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Performance of compact cotton (*Gossypium hirsutum* L.) genotypes to varied nutrient levels under high density planting system in winter irrigated condition

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Abstract
A field study was conducted during winter season (August-January) of 2018-19 in Tamil Nadu Agricultural University, Coimbatore to study the influence of compact cotton (*Gossypium hirsutum* L.) genotypes to varied nutrient levels under high density planting system. There were twelve treatment combinations, containing three variety/genotype in main plot (M_1-CO 15, M_2- TCH 1819 and M_3- TCH 1822) and four nutrient levels in sub plots (S_1- 100% Recommended dose of fertilizer (RDF), S_2- 125%RDF, S_3- 150%RDF and S_4-STCR based recommendation and the experiment was replicated thrice in a split plot design. The results revealed that growth of cotton crop like plant height, leaf area index and drymatter production was higher in CO 15 variety than other genotypes. Genotype TCH 1822 recorded higher yield (2335 kgha^{-1}) with higher boll weight (4.72 gboll^{-1}) than others. Application of 150% RDF (100:50:50 kg NPKha^{-1}) recorded higher growth parameters while application of 125% RDF (100:50:50 kg NPKha^{-1}) recorded higher yield (2324 kgha^{-1}) with more number of bollsplant^{-1} (13.78) and higher boll weight (4.53 gboll^{-1}) over other levels.

Keywords: Cotton, high density planting system, variety/genotype, nutrient levels, growth, yield

Introduction
Cotton (*Gossypium* spp.), the white gold is the widely used natural fibre and leading fibre crop around the world so called as ‘King of fibres’. It is grown in more than 100 countries under diverse agro-climatic conditions around the world (Anon., 2012) [3]. The cotton farming systems vary widely between geographical areas. In countries such as USA, Australia and Brazil, cotton is grown on larger, modernized farms using more mechanized technology. In India, it is in small-scale with labour intensive production like hand weeding and picking. The high density planting system 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 (Venougopalan *et al*., 2013) [20]. The availability of compact genotypes, altering of crop geometry, application of growth regulators and application of fertilizers on need based will bring the high density cotton under mechanized cultivation in India.
To mechanize the cotton cultivation since it is a labour intensive and to increase the profitability, compact cotton genotypes provide a great scope. Compact genotypes are ideally suited for machine pickings and high density planting because of their short stature, lesser vegetative growth, fewer and shorter fruiting branches, short inter branch and inter boll distance and synchronous maturity(Coffey and Davis, 1981) [6]. Due to their earliness it can be harvested in two or three pickings (Patil *et al*., 2007) [12].
Mostly all plants require the same mineral elements; however, the quantity, rate and timing of uptake vary with crop, variety, climate and soil characteristics. For every 100 kg of seed cotton produced, the crop depleted the soil by 6-7 kg of N, 1.9-2.5 kg P, 6-8 kg of K (Singh and Blaise, 2000) [15]. It is necessary to find whether the demand for nutrients is greater under high density planting system (HDPS) since the plant population is higher. So, to sustain the cotton productivity with economic and environmental safety, there is a need to optimize the nutrient requirement for *Gossypium hirsutum* of compact variety/genotypes at a spacing of 100 x 10 cm accommodating 1,00,000 plantsha^{-1}. Hence, the present study was formulated to study the nutrients influence on varieties/genotypes suits for HDPS.

Materials and methods

A field experiment was conducted at Cotton Breeding Station, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore, located in the Western Agro-climatic zone of Tamil Nadu (11° 02’ N latitude, 76° 93’ E longitude and at an altitude of 428.5 metresabove mean sea level) during winter season (August-January) of 2018-19 and the rainfall received during the cropping season was 331.4 mm. The soil from the experimental field belongs to Irugur series exhibiting red sandy clay loam texture, slightly alkaline reaction (8.26) and non – saline conditions (0.45dSm^{-1}). The initial soil fertility status showed medium organic carbon (0.59%), low available N (224.7 kg ha^{-1}) and high available P (70.80 kg ha^{-1}) and available K (1318 kg ha^{-1}).

The experiment was laid out in a split plot design with three replications. The experiment comprised of twelve treatment combinations, containing three variety/genotype in main plot (M_1-CO 15, M_2- TCH 1819 and M_3- TCH 1822) and four nutrient levels in sub plots (S_1–100% Recommended dose of fertilizer (RDF)(80:40:40 kg NPK ha^{-1}), S_2-125% RDF(100:50:50 kg NPK ha^{-1}), S_3-150% RDF (120:60:60 kg NPK ha^{-1}) and S_4-STCR based recommendation (for 100% RDF with target yield of 2.5 tha^{-1}).

The following production factors are common for all the treatments as per CPG (2012) [7]. Urea (46% N), diammonium phosphate (18% N, 46% P_2O_5) and muriate of potash (60% K_2O) were used as source of N, P and K, respectively and FYM of 12.5 tha^{-1} were applied as basal. Before sowing, seeds were treated with biofertilizers of *Azospirillum* (600 gha^{-1}) and Phosphobacteria (600 gha^{-1}) and then, treated seeds were sown by hand dibbling with the spacing of 100 x 10 cm along the sides of ridges on 25thAugust 2018. TNAU micronutrient mixture was applied @ 15 kgha^{-1} after sowing. Growth retardent of Mepiquat chloride @ 50 g a.i.ha^{-1} was sprayed at square formation and boll development stages. Foliar spray of TNAU Cotton plus @ 6.25 kgha^{-1} was sprayed at flowering and at boll formation stages. Observations were recorded as per the standard procedure laid out for cotton crop and the data were subjected to statistical analysis as described by Gomez and Gomez (2010) [8].

Results and Discussion

Plant height (cm)

Plant height differs significantly among the varieties/genotypes and also among the fertilizer levels (Table 1). Significantly higher plant height was observed in variety CO 15 (109.9 cm) followed by TCH 1819 (94.78 cm) which was on par with TCH 1822 (93.17) and recorded lower plant height.This is because of the compact types had a shorter stature, attributable to shorter plant height (Ahmed, 2000) [1]. Similar results were reported by Tamilselvam *et al*. (2013) [17]. Among the levels of fertilizer, 150% RDF (120:60:60 kg NPKha^{-1}) recorded significantly higher plant height (104.3 cm) over the other treatments which was on par with 125% RDF (101.7 cm). STCR based nutrient management observed lower plant height (94.21 cm) while it was on par with 100% RDF (97.02 cm). These results are in conformity with the findings of Zarina *et al*. (2011) [21], Udikeri and Shashidhara (2017) [19] reported that plant height increased linearly with each increment of N from 0 to 150 kgha^{-1}. However interaction effect of variety/genotype and nutrient levels were found non-significant (Table 1).

Leaf Area Index (LAI)

There existed a significant difference in leaf area index of cotton (Table 1a). Among the variety/genotype, CO 15 variety recorded significantly higher LAI of 2.67 compared to other genotypes. More number of leaves produced in CO 15 variety with almost similar size of leaves with other genotypes resulted in increased LAI. Differences in leaf area index might be differences in genetic makeup *viz*., short stature, number of leaves per plant and shape of leaf as the broad leaf characters and okra type leaf characters (Kumar *et al*., (2017) [10]. Leaf area index was significantly influenced by various levels of fertilizer and among the different nutrient levels, 150% RDF (120:60:60 kg NPKha^{-1}) recorded higher LAI (2.46) and STCR based nutrient level recorded lower LAI (1.57).This might be due to high N levels in soil cause excessive vegetative growth (Gormus *et al*., 2016) [9]. This finding was similar to that of Zarina *et al*. (2011) [21].Significant interaction effect of variety/genotype with different levels of fertilizer was also noticed in leaf area index. Interactions of variety/genotype and nutrient levels were found to be significant (Table 1a). Combination of CO 15 variety along with 150% RDF recorded significantly higher leaf area index (3.15) over others. Generally application of more fertilizer increases the vegetative growth by producing more number of leaves since CO 15 have okra type leaf structure and it can produce more leaves per plant. Such finding was in close confirmation with Udikeri and Shashidhara (2017) [19].

Drymatter production (kg ha^{-1})

Dry matter production varied significantly due to variety/genotypes and due to nutrient levels (Table 1). Cotton variety CO 15produced significantly more DMP (8453 kg ha^{-1}) followed by TCH 1822 (7785kg ha^{-1}) which was on par with TCH 1819 (7543kg ha^{-1}), however it recorded lesser DMP. Higher drymatter production by CO 15 was mainly due to higher growth parameters (plant height and leaf area index) and higher yield attributes like number of sympodiaplant^{-1}, sympodial length and number of bollsplant^{-1}. Similar results were found by Siddiqui *et al*. (2007) [14] who revealed that the drymatter produced per plant alone does not reflect on the efficiency of the genotypes, but its greater partitioning into the reproductive parts is the real index of its effectiveness. The DMP from 150% RDF (120:60:60 kg NPKha^{-1}) recorded significantly higher (8476kg ha^{-1}) than other levels but it was on par with 125% RDF (8200kg ha^{-1}). Lower dry matter production (7361kg ha^{-1}) was obtained from STCR based fertilizer level while it was on par with 100% RDF. Increase in fertilizer level increases the growth characters which in turn increases the DMP. This finding was similar as that of Udikeri and Shashidhara (2017) [19] reported that increase in application of fertilizer dose increases the drymatter production. Non-significant difference was observed among their interactions (Table 1).

Table 1: Effect of variety/genotypes and nutrient levels on growth of cotton at harvest under HDPS

Treatments	Plant height (cm)	Drymatter production (kg ha^{-1})
Main plot		
M_1	109.9	8453
M_2	94.78	7543
M_3	93.17	7785
SEd	4.93	233
CD (P=0.05)	13.70	647
Sub plot		
S_1	97.02	7671
S_2	101.7	8200
S_3	104.3	8476
S_4	94.21	7361
SEd	2.82	296
CD (P=0.05)	5.92	621
Interactions		
M x S		
SEd	6.50	501
CD (P=0.05)	NS	NS
S x M		
SEd	4.88	512
CD (P=0.05)	NS	NS

Table 1(a): Effect of variety/genotypes and nutrient levels on leaf area index of cotton at 120 DAS under HDPS

Treatments	M_1	M_2	M_3	Mean
S_1	2.49	1.34	1.64	1.82
S_2	2.72	1.50	1.79	2.00
S_3	3.15	2.22	2.01	2.46
S_4	2.33	1.07	1.30	1.57
Mean	2.67	1.53	1.68	
	M	S	M x S	S x M
SEd	0.08	0.06	0.12	0.11
CD(P=0.05)	0.22	0.13	0.30	0.23

Number of sympodial branches plant^{-1}

Significant difference was noted among the variety/genotypes on number of sympodial branches per plant (Table 2). Significantly more number of sympodial branches (18.00) were produced by CO 15 variety while TCH 1822 produced lesser sympodia (10.12) which was on par with TCH 1819 (10.72). This difference might be due to genetic makeup of the plant. This result is in accordance with the findings of Udikeri and Shashidhara (2017) [19] who stated that lower number of sympodial branches per plant was produced by compact genotypes. Different levels of nutrient and also their interaction with variety/genotype were found to be non-significant on number of sympodia (Table 2). This was due to morphological differentiation, apical dominance, plant height and also resources availability to different cotton genotypes as suggested by Bharathi *et al*. (2012) [5].

Sympodial length (cm)

Variety/genotypes had a significant influence on sympodial length (Table 2) and the genotype TCH 1819 recorded lower sympodial length (11.08 cm) which was on par with TCH 1822 (11.86 cm) while higher sympodial length (22.75 cm) was noted from CO 15.The variation in the sympodial length is mainly due to the genetic makeup of the plant, since CO 15 is a semi compact type, whereas other two genotypes are compact in nature. Shorter sympodial length facilitates mechanization. There was no significant difference among the nutrient levels on sympodial length (Table 2) and it was similar to the result of Sanket *et al*. (2017) [13]. Interaction effect also found to be non-significant (Table 2).

Number of bolls plant^{-1}

Number of bolls per plant was significantly influenced by variety/genotypes, nutrient levels and also among their interactions (Table 2a). The variety CO 15 produced significantly more number of bolls per plant (14.84) followed by TCH 1822 (11.06) which was on par with TCH 1819 produced lower number of bolls (10.89). This difference might be due to genetic potential of the plant. Similar result was reported by Ajayakumar *et al*. (2017) [2]. Application of 125% RDF (100:50:50 kg NPKha^{-1}) recorded significantly more bolls per plant (13.78) compared to other fertilizer doses and it was followed by 100% RDF (12.22) and 150% RDF (12.19). This might be due to increase in fertilizer doses increase the number of bollsplant^{-1} upto a certain level. It is in conformity with the findings of Pandagale *et al*. (2015) [11] and Basha *et al*. (2017) [4]. Lower number of bolls (10.87) was produced by the application of STCR based nutrient level. Interaction effect of CO 15 variety with the application of 125% RDF produced significantly more number of bollsplant^{-1} (16.67). This differential response of yield contributing character was due to the genetic potential and resource availability to the crop. Udikeri and Shashidhara (2017) [19] also reported similar findings.

Boll weight (gboll^{-1})

Boll weight was significantly influenced by variety/genotypes (Table 2) and the genotype TCH 1822 recorded significantly higher boll weight (4.72 g) which was on par with TCH 1819 (4.46 g).Lower boll weight (4.26 g) was recorded with CO 15. The difference in genotypes in their yield potential might be depending on many physiological processes, which are controlled by both genetic makeup of the plant and the environment (Udikeri and Shashidhara, 2017) [19]. There was no significant influence among the different levels of fertilizer and also among their interactions with variety/genotype (Table 2). Application of increased levels of fertilizer increases the boll weight but it did not influence the boll weight significantly. Such finding is in close confirmation with the findings of Sanket *et al*. (2017) [13].

Seed cotton yield (kgha^{-1})

Seed cotton yield was significantly influenced due to variety/genotypes (Table 2). TCH 1822 recorded significantly higher seed cotton yield (2335 kgha^{-1}) which was on par with TCH 1819 (2193 kgha^{-1}) and lower yield was obtained from the variety CO 15 (2061 kgha^{-1}) while it was on par with TCH 1819. The differences in seed cotton yield by the genotypes might be the yielding ability of a genotype is the reflection of its yield attributing characters like more number of matured open bolls and boll weight (Sisodia and Khamparia (2007) [16], Tuppad (2015) [18]). Since the genotype TCH 1822 is resistance to bollworm attack and produced healthy matured bolls with more boll weight. Application of different fertilizer doses significantly influenced the seed cotton yield (Table 2). Significantly higher seed cotton yield (2324 kgha^{-1}) was recorded from the application of 125% RDF (100:50:50 kg NPKha^{-1}) as similar to findings of Basha *et al*. (2017) [4], however which was on par with 100% RDF (2233 kgha^{-1}) and STCR based nutrient application recorded 2182 kgha^{-1}. Lower yield of 2046 kgha^{-1} was obtained from the usage of 150% RDF (120:60:60 kg NPKha^{-1}). Overuse of fertilizer causes excessive vegetative growth, delayed maturity, produces more number of immature bolls (hardlocks), increased boll rot and invited sucking pests which further leads to reduction in the yield as reported by Venugopalan *et al*. (2013) [20] and Gormus *et al*. (2016) [9]. Interaction effect did not show any significant influence on seed cotton yield (Table 2).

Table 2: Effect of variety/genotypes and nutrient levels on yield of cotton at harvest under HDPS

Treatments	Number of sympodiaplant^{-1}	Sympodial length (cm)	Boll weight (gboll^{-1})	Seed cotton yield (kgha^{-1})
Main plot				
M_1	18.00	22.75	4.26	2061
M_2	10.72	11.08	4.46	2193
M_3	10.12	11.86	4.72	2335
SEd	0.44	0.50	0.12	70
CD (P=0.05)	1.23	1.37	0.33	195
Sub plot				
S_1	12.91	15.10	4.48	2233
S_2	13.24	15.76	4.53	2324
S_3	13.32	15.43	4.49	2046
S_4	12.31	14.63	4.44	2182
SEd	0.49	0.50	0.19	76
CD (P=0.05)	NS	NS	NS	160
Interactions				
M x S				
SEd	0.85	0.90	0.31	134
CD (P=0.05)	NS	NS	NS	NS
S x M				
SEd	0.84	0.87	0.33	132
CD (P=0.05)	NS	NS	NS	NS

Table 2(a): Effect of variety/genotypes and nutrient levels on number of bollsplant^{-1}of cotton at harvest under HDPS

Treatments	M_1	M_2	M_3	Mean
S_1	14.20	11.20	11.27	12.22
S_2	16.67	12.17	12.50	13.78
S_3	16.17	10.03	10.37	12.19
S_4	12.33	10.17	10.10	10.87
Mean	14.84	10.89	11.06	
	M	S	M x S	S x M
SEd	0.42	0.38	0.70	0.65
CD (P=0.05)	1.15	0.79	1.64	1.37

Conclusion

The present field experiment inferred that the compact cotton genotypes performed differently and also nutrient levels had also varied significantly on growth and yield under HDPS. Though the variety CO 15 and also the nutrient level 150% RDF produced higher plant height, leaf area index and drymatter production, the yield was low. Under high density planting system, genotypes TCH 1822 and TCH 1819 performed better to obtain higher yield with the application of 125% RDF. To save cost on nutrients, soil test based application (55 kg N, 20kg P_2O_5 and 20 kg K_2O) is sufficient to obtain comparable with Recommended Dose of Fertilizer.

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