INTERNATIONAL JOURNAL OF RESEARCHES IN BIOSCIENCES, AGRICULTURE & TECHNOLOGY
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www.vmsindia.org

Effect of Planting Geometry and Varieties on Morpho-Physiological Parameters and Yield of Cotton

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Abstract

A field experiment entitled "Effect of high planting geometry and varieties on morpho-physiological parameters and yield of cotton" was carried out in field of Cotton Research Unit, Dr. PDKV, Akola, during *kharif* season of 2016 on clayey soil. The experiment was laid out in split plot design with three replications. There were twelve treatment combinations comprising of four different varieties viz., AKH-1301, AKH-1302, AKH-081and SURAJ with three plant spacings viz., 45 x 10 cm^2, 60 x10 cm^2 and 60 x 15 cm^2, the different varieties were allotted to main plot and plant spacings were accommodated in sub plots. Significant variation for varieties and spacing was observed for all the traits studied. Interaction effects were significant for few traits only. The variety AKH-1301 recorded significantly higher plant height and dry matter $plant^{-1}$ but variety AKH-081was higher for seed cotton yield $plot^{-1}$. The plant spacing 60 x 15 cm^2 recorded significantly higher number of sympodial branches $plant^{-1}$ and dry matter $plant^{-1}$. The seed cotton yield ha^{-1} was higher in plant spacing of 60 x 10 cm^2 due to more plant population $unit^{-1}$ area than spacing of 60 x 15 cm^2. It is summarized from this study that variety AKH-081 responded well to higher plant spacing of 45 x 10 cm^2 and spacing of 60 x 10 cm^2 recorded maximum seed cotton yield of 2356 kg ha^{-1} and 2210 kg ha^{-1} respectively.

Key word: Plant geometry, varieties, morpho-physiological parameters, yield)

INTRODUCTION

In India, Maharashtra ranks first in cotton production area with 38.28 lakh ha, production of 71.25 lakh bales and average productivity of 342 kg lint ha^{-1}, which is lowest as compared to national average of 503 kg lint ha^{-1}. In Maharashtra state, Vidarbha is the largest cotton growing region accounting for 15.23 lakh ha acreage with production of 25 lakh bales and productivity 279 kg lint ha^{-1} (Annonymous,2016).

In Vidarbha out of four cultivated species, major area is under *Gossypium hirsutum* which is commonly called as *'American cotton'*. Under this group of cotton, number of varieties and hybrids are released and doing well on farmer's fields. Recently some of the varieties having better yield potential than the existing are released or at pre-released stage. However, the agronomic practices such as suitable planting geometry for obtaining optimum plant population and in cotton are important to determine the maximum yield.

Optimum planting geometry enables to improve the efficiency of individual plants as it is ultimately connected with root development as well as shoot growth. Plant may show better growth and development and give higher yield per plant but may not give maximum yield per unit area because of inadequate plant population.

Thus, for realizing potential economic yield, the optimum planting geometry is essential. The probable reasons for poor productivity of cotton in this region are attributed to its rainfed cultivation and erratic behavior of rainfall in its occurrence, distribution and frequency, less adaptability of recommended cotton production techniques, growing of cotton on marginal and sub-marginal land approach and very limited use of fertilizer. Farmers from Vidarbha region are not fully aware about balanced fertilizer management of cotton for different hybrids, and only believe in application of nitrogenous fertilizers, due to that production as well as quality of cotton fibre decreases year by year and soil become deficient in micro and macro nutrients. Besides that, farmers want to produce maximum seed-cotton from per unit area through maintaining higher plant geometry without any consideration of optimum plant population. Due to higher plant geometries, plant becomes more susceptible to pest and diseases as compared to optimum plant geometry.

Keeping in mind the struggle between plants for getting more plant nutrients and moisture, it is essential to find out the appropriate combination between variety and spacing to achieve the maximum yield under rainfed condition. Hence, this study on "Effect of planting geometry and varieties on morpho-physiological parameters and yield in cotton" was conducted.

MATERIALS AND METHOD

The field experiment was conducted on field of cotton research unit Dr. PDKV Akola during 2015-16 in *kharif* season. The experiment was laid out in split plot design with three replications. The experiment consisted of twelve treatment combinations comprising of four varieties (AKH-1301, AKH-1302, AKH-081 and Suraj) as main plot and three spacing (45 X10 cm^2 - 2,22,222 plants ha^{-1}, 60 X 10 cm^2 -1,66,666 plants ha^{-1}, 60 X 15 cm^2 -1,11,111 plants ha^{-1}). The gross and net plot sizes were 3.6 m x 3 m and 2.4 m x 2.4 m respectively. Appropriate agronomic package of practice and timely plant protection measures and interculture operations were undertaken to maintain a healthy crop. Observations on morpho-physiological parameters and yield like plant height (cm), Number of functional leaves, leaf area (dm^2), dry matter accumulation $plant^{-1}$, sympodial branches $plant^{-1}$, monopodal $plant^{-1}$ at 60 DAE, seed cotton yield kg $plot^{-1}$ and seed cotton yield kg ha^{-1} were recorded. The experimental data collected during the course of investigation were statistically analyzed with split plot design programme on computer by adopting standard statistical techniques of analysis of variance (Gomez and Gomez, 1984). Wherever, the results were significant, critical differences at P = 0.05 levels were calculated for comparison of treatment means. Data on interaction effects are presented wherever found significant.

RESULTS AND DISCUSSION

Data regarding characters related to morpho-physiological parameters and yield traits are given in table 1.

Plant height

A glance of data would indicate that mean plant height was increased with successive stage of crop growth up to harvest. The mean of plant height at different growth stages ranged from 19.68 cm at 30 DAE to 89.25 cm at harvest. Increase in mean height was more between 60–90 DAE with a rate of increase of 1.45 cm per day. The rate of increase in plant height declined subsequently. Plant height was significantly influenced by different varieties throughout the crop growth period except at 30 DAE. The variety AKH-1301 (V_1) was found to be at par with AKH-1302 (V_2) but significantly superior over the variety AKH-081 (V_3) and SURAJ (V_4) from 60 DAE onwards till harvest. Similar to this result Bharathi *et al.* (2012) reported that variety KDCHH 712 recorded significantly higher plant height over the variety NCS 145 in cotton. **P**lant height was significantly influenced by various plant densities throughout the crop growth period except at 30 and 60 DAE. A spacing 45 x 10 cm^2 recorded significantly more plant height than 60 X 10 cm^2 and 60 X15 cm^2 from 90 DAE onwards till harvest. Jagtap and Bhale (2010) in accordance to this result reported maximum plant height (242.59 cm) at high plant population (90 x 6 cm^2). It was observed that reduction in plant height under wider plant geometry was due to suppression of apical dominance as against closer spacing which induced more vertical growth due to congestion of plant per unit area. The interaction effects due to different levels under study were found to be non-significant in respect to plant height.

Number of functional leaves $plant^{-1}$

The mean number of functional leaves $plant^{-1}$ were found to increase from 30 to 90 DAE and decreased thereafter. Leaf production was more during period of 60 to 90 DAE and produced leaves the rate of 1.23 leaves $plant^{-1}$ day^{-1}. The rate in production of leaves at maturity stage declined due to dropping of older leaves by leaf senescence. The effect of different varieties were found to be non significant in respect of number of functional leaves $plant^{-1}$ at all stages of observation. The differences due to various plant geometry for this trait was significant at all progressive stages except 30 DAE. It was observed that the number of leaves $plant^{-1}$ was showing increasing trend with increase in plant geometry. The maximum number of functional leaves $plant^{-1}$ was recorded under 60 x 15 cm^2 planting geometry which was at par with 60 x 10 cm^2 and significantly superior to 45 x 10 cm^2 at 30, 120 DAE and at harvest. Also spacing of 60 x 15 cm^2 was superior over the 45 x 10 cm^2 and 60 x 10 cm^2 cm at 90 DAE. It was mainly due to the wider space and less plant density under 60 x 15 cm^2. Under less plant density, plant utilized light (solar energy), moisture and nutrients efficiently as compared to closer plant geometry of 45 x 10 cm^2 and 60 x 10 cm^2 where there was more competition among plants for production factors. Similar to this results Hake *et al.*(1992) and Madiwalar and Prabhakar (1998) also reported that more number of functional leaves $plant^{-1}$ in cotton were obtained in wider spacing. Interaction effect was found to be non- significant in respect of number of functional leaves per plant.

Leaf area $plant^{-1}$ (dm^2)

Leaf area being photosynthetic surface plays a vital role in production and availability of photosynthates for seed cotton production. Leaf area $plant^{-1}$ expanded progressively up to 90 DAE and reached to its maximum of 38.65 dm^2 and decreased subsequently due to leaf senescence towards harvest stage. The rate of leaf area expansion was more between 60 to 90 DAE with a rate of 0.896 dm^2 per day. The effect different varieties were found to be non significant in respect of Leaf area (dm^2) $plant^{-1}$ at all stages of observation. Treatment differences were observed due to varied plant geometry in respect of leaf area $plant^{-1}$ throughout the growth stages except at 30 and 60 DAE. The wider spaced plants under 60 x 15 cm^2 planting geometry produced significantly higher leaf area than closer plant geometry of 45 x 10 cm^2 and 60 x 10 cm^2 at 90, 120 and at harvest.

Leaf area was higher in 60 x 15 cm^2 due to wider plant geometry which recorded less plant density and enjoyed more space, light, moisture and nutrient efficiently, solar radiation penetration and utilization of nutrient in a better way to produce effective leaf area $plant^{-1}$ in 60 x 30 cm^2 as compared to 45 x 10 cm^2 and 60 x 10 cm^2, where there was more competition for light, moisture, space and nutrient among plant due to high plant density . This showed that closer plant geometry with higher plant density $unit^{-1}$ area produced higher degree of competition for natural resources and caused reduction in leaf area. These results were similar to earlier finding of Pendharkar *et al.*(2011) who also observed maximum leaf area at planting spacing of 90 x 60 cm^2. The Interaction effects between different varieties and planting geometry found to be non-significant in respect of leaf area $plant^{-1}$.

Dry matter accumulation $plant^{-1}$(g)

The accumulation of dry matter $plant^{-1}$ is probably the best index of growth put forth by crop. It is observed that dry matter accumulation $plant^{-1}$ increased progressively up to 120 DAE, from 1.85 g to 52.74 g $plant^{-1}$ and reached to its maximum at 120 DAE due to the more leaf and boll weight. While subsequent decline in dry matter production at harvest was observed upto 49.70 g $plant^{-1}$, which was due to leaf senescence. The rate of increase in dry matter accumulation was quite less at 30 DAE while maximum rate of dry matter accumulation was observed between 90 to 120 days, i.e. accumulated from 32.66 to 55.83 g dry matter $plant^{-1}$ (0.67g day^{-1}). Effect of different varieties on the dry matter accumulation $plant^{-1}$ was observed to be significant at all stages of plant growth except 30 and 60 DAE. It was observed that variety AKH-1301 (V_1) recorded significantly higher dry matter accumulation $plant^{-1}$ over the variety AKH-081(V_3) and at par with AKH-1302 (V_2) and SURAJ (V_4) at 90 DAE but at harvest it was at par with only SURAJ (V_4). Similarly, variety SURAJ (V_4) recorded higher dry matter accumulation $plant^{-1}$ over the variety AKH-081(V_3) but at par with AKH-1301 (V_1) and AKH-1302 (V_2) at 120 DAE. Similar to this result **Nehra *et al.* (2004[b]) also observed that among the different varieties evaluated *viz.*, LHH 144, MECH 915 Bt, MECH 915 non Bt, MICH 162 Bt and MECH 162 non Bt, the variety LHH 144 recorded significantly higher dry matter accumulation.** Effect of plant geometry on the dry matter accumulation $plant^{-1}$ was observed to be significant at all stages of growth except 30 DAE. Dry matter accumulation increased with decrease in plant density at wider spacing 60 x 15 cm^2 which recorded significantly higher dry matter accumulation $plant^{-1}$ as compared to 45 x 10 cm^2 and 60 x 10 cm^2 plant geometry. Similarly, the plant geometry of 60 x 10 cm^2 also produced maximum dry matter accumulation $plant^{-1}$ over the plant geometry of 45 x 10 cm^2 at 60, 90, 120 DAE and at harvest. Decline in dry matter production at harvest stage was due to dropping of leaves by senescence, the maximum dry matter accumulation was at 120 DAE under wider plant geometry of 60 x 15 cm^2.

Significantly highest dry matter accumulation $plant^{-1}$ under wider plant geometry 60 x 15 cm^2 (S_3) was due to light (solar energy), moisture and nutrients more available $plant^{-1}$ unit area which resulted in maximum growth of photosynthetic structure i.e. leaf area with improved rate of biomass synthesis and consequently dry matter accumulation $plant^{-1}$. This is because dry matter accumulation is directly correlated with photosynthesis. Thus, plant under wider spacing have more photosynthetic active than under closer spacing. The significant decrease in dry matter accumulation $plant^{-1}$ with increase in population pressure. In contrary to this results Jagtap and Bhale (2010) obtained maximum dry matter accumulation $plant^{-1}$ under 90 x 90 cm^2 in cotton.

The interaction effects due to different levels under study were found to be significant in respect to dry matter accumulation $plant^{-1}$ at 120 DAE and at harvest. It was observed that at 120 DAE and at harvest the treatment combination of V_1 X S_3 (AKH-1301 with 60 x 15 cm^2) produced significantly more dry matter $plant^{-1}$ than all the treatment combinations at 120 DAE and at harvest.

Number of sympodial branches plant^{-1}

Sympodial branches plant^{-1} were recorded from 60 DAE onwards at an interval of 30 days. Sympodial branches plant^{-1} were found to increase with the age of crop and attained maximum number at harvest stage. Number of sympodial branches plant^{-1} increased from 2.30 (60 DAE) to 5.71 (at harvest stage). The maximum rate of increase in sympodial branches was recorded during 60–90 DAE. The effect of different varieties were found to be not significant in respect of sympodial branches plant^{-1} at all stages of observation. The effect of plant geometry on sympodial branches was found to be significant at all the stages of crop growth except 30DAE. Plant under wider spacing of 60 x 15 cm^2 produced significantly more number of sympodial branches plant^{-1} than those recorded under closer planting geometry of 45 x 10 cm^2 and 60 x 10 cm^2. Plant geometry of 60 x 10 cm^2 was at par with closer plant geometry of 45 x 10 cm^2 at 120 DAE and at harvest but produced significantly higher sympodial branches plant^{-1} at 60 DAE. The lower plant height of *hirsutum* cotton under wider spacing was due to suppression of apical dominance which resulted in increased branching and vice versa to closer spacing. Under closer spacing increasing the plant population per unit area might have increased competition for light and congestion in the growing crop plants which induced more vertical growth through inter nodal elongation. Thus most of the photosynthates consumed in vertical growth restricted lateral spread (branching). Similar to this results Sisodia and Khamparia (2007) reported decrease in number of sympodia with increase plant densities in cotton. Interaction effect among different varieties and plant geometry was not significant in respect to sympodial branches plant^{-1}.

Number of monopodial branches plant^{-1}

The effect different varieties were found to be not significant in respect of monopodial branches plant^{-1} at 60DA. The effect plant geometry was found to be not significant in respect of monopodial branches plant^{-1} at 60DAE. Interaction effect among different varieties and plant geometry (V x S) was also not significant in respect to sympodial branches plant^{-1}.

Seed cotton yield plot $^{-1}$ (kg)

Seed cotton yield plot^{-1} was 1.18 kg. It was observed that the variety AKH-081(V_3) recorded significantly more seed cotton yield plot^{-1} (1.24 kg) than variety AKH-1301(V_1), AKH-1302(V_2) and SURAJ (V_4). Similarly variety SURAJ (V_4) was found to be at par with varieties AKH-1301(V_1) and AKH-1302(V_2) in respect of seed cotton yield plot^{-1}. Differences due to various plant spacing on the seed cotton yield plot^{-1} were significant. Plant spacing of 45 x 10 cm^2 (1.19 kg) and 60 x 10 cm^2 (1.26 kg) recorded significantly higher seed cotton yield plot^{-1} than the spacing of 60 x 15 cm^2 (1.08 kg). The increase in seed cotton yield plot^{-1} in closer spacing might be due to higher plant population. Such beneficial results were also observed by Narayana *et al.* (2008), Reddy *et al.*(2008) Mohapatra and Nanda (2011) and Paslawar *et al,*(2015), who also reported increased seed cotton yield plot^{-1} in closer spacing in cotton. Interaction was found to significantly influence seed cotton yield plot^{-1}. The treatment combination of V_3S_1 ie., variety AKH-081 with spacing 45 x 10 cm^2 produced significantly higher seed cotton yield (1.36 kg) plot^{-1} than all other treatment combinations. The lowest yield was recorded in treatment combination V_1S_3 (variety AKH-1301 with spacing 60 x 15 cm^2).

Seed cotton yield ha^{-1} (kg) On an average seed cotton yield ha^{-1} was 2040 kg. It was observed that the variety AKH-081(V_3) recorded significantly more seed cotton yield ha^{-1} (2155 kg) than all other varieties. Similarly variety AKH-1302 (V_2) remained at par with varieties AKH-1301(V_1) and SURAJ (V_4) in respect of seed cotton yield ha^{-1}. Significant influence of varieties on seed cotton yield ha^{-1} was reported by **Venugopalan *et al.* (2011).** Differences due to various plant spacing on the final yield performance in terms of seed cotton yield ha^{-1} were significant. A closer spacing of 45 x 10 cm^2 and 60 x10 cm^2 recorded significantly higher seed cotton yield of 2058 kg ha^{-1} and 2190 kg ha^{-1} respectively than wider plant spacing of 60 x 15 cm^2 (1871 kg ha^{-1}). The closer density of 2,22,222 plant ha^{-1} and 1,66,666 plant ha^{-1} recorded more seed cotton yield kg ha^{-1} ie. 10% and 17% respectively over control plant density (1,11,111 plant ha^{-1}). The increase in seed cotton yield in closer spacing was due to significantly higher plant population unit^{-1} area. But here plant population of 1,66,666 plant ha^{-1} recorded more yield than 2,22,222 plant ha^{-1}, because number of picked bolls plant^{-1} (3.20 plant^{-1}) was lower than plant population of 1,66,666 plant ha^{-1} (4.97 plant^{-1}). It is also due to difference in boll weight i.e. 2.66 g boll^{-1} in 45 x10 cm^2 spacing and 2.82 g boll^{-1} in 61 x10 cm^2 spacing. The increase in seed cotton yield in closer spacing was due to significantly higher plant population unit^{-1} area. In comparison to closer spacing wider spacing recorded more number of picked bolls and yield plant^{-1} but higher plant population, which compensated the yield plant^{-1} even though there were lesser number of picked bolls and yield plant^{-1}. Lower plant population is the major cause for its lower seed cotton yield. Similar to this finding Sharma (2004), Raut *et al.* (2005), Reddy *et al.*(2008) and Mohapatra and Nanda (2011) also reported increased yield in closer spacing in cotton. Paslawar *et al.* (2015) also reported highest seed cotton yield (3108 kg ha^{-1}) with high density (2.22 lakh ha^{-1}) in cotton. Interaction effect (V x S) was found to statistically and significantly influence seed cotton yield ha^{-1}. The treatment combination of (V_3S_1) variety AKH-081 with spacing 45 x10 cm^2 produced significantly higher seed cotton yield (2356 kg ha^{-1}) than all other treatment combinations. The lowest yield of 1791 kg ha^{-1} was recorded in treatment combination V_1S_3 (AKH-1301 with spacing 60 x 15 cm^2).

Benefit cost ratio

Mean benefit : cost ratio was 3.00. It was observed that the variety AKH-081(V_3) gave significantly more benefit : cost ratio (3.15) than all other varieties. Plant geometry of 60 x 10 cm^2 recorded higher benefit : cost ratio than spacings of 45 x 10 cm^2 and 60 x 15 cm^2 spacing. In accordance to this result Chavan *et al.* (2011) ,Wankhede *et al.* (2003), Reddy *et al.*(2008) and Mohapatra and Nanda (2011) also observed significant influence of variety and spacing on benefit :cost ratio in cotton. Paslawar *et al.* (2015) also reported highest B: C ratio of 3.17 in 45 x 10 cm^2 spacing. It is inferred from this study that variety AKH-081 recorded significantly superior performance for all the traits studied with BC ratio of 3.15. Similarly plant spacing of 60 x 10 cm^2 showed significant and superior performance for all the traits studied having B:C ratio of 3.22. The variety AKH-081 responded well to higher plant density with a spacing of 45 x 10 cm^2 and recorded maximum seed cotton yield (2356 kg ha^{-1}).

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Table 1. Effect of high plant density and varieties on morpho-physiological parameters and yield in cotton

Treatments	**Plant height (cm)**					**No. of functional leaves**					**Leaf area (dm^2)**				
	30 DAE	**60 DAE**	**90 DAE**	**120 DAE**	**At Harvest**	**30 DAE**	**60 DAE**	**90 DAE**	**120 DAE**	**At Harvest**	**30 DAE**	**60 DAE**	**90 DAE**	**120 DAE**	**At Harvest**
Main plot treatment- Varieties (Genotypes)															
V_1-AKH-1301	20.04	41.92	86.45	91.51	92.98	8.24	27.13	64.32	61.03	34.91	1.64	11.35	38.73	37.78	22.85
V_2-AKH-1302	19.61	41.22	85.62	91.03	92.45	8.04	26.40	64.20	61.60	35.29	1.53	12.23	39.21	37.72	23.45
V_3-AKH-081	19.18	37.90	77.76	80.55	81.74	7.89	26.78	62.11	59.93	34.47	1.78	11.90	37.68	36.85	22.46
V_4-SURAJ	19.89	38.04	84.22	88.66	89.84	7.80	26.07	63.82	61.43	35.67	1.84	11.60	38.97	37.47	23.65
SE(m)±	0.23	0.67	0.60	0.52	0.44	0.13	0.70	0.48	0.35	0.39	0.08	0.48	0.33	0.21	0.25
CD at 5%	**NS**	**2.32**	**2.07**	**1.78**	**1.52**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
Sub plot treatment - Plant densities (Spacings)															
S_1-45 X 10 cm^2 (2,22,222 plants/ha)	19.57	40.23	84.95	88.50	90.13	7.88	25.70	60.20	58.07	31.98	1.72	11.88	37.82	36.77	21.48
S_2-60 x 10	20.00	39.27	83.09	88.19	89.	8.17	26.72	64.17	61.01	35.	1.69	11.92	38.51	37.37	23.

cm² (1,66,666 plants/ha)					22					65					36
S_3- 60 x 15 cm² (1,11,111 plants/ha)	19.47	39.81	82.50	87.12	88.41	7.92	27.37	66.48	63.93	37.62	1.69	11.51	39.62	38.22	24.47
SE(m)±	0.18	0.33	0.54	0.28	0.28	0.11	0.43	0.30	0.27	0.42	0.04	0.31	0.32	0.26	0.22
CD at 5%	**NS**	**NS**	**1.22**	**0.80**	**0.84**	**NS**	**1.30**	**0.90**	**0.81**	**1.26**	**NS**	**NS**	**0.97**	**0.77**	**0.65**
Interaction (V X S)															
SE(m)±	0.36	0.66	0.81	0.53	0.56	0.21	0.87	0.60	0.54	0.59	0.08	0.61	0.65	0.51	0.44
CD at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
GM	**19.68**	**39.77**	**83.51**	**87.94**	**89.25**	**7.99**	**26.59**	**63.61**	**61.00**	**35.08**	**1.70**	**11.77**	**38.65**	**37.45**	**23.10**

Treatments	**Dry matter accumulation plant^{-1} (g)**					**Sympodia branches plant^{-1}**				**Monopodia plant^{-1} at 60 DAE**	**Seed cotton yield (kg/plot)**	**Seed cotton yield (kg/ha)**	**BC ratio**
	30 DAE	**60 DAE**	**90 DAE**	**120 DAE**	**At Harvest**	**60 DAE**	**90 DAE**	**120 DAE**	**At Harvest**				
Main plot treatment- Varieties (Genotypes)													
V_1- AKH-1301	1.82	16.48	33.30	53.56	51.10	2.16	5.02	5.49	5.60	0.64	1.15	1993	2.94
V_2- AKH-1302	1.81	16.84	32.32	52.58	49.30	2.13	5.00	5.56	5.69	0.64	1.15	2001	2.93
V_3- AKH-081	1.85	15.87	30.58	50.90	47.62	2.36	5.16	5.53	5.69	0.60	1.24	2155	3.15
V_4- SURAJ	1.93	16.82	32.70	53.93	50.78	2.40	5.08	5.71	5.87	0.69	1.16	1997	2.96
SE(m)±	0.07	0.38	0.43	0.24	0.25	0.15	0.09	0.09	0.05	0.06	0.01	14.22	-
CD at 5%	**NS**	**NS**	**1.50**	**0.85**	**0.87**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.03**	**49.22**	-
Sub plot treatment- Plant densities (Spacings)													

S_1-45 X 10 cm^2 (2,22,222 plants/ha)	1.72	15.52	30.61	48.29	45.28	2.23	4.73	5.37	5.50	0.68	1.19	2058	2.99
S_2- 60 x 10 cm^2 (1,66,666 plants/ha)	1.91	16.61	31.97	52.53	50.25	2.33	5.05	5.47	5.60	0.62	1.26	2190	3.22
S_3- 60 x 15 cm^2 (1,11,111 plants/ha)	1.92	17.35	34.09	57.41	53.58	2.33	5.42	5.88	6.03	0.63	1.08	1871	2.77
SE(m)±	0.07	0.24	0.27	0.23	0.35	0.10	0.07	0.07	0.06	0.05	0.01	13.56	-
CD at 5%	**NS**	**0.71**	**0.82**	**0.68**	**1.06**	**NS**	**0.22**	**0.20**	**0.18**	**NS**	**0.02**	**40.65**	-
Interaction (V X S)													
V_1S_1				48.17	45.63						1.16	2017	
V_1S_2				52.38	50.37						1.26	2193	
V_1S_3				60.13	57.30						1.03	1791	
V_2S_1				48.67	45.73						1.12	1951	
V_2S_2				52.20	49.37						1.26	2182	
V_2S_3				56.87	52.80						1.06	1847	
V_3S_1				47.23	45.10						1.36	2356	
V_3S_2				51.57	48.47						1.27	2210	
V_3S_3				53.90	49.30						1.09	1899	
V_4S_1				49.10	44.63						1.10	1908	
V_4S_2				53.97	52.80						1.25	2175	
V_4S_3				58.73	54.90						1.12	1947	
SE(m)±	0.14	0.48	0.55	0.46	0.71	0.19	0.15	0.13	0.12	0.11	0.02	27.12	-
CD at 5%	**NS**	**NS**	**NS**	**1.37**	**2.12**	**NS**	**NS**	**NS**	**NS**	**NS**	**0.05**	**81.31**	-
GM	**1.85**	**16.50**	**32.22**	**52.74**	**49.70**	**2.26**	**5.06**	**5.57**	**5.71**	**0.64**	**1.18**	**2040**	**3.00**

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