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INFLUENCE OF GENOTYPES AND PLANT DENSITY ON THE GROWTH AND YIELD OF COTTON

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ABSTRACT

Field experiments were conducted during *winter* irrigated season of 2013-14 and 2014-15 at South Indian Textile Mill Association Farm, (SIMA) Udumalpet with the objective to find out the influence of different genotypes and spacings (high density) on the growth and yield of cotton (*Gossypium hirsutum L.*). The experiments were laid out in a split plot design replicated thrice. Three genotypes *viz,* genotype SHS 102, genotype SHS 374, genotype SHS-2-4 and one variety Anjali were fitted in the main plot and four spacings *viz.*, 45 x 15 cm (Very high density), 45 x 20 cm, 60 x 15 cm (High density) and 60 x 20 cm (Medium high density) respectively were tried in the sub plot. The results of the experiments revealed that all the growth parameters were higher with the genotype SHS 102 and genotype SHS 374. Among the different spacings tested, 45 x 15 cm spacing recorded better growth parameters in the early stages, but, at later stages, 60 x 15 cm spacing recorded better growth parameters. With regard to yield, among the cotton genotypes, genotype SHS 102 and genotype SHS 374 recorded higher seed cotton yield. Among the plant spacings, 60 × 15 cm favourably increased the yield. With regard to the treatment combinations, the genotype SHS 102 and SHS 374 registered better growth components and seed cotton yield at a plant spacing of 60 × 15 cm and both were comparable with each other during both the years of study.

Key words : *Growth, yield, genotypes, plant density, cotton.*

Cotton is a natural part of everyday life which serves the mankind from the cradle to the grave. Cotton plays a key role in socio-economic and political affairs of the world (Kairon *et al.*, 2004). Cotton is one of the most ancient and very important commercial fibre crops of global perspective. Cotton has a significant role in Indian agriculture in terms of industrial development, employment generation and national economy.

The manipulation of row spacing, plant density and the spatial arrangements of cotton plants for obtaining higher yield have been attempted by agronomists for several decades in many countries. The most commonly tested plant densities range from 5 to 15 plants m^{-2} (Kerby *et al.*, 1990) resulting in a population of 50000 to 150000 plants ha^{-1}. The concept on high density cotton planting, more popularly called Ultra Narrow Row (UNR) cotton was initiated by Briggs *et al.* (1967). Ultra narrow row cotton has row spacings as low as 20 cm and plant population on the range of 2 to 2.5 lakh plants ha^{-1}, while conventional cotton is planted in rows of 90 to 100 cm apart and has a plant population of about 1,00,000 plants ha^{-1}. However in India, the recommended plant density for cotton seldom exceeded 55,000 plants ha^{-1}.

The advantages of high density planting system include better light interception, efficient leaf area development and early canopy closure which will shade out the weeds and reduce their competitiveness (Wright *et al.*, 2011). Therefore, the high density planting system (HDPS) is now being conceived as an alternate production system having a potential for improving the productivity and profitability, increasing input use efficiency, reducing input costs and minimizing the risks associated with the current cotton production system in India.

Genotype selection, a key management component in any cropping system, is even more critical in high density planting system. High yielding potential is a predominant consideration with early maturity of the crop. But, plant size and fibre properties are also important factors to be considered.

So far, limited research has been done on this aspect in India. In this context, this experiment was conducted with a view to find out the influence of cotton genotypes under different plant densities on the growth and yield of cotton.

MATERIALS AND METHODS

Field experiments were conducted at SIMA Research Farm during the year 2013-14 and 2014-15 during winter to evaluate different plant density on the growth and yield of cotton genotypes.

The experiments were laid out in split plot design replicated thrice with four cotton genotypes viz., genotype SHS 102, genotype SHS 374, genotype SH-2-4 and Anjali and four spacings viz., 45×15 cm, 45× 20 cm, 60 × 15 cm and 60 × 20 cm. The soil of the experimental site was sandy clay loam in texture, belonging to *Typic Ustropept.* The nutrient status of soil at the beginning of experiment ble-1 : Effect of cotton genotypes and plant density on plant height (cm) of cotton.

Treatment	2013-14			2014-15		
	40 DAS	80 DAS	120 DAS	40 DAS	80 DAS	120 DAS
Genotypes						
- Genotype SHS 102	39.05	75.48	88.47	54.52	102.2	119.6
- Genotype SHS 374	36.60	72.53	83.39	49.46	91.47	107.2
- Genotype SHS-2-4	34.95	68.75	76.61	44.99	76.32	92.17
4 - Anjali	33.75	59.85	68.96	33.92	55.26	77.71
Ed	0.96	1.80	1.98	1.15	2.01	2.56
D (P=0.05)	2.34	4.42	4.84	2.82	4.93	6.27
Plant spacing (cm)						
- 45 × 15 cm	37.98	74.90	88.98	52.28	90.57	110.20
- 45 × 20 cm	37.23	71.03	85.95	48.76	87.45	106.43
- 60 × 15 cm	35.88	66.68	74.81	42.88	78.51	92.70
- 60 × 20 cm	33.28	64.00	67.68	38.98	68.70	87.31
Ed	0.89	1.71	1.95	1.16	2.13	2.54
D (P = 0.05)	1.84	3.52	4.03	2.40	4.39	5.24
nteraction	NS	NS	NS	NS	NS	NS

ble-2 : Effect of cotton genotypes and plant density on leaf area index of cotton (2013-14).

reatment	40 DAS					80 DAS					120 DAS				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S4	Mean
V_1	2.47	2.36	2.24	2.15	2.30	3.17	2.96	2.81	2.69	2.91	3.65	3.50	3.31	3.19	3.41
V_2	2.29	2.21	2.08	1.76	2.08	2.86	2.76	2.60	2.21	2.61	3.39	3.26	3.08	2.61	3.08
V_3	1.73	1.66	1.29	1.26	1.49	2.22	2.09	1.64	1.62	1.89	2.56	2.46	1.91	1.86	2.20
V_4	1.68	1.50	1.44	1.41	1.51	2.15	2.03	1.59	1.57	1.84	2.49	2.39	1.86	1.81	2.14
Mean	2.04	1.93	1.76	1.65		2.60	2.46	2.16	2.02		3.02	2.90	2.54	2.37	
		SEd	CD (P=0.05)					SEd	CD (P=0.05)			SEd		CD (P=0.05)	
V		0.05	0.13					0.06	0.15			0.07		0.18	
S		0.04	0.09					0.06	0.12			0.07		0.15	
V at S		0.10	0.21					0.12	0.26			0.14		0.31	
S at V		0.09	0.20					0.12	0.25			0.14		0.30	

V_1	:	Culture SHS 102	S_1	:	45 × 15 cm
V_2	:	Culture SHS 374	S_2	:	45 × 20 cm
V_3	:	Culture SHS-2-4	S_3	:	60 × 15 cm
V_4	:	Anjali	S_4	:	60 × 20 cm

s low in available nitrogen (190 kg ha^{-1}), medium in ailable phosphorus (13.2 kg ha^{-1}) and medium in available tassium (346 kg ha^{-1}). The cotton crop was raised as per treatments by following all the standard package of ctices.

Observations on growth parameters such as plant ight, LAI, DMP and seed cotton yield were recorded.

SULTS AND DISCUSSION

nt height (Table 1) : During both the years, among the ton genotypes, genotype SHS 102 recorded nificantly taller plants at all the stages followed by notype SHS 374 and both were comparable at 80 DAS. ese were followed by genotype SHS-2-4 at all the ges of observation. This might be due to better sorption of nutrients and genetic nature of the plants. The iety Anjali recorded comparably shorter plants at all the ges of observation. Difference observed for plant height ong cotton varieties can be attributed to variation in netic makeup of plants. These results are supported by the findings of Anwar *et al.* (2002) and Copur (2006) who also reported significant differences among cultivars for plant height.

Considering the plant spacing, closer spacing of 45 x 15 cm (very high density) recorded taller plants followed by the spacing 45 x 20 cm (high density) . The least plant height was observed under the spacing of 60 x 20 cm (medium high density).

With respect to plant spacing, closer spacing of 45 x15 cm (very high density) and 45 x 20 cm (high density) recorded taller plants. In general the plant height increased with decrease in plant spacing. This might be due to competition for light. Earlier studies have already revealed an increase in plant height due to high plant density (Seibert *et al.*, 2006; Bhalerao *et al.*, 2010; Nehra and Yadav, 2012). The findings of Ali *et al.* (2011) who observed that the crop sown at 45 cm plant spacing tended to produce the shortest plants throughout the whole study period, while, the tallest plants were recorded with 15 cm plant spacing as compared

le-3 : Effect of cotton genotypes and plant density on leaf area index of cotton (2014-15).

atment	40 DAS					80 DAS					120 DAS				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S4	Mean
V_1	2.66	2.60	2.14	2.19	2.40	3.32	3.26	2.68	2.74	3.00	3.82	3.74	3.08	3.15	3.45
V_2	2.53	2.08	1.87	1.91	2.10	3.16	2.60	2.34	2.39	2.62	3.64	2.99	2.69	2.75	3.01
V_3	1.66	1.60	1.18	1.53	1.49	2.07	2.00	1.47	1.92	1.86	2.38	2.29	1.69	2.20	2.14
V_4	1.61	1.55	1.14	1.49	1.45	2.01	1.94	1.43	1.86	1.81	2.32	2.23	1.64	2.14	2.08
Mean	2.11	1.96	1.58	1.78		2.64	2.45	1.98	2.23		3.04	2.81	2.27	2.56	
		SEd		CD (P=0.05)				SEd	CD (P=0.05)			SEd		CD (P=0.05)	
V		0.05		0.12				0.06	0.15			0.07		0.17	
S		0.04		0.10				0.06	0.13			0.07		0.15	
at S		0.10		0.21				0.12	0.26			0.14		0.31	
at V		0.09		0.20				0.12	0.25			0.14		0.30	

V_1	:	Culture SHS 102	S_1	:	45 × 15 cm
V_2	:	Culture SHS 374	S_2	:	45 × 20 cm
V_3	:	Culture SHS-2-4	S_3	:	60 × 15 cm
V_4	:	Anjali	S_4	:	60 × 20 cm

-4 : Effect of cotton genotypes and plant density on dry matter production (kg/ha) of cotton (2013-14).

atment	40 DAS					80 DAS					120 DAS				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S4	Mean
V1	1614	1335	1554	1240	1436	3394	3693	4125	3561	3693	4659	4920	5684	4702	4991
V2	1371	1224	1357	1022	1244	3922	3304	3687	3180	3523	5275	4560	4811	4351	4749
V3	1340	970	1039	810	1040	2927	2507	2986	2302	2680	4039	3642	4012	3265	3739
V4	997	768	995	745	876	2530	1940	2568	1957	2249	3546	2864	3546	2765	3180
Mean	1330	1074	1236	954		3193	2861	3342	2750		4380	3996	4513	3771	
	SEd		CD (P=0.05)			SEd		CD (P=0.05)			SEd		CD (P=0.05)		
V	30		75			77		189			107		261		
S	29		60			77		159			105		217		
at S	59		122			155		319			211		436		
at V	58		121			154		319			211		435		

V_1	:	Culture SHS 102	S_1	:	45 × 15 cm
V_2	:	Culture SHS 374	S_2	:	45 × 20 cm
V_3	:	Culture SHS-2-4	S_3	:	60 × 15 cm
V_4	:	Anjali	S_4	:	60 × 20 cm

5 cm plant spacing in silt loam soil of Pakistan is in port of the present findings. The availability of zontal space for individual plant in narrow rows uced due to which intense inter plant competition for ient and light suppressed node appearance and its grew taller in respect of vertical space

f Area Index (Table 2 and 3) : Among the cotton otypes, during both the years, comparably higher LAI observed with genotype SHS 102 followed by otype SHS 374 and SHS-2-4 at all the stages. The otype SHS 102 recorded significantly higher LAI wed by genotype SHS 374 and SH-2-4. The variety li recorded the least LAI.

The genotype SHS 102 recorded significantly higher in both the experiments conducted which is ascribed to better absorption of nutrients, synthesis of more osynthates and thus improving general vigour of the t and hence higher LAI. Difference observed for LAI ng cotton varieties can also be attributed to variation enetic makeup of plants as reported by Anwar *et al.* (2002) and Copur (2006). The LAI was found to decrease at maturity phase due to leaf senescence.

Comparing the plant spacing, the spacing of 45 x 15 cm recorded significantly higher LAI of 2.04, 2.60 and 3.02 at 40, 80 and 120 DAS, respectively followed by 45 x 20 cm. The plants under the spacing of 60 x 20 cm recorded the least LAI. Similar trend of results was observed in 2014-15 also.0.30

Among the treatment combinations, the genotype 102 at the spacing of 45 x 15 cm registered higher LAI (2.47, 3.17 and 3.65 at 40, 80 and 120 DAS, respectively in the year 2013-14) followed by genotype SHS 102 at 45 x 20 m and genotype SHS 374 at the spacing of 45 x 15 cm and were comparable with each other. Similar trend of results was evident in the year 2014-15 also.

Higher LAI was recorded with the spacing of 60 × 15 cm due to less availability of space for individual plant that lead to growth of taller plants utilizing its vertical space which produced more number of leaves. Arjun *et al.* (2010)

Table-5 : Effect of cotton genotypes and plant density on dry matter production (kg/ha) of cotton (2014-15).

Treatment	40 DAS					80 DAS					120 DAS				
	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S_4	Mean	S_1	S_2	S_3	S4	Mean
V_1	1712	1466	1637	1320	1534	3558	3773	4274	3680	3821	4796	5080	5741	4958	5144
V_2	1559	1302	1485	1156	1376	4128	3569	3765	3327	3697	5549	4811	5070	4491	4980
V_3	1424	1023	1286	878	1153	3161	2708	3054	2486	2852	4272	3774	4232	3481	3940
V_4	1071	860	1017	767	929	2732	2095	2655	1990	2368	3706	3066	3704	2926	3351
Mean	1441	1163	1356	1030		3395	3036	3437	2871		4581	4183	4687	3964	
	SEd		CD (P=0.05)			SEd		CD (P=0.05)			SEd		CD (P=0.05)		
V	32		79			81		199			112		273		
S	32		65			81		167			110		226		
V at S	63		131			162		334			220		455		
S at V	63		130			162		334			219		453		

V_1	:	Culture SHS 102	S_1	:	45 × 15 cm
V_2	:	Culture SHS 374	S_2	:	45 × 20 cm
V_3	:	Culture SHS-2-4	S_3	:	60 × 15 cm
V_4	:	Anjali	S_4	:	60 × 20 cm

Table-6 : Effect of cotton genotypes and plant density on yield of cotton (q/ha).

Treatment	2013-14					2014-15				
	S_1	S_1	S_1	S_1	S_1	S_1	S_2	S_3	S_4	Mean
V_1	22.72	22.72	22.72	22.72	22.72	23.17	23.90	25.48	23.68	24.06
V_2	18.90	18.90	18.90	18.90	18.90	19.27	21.92	24.99	21.65	21.96
V_3	15.15	15.15	15.15	15.15	15.15	14.96	17.08	21.99	19.51	18.38
V_4	14.18	14.18	14.18	14.18	14.18	15.02	16.22	21.39	19.24	17.97
Mean	17.74	17.74	17.74	17.74	17.74	18.11	19.78	23.46	21.02	
	SEd		SEd		SEd	SEd		SEd		
V	0.58		0.58		0.58	0.58		0.58		
S	0.41		0.41		0.41	0.41		0.41		
V at S	0.92		0.92		0.92	0.92		0.92		
S at V	0.82		0.82		0.82	0.82		0.82		

V_1	:	Culture SHS 102	S_1	:	45 × 15 cm
V_2	:	Culture SHS 374	S_2	:	45 × 20 cm
V_3	:	Culture SHS-2-4	S_3	:	60 × 15 cm
V_4	:	Anjali	S_4	:	60 × 20 cm

showed that planting cotton at 15 and 22.5 cm spacing produced higher LAI while a further increase in plant pacing reduced LAI significantly in sandy loam soil of Faisalabad, Pakistan. The leaf area index was reduced with wider plant spacing of 60 × 20cm. This is in consonance with the earlier findings of Singh *et al.* (2011) and Brodrick *et al.* (2013). Krieg (1996) noted that there was greater light interception per unit of soil area at the same LAI in narrower rows than with wider ones. The greater light interception could indicate that the leaf area was more uniformly distributed over the soil surface with narrow rows, instead of concentrated over the row centers as with wide rows.

Dry matter production (Table 4 and 5) : Among the different cotton genotypes, genotype SHS 102 recorded significantly higher DMP followed by genotype SHS 374 and both were comparable at 80 and 120 DAS. The variety Anjali recorded lower DMP at all the stages. The same trend of results was evident in 2014-15 also. The genotype SHS 102 recorded significantly higher dry matter production. This might be due to higher LAI and number of leaves as evidenced in the present investigation.

Among the plant spacings in 2013-14, higher DMP was observed under the plant spacing of 45 x 15 cm followed by 60 x 15 cm at 40 DAS. However, at 80 and 120 DAS, the plants under 60 x 15 cm spacing recoded higher DMP followed by 45 x 15 cm and both were comparable. The least DMP was recorded under 60 x 20 cm of spacing at all the stages of observation. Similar trend was observed in 2014-15 also.

The plant DMP was significantly higher with the plant spacing of 60 x 15 cm which might be due to the higher uptake of major nutrients and especially better assimilation of nitrogen and the resultant increase in LAI. With increase in plant population the DMP was decreased due to lower biomass production. Wider spacing recorded higher DMP due to the lesser competition for resources which in better assimilation of nutrients and showed that individual plant dry matter production was higher. This is in confirmation with the findings of Bhalerao and Godavari (2010), Balkcom *et al.* (2010), Dong *et al.* (2012) and Bhalerao *et al.* (2010) who found that crop growth rate and DMP palnt^{-1} was significantly higher when cotton plants were widely spaced than cotton planted closely.

During 2013-14, among the treatment combinations, the genotype 102 at the spacing of 45 x 15 cm registered higher DMP (1614 kg ha^{-1}at 40 DAS) followed by genotype SHS 102 at 60 x 15 cm and genotype SHS 374 at 45 x 15 cm and 60 x 15 cm of plant spacing. At 80 and 120 DAS, the genotype 102 at the spacing of 60 x 15 cm registered higher DMP followed by genotype SHS 374 at 45 x 15 cm and both were comparable among themselves. The least DMP was recorded by the treatment combination of the variety Anjali at 60 x 20 cm spacing at all the stages of observation.

Similar trend was evident in the year 2014-15 also.

Seed cotton yield (Table 6) : Among the cotton genotypes, genotype SHS 102 recorded significantly higher seed cotton yield of 24.20 and 24.06 q ha^{-1} during 2013-14 and 2014-15, respectively. The variety Anjali recorded lower seed cotton yield (17.51 and 17.97 q ha^{-1}during 2013-14 and 2014-15, respectively). However, the yield obtained under the variety Anjali was comparable with the genotype SHS-2-4 during both the years of study.

Among the genotypes, genotype SHS 102 recorded higher seed cotton yield followed by genotype SHS 374 during both the years of study. The yield reduction due to genotype SHS 374 was 11.85 per cent during 2013-14 and 8.72 per cent during 2014-15 comparing the yield under genotype SHS 102. The genotype SHS 102 and 374 recorded comparably higher yields over the other cotton genotypes, which could be attributed due to the increased sympodial branches, fruiting points, higher boll setting and boll numbers as evidenced in the present study.

Better vegetative growth and profuse boll bearing has taken a major share in increasing the seed cotton yield of genotype SHS 102 and SHS 374 over other cotton genotypes. Ongoing growth and development events pertaining to biomass and square production, leaf area maintenance with canopy development were favourably influenced thus realizing higher productivity reflected through higher partitioning of assimilates into the developing bolls. Further the higher seed cotton yield might be attributed due to higher retention of bolls from the first flush of flowers like Bt hybrids with no boll damage. This might have resulted due to utilization of more nutrient energy in the nourishment of maximum number of bolls that were saved from the boll damage. This is in confirmation with the earlier findings of Mayee *et al.* (2004) and Nehra *et al.* (2004) who found that Bt cotton hybrids recorded significantly higher seed yield than non-Bt hybrids because of higher boll retention and significantly higher seed cotton yield reduced bollworm damage.

Among the plant spacings, the plant spacing of 60 × 15 cm recorded significantly higher seed cotton yield (23.01q ha^{-1} in 2013-14 and 23.46 q ha^{-1} in 2014-15) followed by 60 × 20 cm spacing. Lower seed cotton yield was observed with the plant spacing of 45 x 15 cm (17.74 and 18.11 q ha^{-1} in 2013-14 and 2014-15, respectively).

Comparing the plant spacings, high density planting with optimum inter and intra row spacing (60 × 15 cm) recorded higher seed cotton yield compared to closer and wider row sapcing (45 x 15 and 60 x 20 cm, respectively). The yield reduction under very high density planting due to closer spacing of 45 x 15 cm was 15.13 per cent in 2013-14 and 15.69per cent in 2014-15 comparing the yield under medium high density planting of 60 x15 cm. The yield reduction under medium high density due to wider spacing (60 x 20 cm) was 8.82 per cent in 2013-14 and 10.40 per cent in 2014-15 comparing the yield under spacing of 60 x 15 cm (medium high density).

In the year 2013-14, adopting a plant spacing of 60 × 15 cm in genotype SHS 102 significantly recorded higher seed cotton yield of 25.19 q ha^{-1} followed by genotype SHS 102 with 60 x 20 cm of plant spacing (24.96 q ha^{-1}) and both were comparable with each other. The least seed cotton yield was recorded under the treatment combination of variety Anjali at 45 x 15 cm spacing.

During 2014-15, the treatment combination of genotype SHS 102 sown at a spacing of 60 x 15 cm recorded higher seed cotton yield followed by genotype SHS 374 with the plant spacing of 60 x 15 cm and genotype SHS 102 at 60 x 20 cm and were comparable with each other. The least seed cotton yield was recorded under the variety Anjali at 45 x 15 cm spacing.

The interaction between cotton genotypes and plant spacing had also significant influence on seed cotton yield. This showed that optimum plant spacing varied depends on the growth habits and canopy alteration from hybrid to hybrid. This is in consonance with the findings of Bapna *et al.* (1976) who reported that optimum plant density is dependant on the inherent vegetative habit of variety and conditions of soil fertility, moisture and cultural practices.

In both the experiments conducted, genotype SHS 102 and 374 had recorded significantly higher yield with a plant spacing of 60 × 15 cm. This is in conformity with the findings of Anjum *et al.* (2010) who found that maximum seed cotton yield was recorded with 75 cm row spacing followed by 60 cm row spacing, whereas minimum seed cotton yield was observed with 90 cm row spacing. From his it is clearly understood that genotype SHS 102 could ccommodate in optimum plant density and the ompetition between the plants are also found to be esser.

Another factor is that wider spacing (medium high ensity planting) paved a way for enhanced availability of utrients to the crop and increased the nutrient uptake hich helped in improved crop growth, which in turn was xpressed in terms of yield. This is in line with the earlier ndings of Bhalerao *et al.* (2008) and Saleem *et al.* (2009) ho reported similar findings.

CONCLUSION

Among the cotton genotypes, genotype SHS 102 followed by genotype SHS 374 recorded better growth parameters and yield. Among the plant spacings, the plant spacing of 45 × 15 cm recorded better growth parameters in the initial stage. But, later, the plant spacing of 60 x 15 cm favourably increased the growth and seed cotton yield of all the cotton genotypes. With regard to the treatment combinations, the genotype SHS 102 and 374 registered better growth components and seed cotton yield at a plant spacing 60 × 15 cm.

REFERENCES

1. Ali, H., M.N. Afzal, F. Ahmad, S. Ahmad, M. Akthar and R. Atif. 2011. Effect of Sowing Dates, Plant Spacing and Nitrogen Application on Growth and Productivity on Cotton Crop. Intern. *J. Scienti. & Eng.Res., 2(9):* 1-6.
2. Anjum, S.A., M.F. Saleem, L. Wang, L. Xue, M.Q. Shahid and S. Ali. 2010. Growth, lint yield and earliness index of cotton (*Gossypium hirsutum* L.) Cultivars under varying row spacing. *Cotton Sci., 22 (6) :* 611-616
3. Anwar, A.M., M.I. Gill, D. Muhammad and M. Afzal. 2002. Evaluation of cotton varieties at different doses of nitrogen fertilizer. *The Pak. Cottons.* 46(1-4), 35-41.
4. Arjun.D., Chakraborthy and K. Srinivasulu. 2010. A review of light interception in plant stands from leaf to canopy in different plant functional types and in species with varying shade tolerance. *Ecol. Res., 25:* 693-714.
5. Balkcom, K.S., A.J. Price, E.V. Santen, D.P. Delaney, D.L. Boykin, F.J. Arriaga, J.S. Bergtold, T.S. Kornecki and R.L. Raper. 2010. Row spacing, tillage system and herbicide technology affects cotton plant growth and yield. *Field Crops Res., 117:* 219-225.
6. Bapna, J.A., C.T. Patel. and V.P. Chaudhari, 1976. Effect of row width, plant population and fertilizer levels on hybrid-4. *Cotton Devpt., 5(3):* 7-9.
7. Bhalerao, P. D., B. R. Patil, P. U. Ghatol and P. P. Gawande. 2010. Effect of spacing and fertilizer levels on seed cotton yield under rainfed condition. *Indian J. Agric. Res., 44(1):* 74-77.
8. Bhalerao, P.D. and S.G. Godavari. 2010. Productivity and profitability of Bt cotton (Gossypium hirsutum) under various plant geometry and fertilizer levels. Indian J. *Agron., 55(1):* 60-63.
9. Bhalerao, P.D., P.P Gawande, P.U Ghatol and B.R. Patil. 2008. Performance of Bt cotton hybrids for various spacing under rainfed condition. Agric. Sci. Digest, 28(1): 54-56.
10. Briggs, R.E., L.L. Patterson, and G.D. Massey. 1967. Within and between-row spacing of cotton. – Arizona Annual Report. P. 6–7. *Univ. of Arizona Agric. Ext. Service, Arizona*
11. Brodrick, R., M.P. Bange, S.P. Milroy and G.L. Hammer. 2013. Physiological determinants of high yielding ultra-narrow row cotton: Canopy development and radiation use efficiency. Field crops Res., 148: 86-94
12. Copur, O. 2006. Determination of yield and yield components of some cotton cultivars in semi-arid conditions. *Pak. J. Biol. Sci., 9(14):* 2572-2578.
13. Dong, H., W. Li, A.E. Eneji and D. Zhang. 2012. Nitrogen rate and plant density effects on yield and late-season leaf senescence of cotton raised on a saline field. *Field Crops Res., 126:* 137-144
14. Kairon, M.S., D.B. Laise and M.V. Venugopalam. 2004. Cotton. In: R. Prasad (ed.) Field Crops Production, ICAR, New Delhi, India. pp. 646- 674.
15. Kerby, T.A., K.G. Cassman and M. Keeley, 1990. Genotypes and plant densities for narrow row cotton systems II leaf area dry matter partitioning. *Crop Sci., 30:* 649-653.
16. Krieg, D.R. 1996. Physiological aspects of ultra-narrow row cotton production. In: Proc. Beltwide Cotton Conf., Nashville, TN. 9-12 Jan. 1996. Nalt. *Cotton Counc. Am.*, Memphis, TN. p. 66.
17. Mayee, C.D., P. Singh, P. Mohan and D.K. Agarwal. 2004. Evaluation of Bt transgenic intra-hirsutum hybrids for yield and fibre properties. *Indian J. of Agric. Sci., 74(1):* 46-47
18. Nehra P.L. and P.S. Yadav. 2012. Effect of spacing and fertilizer levels on Hirsutum cotton variety H 1300 in canal command area of North West Rajasthan. *J. Cotton Res. Dev., 26(2):* 207-208
19. Nehra, P.L., K.C. Nehara and P.D. Kumawat. 2004. Performance of Bt cotton hybrids at different spacings in canal command area of North-Western Rajasthan. *J. Cotton. Res. Dev., 18(2):* 189-190.
20. Saleem, M.F., S.A. Anjum, A. Shakeel, M.Y. Ashraf and H.Z. Khan. 2009. Effect of row spacing on earliness and yield in Cotton. *Pak. J. Biol., 41(5):* 2179-2188.
21. Seibert, J.D. and A.M. Stewart and B.R. Leonard. 2006. Comparative growth and yield of cotton grown in various densities and configurations. *Agron. J., 98:* 562-568.
22. Singh, D., R. Pandy and V. Kumar. 2011. Performance of Bt and Non Bt cotton hybrids at wider spacing in north western plain zones. *J. Cotton. Res. Dev., 25(2) :*217-220.
23. Wright, D. L., J. J., Marois, R. K. Sprenkel and J. R. Rich. 2011. Production of Ultra Narrow Row Cotton. University of Florida (UF), IFAS Extension. SS-AGR-83.