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NFLUENCE OF GENOTY PES AND PLANT DENSITY ON THE NUTRIENT UPTAKE AND IELD OF COTTON AND SOIL FERTILITY

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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 nutrient uptake and yield of cotton (G*ossypium hirsutum L.*) and soil fertility status. 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 among the cotton genotypes, the genotype SHS 102 and genotype SHS 374 recorded higher nitrogen, phosphorus and potassium uptake at all the stages and higher seed cotton yield. Among the different plant spacings, 60 × 15 cm spacing recorded significantly higher nitrogen, phosphorus and potassium uptake and seed cotton yield than the other plant spacings. The plots in which the variety Anjali was cultivated recorded higher soil available nitrogen, phosphorus and potassium followed by genotype SHS-2-4. The plant spacing 45 x15 cm registered higher soil available nutrients followed by 45 x 20 cm.

ey words : *Nutrient uptake, yield, genotypes, plant density, cotton, soil fertility.*

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

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

The advantages of high density planting system nclude better light interception, efficient leaf area development and early canopy closure which will shade ut 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 nutrient uptake and yield of cotton (G*ossypium hirsutum L.*) and soil fertility status.

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 the nutrient uptake and yield of cotton (G*ossypium hirsutum L.*) and soil fertility status.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 was low in available nitrogen (190 kg ha^{-1}), medium in available phosphorus (13.2 kg ha^{-1}) and medium in available

e-1 : Effect of cotton genotypes and plant density nitrogen uptake (kg ha^{-1}) by cotton.

Treatment	2013-14			2014-15		
	40 DAS	80 DAS	120 DAS	40 DAS	80 DAS	120 DAS
notypes						
- Genotype SHS 102	17.54	55.56	78.68	18.41	58.34	82.61
- Genotype SHS 374	15.83	48.47	71.51	16.62	50.90	72.98
- Genotype SHS-2-4	14.85	46.98	61.09	15.59	49.33	64.57
- Anjali	12.65	39.34	53.64	13.29	41.30	57.99
Ed	0.39	1.24	1.73	0.41	1.31	1.82
D (P=0.05)	0.97	3.04	4.24	1.01	3.20	4.46
ant spacing (cm)						
- 45 × 15 cm	14.69	44.12	55.04	15.42	46.33	63.76
- 45 × 20 cm	15.00	47.07	60.82	15.75	49.42	65.61
- 60 × 15 cm	15.90	51.95	80.82	16.69	55.54	84.86
- 60 × 20 cm	15.28	47.22	68.24	16.04	49.58	63.92
Ed	0.38	1.21	1.69	0.40	1.27	1.77
D (P=0.05)	0.79	2.49	3.49	0.83	2.61	3.65
teraction	NS	S	S	S	S	S

ble-2 : Effect of cotton genotypes and plant density phosphorus uptake (kg ha^{-1}) by cotton.

Treatment	2013-14			2014-15		
	40 DAS	80 DAS	120 DAS	40 DAS	80 DAS	120 DAS
enotypes						
V_1 - Genotype SHS 102	3.36	11.91	13.10	3.53	12.50	13.75
V_2 - Genotype SHS 374	2.74	9.49	10.44	2.88	9.97	10.96
V_3 - Genotype SHS-2-4	2.73	8.46	9.30	2.87	8.88	9.77
V_4 - Anjali	2.34	7.41	8.15	2.45	7.78	8.56
SEd	0.07	0.26	0.28	0.07	0.27	0.30
CD (P=0.05)	1.17	0.63	0.69	0.18	0.66	0.73
Plant spacing (cm)						
S_1 - 45 × 15 cm	2.58	7.99	8.79	2.71	8.39	9.23
S_2 - 45 × 20 cm	2.67	8.56	9.42	2.81	8.99	9.89
S_3 - 60 × 15 cm	3.27	11.46	12.60	3.43	12.03	13.23
S_4 - 60 × 20 cm	2.65	9.26	10.18	2.79	9.72	10.69
SEd	0.07	0.24	0.27	0.07	0.26	0.28
CD (P=0.05)	1.15	0.50	0.55	0.15	0.53	0.58
nteraction	S	S	S	S	S	S

tassium (346 kg ha^{-1}). The cotton crop was raised as per e treatments by following all the standard package of ractices.

Nutrient uptake by the crop was estimated using andard procedures. Observations on seed cotton yield ere recorded. The post harvest soil nutrient status was nalysed.

ESULTS AND DISCUSSION

utrient Uptake

itrogen uptake : Among the cotton genotypes, omparably higher nitrogen uptake was recorded by the otton genotype SHS 102 followed by genotype SHS 374 and genotype SHS-2-4 in the year 2013-14 at all the stages of observation (Table 1). The variety Anjali recorded the least uptake of nitrogen.

With regard to plant spacings, plants under the spacing of 60 × 15 cm recorded significantly higher nitrogen uptake compared to all other spacings tested, followed by 60 × 20 and 45 x 20 cm at all the stages. Significantly lower uptake of nitrogen was observed under 45 x 15 cm spacing at 80 and 120 DAS.

The nutrient upatake was significantly influenced by cotton genotypes and plant spacings. The genotype SHS 102 had higher nitrogen uptake over the other cotton genotypes irrespective of stages which in turn contributed

ble-3 : Effect of cotton genotypes and plant density potassium uptake (kg ha^{-1}) by cotton.

Treatment	2013-14			2014-15		
	40 DAS	80 DAS	120 DAS	40 DAS	80 DAS	120 DAS
Genotypes						
V_1 - Genotype SHS 102	17.86	50.21	56.56	18.75	52.72	59.39
V_2 - Genotype SHS 374	15.75	40.03	45.09	16.54	42.03	47.34
V_3 - Genotype SHS-2-4	15.13	35.66	40.17	15.88	37.45	42.18
V_4 - Anjali	12.85	31.26	35.21	13.49	32.82	36.97
SEd	0.40	1.08	1.22	0.42	1.14	1.28
CD (P=0.05)	0.98	2.65	2.98	1.02	2.78	3.13
Plant spacing (cm)						
S_1 - 45 ´ 15 cm	14.49	33.70	37.96	15.21	35.39	39.86
S_2 - 45 ´ 20 cm	15.13	36.11	40.67	15.89	37.91	42.71
S_3 - 60 ´ 15 cm	16.37	48.31	54.42	17.19	50.73	57.14
S_4 - 60 ´ 20 cm	15.60	39.04	43.97	16.37	40.99	46.17
SEd	0.39	1.03	1.16	0.41	1.08	1.21
CD (P=0.05)	0.81	2.12	2.38	0.85	2.22	2.50
Interaction	S	S	S	S	S	S

ble-4 : Effect of cotton genotypes and plant density on yield of cotton (q ha^{-1}).

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

more reproductive bodies and ultimately higher yield as evidenced in this investigation. Active physiological process and accelerated growth might have enhanced the nitrogen uptake by this cotton genotype. The top yielder's of the experiment genotype SHS 102 and genotype 374 had recorded significantly higher nitrogen uptake as compared to other genotypes which showed the positive coherent correlation between nitrogen uptake and seed cotton yield. This is in consonance with the earlier report of Poonguzhalan (2003) who reported that nitrogen uptake had positive correlation with yield.

Among the spacing, higher nitrogen uptake was recorded with 60 × 15 cm which might be due to optimum plant population and less competition for nutrients. This is in line with the findings of Devraj *et al.* (2011), Janat and Khalout (2011) and Brodrick *et al.* (2012) who found that quantum of N, P and K removal per unit area was found to be linearly related to plant density.

Phosphorus uptake : Among the cotton genotypes, genotype SHS 102 recorded comparably higher phosphorus uptake at all the stages followed by genotype SHS 374 and both were comparable with each other at 40 DAS (Table 2). The variety Anjali recorded the least phosphorus uptake at all the stages of observation.

Comparing the different plant spacings tested, 60 × 15 cm spacing recorded significantly higher phosphorus uptake (3.27, 11.46 and 12.60 kg ha^{-1} at 40, 80 and 120 DAS, respectively in 2013-14) than the other plant spacings. The least phosphorus uptake was registered under closure spacing of 45 x 15 cm.

Table-5 : Effect of cotton genotypes and plant density on post-harvest soil available NPK (kg ha^{-1}).

Treatment	2013-14			2014-15		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Genotypes						
V_1 - Genotype SHS 102	205.9	12.35	257.3	175.0	11.53	247.0
V_2 - Genotype SHS 374	225.8	13.55	282.3	192.0	12.65	271.0
V_3 - Genotype SHS-2-4	240.8	14.45	301.0	204.7	13.48	288.9
V_4 - Anjali	259.9	15.60	324.9	221.0	14.56	311.9
SEd	6.66	0.40	8.33	5.66	0.37	7.99
CD (P=0.05)	5.45	0.98	20.38	13.86	0.91	19.56
Plant spacing (cm)						
S_1 - 45 × 15 cm	241.9	14.51	302.3	205.6	13.54	290.2
S_2 - 45 × 20 cm	237.1	14.22	296.4	201.5	13.28	284.5
S_3 - 60 × 15 cm	223.4	13.41	279.3	189.9	12.51	268.1
S_4 - 60 × 20 cm	230.0	13.80	287.6	195.5	12.88	276.1
SEd	16.30	0.33	6.82	4.64	0.31	6.55
CD (P=0.05)	11.26	0.68	14.07	9.57	0.63	13.51
Interaction	NS	NS	NS	NS	NS	NS

The cotton genotypes SHS 102 and SHS 374 warranted more amount of phosphorus at the boll forming phase expressed with higher P uptake and this might be one of the reasons for higher boll weight and higher boll number besides its genetic makeup. This is in confirmation with the earlier findings Srinivasasn and Venkatesan (2002) who observed that higher phosphate and plant uptake at the boll development phase favourably increased the boll number and development. The N, P, and K uptake was higher under optimum density of planting and this is in conformity with the earlier findings of Jain and Katti (1983) and they found that quantum of N, P and K removal per unit area was found to be inversely related to plant density and nutrient absorption by individual plants.

Potassium uptake : The genotype SHS 102 recorded significantly higher potassium uptake followed by genotype SHS 374 at 40, 80 and 120 DAS (Table 3). The variety Anjali recorded the least uptake.

Considering the plant spacings, plants under the spacing of 60 × 15 cm recorded significantly higher potassium uptake (16.37, 48.31 and 54.42 kg ha^{-1} at 40, 80 and 120 DAS, respectively in 2013-14) compared to all other spacings tested, followed by 60 x 20 cm and 45 x 20 cm at all the stages. Significantly lower uptake of potassium was observed under 45 x 15 cm spacing at all the stages of observation.

The genotype SHS 102 registered higher uptake of K followed by genotype SHS 374. This might be due to better growth of these genotypes even from the earlier stages which led to higher uptake.

Among the spacing, higher potassium uptake was recorded with 60 × 15 cm which might be due to optimum plant population and less competition for nutrients. This is in line with the findings of Govindan (1989) who reported that optimum plant density (1, 00,000 plants ha^{-1}) significantly increased the uptake of potassium.

Seed cotton yield (Table 4) : 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 (Table 4). 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

rough higher partitioning of assimilates into the eveloping bolls. Further the higher seed cotton yield ight be attributed due to higher retention of bolls from e first flush of flowers like Bt hybrids with no boll amage. This might have resulted due to utilization of ore nutrient energy in the nourishment of maximum mber of bolls that were saved from the boll damage. is is in confirmation with the earlier findings of Mayee *et* (2004) and Nehra *et al.* (2004) who found that Bt cotton brids recorded significantly higher seed yield than n-Bt hybrids because of higher boll retention and gnificantly higher seed cotton yield reduced bollworm amage.

Among the plant spacings, the plant spacing of 60 × cm recorded significantly higher seed cotton yield 3.01q ha^{-1} in 2013-14 and 23.46 q ha^{-1} in 2014-15) llowed by 60 × 20 cm spacing. Lower seed cotton yield as observed with the plant spacing of 45 x 15 cm (17.74 nd 18.11 q ha^{-1} in 2013-14 and 2014-15, respectively).

Comparing the plant spacings, high density planting th optimum inter and intra row spacing (60 × 15 cm) corded higher seed cotton yield compared to closer and der row sapcing (45 x 15 and 60 x 20 cm, respectively). he yield reduction under very high density planting due closer spacing of 45 x 15 cm was 15.13 per cent in 013-14 and 15.69per cent in 2014-15 comparing the eld under medium high density planting of 60 x15 cm. he yield reduction under medium high density due to der spacing (60 x 20 cm) was 8.82 per cent in 2013-14 nd 10.40 per cent in 2014-15 comparing the yield under pacing of 60 x 15 cm (medium high density).

In the year 2013-14, adopting a plant spacing of 60 × 5 cm in genotype SHS 102 significantly recorded higher eed cotton yield of 25.19 q ha^{-1} followed by genotype HS 102 with 60 x 20 cm of plant spacing (24.96 q ha^{-1}) nd both were comparable with each other. The least eed cotton yield was recorded under the treatment ombination of variety Anjali at 45 x 15 cm spacing.

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

The interaction between cotton genotypes and plant pacing had also significant influence on seed cotton ield. This showed that optimum plant spacing varied epends on the growth habits and canopy alteration from ybrid to hybrid. This is in consonance with the findings of apna *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 at 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 this it is clearly understood that genotype SHS 102 could accommodate in optimum plant density and the competition between the plants are also found to be lesser.

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

Post harvest available soil nutrients

Available nitrogen : Among the genotypes, the plot in which the variety Anjali was cultivated registered higher soil available nitrogen (259.9 and 221.0 kg ha^{-1} during 2013-14 and 2014-15, respectively) followed by genotype SHS-2-4 (Table 5). The plot in which genotype SHS 102 and 374 were cultivated recorded lesser available nitrogen.

Regarding the plant spacings, plant spacing of 45 x 15 cm registered higher soil available nitrogen (241.9 and 205.6 kg ha^{-1} during 2013-14 and 2014-15, respectively) followed by 45 x 20 cm spacing. The plant spacing of 60 x 15 cm recorded the least soil available nitrogen during both the years of the study.

Available phosphorus : With respect to cotton genotypes, the plot in which the variety Anjali was cultivated recorded higher available phosphorus (15.60 and 14.56 kg ha^{-1} during 2013-14 and 2014-15, respectively) followed by genotype SHS-2-4 during both the years (Table 5). The least available phosphorus was recorded in plot cultivated with genotype SHS 102 during both the years.

Among the plant spacings, plant spacing of 45 x 15 cm registered higher soil available phosphorus followed by 45 x 20 cm and both were comparable with each other during both 2013-14 and 2014-15. The spacing of 60 x 15 cm and 60 x 20 cm recorded lesser available phosphorus.

Available potassium : Higher soil available potassium was recorded under variety Anjali followed by genotype SHS-2-4 during both the years(Table 5). The genotype SHS 102 recorded lesser available K during both the years of study.

With regard to plant spacings, higher soil available tassium (302.3 and 290.2 kg ha^{-1} during 2013-14 and 14-15, respectively) was recorded under 45 x 15 cm acing followed by 45 x 20 cm spacing and both were mparable with each other during both the years of study.

Cotton is a deep-rooted crop, voracious feeder of trients that responds well for nitrogen but not with osphorous and potassium (Blaise, 2004). Cotton quires the constant supply of nutrients; the response s more during flowering and boll development.

The soil available nitrogen, phosphorus and tassium were significantly influenced by different cotton notypes during both the years (Fig. 18 and 19). The ailable N, P and K was higher with the variety Anjali and is might be due to lower dry matter produced with a sult of lower nutrient uptake at all the stages of nutrient alysis which lead to more quantity of N, P and K ailability in soil over other genotypes.

With regard to plant spacings, higher available N,P nd K was recorded with closer spacing of 45 x 15 cm and is might be due to lesser amount of nutrient uptake and y matter production under closer spacing as evidenced the present investigation.

ONCLUSION

mong the cotton genotypes, the genotype SHS 102 and enotype SHS 374 recorded higher nitrogen, phosphorus nd potassium uptake at all the stages and seed cotton eld. Among the different plant spacings, 60 × 15 cm pacing recorded significantly higher nitrogen, hosphorus and potassium uptake and seed cotton yield han the other plant spacings. The plots in which the ariety Anjali was cultivated recorded higher soil available itrogen, phosphorus and potassium followed by enotype SHS-2-4. The plant spacing of 45 x15 cm egistered higher soil available nutrients followed by 45 x 0 cm.

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