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Effect of Plant Density and Nitrogen Levels on Yield and Soil by Cotton (*Gossypium hirsutum* L.)

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ABSTRACT: A Field experiment was conducted at Cotton Improvement Project, MPKV, Rahuri during Kharif-2022 to find out the optimum plant geometry and nitrogen levels for Cotton hybrid MRC-7938 BG II, with three plant geometries (120 cm × 45 cm, 120 cm x 60 cm and 120 cm × 75 cm) and three nitrogen levels (75, 100, 125 % RDN.). Outcome of this research revealed that the closer spacing (120 cm × 45 cm) had Significantly higher total seed Cotton yield (1784.67 kg ha^{-1}) and No. of Bollsm^{-2} (67.84m^{-2}) than other plant geometry of 120 cm × 60 cm and 120 cm × 75cm, Even Though yield attributing parameters such as bolls plant^{-1} (46.30), average boll weight (5.33 gm) and seed Cotton yield per plant (66.51 gm)were statically improved in wider as compared to closer spacing. Higher Nitrogen dose (125% RDN) gave higher average boll weight (5.17 gm), No. of bolls per plant (44.15), No. of bolls per m^2 (62.83), seed Cotton yield per plant (65.98 gm) total seed Cotton yield per hectare (1744.22). From the present investigation it can be concluded that the *Kharif Bt.* Cotton variety MRC-7938 shall be sown at spacing 120 cm × 45 cm and apply nitrogen of 125 % RDN under the Maharashtra conditions for getting higher yields, gross monetary returns and net monetary returns with higher benefit cost ratio under the specific Agro-climatic zone IV b.

Keywords: Cotton, spacing, seed Cotton Yield and nitrogen levels.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is one of the most important fibre crop playing key role in economics and social affairs of the world. Cotton (*Gossypium* spp.) is the world's leading natural textile fibre crop despite severe competition from the synthetic fibre continues to enjoy a place of pride in textile industry so it is known as the **'The king of appraisal fibres'** and **'white Gold.'** Cotton fabric is the most skin friendly of all natural fibres available on earth. Cotton contributes about 35 % of the global fabric needs and 60 % of clothing in India (CICR). It is estimated that in India more than 10 million farmers cultivate cotton and the textile industry is the largest agriculture-based industry that gave about 30 million people employment in cotton value addition (CICR website).

Cotton is grown around 60 countries in the world, Cotton in India is grown in eleven states (Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, Maharashtra, Madhya Pradesh, Gujarat, Rajasthan, Haryana and Punjab) under 40% irrigated and 60% rainfed conditions (CICR). Maharashtra has the largest area of 4.0 to 4.2 million hectares of cotton area with more than 90% under rain-fed farms. Area under the cotton is 13 million hectare (Ministry of Agriculture & Farmers Welfare Annual Report 2021-2022) and production is 36.22 million Bales of 170 Kg each (1st advance estimates 2021-2022). Export of raw cotton, Yarn, textile garments, cotton seed cake, etc. earns valuable foreign exchange cotton is the 7th most exported agricultural commodity in terms of the value *i.e.,*13968 crores and nearly 1.214 million Bales of cotton was exported from India (Ministry of Agriculture & Farmers Welfare Annual Report 2021-2022).

According to the data of cotton corporation of India (CCI) Maharashtra state has the highest has the highest area under cotton at 41.84 lakh hectares, but its average lint yield per hectare is lowest among all the states below 350 kgha^{-1}. So, there is a need to increase the productivity and this is possible through the cultivation of the *Bt.* Cotton hybrids with suitable agronomic practices e.g. proper spacing and nutrient management Spacing affects plant growth and fruiting through its effects on the microclimate of the crop. *Bt.* Cotton crop may be producing excessive reproductive growth at close plant geometry. However, numerically lower monopodial with closer plant geometry and lower sympodial with wider plant geometry were observed indicating more period under vegetative growth with wider spacing (Buttar *et al.,* 2007). Closer plant geometry also recorded higher seed cotton yields (Satyanarayana and Setty 2008).

Nutrient management in cotton is complex due to simultaneous production of vegetative and reproductive structures during the active growth phase. The nutrient supplementation period can be increased, which provides long time from square formation to boll development. Hence, nutrient requirement during critical stages can be better met. Need for major nutrients especially nitrogen and potassium rise dramatically when bolls are set on the plants which are major sinks for potassium and high concentrations of potassium are required to maintain sufficient water pressure (water potential) for fibre elongation. Most of the cotton growing soils are losing their fertility level due to continuous mining of the nutrients from the soil.

Thus, an efficient nutrient management plan is the key in the light of the negative nutrient balances. Nutrients management in *Bt.* Cotton is a better challenge to boost production and productivity.

Cultivar selection, a key management component in any cropping system is even more critical in various crop geometry of Cotton production. While high yield potential is a predominant consideration, maturity, plant size, the transgenic present, and fibre properties are also major factors to consider (Pettigrew and Jones 2001). The maximum exploitation of these genotypes can be achieved only after determining their optimum planting densities in comparison to recommended cotton varieties. In general, it was observed that lower plant densities produce high values of growth and yield attributes per plant, but yield per unit area was higher with higher plant densities (Sharma *et al.,* 2000).

MATERIALS AND METHODS

An experiment was conducted during Kharif 2022 at Cotton Improvement Project, MPKV, Rahuri. The geographical situation of Rahuri is on 19.38°N latitude and 74.65°E longitude, with an elevation of 511 metres above mean sea level, and the experiment had nine treatment combinations comprised of the cotton hybrid (MRC-7938 BG II), Three plant geometries (120 cm × 45 cm, 120 cm × 60 cm and 120 cm × 75 cm) as one factor and three nitrogen levels (75, 100 and 125% RDN) as another factor the design was laid out in FRBD with three replications. Experimental field was well prepared by two ploughing followed by harrowing and cultivator and one planking for uniform levelling were performed for sowing of cotton. The soil was medium black in available nitrogen (172 $kgha^{-1}$), phosphorus (12 $kgha^{-1}$) and high in available potassium (610 $kgha^{-1}$) during the crop season. The crop was sown in third week of June by dibbling 2 seeds per hills and full dose of phosphorus and potash were applied before sowing while nitrogen (Urea) was applied in three split doses at the time of sowing, 30 DAS and 60 DAS in 20:40:40 ratio respectively. All production and protection measures were applied as per package of the zone IV b of Rajasthan.

RESULTS AND DISCUSSION

1. Average boll weight. The statistically analysed data in Table 1 and 2. Revealed that average boll weight was higher in the wider spacing (120 cm × 75 cm) *i.e.,* 5.33 gm compared to other spacings. Remarkably higher average boll weight was recorded under higher nitrogen level (125% RDN) *i.e.,* 5.71 gm at harvest and the treatment combination S_3N_3 *i.e.,* spacing 120 cm × 75 cm fertilized with 125 % RDN (5.47 gm) but it was statistically at par with treatment combination S_3N_2*i.e.,* spacing 120 cm × 75 cm fertilized with 100 % RDN (5.33 gm). So the greater average boll weight at higher plant spacing might be due to less competition and availability of resources. These results are in line with those of Hussain *et al.* (2000); Boquet (2005) who reported that by increasing plant density average boll weight decreases.

2. Number of bolls per plant. The statistically analysed data in Table 1 and 2. Revealed that number of bolls per plant was higher in the wider spacing (120 cm × 75 cm) *i.e.,* 46.30 compared to other spacings. Remarkably higher number of bolls per plant was recorded under higher nitrogen level (125%RDN) *i.e.,* 44.15 at harvest Increase in number of bolls per plant with increasing plant spacing can be attributed to more availability of space, less competition and more number of sympodial branches per plant. These results are in line with those of Siddiqui *et al.* (2007) who stated that increase in density decreases number of bolls per plant.

3. Number of bolls per m^2. The statistically analysed data in Table 1 and 2. Revealed that number of bolls per m^2 was higher in the closer spacing (120 cm × 45 cm) *i.e.,* 67.84 compared to other spacings. Higher number of bolls per m^2 was recorded in closer spacing due to more number of plants accommodated per unit area and the similar results were noted by Venugopalan *et al.* (2011); Bhalerao *et al.* (2012). Remarkably higher number of bolls per m^2 was recorded under higher nitrogen level (125% RDN) *i.e.,* 62.83 at harvest this might be due to good vegetation growth of plant. Similar results were observed by Munir *et al.* (2015) and the treatment combination S_1N_3 *i.e.,* spacing 120 cm × 45 cm fertilized with 125 % RDN (71.37).

4. Seed Cotton yield per plant. The statistically analysed data in Table 1 and 2. Revealed that seed Cotton yield per plant was higher in the wider spacing (120 cm × 75 cm) *i.e.,* 66.51 gm compared to other spacings. Remarkably higher seed Cotton yield per plant was recorded under higher nitrogen level (125% RDN) *i.e.,* 65.93 gm at harvest and the treatment combination S_3N_3 *i.e.,* spacing 120 cm × 75 cm fertilized with 125 % RDN (71.75 gm)were reported by Sharma *et al*. (2001).

5. Total seed Cotton yield per hectare. The statistically analysed data in table 1 and 2. Revealed that total seed Cotton yield per hectare was higher in the closer spacing (120 cm × 45 cm) *i.e.,* 1782.44 kg ha^{-1} compared to other spacings. Remarkably higher total seed Cotton yield per hectare was recorded under higher nitrogen level (125% RDN) *i.e.,* 1744.22 kg ha^{-1} at harvest and the treatment combination S_3N_1 *i.e.,* spacing 120 cm × 75 cm fertilized with 125 % RDN (1864.67 kg ha^{-1}) were reported by Sharma *et al*. (2000).

6. Balance sheet of nutrients. Available nitrogen after harvest of crop was significantly influenced due to nitrogen levels Remarkably higher available nitrogen in soil was recorded under higher nitrogen level (125% RDN) was 177.74 kg ha^{-1} at harvest almost similar findings were also reported by Nalyani *et al.* (2010).

Nutrient uptake (nitrogen, Phosphorous and potassium uptake) was recorded highest in higher nitrogen levels (125% RDN) and the values were 114.46, 25.65 and 70.38 kg ha^{-1} at harvest for nitrogen, phosphorous and potassium uptake of plant respectively.

Table 1: **Yield parameters as influenced by spacing and nitrogen levels.**

Treatments	Avg. Boll weight (gm)	No. of bolls $plant^{-1}$	No. of $bollsm^{-2}$	Seed Cotton yield $plant^{-1}$ (gm)	Total seed Cotton yield $plant^{-1}$ (Kg ha^{-1})
Spacing (S)					
S_1 (120 × 45 cm)	4.23	36.84	67.84	55.08	1784.67
S_2 (120 × 60 cm)	4.91	44.58	61.88	65.03	1660.56
S_3 (120 × 75 cm)	5.33	46.30	51.44	66.51	1569.89
S.E. ±	0.046	0.190	0.276	0.596	13.202
C.D. at 5 %	0.139	0.570	0.828	1.787	39.582
Nitrogen Levels (N)					
$N_1$75% RDN (117:81:32 NO_3^- : P_2O_5: k_2O Kg ha^{-1})	4.49	41.53	58.93	59.98	1606.78
$N_2$100% RDN (156:81:32 NO_3^- : P_2O_5: k_2O Kg ha^{-1})	4.82	42.04	59.40	60.65	1664.11
$N_3$125% RDN (196:81:32 NO_3^- : P_2O_5: k_2O Kg ha^{-1})	5.17	44.15	62.83	65.98	1744.22
S.E. ±	0.046	0.190	0.276	0.596	13.202
C.D. at 5 %	0.139	0.570	0.828	1.787	39.582
Interaction (Spacing × Nitrogen levels)					
S.E. ±	0.080	0.329	0.478	1.032	22.867
C.D. at 5 %	0.242	NS	1.435	3.096	68.558

Table 2: **Interaction of spacing and nitrogen levels on yield attributes.**

Treatments	Avg. Boll weight (gm)	No. of bolls m^{-2}	Seed Cotton yield $plant^{-1}$ (gm)	Total seed Cotton yield $plant^{-1}$ (Kg ha^{-1})
S_1N_1 (T1)	3.40	65.46	53.10	1729.00
S_1N_2 (T2)	4.40	66.70	54.36	1760.33
S_1N_3 (T3)	4.90	71.37	57.77	1864.67
S_2N_1 (T4)	4.87	61.13	64.78	1653.33
S_2N_2 (T5)	4.73	60.33	61.89	1622.00
S_2N_3 (T6)	5.13	64.17	68.41	1706.33
S_3N_1 (T7)	5.20	50.18	62.07	1438.00
S_3N_2 (T8)	5.33	51.18	60.65	1610.00
S_3N_3 (T9)	5.47	52.96	65.98	1661.67
S.E. ±	0.080	0.478	1.032	22.867
C.D. at 5 %	0.242	1.435	3.096	68.558

Table 3: Balance sheet of nutrients.

Treatments	A			B			C			D [(A+B) – C]			E			F (E – D)			G (E – A)		
	Initial nutrient status of soil (kg ha^{-1})			Nutrients added by the fertilizers (kg ha^{-1})			Total Nutrient uptake by Cotton crop (kg ha^{-1})			Expected nutrient balance (kg ha^{-1})			Actual post-harvest nutrient status of soil (kg ha^{-1})			Apparent Gain/Loss of nutrients in soil (kg ha^{-1})			Actual Gain/Loss of nutrients in soil (kg ha^{-1})		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
T_1	172.6	12	610.2	117.0	81.3	32.5	75.8	13.3	43.6	213.8	80	599.1	162.9	11.2	590.8	-50.9	-68.8	-8.3	-9.7	-0.8	-19.4
T_2	172.6	12	610.2	156.0	81.3	32.5	95.2	17.3	57.2	233.4	76	585.5	170.1	10.6	590.0	-63.3	-65.4	4.5	-2.5	-1.4	-20.2
T_3	172.6	12	610.2	196.0	81.3	32.5	114.1	25.6	69.1	254.5	67.7	573.6	174.2	10.4	589.4	-80.3	-57.3	15.8	1.6	-1.6	-20.8
T_4	172.6	12	610.2	117.0	81.3	32.5	76.1	14.4	45.6	213.5	78.9	597.1	162.4	10.8	591.1	-51.1	-68.1	-6	-10.2	-1.2	-19.1
T_5	172.6	12	610.2	156.0	81.3	32.5	94.5	18.6	56.6	234.1	74.7	586.1	171.4	10.6	590.3	-62.7	-64.1	4.2	-1.2	-1.4	-19.9
T_6	172.6	12	610.2	196.0	81.3	32.5	113.7	26.0	70.9	254.9	67.3	571.8	175.5	10.3	589.8	-79.4	-57	18	2.9	-1.7	-20.4
T_7	172.6	12	610.2	117.0	81.3	32.5	75.3	14.3	42.6	214.3	79	600.1	164.3	11.4	590.3	-50	-67.6	-9.8	-8.3	-0.6	-19.9
T_8	172.6	12	610.2	156.0	81.3	32.5	95.3	18.8	58.5	233.3	74.5	584.2	169.7	10.5	590.0	-63.6	-64	5.8	-2.9	-1.5	-20.2
T_9	172.6	12	610.2	196.0	81.3	32.5	114.2	25.4	71.1	254.4	67.9	571.6	174.8	10.1	590.5	-79.6	-57.8	18.9	2.2	-1.9	-19.7
Mean	172.6	12	610.2	196.0	81.3	32.5	94.9	19.3	57.2	234.0	74	585.5	169.5	10.6	590.2	-64.5	-63.4	4.7	-3.1	-1.4	-20

CONCLUSIONS

From the present investigation it can be concluded that the *Kharif Bt.* Cotton variety MRC-7938 shall be sown at spacing 120 cm × 45 cm and apply nitrogen of 125 % RDN under Maharashtra conditions for getting higher yields with best use of resources and money.

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