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Plant Density and Genotype Evaluation for High Density Planting System of Cotton under Rainfed Condition

A. D. Pandagale[1]*, K. S. Baig[1*], S. S. Rathod[1] and T. B. Namade[2]

[1]Cotton Research Station, Nanded (M.S.), India
[2]College of Agriculture, Wadala, Dist. Solapur, India

**Corresponding author*

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A B S T R A C T

A field experiment was conducted to evaluate optimum plant density and suitable *G. hirsutum* cotton genotype for high density planting system under rainfed condition. Plant growth parameters, seed cotton yield and economics of cotton genotypes under various high planting densities were studied during *kharif*, 2013-14 to 2015-16 on medium soil. Increase in plant density has reduced monopodial branches plant^{-1} whereas, number of bolls plant were increased with increase in density. The plant density of 1.66 lakh plants ha^{-1} (spacing 60 x 10 cm) resulted in higher seed cotton yield (1705 kg ha^{-1}) and net monetary returns (Rs. 40,496/- ha^{-1}). The *hirsutum* cotton genotypes NH 615, NH 635 and Suraj were found suitable for high density planting system as exhibited greater number of bolls plant^{-1}, yield plant^{-1}, seed cotton yield ha^{-1} (1742 kg ha^{-1} and 1683 kg ha^{-1}, respectively) and monetary returns. The genotype Suraj was found to be high ginner (37.40 per cent) followed by NH 615 (37.35 per cent).

Introduction

Cotton is one of the principal commercial crops. It plays a vital role in Indian economy. It provides employment on farming, processing and marketing sectors. It provides basic raw material to ginning - pressing, textile industry and export - import of yarn and fabrics. India ranks first in area (122 lakh ha) and production (380 lakh bales) on the globe with 38.13% area and 26.75 % production during 2019-20 (Anonymous, 2020). In India, Maharashtra state has highest average (42 lakh ha). Although, productivity in the state is very low (334 kg lint ha^{-1}) as compared to national (501 kg lint ha^{-1}). Weather aberrations, dominance of rainfed area and cultivation of cotton in shallow and light soils are some of the major reasons for low productivity in central zone. Further, cotton hybrids are predominantly cultivated in India and high cost of *Bt* cotton hybrid seeds is also one of the reasons for farmers indebtness during recurrent crop failure. For improving the productivity and profitability in this region, it necessitates a system which should be alternative for these reasons to the existing *Bt* cotton hybrid cultivation.

High density planting system (HDPS) leads to rapid canopy closing leading to reduced soil water evaporation. Better genotypes which are suitable for HDPS is an option to increase productivity in rainfed cotton with shallow to medium soils. Early maturity in shallow to medium soils doesn't support excessive vegetative growth leading to make high density planting system suitable for upland shallow to medium soils. Genotypes having adoptions in high density is most necessary for HDPS. Conventional and late maturing hybrids often experience terminal drought resulting in low yields (Jost and Cothren, 2001). One need compact, and early genotypes with synchronous boll opening and minimum monopodial branches for HDPS. Spatial arrangement of compact and short statured plants by agronomic manipulation of row spacing with increased plant density can obtain higher yield. There is better light interception, greater leaf area, low weed competition and earliness in crop maturity by adoption of ultra-narrow row cotton (Wright *et al.*, 2011). Early maturity by adoption ultra-narrow cotton can make this higher density planting system suitable to shallow to medium soils where. One needs compact and early genotypes with synchronous boll opening and minimum monopodial branches for HDPS. Spatial arrangement of compact and short statured plants by agronomic manipulation of row spacing with increased plant density can obtain higher yield. There is better light interception, greater leaf area, low weed competition and earliness in crop maturity by adoption of ultra-narrow row cotton (Wright *et al*., 2011). Selection of suitable genotypes and spacing *i.e.* plant population aim at improving the productivity. Present day cotton hybrids are tall growing, spreading type with long duration. Cultivation of *hirsutum* or *arboreum* cotton varieties may be an option to high seed cost which further can reduce production cost with low fertilizer requirement as compared to *Bt* cotton hybrids. Some of the recently released varieties are known for their tolerance to drought, sucking pests and diseases. Jagannathan and Venkitaswamy (1996) revealed that dwarf compact genotypes responded favourably to a population of 1, 11,000 plants ha^{-1} on Vertisols.

Hence an experiment was conducted to find out suitable *hirsutum* cotton genotype for high density planting system and identification of optimum plant density for those genotypes under high density planting system.

Materials and Methods

The field experiment was conducted at Cotton Research Station, Nanded (M.S.) during *kharif* seasons of year 2013-14 to 2015-16 under TMC MM I 1.4 project. The objectives were to evaluate performance of *hirsutum* genotypes under high density planting system with respect to yield and to identify optimum plant density for HDPS under rainfed condition. Nanded is located in Maharashtra state, India which lies in central cotton growing zone at 19.13° North latitude and 77.34° East longitude with an altitude of 362 m above mean sea level. The experiment was conducted with three replication and laid out in split plot design. The soil was medium black with low available nitrogen, medium available phosphorus and high potassium content with soil depth up to 75 cm. The treatments were consisted of three plant densities in main plot *viz.*, 2.22 lakh ha^{-1} (45 x 10 cm), 1.66 lakh ha^{-1} (60 x 10 cm) and 1.11

lakh ha^{-1} (75 x 10 cm) with five *hirsutum* cotton varieties, NH 615, AKH 081, Suraj, NH 545 and NH 635 in sub plot. The crop was sown in 25th, 29th and 25th MW during year 2013-14, year 2014-15 and year 2014-15, respectively. Sowing was delayed in year 2014-15 due to late onset of monsoon. Surplus (52 per cent) rainfall was received during year 2013-14 (June to December) whereas, 46.3 and 37.75 per cent deficit rains over average rainfall were received during later two years. The crop was grown with other recommended package of practices under rainfed condition.

Results and Discussion

Growth characters

The effect of plant densities was not evident on mean plant height and number of sympodial branches plant^{-1} (Table 1). Significant increase in monopodia plant^{-1} (0.79) was observed with lower plant density (1.11 lakh ha^{-1}). Ajaykumar *et al.*, (2017); Udikeri and Shashidhara (2017) also observed increase in number of monopodia plant^{-1} in wider row spacing. Only numerical increase in plant height and reduction in sympodial branches were observed due to increase plant density. All the genotypes exhibited almost similar mean plant height and didn't differed in number of branches plant^{-1}.

Yield attributes and seed cotton yield ha^{-1}

Plant density

The highest number of bolls m^{-2} were recorded in density 2.22 lakh/ha (91.00) which was at par with 1.66 lakh/ha (88.07). Ajaykumar *et al.*, (2017) reported that maximum LAI in higher plant density utilized all natural resources like solar radiation, moisture, space and nutrients resulting in more photosynthesis leading to more number of bolls per unit area, which ultimately improved seed cotton yield. Udikeri and Shashidhara (2017) quoted more boll weight and light transmission in wider spacing whereas, more light absorption in closer spacing.

Mean yield plant^{-1} and boll weight were statistically similar for all the plant densities however, 1.66 lakh ha^{-1} recorded higher numerical values (Table 1). Pradeep Kumar *et al.*, (2017) also reported similar boll weight under different plant densities at Parbhani (MS) under HDPS. Better development of individual plants in wider rows couldn't compensate the yield on area basis.

The seed cotton yield for first year were higher as rains were received in September – October months during boll development stage whereas, deficient rains along with early cessation observed in later two years resulted in low yields (Table 2). Based on pooled mean of three years, plant density of 1.66 lakh ha^{-1} (spacing 60 x 10 cm) recorded highest seed cotton yield (1705 kg ha^{-1}) which was on par with density 2.22 lakh ha^{-1} *i.e.* spacing 45 x 10 cm (1679 kg ha^{-1}). Both higher plant densities (1.66 lakh and 2.22 lakh ha^{-1}) recorded 14.50 and 12.76 per cent increase in seed cotton yield, respectively over lowest density (1.11 lakh ha^{-1}) significantly. Although number of sympodial branches plant^{-1}, yield plant^{-1} and boll weight were not affected due plant densities, even though increase in number of plants per unit area could have compensated the decrease in yield plant^{-1} under high density. This decrease in yield attributes might be caused due to over population of plants in unit area and more competition for light, air, nutrients and moisture (Udikeri and Shashidhara, 2017). Khargkharate *et al.*, (2017) also reported significant yield in 60 x 10 cm spacing (1.66 lakh plants ha^{-1}) over conventional at Akola (MS).

The narrow row spacing might have allowed more interception of light which has translated in yield. Optimum plant density has parabolic relationship with yield which was a function of the genotype, soil type, climate and management (Venugopalan *et al.*, 2013). Increase in yield in HDPS was also reported by Arunvenkatesh and Rajendran (2013); Paslawar *et al.*, (2015); Pradeep Kumar *et al.*, (2017); Nalayini and Manickam (2018). The plant density didn't affect the ginning outturn during all the years and on pooled mean basis (Table 2). Similar results were also reported by Arunvenkatesh and Rajendran (2013); Nalayini and Manickam (2018).

Table.1 Mean plant growth and yield contributing characters as influenced by plant densities and genotypes

Treatment	Plant height (cm)	Mono-podia plant^{-1}	Sympodia plant^{-1}	Yield plant^{-1} (g)	No. of Bolls m^{-2}	Boll weight (g)
Plant density (D)						
D_1 : 2.22 lakh ha^{-1} (45 x 10 cm)	76.33	0.55	9.00	8.61	91.00	1.81
D_2 : 1.66 lakh ha^{-1} (60 x 10 cm)	75.96	0.66	9.85	10.75	88.07	1.93
D_3 : 1.11 lakh ha^{-1} (75 x 10 cm)	74.59	0.79	10.29	12.48	76.98	2.01
SE±	1.01	0.02	0.34	0.92	3.26	0.06
CD at 5%	N.S.	0.05	N.S.	N.S.	9.43	N.S.
Genotypes (G)						
G_1 : NH 615	75.04	0.62	10.02	11.47	92.12	1.97
G_2 : AKH 081	73.55	0.71	9.66	10.21	80.39	1.89
G_3 : Suraj	77.59	0.68	9.50	9.24	72.95	2.03
G_4 : NH 545	75.37	0.64	9.60	10.76	90.37	1.87
G_5 : NH 635	76.59	0.66	9.78	11.39	90.93	1.83
SE±	1.46	0.03	0.24	0.51	3.40	0.06
CD at 5%	N.S.	N.S.	N.S.	1.47	9.83	N.S.
Interaction D x G						
SE±	2.54	0.05	0.42	0.88	5.89	0.11
CD at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
GM	75.63	0.66	9.71	10.61	85.35	1.92

Table.2 Seed cotton yield (kg ha^{-1}) as influenced by plant densities and genotypes

Treatment	Seed cotton yield (kg ha^{-1})				Ginning out turn (%)
	2013-14	2014-15	2015-16	Pooled Mean	
Plant density (D)					
D_1 : 2.22 lakh ha^{-1} (45 x 10 cm)	2553	1287	1196	1679	36.06
D_2 : 1.66 lakh ha^{-1} (60 x 10 cm)	2674	1282	1157	1705	36.14
D_3 : 1.11 lakh ha^{-1} (75 x 10 cm)	2359	1062	1047	1489	36.40
SE±	104.35	34.97	31.54	32.65	0.18
CD at 5%	304.12	101.91	91.92	94.41	N.S.
Genotypes (G)					
G_1 : NH 615	2747	1254	1225	1742	37.35
G_2 : AKH 081	2347	1117	1080	1515	35.13
G_3 : Suraj	2588	1260	1026	1625	37.40
G_4 : NH 545	2403	1218	1048	1556	36.07
G_5 : NH 635	2558	1203	1289	1683	35.16
SE±	69.86	44.02	29.94	33.76	0.27
CD at 5%	203.59	128.30	87.26	97.63	0.73
Interaction D x G					
SE±	121.00	76.24	51.86	58.48	0.46
CD at 5%	352.64	222.22	N.S.	N.S.	1.27
GM	2529	1210	1133	1624	36.22

Table.3 Economics of plant densities and genotypes under HDPS (pooled mean)

Treatment	GMR (Rs. /ha)	NMR (Rs. /ha)	B:C ratio
Plant density (D)			
D_1 : 2.22 lakh ha^{-1} (45 x 10 cm)	77083	38294	1.95
D_2 : 1.66 lakh ha^{-1} (60 x 10 cm)	78468	40496	2.01
D_3 : 1.11 lakh ha^{-1} (75 x 10 cm)	68689	32472	1.85
SE$\pm$	1666	1517	-
CD at 5%	4818	4387	-
Genotypes (G)			
G_1 : NH 615	80292	41926	2.03
G_2 : AKH 081	69704	32701	1.84
G_3 : Suraj	74825	37161	1.95
G_4 : NH 545	71505	34253	1.88
G_5 : NH 635	77409	39395	1.99
SE$\pm$	1601	1401	-
CD at 5%	4631	4051	-
Interaction D x V			
SE$\pm$	2774	4226	-
CD at 5%	N.S.	N.S.	-
GM	74747	37088	1.94

Genotypes

The genotype NH 615 recorded highest mean yield plant^{-1} (11.47 g), bolls m^{-2} (92.12) and seed cotton yield (1742 kg ha^{-1}). It was found on par with NH 635 (1683 kg ha^{-1}). Seed cotton yield ha^{-1} is the product of number of bolls per unit area and individual boll weight. Genotypes NH 615, NH 635 and Suraj were found significantly superior over AKH 081. These results are in conformity with best performance of genotype NH 615 under HDPS at Akola, Nanded, Nagpur and Nandyal under rainfed condition whereas, average performance of Suraj at thirteen locations was better during 2010-11 (AICCIP, 2012). The genotypes had significant variations in ginning out turn (Table 2). Genotype Suraj recorded highest mean GOT (37.40 %) followed by NH 615 (37.35%).

Economics

Highest mean GMR (Rs. 78,468/- ha^{-1}), NMR (Rs. 40,496/- ha^{-1}) and B:C ratio (2.01) were obtained from plant density 1.66 lakh plants ha^{-1} (geometry 60 x 10 cm). Increase in NMR by 24.71 per cent and 17.93 per cent, respectively was received by adopting high density of 1.66 lakh and 2.2 lakh plants ha^{-1} over 1.11 lakh ha^{-1} (Table 3). More monetary returns from higher density were also reported by Paslawar *et al.,* (2015); Khargkharate *et al.,* (2017); Pradeep Kumar (2017); Udikeri and Shashidhara, (2017).

Increase in seed cotton yield ha^{-1} has depicted in increased monetary values of genotypes. Genotype NH 615 recorded highest mean monetary values (GMR- Rs. 80,292/- ha^{-1}, NMR – Rs. 41,926 /- ha^{-1} and B:C ratio 2.03).

In conclusion, cotton yields on medium to shallow soils can be increased by high density planting system. Spacing 60 x 10 cm (plant density of 1.66 lakhs plants ha^{-1}) is optimum for HDPS of *hirsutum* cotton genotypes on medium soil type. *Hirsutum* varieties NH 615, NH 635 and Suraj were found suitable for higher seed cotton yield under HDPS.

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