products from quality protein maize was completely eliminated from the knowledge test as none of the rural women was aware about this technology. Two components of value added mushroom products *i.e.* mushroom sauce and mushroom *murrabba* were also eliminated from the knowledge test for the same reason. Thus, the 68 test items included for knowledge test were pre-tested by administering it to 60 respondents who were outside the main sample selected for this study.

E. **Item Analysis**

Item analysis was carried out to yield two types of information *viz.*, indices of 'item difficulty' and 'item discrimination'. The index of item difficulty indicates the extent to which an item was difficult. The latter provides information on how well an item measures or discriminates a well-informed respondent from a poorly informed respondent. Pre-testing of the items was done by administering the questions to 60 respondents who were outside the main sample. All the 68 items were administered to each of the respondent. The scoring pattern was '1' for each correct answer and '0' for each incorrect answer. After computing the total scores of all the 60 respondents on 68 items, they were arranged in descending order. Afterwards, the respondents were divided into six equal groups of 10 members each and were labelled as G1, G2, G3, G4, G5 and G6. For the purpose of item analysis, the middle two groups G3 and G4 were eliminated, keeping only four extreme groups with high and low scores.

F. **Item Difficulty Index (P)**

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

$$\text{D.I.} = \frac{\text{No.of respondents answering correctly}}{\text{Total no.of respondents}} \times 100$$

G. **Discrimination Index (E 1/3)**

An item discrimination index (E 1/3), which indicates the level of discrimination between well informed and poorly informed respondents, was computed using the given formula -

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

Where,

S1, S2, S5 and S6= Frequencies of correct answers in the groups G1, G2, G5 and G6.

N= Total no. of respondents of the sample selected for the item analysis *i.e.* 60.

Values of discrimination index ranges from 0 to 1. The items with discrimination index ranging from 0.20 to 0.80 were selected for the final test. These are the items that can discriminate between the well informed and the poorly informed respondents.

H. **Point Biserial Correlation ($r_p$ bis)**

The main aim of calculating point biserial correlation was to work out the internal consistency of the items *i.e.*, the relationship of the total score to a dichotomized answer to any given item. In a way, the validity power of the item was computed by the correlation of the individual item of preliminary knowledge test calculated by using the formula suggested by Garret (1966).

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

Where,

**$r_p$ bis** = Point biserial correlation

$M_p$ = Mean of the total scores of the respondents who answered the item correctly or

$$M_p = \frac{\text{Sum of total of xy}}{\text{Total no.of correct answers}}$$

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

$$\text{or } M_q = \frac{\text{Sum total of x} - \text{Sum total of y}}{\text{Total no.of incorrect answers}}$$

$\sigma$ = Standard deviation of the entire sample (60 respondents) p= Proportion of the respondents giving correct answer to an item or

$$p = \frac{\text{Total no.of correct answers}}{\text{Total no.of respondents}}$$

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

q= 1-p

x= Total score of the respondent for all items

y= Response of the individual for specific items (correct-2, incorrect-1)

Items having significant point biserial correlation either at 1 percent or 5 per cent level were selected for the final test of the knowledge.

I. **Final selection of items**

Out of 68 items, 47 items were finally selected based on the following criteria: Items with difficulty level indices ranging from 20 to 80; Items with discrimination indices ranging from 0.20 to 0.80; Items having significant point biserial correlation either at 1% or at 5% level. The final selected knowledge test items consisted of 47 objective/closed ended and open ended questions.

J. **Reliability of the test**

Test and Re-test method

The test was administered twice to 60 respondents who were aware of all the nine homestead technologies separately at an interval of two weeks. The two sets of knowledge scores were obtained and put to correlation analysis. The correlation co-efficient (r=0.908) was highly significant indicating a high degree of dependability of the instrument for measuring knowledge of rural women about homestead technologies of RAU.

K. **Validity of the test**

Content Validity

The test included an exhaustive list of test items representing all the major areas on homestead technologies of RAU, collected from literatures and in consultation with the Scientists of RAU. The items were collected from various sources as mentioned earlier and in consultation with the Scientists of RAU. Hence, it was assumed that the scores obtained by the respondents by administering the knowledge test under study, measures what it is supposed to measure. Thus, the knowledge test developed in the present study measures knowledge about homestead technologies of RAU. It showed a greater degree of reliability and validity. The developed test was administered to the final respondents under study to assess their knowledge level.

**2.0 Overall knowledge level of the respondents on homestead technologies**

The knowledge level of the respondents on homestead technologies of RAU was studied to ascertain the degree of awareness and understanding of the selected technologies by the rural women. The extent of adoption of various homestead technologies largely depends on the knowledge level possessed by the respondents.

The data in Table 1 represented knowledge level of the respondents on homestead technologies of RAU from which it was clear that majority (65.78%) of the respondents possessed medium level of knowledge on homestead technologies of RAU. It was followed by 17.33% and 16.89% of the respondents under high and low knowledge level categories.

**Table 1. Distribution of respondents based on their overall knowledge level (N=225)**

| S. No. | Category | Frequency (f) | Percentage (%) |
|---|---|---|---|
| 1 | Low | 38 | 16.89 |
| 2 | Medium | 148 | 65.78 |
| 3 | High | 39 | 17.33 |
| **Total** | **225** | **100.00** | |

Mean= 119.35; Standard Deviation=10.89

### 2.1 Technology – wise knowledge level of the respondents

Distribution of respondents on the basis of their knowledge about the nine selected homestead technologies is presented in Table 2. The data in this table provides in-depth information on the knowledge level of the respondents with respect to each of the homestead technologies.

Fruit and vegetable preservation- It is evident from the data that majority (75.11%) of the respondents had low level of knowledge which was followed by medium (17.33%) and high (7.56%) level of knowledge on fruit & vegetable preservation. Stitching and Embroidery- The distribution of respondents revealed that majority (45.34%) of the respondents possessed medium level of knowledge, followed by low (37.33%) and high (17.33%) level of knowledge. Value addition to garments- The data revealed that majority (70.22%) of the respondents had low level of knowledge on value addition to garments. 15.56 per cent of the respondents had high level and 14.22 per cent had medium level of knowledge about this technology. Art and craft making- The findings of Table 2 inferred that majority (72.44%) of the respondents had low level of knowledge on art & craft making. It was followed by medium (24.0%) and high (3.56%) level of knowledge.

**Table 2. Distribution of respondents (technology–wise) based on their knowledge level (N=225)**

| S.No. | Homestead technology | Category | | |
|---|---|---|---|---|
| | | Low | Medium | High |
| 1 | Fruit and vegetable preservation | 169(75.11) | 39(17.33) | 17(7.56) |
| 2 | Stitching & embroidery | 84(37.33) | 102(45.34) | 39(17.33) |
| 3 | Value addition to garments | 158(70.22) | 32(14.22) | 35(15.56) |
| 4 | Art & craft making | 163(72.44) | 54(24.00) | 8(3.56) |
| 5 | Value added products from cereals & pulses | 54(24.00) | 114(50.67) | 57(25.33) |
| 6 | Mushroom production | 98(43.56) | 124(55.11) | 03(1.33) |
| 7 | Value added mushroom products | 106(47.11) | 62(27.56) | 57(25.33) |
| 8 | Vermicompost technology | 77(34.22) | 133(59.11) | 15(6.67) |
| 9 | Apiculture | 97(43.11) | 99(44.00) | 29(12.89) |

*** The figures in parenthesis indicate percentages**

Value added products from cereals and pulses- It was observed from the Table 2 that majority (50.67%) of the respondents possessed medium level of knowledge about this technology, followed by 25.33 per cent of the respondents with high level of knowledge, while 24.0 per cent of the respondents with low level of knowledge about this technology. Mushroom production**-** Majority (55.11%) of the respondents had medium level of knowledge on mushroom production whereas 43.56 per cent and 1.33 per cent of them had low and high level of knowledge, respectively.

Value added mushroom products **–**The percentage of respondents with low, medium and high knowledge level was 47.11, 27.56 and 25.33, respectively. Vermicompost technology**-** The data of the above table highlighted that majority (59.11%) of the respondents had medium level of knowledge about vermicompost technology. It was followed by respondents in low (34.22%) and high (6.67%) category of knowledge. Apiculture**-** It is noted that majority (44.0%) of the respondents had medium level of knowledge about apiculture, followed by 43.11% of the respondents having low level of knowledge and

12.89% of them having high level of knowledge about apiculture. It is clearly evident from Table 2 that with respect to four technologies *i.e.* fruit & vegetable preservation, value addition to garments, art & craft making and value added mushroom products, majority of the respondents had low knowledge level where as for rest of the technologies majority of them had medium knowledge. None of them were found to possess high knowledge in any of these technologies. The result shows that majority (65.78%) of the respondents had medium level of knowledge about homestead technologies of RAU. Though all the respondents were aware of all the selected homestead technologies, majority of them had medium knowledge. Technology-wise knowledge analysis revealed that knowledge level of majority of the respondents in case of stitching and embroidery, mushroom production vermicompost technology and apiculture were medium to low. Whereas, knowledge level were low to medium among majority of the respondents on technologies such as fruit and vegetable preservation, art and craft making and value added products from mushroom. Hence, KVK scientists, officials of ATMA (Department of Agriculture) and NGOs should focus on these areas by intensive trainings, exposure visits and demonstrations. Narayanaswamy *et al.* (2005) in their study revealed that majority (54.0%) of the farmers had medium level of knowledge about organic sericulture practices. Jayalakshmi and Santha (2008) revealed that overall knowledge level of farm women on sustainable plant protection technologies was found to be low in paddy.

## CONCLUSION

It is concluded from the findings of this study that the knowledge level of the respondents ranged from low to medium level for all the nine selected homestead technologies. Hence, there is a strong need for the research scientists and the extension personnel to create wide awareness of these technologies and to see that the developed technologies get disseminated throughout the length and width of the State. These technologies need to be popularized through formal and informal channels.

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# TECHNICAL EFFICIENCY OF ORGANIC AND CONVENTIONAL FARMING IN RICE IN VISAKHAPATNAM DISTRICT– A STOCHASTIC FRONTIER PRODUCTION APPROACH

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**ABSTRACT**

Organic farming combines tradition, innovation and science to benefit the shared environment and promote fair relationships with a good quality of life (IFOAM, 2016). It enhances profit and efficiency by improving management and by conserving soil, water, energy and biological resources. However, there are certain difficulties in practicing organic farming in larger areas. The Stochastic Frontier Production Function (SFPF) was employed to study the technical efficiency of organic and conventional farming in rice. Further, Multiple regression model was employed to analyze the factors determining technical efficiency of farmers in both the types of farming. The mean technical efficiency of organic farming was 86 per cent, Whereas, in conventional farming, it was 79 per cent. The technical efficiency was found to be relatively higher in organic farming as compared to conventional farming. In organic farming education, experience, extension services and training programmes attended by farmers were positively significant indicating their positive contribution to the technical efficiency. Whereas, age and distance to market were negatively significant for organic farming. In conventional farming market price and education were positively significant. The expenditure on seeds was negative, however non- significant in both organic and conventional farming.

## INTRODUCTION

The demand for organic food is steadily increasing both in developed and developing countries, with annual growth rate of 20-25 per cent. The total volume of export from India during 2016 was 263687 million tones valuing about Rs 298 million USD (APEDA, 2016). Organic agriculture does not need costly investments in irrigation, energy and external inputs, but rather organic agricultural policies have the potential to improve local food security, especially in marginal areas. Hence, the present research work was taken up with the objective of comparing and analyzing the technical efficiency, besides estimating the factors effecting technical efficiency of organic farming and conventional farming in rice.

## MATERIAL AND METHODS

Visakhapatnam district was selected purposively for studying the technical efficiency of organic farming and conventional farming in rice. The district was having the highest acreage under rice cultivation in North Coastal Zone of Andhra Pradesh. Within the district three mandals *viz.,* Paderu, Hukumpeta and Chinthapalli were selected as most of the farmers of these mandals were practicing organic rice farming. Three villages from each mandal based on the highest number of organic farmers were selected. Five organic and five conventional farmers were selected randomly from each village making the sample size to 90 constituting 45 organic farmers and 45 conventional farmers. The Stochastic Frontier Production Function (SFPF) technique was employed to study the technical efficiency of organic farming and conventional farming in rice. The variables selected include land, human labour, bullock and machine power, value of seed, manures, fertilizers (bio/ synthetic) and pesticides (bio/ synthetic) as the case may be. Multiple regression model was employed to analyse the factors determining technical efficiency of farmers.

## RESULTS AND DISCUSSION

The results of the estimated Stochastic Frontier Production Function for the selected sample of farmers practicing organic and conventional farming are presented in Table1. The results revealed that the per hectare value of output in organic farms was positively related to bio fertilizers, bio pesticides, seed, bullock and machine labour incurred in production. The relation of human labour input was positive and significant at 1 per cent level. Cost on organic manures was significant at 5 per cent level.

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**Table 1. Estimated Frontier production function for rice in organic and conventional farming**

| Coefficients | Organic Farmers | Conventional Farmers |
|---|---|---|
| Constant | 4.88<br>(4.92) | 1.63<br>(1.01) |
| Land | 0.45<br>(0.28) | 0.12<br>(0.61) |
| Human Labour | 1.62*<br>(2.84) | 0.14**<br>(2.69) |
| Bullock and Machine power | 0.01<br>(0.106) | 0.13<br>(1.22) |
| Seed | 0.26**<br>(2.05) | 0.47**<br>(2.52) |
| Manures | 0.27**<br>(2.21) | 0.008<br>(0.32) |
| Fertilisers (Organic /Synthetic) | 0.89<br>(0.15) | 0.11**<br>(2.25) |
| Pesticides (Organic /Synthetic) | 0.87**<br>(0.15) | 0.58<br>(1.43) |
| $\delta 2$ | 0.048*<br>(3.73) | 0.019*<br>(4.49) |
| $\gamma$ | 0.72*<br>(2.76) | 0.99*<br>(2.96) |
| Log likelihood | -45.9 | 36.89 |
| Mean TE | 0.86 | 0.79 |
| N | 45 | 45 |

**Note:** Figures in parentheses are the values of t-statistic ; * and ** denote that the coefficients are significant at 1 per cent and 5 per cent, respectively

The significant value of $\gamma$ indicates that the difference between observed output and actual output was not only due to factors that are beyond the farmer's control, but also due to some technical inefficiency. The value of $\gamma$ (0.72) signifies that 72 per cent of the difference in observed and the frontier output was primarily due to factors which are under the control of the farmers. The mean technical efficiency of organic farms was estimated as 86 per cent. This implied that the technical inefficiency was 14 per cent. Hence, reorganization of existing inputs in an efficient manner in organic farming could increase the output further by 14 per cent.

In case of conventional farming, coefficients of all the inputs had registered positive signs. Most of these coefficients are statistically significant at one and five per cent level of significance. The value of $\gamma$ (0.99) signifies that 99 per cent of the difference in observed and the frontier output is primarily due to factors, which are under the control of the farmers. The mean technical efficiency of conventional farms was estimated as 79 per cent. This implies, using the existing inputs in an efficient manner, the conventional farms can increase the output by 21 per cent and reach the frontier production level.

From the results of the Table 1 it is seen that in organic farming expenditure on seed, manures and bio pesticide were significant at 5 per cent level, whereas, expenditure on human labour was significant at 1 per cent. It may be due to the reason that organic farming was considered labour intensive involving operations like weeding and manurial application. In case of conventional farming expenditures on human labour, seed and synthetic fertilizer were significant at 5 per cent.

A comparision of organic and conventional farming revealed that the technical efficiency was found to be relatively higher in organic farming (86%) as compared to conventional farming (79%). These results were corroborated with Lakner *et al.* (2015) and Madau (2005), who stated that technical efficiency is higher in organic farms compared to conventional farms in rice.

**Factors affecting technical efficiency**

The influence of identified factors on technical efficiency of organic farming and conventional farming was studied using multiple regression model and the results are presented in the following equations. The Multiple Linear regression equations are given here under for organic farming and conventional farming:

**a. Organic farming**

TEi = 0.53* (3.21) - 0.0016(-0.78) X1+ 0.003 X2 (1.44) + 0.045 X3 (1.61)+ 0.0006 X4 (0.14) –0.07 X5 (-1.27) + 0.0012 X6 (1.75) + 0.26** X7 (2.821)+ 0.07 X8 (0.630) - 0.0076*X9 (-2.580)+ 0.0127* X10 (5.27) - 0.0012* X11 (-8.270) + 0.0255* X12 (3.71)+ 0.014* X13 (5.021) + 0.047* X14 (4.80)+ et

Coefficient of multiple determination ($R^2$) = 0.854

N = 45

**b. Conventional farming:**

TEi = 0.35**(2.48) - 0.0154 X1 (-1.33) -0.0012 X2 (-1.186)+ 0.013 X3 (0.82)- 0.001 X4 (-0.820) - 0.0036 X5 (-0.960)+ 0.0036 X6 (-0.960)+ 0.04** X7 (2.53)+ 0.018 X8 (0.454)+0.0011 X9 (0.960)+ 0.0037** X10 (2.15) + 0.0006 X11 (0.201)- 0.0037 X12 (-0.395)+ 0.008 X13 (1.948)+ 0.0006 X14 (0.108)+et

Coefficient of multiple determination ($R^2$) = 0.770

N = 45

Where TEi = Technical Efficiency of $i^{th}$ farmer (organic farmer)

$X_1$ = Expenditure on seeds (Rs $ha^{-1}$)

$X_2$ = Expenditure on organic/ synthetic fertilizers (Rs $ha^{-1}$)

$X_3$ = Expenditure on manures (Rs $ha^{-1}$)

$X_4$ = Expenditure on organic/ synthetic pesticides (Rs $ha^{-1}$)

$X_5$ = Expenditure on human labour (Rs $ha^{-1}$)

$X_6$ = Expenditure on bullock and machine power (Rs $ha^{-1}$)

$X_7$ = Market price (Rs $ha^{-1}$)

$X_8$ = Yield (q $ha^{-1}$)

$X_9$ = Age of the farmer (years)

$X_{10}$ = Education (years)

$X_{11}$ = Distance to the market (km)

$X_{12}$ = Experience of the farmer in farming (years)

$X_{13}$ = Extension services (frequency)

$X_{14}$ = Training programmes attended (in no.)

e = error term

Note:

1. Figures in parentheses are the values of t-statistic.
2. * and ** denote that the coefficients are significant at 1 per cent and 5 per cent level of significance, respectively.

The results of the estimated regression functions revealed that the explanatory power of the model $R^2$ was 85.4 per cent in organic rice. This implied that all explanatory variables together were explaining 85.4 per cent of variation in technical efficiency in organic rice. In case of conventional farms, the explanatory power of the model $R^2$ was 77 per cent. This implied that all explanatory variables together are explaining 77 per cent of variation in technical efficiency in conventional rice.

In organic farming, one unit increase in the extension services resulted in 0.014 units increase in the technical efficiency and if an increase in training programmes regarding organic farming were increased by one unit there was 0.047 units of the increase in technical efficiency. Similarly, if there was decrease in the distance to market the technical efficiency would increase which was indicated by the negative sign of the coefficient variable. Expenditure on seeds and human labour were negative but non–significant. Expenditure on bio-fertilizers, manures, bio-pesticides, machine labour and yield were positive but non- significant. Market price was significant at 5 per cent level of significance indicating as the market price could be increased by one unit, the technical efficiency was increased by 0.26 units. Age was negatively significant at one per cent level of significance indicating as the age of the farmer was increased, technical efficiency would decrease by 0.0076 units. Education was positively significant at one per cent level of significance indicating as the education of the farmer was increased, technical efficiency was increased by 0.0127 units. Distance to market was negatively significant at one per cent level of significance indicating as distance to market was increased by one unit, technical efficiency would be reduced by 0.0012 units. Experience of the farmer in organic farming was positively significant at one per cent level indicating as the experience was increased by one unit technical efficiency would be increased to 0.0255 units.

In conventional farming expenditure on seeds, fertilizers, pesticides, human labour and experience were negative and non- significant. Hence, with the decrease in expenditure on these variables the technical efficiency (Y) which was the dependent variable would be increased. Market price and education were significant at 5 per cent level of significance. Similar results were observed in the study by Long (2015) and Ramesh and Santha (2008) who stated that expenditure on seed, organic manure and biofertilizers in organic rice cultivation and expenditure on herbicide and machine labour in conventional rice cultivation were significantly influencing the technical efficiency.

The results revealed that the expenditure on seed was negative and non-significant, in both organic and conventional farming. Market price was significant at 5% level in organic and conventional farming, indicating that there is a positive effect of market price on technical efficiency. In case of organic farming, as more youth were participating in organic farming in the study area, age was negatively significant at 1 per cent level indicating that as the age increased technical efficiency was decreased. Education was positively significant at 1% level in organic farming and at 5% level in conventional farming indicating that as education increases, technical efficiency also increases. In case of organic farming distance to market was negatively significant at 1% level indicating that as the distance to market increases the technical efficiency was decreased, whereas, experience was positively significant indicating, as the experience increased the technical efficiency of the farmer would be increased. In organic farming extension services and training programmes attended by the farmers were positively significant at 1% level, indicating that the technical efficiency of the farmer was increased with the extension services offered to them and training programmes attended by the farmers.

## CONCLUSIONS

A comparision of organic and conventional farming revealed that the technical efficiency was found to be relatively higher in organic farming (86 %) as compared to conventional farming (79%). The explanatory power of the model $R^2$ varies with 85.4 per cent in organic farming, while it was 77 per cent in case of conventional farming. In organic farming the significant factors influencing technical efficiency were market price, age, education, distance to market, experience, extension services and training programmes attended by the farmers. In conventional farming the significant factors influencing technical efficiency were market price and education.

As the technical efficiency was high in organic farming, the government may take measures for the smooth supply of the required inputs *viz.,* bio fertilizers and bio pesticides at village level, through fair price shops or through cooperatives. As the extension services and training programmes are positively influencing the technical efficiency in organic farming, more emphasis has to be given by the extension workers to bring awareness at grass root level to enhance the organic rice farming and thus increase the technical efficiency in farming. As weed infestation was high in organic farming which increased the human labour cost, research should be done to reduce the weed infestation by natural means.

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# EFFECT OF $KNO_3$ ON GERMINATION AND VIGOUR OF MANGO ROOTSTOCKS

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**ABSTRACT**

Mango (*Mangifera indica* L.) is mainly propagated through asexual method. Most of the mango cultivars grown in India are mono embryonic. For producing true to type seedlings veneer grafting is most common and successful method. Use of poly embryonic root stock for propagation is an alternative source and can produce more number of true to type plants from single seed. The polyembryonic seedlings are sturdy and the trees usually bear sufficient quantities of seed. Monoembryonic types generally produce vigorous seedlings, but weak plants. Mango seeds retain viability for only a short time and seeds more than a couple of weeks old frequently will not germinate. Consequently, seed should be removed from mature fruit and planted within a short time (Sauls and Campbell, 1994).Keeping this as objective, an attempt was made to improve the germination and vigour of seeds.

A study on the effect of $KNO_3$ on germination and vigour of mango rootstocks was done at Mango experimental plot, Division of Fruit crops, Indian Institute of Horticulture Research, Bangalore during the year 2013. For the study, mango stones of fourteen root stocks and two commercial cultivars were collected from matured fruits in the month of June. Edible mesocarp and peel were separated from the stones and dried in the shade. Stones were treated with $KNO_3$@ 2% ($T_1$) and water soaked ($T_2$-Control) for 24 hours and were sown in polybags containing 2:1:1 ratio of soil, sand and FYM in three replications arranged in factorial randomised block design. The stones were irrigated regularly along with other operations *viz.,* weeding and plant protection measures. Observations on germination, extent of polyembrony, plant height, no. of leaves and stem girth were measured at regular intervals by adopting standard procedure. A perusal of data presented in Table 1 revealed that there was a significant difference in $KNO_3$ treated mango root stocks and commercial varieties against control. Between the treatments, stones treated with $KNO_3$ showed minimum days (21 days) for initiation of germination compared to control (27days).

Among the rootstocks and commercial varieties of mango, Totapuri showed early initiation of germination by 19 days, which was on par with Olour (20 days), Alphonso (20 days), Chandrakaran (21 days), Vellaikolomban (23 days) and late initiation was observed with Mylipilian and Kurukkan by 27days. The interaction between treatments and root stocks was non-significant. Commercial cultivars Totapuri (16 days) and Alphonso (17 days) showed early initiation of germination by treating with $KNO_3$ @ 2% compared to other rootstocks and control treatment.

The commercial cultivars Totapuri (28 days) and Alphonso (28 days) showed minimum days for 50% germination compared to polyembryonic rootstock. Among the rootstocks, Kensington showed maximum days (38 days) for 50% germination. Significant difference in days taken for 50% germination was observed between the treatments. Stones treated with $KNO_3$@ 2% showed minimum days (29 days) for 50% germination, whereas, control showed maximum days (35 days) for germination. Eventhough there was nonsignificant difference on days taken for 50% germination with interaction effect of root stocks and treatments, the commercial cultivars Alphonso (25 days) and Totapuri (26 days) treated with $KNO_3$@2% showed early germination compared to control.

The data presented in Table 2 revealed that among the rootstocks the commercial cultivars showed highest (83.5%) germination percentage in Bappakai and lowest (26.5%) was in Chandrakaran.

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**Table 1. Effect of $KNO_3$ on days taken for initiation of germination and 50% germination of mango seedlings**

| Varieties (V) | Days taken for initiation of germination | | | Days taken for 50 % germination | | |
|---|---|---|---|---|---|---|
| | Treatments (T) | | Mean(V) | Treatments (T) | | Mean(V) |
| | $T_1$ $KNO_3$ @ 2% | $T_2$ (Control) | | $T_1$ $KNO_3$ @ 2% | $T_2$ (Control) | |
| $V_1$-Olour | 18.5 | 22.5 | **20.5** | 29.0 | 35.5 | **32.2** |
| $V_2$-Nekkare | 24.5 | 30.0 | **27.2** | 33.5 | 37.5 | **35.5** |
| $V_3$-Mylipilian | 25.0 | 30.5 | **27.7** | 27.5 | 38.5 | **33.0** |
| $V_4$-EC-95862 | 21.0 | 27.0 | **24.0** | 31.0 | 33.5 | **32.2** |
| $V_5$-Chandrakaran | 22.0 | 27.0 | **24.5** | 26.5 | 38.5 | **32.5** |
| $V_6$-Prior | 18.5 | 24.0 | **21.2** | 30.5 | 33.5 | **32.0** |
| $V_7$-Kitchner | 21.5 | 27.0 | **24.2** | 30.0 | 35.5 | **32.7** |
| $V_8$-Starch | 22.5 | 28.5 | **25.5** | 26.0 | 36.5 | **31.2** |
| $V_9$-Muvandan | 20.5 | 26.0 | **23.2** | 28.0 | 32.5 | **30.2** |
| $V_{10}$-Vellaikolamban | 20.5 | 26.5 | **23.5** | 30.0 | 35.5 | **32.7** |
| $V_{11}$-Bappakai | 23.5 | 30.0 | **26.7** | 30.0 | 36.5 | **33.2** |
| $V_{12}$-Peach | 22.0 | 28.5 | **25.2** | 28.0 | 33.5 | **30.7** |
| $V_{13}$-Kurukkan | 25.0 | 30.5 | **27.7** | 34.0 | 41.0 | **37.5** |
| $V_{14}$-Kensington | 24.5 | 30.0 | **27.2** | 34.5 | 42.0 | **38.2** |
| $V_{15}$-Alphonso | 17.5 | 24.0 | **20.7** | 25.5 | 31.5 | **28.5** |
| $V_{16}$-Totapuri | 16.5 | 22.0 | **19.2** | 26.0 | 30.5 | **28.2** |
| **Mean (T)** | **21.4** | **27.1** | | **29.3** | **35.7** | |
| | F-test | S. Em $\pm$ | CD@1% | F-test | S. Em $\pm$ | CD@1% |
| T | ** | 0.53 | 1.60 | ** | 0.48 | 1.46 |
| V | ** | 1.51 | 4.53 | ** | 1.37 | 4.13 |
| TXV | NS | - | - | NS | - | - |

**Significant @ 1% ;  NS-Non Significant

**Table 2. Effect of $KNO_3$ on germination percentage and extent of polyembrony of mango seedlings**

| Varieties (V) | Germination percentage | | | Emergence of polyembronic seedlings | | |
|---|---|---|---|---|---|---|
| | Treatments (T) | | Mean(V) | Treatments (T) | | Mean(V) |
| | $T_1$ $KNO_3$ @ 2% | $T_2$ (Control) | | $T_1$ $KNO_3$ @ 2% | $T_2$ (Control) | |
| $V_1$-Olour | 56.5 | 48.0 | **52.2** | 1.0 | 1.31 | **1.16** |
| $V_2$-Nekkare | 81.0 | 75.0 | **78.0** | 1.0 | 1.25 | **1.13** |
| $V_3$-Mylipilian | 49.0 | 38.0 | **43.5** | 1.0 | 1.28 | **1.14** |
| $V_4$-EC-95862 | 77.0 | 70.0 | **73.5** | 1.0 | 1.45 | **1.23** |
| $V_5$-Chandrakaran | 32.5 | 20.5 | **26.5** | 1.0 | 1.45 | **1.23** |
| $V_6$-Prior | 63.5 | 53.5 | **58.5** | 1.0 | 1.45 | **1.23** |
| $V_7$-Kitchner | 85.5 | 77.5 | **81.5** | 1.0 | 1.38 | **1.19** |
| $V_8$-Starch | 53.5 | 44.5 | **49.0** | 1.0 | 1.08 | **1.04** |
| $V_9$-Muvandan | 83.5 | 76.5 | **80.0** | 1.0 | 1.35 | **1.18** |
| $V_{10}$-Vellaikolamban | 41.0 | 31.5 | **36.2** | 1.0 | 1.35 | **1.18** |
| $V_{11}$-Bappakai | 87.0 | 80.0 | **83.5** | 1.0 | 1.17 | **1.09** |
| $V_{12}$-Peach | 51.5 | 44.0 | **47.7** | 1.0 | 1.30 | **1.15** |
| $V_{13}$-Kurukkan | 71.0 | 63.0 | **67.0** | 1.0 | 1.43 | **1.21** |
| $V_{14}$-Kensington | 41.5 | 35.0 | **38.2** | 1.0 | 1.55 | **1.28** |
| $V_{15}$-Alphonso | 81.0 | 76.5 | **78.7** | 1.0 | 1.00 | **1.00** |
| $V_{16}$-Totapuri | 71.0 | 60.0 | **65.5** | 1.0 | 1.00 | **1.00** |
| **Mean (T)** | **64.1** | **55.8** | | **1.0** | **1.30** | |
| | F-test | S. Em $\pm$ | CD@1% | F-test | S. Em $\pm$ | CD@1% |
| T | ** | 0.57 | 1.72 | ** | 0.04 | 0.13 |
| V | ** | 1.62 | 4.87 | ** | 0.13 | 0.38 |
| TXV | NS | - | - | ** | 0.18 | 0.54 |

**Significant @ 1%; NS-Non Significant

**Table 3. Effect of $KNO_3$ on vigour of mango seedlings at 150 days after sowing**

| Varieties (V) | Plant height (cm) | | | No. of leaves | | | Stem girth (cm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Treatments (T) | | Mean(V) | Treatments (T) | | Mean(V) | Treatments (T) | | Mean(V) |
| | $T_1$ $KNO_3$ @ 2% | $T_2$ (Control) | | $T_1$ $KNO_3$ @ 2% | $T_2$ (Control) | | $T_1$ $KNO_3$ @ 2% | $T_2$ (Control) | |
| $V_1$-Olour | 19.1 | 11.9 | **15.5** | 13.0 | 7.7 | **10.3** | 0.62 | 0.41 | **0.51** |
| $V_2$-Nekkare | 26.4 | 17.4 | **21.9** | 11.2 | 7.7 | **9.4** | 0.67 | 0.43 | **0.55** |
| $V_3$-Mylipilian | 26.0 | 15.7 | **20.8** | 11.8 | 7.2 | **9.5** | 0.67 | 0.46 | **0.56** |
| $V_4$-EC-95862 | 25.9 | 16.4 | **21.1** | 11.1 | 6.7 | **8.9** | 0.76 | 0.49 | **0.63** |
| $V_5$-Chandrakaran | 15.1 | 10.7 | **12.9** | 5.2 | 5.7 | **5.4** | 0.58 | 0.37 | **0.47** |
| $V_6$-Prior | 24.0 | 14.7 | **19.4** | 9.7 | 7.6 | **8.6** | 0.74 | 0.45 | **0.60** |
| $V_7$-Kitchner | 32.6 | 21.2 | **26.9** | 13.9 | 8.2 | **11.0** | 0.82 | 0.50 | **0.66** |
| $V_8$-Starch | 16.6 | 11.9 | **14.2** | 13.2 | 7.5 | **10.3** | 0.59 | 0.42 | **0.50** |
| $V_9$-Muvandan | 25.5 | 19.0 | **22.2** | 12.6 | 10.2 | **11.4** | 0.90 | 0.54 | **0.72** |
| $V_{10}$-Vellaikolamban | 17.6 | 9.9 | **13.7** | 5.2 | 4.4 | **4.8** | 0.57 | 0.51 | **0.54** |
| $V_{11}$-Bappakai | 32.0 | 19.8 | **25.9** | 14.30 | 9.1 | **11.7** | 0.78 | 0.52 | **0.65** |
| $V_{12}$-Peach | 18.9 | 11.8 | **15.3** | 7.6 | 6.7 | **7.1** | 0.64 | 0.43 | **0.53** |
| $V_{13}$-Kurukkan | 17.9 | 11.9 | **14.9** | 10.3 | 7.3 | **8.8** | 0.65 | 0.44 | **0.54** |
| $V_{14}$-Kensington | 14.3 | 8.9 | **11.6** | 9.5 | 7.4 | **8.4** | 0.63 | 0.43 | **0.53** |
| $V_{15}$-Alphonso | 35.0 | 24.6 | **29.8** | 11.7 | 8.5 | **10.1** | 0.80 | 0.49 | **0.65** |
| $V_{16}$-Totapuri | 30.3 | 21.0 | **25.6** | 14.3 | 9.4 | **11.8** | 0.73 | 0.47 | **0.60** |
| **Mean (T)** | **23.6** | **15.4** | | **10.9** | **7.6** | | **0.70** | **0.46** | |
| | F-test | S. Em ± | CD@1% | F-test | S. Em ± | CD@1% | F-test | S. Em ± | CD@1% |
| T | ** | 0.59 | 1.79 | ** | 0.19 | 0.57 | ** | 0.01 | 0.03 |
| V | ** | 1.69 | 5.07 | ** | 0.54 | 1.62 | ** | 0.03 | 0.09 |
| TXV | NS | - | - | ** | 0.76 | 2.29 | * | 0.04 | 0.11 |

**Significant @ 1%; *Significant @ 5% ; NS-Non Significant

Between the treatments $KNO_3$@2% treated stones showed 14.9 per cent more germination compared to control treatment. The interaction effect of rootstocks and treatment was nonsignificant. The stones treated with $KNO_3$ @2% in the rootstock Bappakai has recorded maximum (87%) germination and minimum (20.5%) was observed with Chandrakaran treated with control. The variation in germination in presoaked stones may be due tothe stimulative effect of chemicals on the stones as well asenhanced the enzymatic process and suppression of inhibition along with synthesis of RNA, which resulted in higher germination. These results are in agreement with the findings of Venkata Rao and Reddy (2005),Padma and Reddy (1998) in mango.

Significant difference was observed between the treatments, rootstocks and also the interaction effect of rootstocks and treatments on the extent of polyembrony as per the data shown in the Table 2. Between the treatments control showed maximum (1.30) emergence of polyembryonic seedlings compared to $KNO_3$. Among the rootstocks Kitchner showed maximum (1.28) emergence of polyembryonic and minimum (1.00) was observed in commercial cultivars *viz.,* Totapuri and Alphonso. The interaction effect of control treatment with Kensington showed maximum emergence of polyembryonic seedlings (1.55) and minimum was in commercial cultivars and also $KNO_3$@2% treated rootstocks. The data presented in the Table 3 revealed that at 150 days after sowing there was significant difference in treatment and varieties on vigour of the seedlings. The stones treated with $KNO_3$ @ 2% showed maximum plant height (23.61 cm), number of leaves (10.91) and stem girth (0.70 cm) compared to control. Among the rootstocks commercial cultivars Alphonso showed maximum plant height (29.85 cm) and minimum (11.63 cm) in Kensington. Maximum stem girth (0.72 cm) was recorded with Muvandan rootstock that was on par with Kitchner (0.66cm), Bappakai (0.65cm), Alphonso (0.65 cm) and minimum (0.47 cm) was recorded with Chandrakaran.

The increased plant height and stem girth was due to the regulation of growth by $KNO_3$ relates almost extensively to its stem elongation properties. Influence of potassium nitrate on stem elongation is by two ways. (1) It has direct effect on stem elongation by inducing cell wall loosening, by increasing cell wall extensibility, stimulating the wall synthesis, reducing the rigidity of cell wall and by increasing cell division leading to more growth. (2) The indirect effect of the chemicals on stem elongation is by increasing the synthesis of IAA (Leopold and Kriedemann, 1983). The increase in seedling height and girth by application of potassium nitrate was also reported by earlier workers Venkata Rao and Reddy (2005) and Shalini *et al.* (1999) in mango.

Similarly, highest number of leaves (11.85) was recorded with Totapuri, which was on par with Bappakai (11.73), Muvandan (11.43), Kitchner (11.08) and lowest was recorded with Vellaikolamban (4.83). The interaction effect was nonsignificant for plant height, number of leaves and stem girth. The production of more number of leaves in varieties and treatments may be due to the vigorous growth induced by $KNO_3$ treatment, more number of branches which in turn facilitates better harvest of sunshine by the plants to produce more number ofleaves. These results obtained on this aspect are in agreement with Venkata Rao and Reddy (2006), Shalini *et al.* (1999) and Khobragode *et al.*(1999) in mango.As there is variation in the number of leaves, their leaf area also showed variation. Variation in leaf area could be expected among the varieties, as the attribute is generally genetic character. Variation in leafarea due to the treatments with hormones and chemicals was also reported by Khobragode *et al.* (1999) in mango who reported that greater leaf area was associated with vigorous rootstocks.

The results obtained from the study indicated that $KNO_3$ showed significant effect on days taken for germination, germination percentage, plant height, number of leaves and stem girth. Among the rootstocks, commercial cultivars Alphonso and Totapuri showed significant response to treatments compared to polyembronic rootstocks eventhough on par and non-significant results obtained on germination and vigour of mango stones.

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Research Note
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# GROWTH AND INSTABILITY ANALYSIS OF CHICKPEA PRODUCTION IN PRAKASAM DISTRICT OF ANDHRA PRADESH

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Pulses are important crops in India. The different pulses grown in India are an integral part of subsistence farming. Pulses play important role in sustainable production system and household nutrition security. Chickpea or *chana* is very important pulse crop in the world after peas and beans. India is the major chickpea producing country. Andhra Pradesh is categorized among the states which show high growth rate of chickpea production in India. Chickpea has been taken up in drought prone districts Kurnool and Prakasam of Andhra Pradesh, which are the top producers of chickpea. The time series data for the period 1976-2016 of Prakasam district regarding production, area and yield of chickpea has been used to compute compound growth rates, Coefficient of variation, Coppock's Instability Index (CII) and for performing decomposition analysis to attain the objectives *i.e.,* to study the growth and instability of chickpea production in Prakasam district.

The study was confined to the area, production and yield of the chickpea crop in Prakasam district, Andhra Pradesh. The data was collected on area, production and yield of chickpea for a period of 39 years *i.e.*, 1976 to 2014 from the Chief Planning Officer, Ongole.

**Compound growth rate (CGR)**

Compound growth rates were estimated to know the growth pattern on area production and yield of chickpea crop in Prakasam district, Andhra Pradesh. The adequacy of the model is indicated by the coefficient of multiple determinations ($R^2$). The growth model was specified as follows:

$$Y = ab^t \quad \text{(OR)}$$

$$\text{Log } Y = \log a + t \log b$$

Where, Y = Dependent variable for which growth rate was estimated

a = intercept

b = regression coefficient

t = time variable

The 'a' and 'b' can be estimated by applying ordinary least squares (OLS). The compound growth rate (CGR%) is calculated by using the formula

r = (antilog of b -1)*100

The significance of the growth rates can be tested by applying student's 't' test *i.e.,*

T = r/SE(r) with (n-2) degrees of freedom

Where,

r is the growth rate

n is the total number of years considered under study

SE(r) is the standard error of growth rate

**Coppock's instability index**

The coefficient of variation represents the ratio of the standard deviation to the mean, and it is a useful statistic for comparing the degree of variation from one data series to another, even if the means are drastically different from each other, it is expressed as percentage.

The simple coefficient of variation (CV) often contains the trend component and thus over estimates the level of instability in time series data characterized by long term trends. To overcome this problem, the instability index (II) given by Coppock's

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instability index of variation is used. Coppock's instability index is a close approximation of the average year to year per cent variation adjusted for trend. The algebraic form of equation is:

$$CII = \left[\left(Antilog\sqrt{log\ v} - 1\right)X\ 100\right]$$

$$log\ v = \sum \frac{\left[log\ \frac{X_{t+1}}{X_t} - m\right]^2}{N-1}$$

Where, $X_t$ = area / production/ yield in the year 't',

N= Number of years

CII= Coppock's instability index,

m= Arithmetic mean of difference between the logs of Xt+1, etc,

log v = Logarithmic variance of the series

**Decomposition analysis**

To measure the relative contribution of area and yield to the total output change for the chickpea crop, the decomposition analysis model of Minhas (1964), as given below was used. Sharma (1977) redeveloped the model and several research workers (Kalamkar *et al*., 2002) used this model and studied growth performance of chickpea crop in Prakasam district.

$$P = \frac{A_0\ \Delta Y}{\Delta P} \times 100 + \frac{Y_0\ \Delta A}{\Delta P} \times 100 + \frac{\Delta Y\ \Delta A}{\Delta P} \times 100$$

Production effect = yield effect + area effect + interaction effect

Thus, the total change in production can be decomposed into three components *viz*., yield effect, area effect and the interaction effect due to change in yield and area.

The results of compound growth rates for area, production and productivity of chickpea crop in of Prakasam district are presented in Table 1. Compound growth rates recorded during the study period for area, production and productivity were 19.4%, 23.3% and 4.9%, respectively and were significant at 1% level of significance. The production of chickpea showed significant higher growth rates when compared to the growth rates of area and productivity. The growth rates of area and productivity showed an increasing trend in the growth rates.

**Table 1. Growth rates of chickpea area, yield and production in Prakasam district**

| S.No. | Particulars | CGR%(1976-2014) | CV (%)1976-2014 | CII(1976-2014) |
|---|---|---|---|---|
| 1. | Area | 19.4** | 120.55 | 44.03 |
| 2. | Production | 23.3** | 127.27 | 74.60 |
| 3. | Productivity | 4.9** | 55.41 | 53.61 |

**Significant at 1% level

The results of coefficient of variation for area, production and productivity of chickpea in Prakasam district, are presented in Table 1. It revealed that the coefficient of variation of chickpea area, production and productivity for the study period was 120.55, 127.27 and 55.41 per cent, respectively. Therefore, production is showing greater variability due to the instability of area. The instability index for area, production and productivity of chickpea crop in Prakasam district, Andhra Pradesh are presented in the Table 1. The results revealed that production variability (74.60) was found highest and lowest variability in area (44.03). Thus, it is observed that production is showing highest instability when compared to area and productivity (Gajbhiye *et al.* (2010), Dhakre and Bhattacharya (2013). The relative contribution of area, yield and their interaction to changes in production of chickpea crop in Prakasam district was presented in the Table 2. The decomposition analysis of the growth of Chickpea crop over the entire study period (1976 - 2014) revealed that growth in production of chickpea was mainly due to interaction effect (784.26 per cent). The productivity and area effects are 14.98 per cent and 200.76 per cent respectively (Sachan and Singh, 2015).

**Table 2. Decomposition of output growth of Chickpea in Prakasam district**

| S.No. | EFFECT | PER CENT (%) |
|---|---|---|
| 1 | Yield effect | 14.98 |
| 2 | Area effect | 200.76 |
| 3 | Interaction effect | 784.26 |

The production of chickpea showed significant higher growth rates when compared to the growth rates of area and productivity. The higher variability was observed in case of chickpea production when compared to area and productivity of chickpea, due to instability of the area. The higher instability is shown by chickpea production when compared with area and productivity of chickpea. It is observed from the results that interaction effect is showing dominating influence on production of chickpea crop in Prakasam district of Andhra Pradesh.

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# EFFICACY OF LEVELS AND SOURCES OF SULPHUR ON YIELD ATTRIBUTES, YIELD AND CAPSAICIN CONTENT OF HOT PEPPER *(Capsicum annum* L. )

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Chilli is one of the important commercial crops in Andhra Pradesh grown in an area of 2.68 lakh ha in the state and ranks first in production and productivity in India. Chilli, being a long duration and energy rich crop, proper manuring and fertilizing in the surface soil along with balanced nutrition with secondary and micronutrients is very much essential because of its shallow root system for higher yield and quality produce (Bidrari, 2000). Increased use of high analysis chemical fertilizers(Urea, DAP, and MOP)under intensive cultivation and neglect of organic manures, has resulted in imbalanced nutrient application which has accentuated the deficiency of secondary and micronutrients. Among the secondary nutrients, sulphur considered as the fourth major nutrient is of paramount importance from the point of view of crop production. On contrary to the general belief that sulphur is important mainly for oilseed crops, several field trials showed significant increase in yield and quality in all other major crops. Keeping these in view, a field study to evaluate the efficacy of levels and sources of sulphur on yield attributes, yield and capsaicin content of hot pepper *(Capsicum annum* L.) was undertaken at Regional Agricultural Research Station, Guntur, during *Kharif* 2006 and 2007 in chilli variety LCA-334.The study was initiated with an objective to study the effect of different levels (7.5 kg ha$^{-1}$, 10 kg ha$^{-1}$, 12.5 kg ha$^{-1}$, 15 kg ha$^{-1}$, 20 kg ha$^{-1}$ and 25 kg ha$^{-1}$) and sources (Cosavit Fertis-WG, Gypsum and Bentonite) of sulphur in different treatment combinations on yield, yield attributes and capsaicin content of hot pepper. The experiment was laid out in randomized block design with three replications.

The treatment details with Recommended Dose of Fertilizer(RDF)of 300N: 60$P_2O_5$:120$K_2O$ kg ha$^{-1}$are as follows: $T_1$- RDF + Soil application of Cosavit Fertis-WG @7.5 kg ha$^{-1}$ at 20-25 DAT; $T_2$- RDF + Soil application of Cosavit Fertis-WG@ 10.0 kg ha$^{-1}$ at 20-25 DAT; $T_3$- RDF + Soil application of Cosavit Fertis-WG@ 12 kg ha$^{-1}$ at 20-25 DAT; $T_4$- $T_1$+ Cosavit Fertis-WG @ 7.5 kg ha$^{-1}$ 30 days after first application; $T_5$- $T_2$ + Cosavit Fertis-WG @10.0 kg ha$^{-1}$ 30 days after first application; $T_6$- $T_3$+ Cosavit Fertis-WG @ 12.5 kg ha$^{-1}$ 30 days after first application; $T_7$- RDF +Gypsum @ 22.5 a.i (125 kg ha$^{-1}$) basal application; $T_8$-RDF +Bentonite @22.5a.i(125 kgha$^{-1}$) basal application; $T_9$- Recommended Dose of Fertilizer (RDF) of 300N: 60$P_2O_5$:120$K_2O$ kg ha$^{-1}$.

The soils of the experimental site at Regional Agricultural Research Station (RARS), Guntur were slightly alkaline with PH of 7.7 with low organic carbon (0.43%), low in available nitrogen 168 kg N ha$^{-1}$ medium in available phosphorous 17.4 kg kg ha$^{-1}$and high in available potassium 954 kg kg ha$^{-1}$. The available calcium and magnesium content was 9.8 g kg$^{-1}$ soil and 2.1g kg$^{-1}$ soil, respectively. The nutrients were applied as per the treatments and recommended package of practices were followed. Data was collected on growth characters, yield attributes and yield and subjected to statistical analysis. The capsaicin content was determined by the procedure outlined by Bajaj and Gurudeep Kaur(1979).

The treatment effects were non significant in respect of plant height and number of branches plant$^{-1}$. However, plants in $T_6$ ($T_3$+ Cosavit Fertis-WG @ 12.5 kg ha$^{-1}$ 30 days after first application) recorded maximum plant height (83.8 cm) and plants in $T_3$ (RDF + soil application of Cosavit Fertis-WG @12.5 kgha$^{-1}$ at 20-25 DAT) recorded maximum number of branches (7.3) (Table 1).

Application of sulphur at different levels and sources did not influence the per cent fruit set. However, plants in $T_4$ ($T_1$+ Cosavit Fertis-WG @ 7.5 kg ha$^{-1}$ 30 days after first application)recorded highest percentage of fruit set (50.0). Better availability of photosynthates and increased levels of various

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**Table1. Efficacy of level and sources of sulphur on yield attributes, yield and capsaicin content of hot pepper**

| Treatments | Plant height (cm) | No. of branches | Fruit Setting (%) | Number of fruits plant$^{-1}$ | Fruit Weight Plant$^{-1}$ (g) | Yield q ha$^{-1}$ | Capsaicin content (%) |
|---|---|---|---|---|---|---|---|
| **$T_1$-** RDF + Soil application of Cosavit Fertis-WG @7.5 kg ha$^{-1}$ at 20-25 DAT | 83.5 | 4.5 | 42.3 | 249.3 | 487.3 | 27.07 | 0.25 |
| **$T_2$-** RDF + Soil application of Cosavit Fertis-WG@ 10 kg ha$^{-1}$ at 20-25 DAT | 82.7 | 7.8 | 44.3 | 278.3 | 490.7 | 27.26 | 0.27 |
| **$T_3$-** RDF + Soil application of Cosavit Fertis-WG@ 12.5 kg ha$^{-1}$ at 20-25 DAT | 82.3 | 7.3 | 45.0 | 296.7 | 500.0 | 27.78 | 0.18 |
| **$T_4$-** $T_1$+ Cosavit Fertis-WG @ 7.5 kg ha$^{-1}$ 30days after first application | 79.6 | 5.2 | 50.0 | 290.0 | 521.7 | 28.55 | 0.32 |
| **$T_5$-** $T_2$ + Cosavit Fertis-WG @10.0 kg ha$^{-1}$ 30 days after first application | 79.9 | 6.1 | 44.7 | 286.7 | 514.0 | 28.21 | 0.23 |
| **$T_6$-** $T_3$+ Cosavit Fertis-WG @ 12.5 kg ha$^{-1}$ 30 days after first application | 83.8 | 4.3 | 42.7 | 271.3 | 504.3 | 28.08 | 0.20 |
| **$T_7$-** RDF +Gypsum @ 22.5 a.i (125 kg ha$^{-1}$) basal application | 73.7 | 5.7 | 49.3 | 254.0 | 504.0 | 27.91 | 024 |
| **$T_8$-** RDF +Bentonite@22.5a.i(125 kg ha$^{-1}$) basal application | 76.5 | 6.8 | 40.6 | 216.3 | 442.3 | 24.57 | 0.23 |
| **$T_9$-** Recommended Dose of Fertilizer (RDF) of 300N: 60$P_2O_5$:120$K_2O$ kg ha$^{-1}$ | 73.7 | 5.7 | 41.0 | 196.3 | 310.0 | 17.22 | 0.17 |
| CD @5 % | NS | 2.2 | NS | 34.7 | 40.5 | 2.36 | 0.075 |
| CV% | 8.7 | 8 | 12.5 | 7.7 | 11 | 11.2 | 18.7 |

endogenous hormones in plant tissue could have been responsible for enhanced pollen germination and tube growth resulting in increased fruit set as opined by Nantha Kumar and Veeraragvathatham (1999).

All the treatments irrespective of levels and source of sulphur application recorded significantly higher number of fruits plant$^{-1}$ over control. The treatment $T_4$ ($T_1$+ Cosavit Fertis-WG @ 7.5 kg ha$^{-1}$, 30days after first application) recorded highest number of fruits plant$^{-1}$ (290) followed by $T_5$ ($T_2$ + Cosavit Fertis-WG @10.0 kg ha$^{-1}$ 30 days after first application) (286.7) and $T_6$ ($T_3$+ Cosavit Fertis-WG @ 12.5 kg ha$^{-1}$ 30days after first application) (271.3)(Table 1.) The treatment $T_4$ ($T_1$+ Cosavit Fertis-WG @ 7.5 kg ha$^{-1}$ 30days after first application) recorded highest fruit weight plant$^{-1}$ (521.7g) and dry chilli yield (28.5 q ha$^{-1}$) followed by $T_5$ ($T_2$ + Cosavit Fertis-WG @10.0 kg ha$^{-1}$, 30 days after first application) (514.0 g) and yield (28.2 q ha$^{-1}$) and $T_6$ ($T_3$+ Cosavit Fertis-WG @ 12.5 kg ha$^{-1}$ 30 days after first application) (504.3g ) and yield (28.08 q ha$^{-1}$). The more number of fruits plant$^{-1}$, increased fruit weight plant$^{-1}$ and increased per cent fruit set were found to be the main contributory factors for the increased yield. The role of sulphur in regulating the hormonal and nutritional balance of the plant resulting in more sink area (fruits) might be the probable reason for higher harvest index as reported by Srinivasan(1996) in blackgram and Majumdar *etal*. (2000) in chilli. Further, sulphur helps in energy transformation and activation of enzymes in carbohydrate metabolism and subsequently greater partitioning of photosynthates in formation of yield attributes. Application of sulphur resulted in increased yield since it is a constituent of amino acid protein production as reported by Nagaiah *et al*. (1998).

The pungency or hotness of chilli is expressed as capsaicin content in terms of percentage. All the treatments irrespective of levels and source of sulphur application recorded significantly higher capsaicin content over control. Among the treatments, $T_4$ ($T_1$+ Cosavit Fertis-WG @ 7.5 kg ha$^{-1}$ 30 days after first application) recorded highest capsaicin content(0.32%) and significantly superior over all other treatments. These results are in accordance with the findings of Ananthi *et al.* (2004) and Poornima *et al.* (2015).

Maximum dry chilli yield (28.55 q ha$^{-1}$) and pungency in terms of capsaicin content (0.32%) was recorded with recommended dose of fertilizer of 300N: 60$P_2O_5$:120$K_2O$ ha$^{-1}$ with soil application of Cosavit Fertis-WG @7.5 kg ha$^{-1}$ as first dose at 20-25 DAT and second dose of 7.5 kg ha$^{-1}$, 30 days after first application was found significantly superior to all the other treatments evaluated and hence can be recommended for high yields with high capsaicin content in chilli.

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Research Note
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# CHEMICAL CHARACTERIZATION OF TWO NEWLY RELEASED RICE VARIETIES IN NORTHERN TELANGANA REGION

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Rice is a staple food consumed by more than half of the world population (FAOSTAT, 2014). It provides 20 percent of the world's dietary energy supply, while wheat supplies 19 per cent and maize (corn) 5 per cent (FAO, 2004). It is the predominant dietary energy source for 17 countries in Asia and the Pacific and 9 countries in North and South Africa. In 59 countries, an average of at least 75g of rice is available per person per day (FAOSTAT, 2014). The total population of these countries is 4.1 billion which indicates that reaching even half of that population would ensure a greater daily nutrient intake among 2 billion people (FFI, 2014).Rice, beyond its nutritive value has got high digestibility and the least allergenic property than all other grains so it can be enjoyed by young and old alike (Betrez-Marquez *et al*., 2005).

Rice is the main constituent of life-saving oral rehydration solutions (ORS), and has been used for treatment of various ailments such as diarrhea, vomiting, fever, hemorrhage, chest pain, wounds and burns. Recent studies recommend rice as a novel food due to its high mineral content, antioxidant properties and low glycemic index for lowering the incidence of lifestyle-related diseases such as heart attack, diabetes and cancer, which have begun to assume epidemic form over the last two decades not only in urban India, but in rural India too (Rhoades, 2008). Rice has a low-fat, low-cholesterol, low-salt contents. It makes a perfect diet for hypertension persons who have been advised salt-restricted diets. It has been noted by modern researchers that wherever-rice is used as the main food, there is a corresponding benefit of youthful vitality and a very low rate of hypertension. Calcium in brown rice, in particular, soothes and relaxes the nervous system and helps relieve the symptoms of high blood pressure (Ahuja *et al*., 2008). Hence, the present study was undertaken to analyse the chemical properties of the selected newly released rice varieties of Northern Telangana region.

One of the new released rice varieties *viz.,* Anjana (JGL-11118) and Pradhyumna (JGL-17004) were procured from Regional Agricultural Research Station, Jagityal, Karimnagar. Proximate analysis was conducted for the two newly released rice varieties of Northern Telangana region. Moisture content of the samples was determined using the procedure given by Association of Official Analytical Chemists (AOAC, 2005). Protein content was estimated from the crude nitrogen content of the sample determined by the Micro Kjeldhal method (N × 6.25) (AOAC, 2005). Fat content was estimated as crude ether extract of the dry material using automatic Gerhardt Soxtherm extraction unit (AOAC, 2005). Crude fiber content of the samples was determined by the procedure of the Association of Official Analytical Chemists (AOAC, 2005). Total ash was determined using the procedure documented by Association of Official Analytical Chemists (AOAC, 2005). Energy and carbohydrate content was calculated by difference method (Gopalan *et al*., 2004). Calcium content of the samples were determined using Titrimetric method (Siong *et al*., 1989). Iron content of the samples was determined using á-á dipyridyl method.

The chemical properties of two newly released rice (*Oryza sativa*) varieties such as Anjana (JGL-11118) and Pradhyumna (JGL-17004) were determined. The content of nutrients like moisture,

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**Table1. Chemical properties of two newly released rice varieties grown in Northern Telangana region (Per 100 g)**

| Variety | Accession No | Moisture (g) | Ash (g) | Protein (g) | Fat (g) | Fibre (g) | Carbohyd-rate (g) | Energy (k.cal) | Minerals | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Iron (mg) | Calcium (mg) |
| Anjana | JGL-11118 | 7.85±0.22 | 0.53±0.13 | 7.9±0.0 | 0.55±0.08 | 0.39±0.10 | 83.11±0.15 | 369.45±0.6 | 0.93±0.04 | 10.3±0.57 |
| Pradhyumna | JGL-17004 | 7.21±0.12 | 0.89±0.02 | 7.53±0.2 | 0.59±0.06 | 0.24±0.05 | 83.7±0.07 | 370.38±0.64 | 0.86±0.06 | 9.3±1.15 |

**Note:** Values are expressed as mean± standard deviation of three determinations ash, protein, Fat, fibre, carbohydrates, energy, iron and calcium were assessed and the results are presented in Table 1. Moisture content of Anjana (JGL-11118) and Pradhyumna (JGL-17004) rice varieties was 7.85 ± 0.2 and 7.21 ± 0.12. The moisture levels were within the acceptable limit (12%) for long term stored rice. Ash content of Anjana (JGL-11118) and Pradhyumna (JGL-17004) rice varieties was 0.53 ± 0.13 and 0.89 ± 0.02. The ash content of rice variety Pradhyumna was higher than the ash content of rice variety Anjana. Dipti *et al.* (2003) reported that ash residual is generally taken to be a measure of the mineral content of materials. High ash content in milled rice is an indication of a good quality of minerals in the rice sample.

The protein content was 7.9 ± 0.0 and 7.53 ± 0.2 g/100 g respectively in Anjana (JGL-11118) and Pradhyumna (JGL-17004). Protein values of samples are within the acceptable limits. Protein content of rice can range from 6%-15% (FAO, 1993). Protein plays an important role in cooked rice texture due to formation of a complex with starch that impairs the swelling of starch granule. Starch granule swelling affects both viscosity intensity and the rate of starch gelatinization. Protein content can vary with the degree of milling (Suwannaporn, 2007).

The fat content was 0.55 ± 0.08 and 0.59 ± 0.06 g/100 g respectively in Anjana (JGL-11118) and Pradhyumna (JGL-17004). Okaka (2005) reported that higher fat content exposes the grains to spoilage during storage due to oxidation. As the fat content of samples are within the acceptable limits, grain spoilage is less.Crude fibre of samples ranged from 0.39±0.10 and 0.24±0.05g/100g. Carbohydrate content of Anjana (JGL-11118) and Pradhyumna (JGL-17004) rice varieties was 83.11 ± 0.62 and 83.7 ± 0.07. Energy values of Anjana (JGL-11118) and Pradhyumna (JGL-17004) rice varieties were 369.45 ± 0.64 and 370.38 ± 0.62 kcal/100g.

Iron content of rice varieties Anjana (JGL-11118) and Pradhyumna (JGL-17004) was 0.93 ± 0.04 and 0.86 ± 0.04 mg/100g. These values are within the range 0.2 to 2.8 mg/100g reported by (Kennedy *et al*., 1975). Calcium content was 9.3 ± 1.15 and 10.3 ± 0.5 mg/100g respectively in Anjana (JGL-11118) and Pradhyumna (JGL-17004). Presence of calcium in rice is a clear indication that when consumed it will aid normal development and maintenance of bones and teeth, clotting of the blood, nerve irritability in the blood (Alaka and Okaka, 2011). If rice is taken as a staple food in large quantity compared to other foods, there will be sufficient contribution of minerals through diet. In conclusion, the chemical characteristics of two rice varieties tested are good. Their proximate composition and minerals were all within acceptable levels. Therefore, the two varieties tested are of good quality.

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# BUYING BEHAVIOUR AND PERCEPTION ON MYCORRHIZAL BIOFERTILIZER PRODUCT- A CASE STUDY

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Excessive dependence on chemical fertilizers with major emphasis on nitrogen and phosphorus and excessive use of pesticides has led to fall in soil fertility, water contamination, polluted water basins, destroyed micro-organisms and friendly insects and making the crop more prone to diseases and unsustainable burden on the ecosystem. It reduces the colonization of plant roots with mycorrhizae and inhibits symbiotic nitrogen fixation by rhizobia due to high nitrogen fertilization. Nutrients are easily lost from soils through fixation, leaching or gas emission leading to reduced fertilizer efficiency. Under this situation, bio-fertilizers offer great potential not only for improving soil fertility but also solubilise insoluble soil phosphates and produces plant growth substances in the soil for efficient use of various resources for increasing crop production on a sustainable basis. Mycorrhiza is a known biofertilizer since long and has been found to be mobilizing various nutrients, including phosphorus, iron and zinc in adequate quantities. Recognizing the importance of bio-fertilizers many companies, government institutes, cooperatives introduced several bio-fertilizers under different brand names. The study attempts to understand the farmers and dealers perception and satisfaction about a bio-fertilizer in the state of Madhya Pradesh. The objectives of the study are to study the buying behaviour of sample farmers and to study the dealers and farmers perception and satisfaction for Actin and other mycorrhiza based biofertilizer products and to identify market constraints and formulate marketing strategies in promoting Actin.

The sample for the study was selected using a multistage purposive cum random sampling technique. Top five districts of Madhya Pradesh

**Table 1. Source of information and mode of payment for purchase of biofertilizers**

| S.No | Source of Information | Frequency | Per cent | Cumulative Per cent |
|---|---|---|---|---|
| 1 | Dealers | 82 | 68.3 | 68.3 |
| 2 | Friends/Neighbours | 16 | 13.3 | 81.7 |
| 3 | IFCP | 16 | 13.3 | 95.0 |
| 4 | Demonstrations | 1 | 0.8 | 95.8 |
| 5 | Farmer meetings | 3 | 2.5 | 98.3 |
| 6 | KVK training | 1 | 0.8 | 99.2 |
| 7 | Internet | 1 | 0.8 | 100.0 |
| | **Total** | 120 | 100.0 | |
| | **Mode of payment** | | | |
| 1 | Cash | 26 | 21.7 | 21.7 |
| 2 | Credit | 94 | 78.3 | 100.0 |
| | **Total** | 120 | 100.0 | |

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having the highest sales of Actin were selected. From the selected five districts purposively four tehsils from each district having mycorrhiza based biofertilizer users were selected. Thus, 20 tehsils were selected and from the selected 20 tehsils randomly three villages from each tehsil were selected. Thus, in total 60 villages were selected for the study. From the selected villages, list of farmers using mycorrhizal biofertilizer was prepared and from the list two farmers were selected randomly. Thus, in total the sample size of farmers was 120 which was post stratified into 94 Actin non users and 26 Actin users.The sample size of dealers was 31 which constituted 16 number of dealers selling only Actin.. The survey work undertaken pertains to the period from January to April, 2016.

**I. Buying Behaviour of the sample farmers**

**(i) Source of information for purchase of biofertilizers:** It is inferred from the Table 1 given below that among the various sources of information, dealers (68.3%) were the major source of information for the farmers to purchase biofertilizers followed by IFCP (Individual Farmer Contact Programme). The majority of farmers purchased bio fertilizers by credit (78.3 per cent) followed by cash (Tandel *et al*., 2015)

**(ii) Place of Purchase:** It can be inferred from Table 2 that majority of the farmers (82.5%) purchased agri-inputs (seed, fertilizers, pesticides and biofertilizers) from town followed by villages (17.5%).

**Table 2. Place of purchase of agri-inputs**

| Place of Purchase | Actin user | Actin non-user | Total |
|---|---|---|---|
| 1. Village | 11 (42.3) | 10 (10.6) | 21 (17.5) |
| 2. Town | 15 (57.7) | 84 (89.4) | 99 (82.5) |
| Total | 26 (100.0) | 94 (100.0) | 120 (100.0) |

(Figures in parentheses indicate percentage to total)

**II. Dealers' and farmers' perception for Actin and mycorrhiza based biofertilizers**

Table 3 infers that the perception of 65.4% of 26 Actin users was that it primarily increases the yield followed by increase in root growth. The perception of 78.7% of 94 Actin non-user sample respondents (using different mycorrhiza based biofertilizer products of different companies) primarily viewed that it increases the yield followed by 54.3 per cent of the respondents who viewed that it increases the root growth. Respondents in the study area mainly viewed that mycorrhiza based biofertilizer products has a significant impact on increase in yield and root growth enhancement. Majority of sample dealers perception for Actin was that it is a mycorrhizal biofertilizer and it primarily increases root growth followed by increase in yield and plant health.

**III. Farmers' and Dealers' Satisfaction for product**

Table 4 infers that majority of farmer respondents were satisfied with the package and results but not satisfied with the price component. The sample dealers were satisfied with the margin levels and packaging but dissatisfied with price, promotion and discounts **(**Weckman and Nina, 2009**).**

The perusal of Table 5 indicates that 90.4 per cent of Actin non-users (sample farmers) lack awareness about Actin brand. The opinion of 56.25 per cent dealers for not purchasing of Actin by aware farmers was that the price was too high (Baconguis *et al*., 2012).

**Table 3. Farmers perception for Actin and other mycorrhiza based biofertilizers and dealers perception on Actin**

| S.No | Farmers Perception for Action and other Mycorrhiza Based Biofertilizers | Actin users (N=26) | Actin non-users (N=94) |
|---|---|---|---|
| 1 | Nutrient uptake enhancer | 9 (34.6) | 23(24.5) |
| 2 | Increase root growth | 13(50.0) | 51(54.3) |
| 3 | Increasing the yield | 17(65.4) | 74(78.7) |
| 4 | Reduces the cost of other fertilizers | 2(7.7) | 4(4.3) |
| 5 | Increases the disease resistance | 2(7.7) | 27(28.7) |
| 6 | Soil reclaimant | 3(11.5) | 11(11.7) |
| | **Dealers perception on Actin (N=31)** | **Frequency** | **Percentage** |
| 1 | As a biofertilizer | 4 | 25 |
| 2 | As a Mycorrhizal biofertilizer | 10 | 62.5 |
| 3 | Fertilizers mobilizing agent | 2 | 12.5 |
| 4 | Improve plant health | 8 | 50 |
| 5 | Increases yield | 8 | 50 |
| 6 | Increases root growth | 12 | **75** |
| 7 | As a supplementary nutrient | 4 | 25 |
| 8 | As a soil reclaimant | 3 | 18.7 |

(Figures in parentheses indicate percentage to total)

**Table 4. Satisfaction level of the sample farmers and dealers**

| S.No | Farmers' satisfaction (N=26) | | | Dealers' satisfaction (N=16) | | |
|---|---|---|---|---|---|---|
| | | **Mean** | **SD** | | **Mean** | **SD** |
| 1 | Price | 2.23 | 0.951 | Price | 1.62 | 0.806 |
| 2 | Package | 4.19 | 0.491 | Promotion | 1.00 | 0.000 |
| 3 | Result | 3.65 | 0.892 | Margin | 3.81 | 0.834 |
| 4 | Overall performance | 3.42 | 0.857 | Discount and Scheme | 1.25 | 1.000 |
| 5 | Packaging | 3.87 | 0.806 | | | |

**V. Marketing strategies in promotion**

It is inferred from Table 6 that the demonstrations (74.29) was the most important promotional activity followed by farmers' meeting (52.58), AV van films (49.23), discounts and schemes (48.65) and through dealers (48.29). Wall painting / posters was the least effective promotional activity according to dealers. (Mishra *et al.*, 2013).

The major findings of the study is dealers were the major source of information for the farmers to purchase biofertilizers followed by IFCP (individual Farmer Contact Programme) and Friends/Neighbour.

**IV. To identify market constraints for Actin**

**Table 5. Market constraints**

| **Farmers Perspective (N=94)** | No awareness | Price constraint | Not used by others in that area | **Total** |
|---|---|---|---|---|
| Actin non-user | 85(90.4) | 8 (8.5) | 1 (1.1) | 94 (100) |
| **Dealers Perspective (N=16)** | No awareness about Actin results | Price is too high | - | **Total** |
| Actin product sellers | 7(43.75) | 9(56.25) | - | 16(100) |

(Figures in parentheses indicate percentage to total)

**Table 6. Promotional activities** **N=16**

| S. No. | Promotional activities | Mean Score | Rank |
|---|---|---|---|
| 1 | Demonstrations | 74.29 | 1 |
| 2 | Farmers' Meeting | 52.58 | 2 |
| 3 | A-V van Films | 49.23 | 3 |
| 4 | Discounts & Schemes | 48.65 | 4 |
| 5 | Through dealers | 48.29 | 5 |
| 6 | Wall painting / posters | 25.97 | 6 |

The majority of the farmers purchased biofertilizers by credit followed by cash from nearby towns. The perception of the majority of sample farmers on Actin and other mycorrhizal biofertilizer products is that it mainly 'increases the yield' and 'root growth'. Sample dealers perceived Actin as a mycorrhizal biofertilizer. The major constraints for purchasing were high price and lack of awareness. Company has to strategize promotional activities *viz.,* field demonstrations and farmers meetings through sales representatives to increase the sales for Actin.

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