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Research Communication

Effect of crop geometry and nitrogen levels on leaf chlorophyll content of cotton (*Gossypium hirsutum*) at different growth stages under rainfed Vertisols

B.B. NAYAK[1], S. BHARATHI[2], M. SREE REKHA[3] AND K. JAYALALITHA[4]

Acharya N.G. Ranga Agricultural University, Lam, Gunter, Andhra Pradesh 522 034

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ABSTRACT

A field experiment was conducted during the rainy (*kharif) season of* 2018–19 at the Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Lam, Gunter, Andhra Pradesh on *Vertisols* under rainfed conditions. To study the effect of crop geometry and nitrogen levels on compact cotton (*Gossypium hirsutum* L.). Leaf chlorophyll content was measured with the Soil Plant Analysis Development meter (SPAD 502 Plus Chlorophyll Meter) at different crop growth stages. Among the various crop geometry studied, maximum chlorophyll (SPAD index) content, functional leaves per square meter and leaf area index (LAI) were recorded with close crop geometry 60 cm × 10 cm. Among nitrogen levels application of 180 kg N/ha recorded maximum chlorophyll content, functional leaves per square meter and LAI. Combined effect on crop geometry and nitrogen levels on chlorophyll content was recorded significant with closer geometry 60cm x10cm along with an application of 180kg N ha^{-1} at 90 days after sowing. Dry matter accumulation (kg/ha) at 30 DAS, 60 DAS, 90 DAS and at harvest was significantly affected by crop geometry and levels of nitrogen but not by their interaction.

Key words: Chlorophyll content, Compact cotton, Crop geometry, Functional leaves, High-density planting, Nitrogen levels, SPAD index, Seed cotton yield

Cotton (*Gossypium hirsutum* L.) is the most important fibre crop of India occupies a major share among cash crops. In India, it is grown predominantly as a rainfed crop. However, cotton productivity in India (487 kg/ha) is very low as compared to the world average productivity (766 kg/ha) (AICCIP, Annual Report, 2020–21). High-density cotton planting system (HDPS) is a new initiative from ICAR-Central Institute for Cotton Research, Nagpur, Maharashtra to improve the productivity. Many cotton-producing countries like Brazil, China, Australia, Spain Uzbekistan, Argentina and Greece tested, proved and adopted a narrow row planting system of cotton as a tool to achieve higher productivity (Venugopalan *et al*., 2013). The adoption of HDPS, along with good fertilizer management and better genotypes, is a viable approach to break the current trend of stagnating yields under primarily rainfed (upland) cotton-growing areas.

A field experiment was conducted during rainy (*kharif)* season of 2018–19 at the Regional Agricultural Research Station Acharya N.G. Ranga Agricultural University, Lam, Gunter, Andhra Pradesh. The experimental soil was classified as clayey in texture, slightly alkaline in reaction (*p*H 8.2), low in organic carbon (0.4%) and available nitrogen (179.6 kg/ha), high in available phosphorus (46.4 kg/ha) and available potassium (638.5 kg/ha). The experiment was laid out in a randomized block design (RBD) with a factorial arrangement and replicated thrice. Compact cotton variety 'LHDP 1' (Lam high density planting1) was the test variety. The treatments consisted of 3 crop geometries, viz. S_1, 60 cm × 10 cm; S_2, 75 cm × 10 cm; S_3, 90 cm × 45 cm in combination with 4 nitrogen levels, viz. N_1, 45 kg N/ha; N_2, 90 kg N/ha; N_3, 135 kg N/ha; N_4, 180 kg/ha. All other cultivation practices followed as per the standard recommendations.

The number of functional leaves produced per m^2 were counted and the average number of leaves/m^2 was worked out. Leaf area was estimated by using the automatic leaf

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[1]**Corresponding author's Email:** nayak.96agri@gmail.com
[1]Ph.D. Scholar, Division of Agronomy, ICAR-Indian Agricultural Research Institute, New Delhi 110 012; [2]Principal Scientist, AICCIP (Agronomy), Regional Agricultural Research Station, Lam, ANGRAU, Guntur, Andhra Pradesh 522 034; [3]Associate Professor, Department of Agronomy, Agricultural College; [4]Professor and Head, Department of Crop Physiology, Agricultural College, Bapatla, Acharya N.G. Ranga Agricultural University, Guntur, Andhra Pradesh 522 034

area meter, model CI 203, CID Inc. USA. The LAI was computed by using the formula given by Watson (1952). Chlorophyll content was measured by a portable soil plant analysis development meter (SPAD 502 plus Chlorophyll Meter) during active growth stages of plants. Three fully expanded leaves from top, middle and bottom per plant were selected. Each leaf was punched at three different places in between the leaf margin and the mid rib and the average of three SPAD values were taken as SPAD index as the final value (Tewolde *et al*., 2008 and Hallikeri *et al*., 2011). The readings were taken at 30, 60 and 90 DAS. Ten plants were taken from the second row and were dried first in shade and then in a hot air oven at 60°C till a constant weight was obtained. Then dry weights were recorded and dry matter accumulation was expressed in kg/ha. Statistical analysis for the data was done following the analysis of variance technique for Randomized Block design with factorial concept as suggested by Gomez and Gomez (1984) at P=0.05.

The number of functional leaves per unit area increased with increased with decrease in spacing. The rate of leaf production was higher during 30 to 90 DAS period and declined thereafter. It was noted that closer crop geometry at 60cm x 10cm recorded higher number of functional leaves per square meter (78,458 and 665 respectively) at 30, 60 and 90 DAS respectively (Table 1). Similar results were reported by Manjula and Shashidhara (2017) and Mahil *et al.* (2018). Application of 180kg N/ha recorded maximum functional leaves per square meter (367, 522 and 632 respectively) and was on a par with 135kg N/ha and significantly superior to 90kg N/ha and 45 kg N/ha (Table 1). Similar findings reported by Ghule *et al*. (2013) and Shukla *et al.* (2013). A clear difference in leaf area index was found due to various crop geometry and it was noted that closer crop geometry of 60cm x 10cm recorded higher leaf area (0.6, 2.8 and 4.5 respectively) which was significantly superior over 75cm x 10cm and 90cm x 45cm at all growth stages (Manjula and Shashidhara, 2017). The application of 180kg N/ha recorded higher LAI followed by 135kg N/ha and it was significantly superior to 90kg N/ha and 45kg N/ha at 60 DAS, 90 DAS (Table 2). These findings are in line with results reported by Shukla *et al.* (2013).

The chlorophyll content (SPAD index) increased gradually in leaves from 30 DAS to 90 DAS. The chlorophyll reading was significantly influenced by different crop geometry tested. Among the various crop geometry studied 60 cm × 10 cm recorded significantly superior chlorophyll content at 30, 60 and 90 DAS (40.8, 43.8 and 46.2) (Table 1). Zaman *et al.,* (2021) also reported that comparing the different spacing, 60 cm × 10 cm registered the highest SPAD value (41.70) as against other wider crop geometries tested. Among the different levels of nitrogen tested, application of 180 kg N/ha recorded maximum chlorophyll content at 60 and 90 DAS (43.3 and 44.6), followed by 135 kg N/ha and found significantly superior over 90 kg N/ha and 45 kg N/ha (Table 1). The highest chlorophyll content at 180 kg N/ha could be due to better assimilation and translocation of photosynthates, and in areas where more nitrogen was applied, the chlorophyll content (SPAD values) rose (Khan *et al.,* 2001). The highest SPAD values were observed at 90 days after planting as also reported by Zaman *et al.* (2021). Interaction of crop geometry and levels of nitrogen was significant at 60 and 90 DAS. Closer geometry at 60 cm × 10 cm with application of 180 kg N/ha recorded maximum chlorophyll values and found significantly superior over all the treatment combinations tested (Table 1). The highest dry matter accumulation was recorded with closer crop geometry of 60cm × 10cm (1460, 2496, 4050 and 8125 kg/ha) and was significantly superior to 75cm × 10cm and 90cm × 45cm at 30, 60, 90 DAS and harvest. At 60 and 90 DAS application of 180 kg N ha^{-1} (1940 and 3458 kg/ha) recorded maximum dry matter accumulation (Table 2) and was on a par with 135 kg N/ha and 90 kg N/ha and significantly superior over 45 kg N/ha. However, at harvest application of 180 kg N/ha (6832 kg/ha) recorded maximum dry matter accumulation and was on a par with 135 kg N/ha.

Plant density has a significant effect on the growth and yield attributes of the cotton plant. The plant population affects crop growth dynamics by imposing competition among plants for space, solar radiation, nutrients and moisture uptake. Indeterminate growth habit of cotton dramatically influences growth and yield of cotton by applied nitrogen fertilizer. Hence nitrogen is commonly considered the most limiting factor for cotton growth, yield and radiation use efficiency. In addition, nitrogen is the fundamental part of several biochemical compounds. Its unavailability influences chlorophyll content, photosynthetic rate, crop growth rate and source-sink association of crops. Nitrogen is the basic component of chlorophyll synthesis in leaves where photosynthesis occurs. Insufficient nitrogen supply often affects the growth of cotton and developmental processes, resulting in a reduced low leaf chlorophyll concentration causes reduction of photosynthetic rate and biomass production, as well as reduced lint yield and poor fibre quality. Photosynthesis is an important chemical reaction in plants, which is affected by leaf chlorophyll content (SPAD value) is an indirect measurement of chlorophyll content which was significantly influenced by crop geometry and nutrient levels. Increased chlorophyll content with close crop geometry might be due to factors such as a higher population density per unit area, more plant competition, which increases nutrient and water intake from the soil and

Table 1. Effect of crop geometry and nitrogen levels on Chlorophyll content (SPAD index) and functional leaves produced/m^2 of compact cotton

Crop geometry (cm)	Chlorophyll content (SPAD index)			Number of functional leaves		
	At 30 DAS	At 60 DAS	At 90 DAS	At 30 DAS	At 60 DAS	At 90 DAS
S_1, 90 × 45	34.2	36.7	38.8	26	120	185
S_2, 75 × 10	37.2	40.9	43.9	75	436	627
S_3, 60 × 10	40.8	43.8	46.2	78	458	665
SEm±	0.4	0.4	0.4	1	7	8
CD (P=0.05)	1.2	1.3	1.2	4	20	23
Nitrogen levels (Kg/ha)						
N_1, 45	36.4	34.9	35.2	60	307	461
N_2, 90	37.4	41.4	42.6	61	326	482
N_3, 135	37.7	42.4	43.3	60	351	504
N_4, 180	38.1	43.3	44.6	58	367	522
SEm±	0.5	0.5	0.5	1	8	9
CD (P=0.05)	NS	1.5	1.4	NS	23	27
Interaction (S×N)						
SEm±	0.8	0.9	0.8	2	13	16
CD (P=0.05)	NS	2.5	2.4	NS	NS	NS

Table 2. Effect of crop geometry and nitrogen levels on LAI and dry mater production of compact cotton

Crop geometry (cm)	Leaf area index (LAI)			Dry-matter Accumulation (kg/ha)			
	At 30 DAS	At 60 DAS	At 90 DAS	At 30 DAS	At 60 DAS	At 90 DAS	At harvest
S_1, 90 × 45	0.173	1.066	2.701	550	928	2,039	3,969
S_2, 75 × 10	0.513	1.809	3.782	934	1,849	3,531	7,216
S_3, 60 × 10	0.603	2.89	4.504	1460	2,496	4,050	8,125
SEm±	0.011	0.03	0.071	28	48	84	151
CD (P=0.05)	0.031	0.09	0.209	83	141	249	446
Nitrogen levels (Kg/ha)							
N_1, 45	0.425	1.833	3.472	969	1,537	2,927	5,937
N_2, 90	0.427	1.893	3.603	979	1,704	3,104	6,311
N_3, 135	0.432	1.953	3.746	983	1,849	3,338	6,667
N_4, 180	0.434	2.007	3.828	995	1,940	3,458	6,832
SEm±	0.012	0.035	0.082	32	55	98	174
CD (P=0.05)	NS	0.104	0.241	NS	163	288	515
Interaction (S×N)							
SEm±	0.021	0.061	0.141	56	96	169	302
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS

helps to boost photosynthetic activity throughout the crop's growth phases and it also might be due to increased nitrogen application improved the soil available nitrogen in rhizosphere which enhanced the uptake of nitrogen and further leading to increased chlorophyll formation, photosynthetic activity and mobilization of photosynthates from sink to sources, and ultimately increased the dry matter accumulation and seed cotton yield. The increase in the chlorophyll content (SPAD index) value might be owing to the fact that the supply of sufficient nitrogen throughout the crop growth period as per requirement of increased plant population under closer crop geometry which might be used for chlorophyll formation (Giri *et al*., 2016). Zaman *et al.,* (2021), reported that the application of 197 kg/ha increased the chlorophyll contents by 32.2% over no nitrogen application. He also reported that 15 cm plant spacing increased chlorophyll contents and the effect of plant spacing, and nitrogen rate was found to be significant on chlorophyll contents. The higher performance of 60 cm × 15 cm with 150% RDF in terms of enhanced SPAD value might be due to its higher nitrogen level along with optimum plant spacing (60 cm × 15 cm) (Arun *et al*., 2020 and Singh *et al*., 2017).

Thus, it can be concluded that closer crop geometry with increased level of nitrogen fertilizer application increases number of functional leaves for unit area, leaf area index and chlorophyll content in leaves, followed by photosynthesis and ultimately increased the dry matter accu-

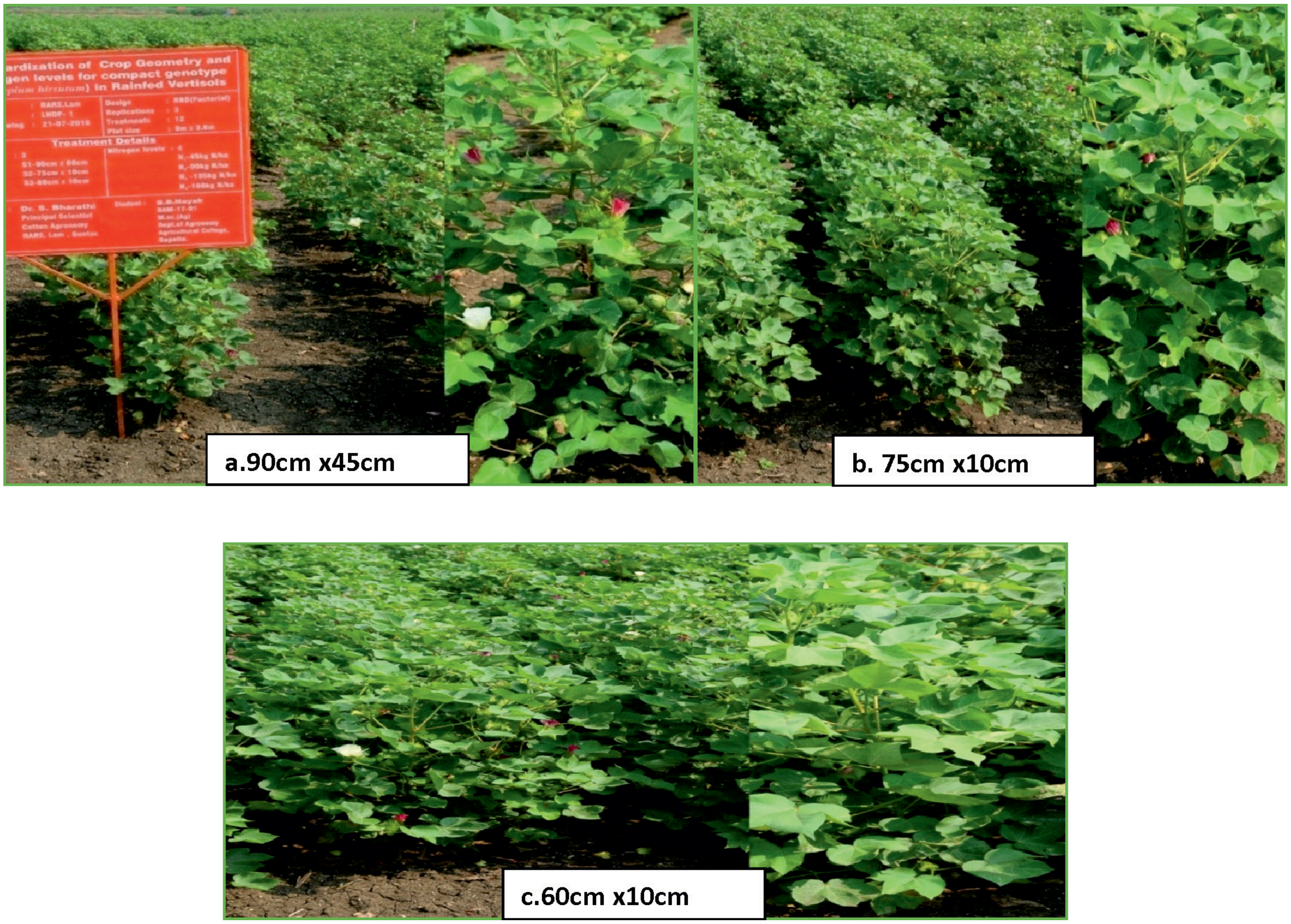

Plate 1. a,b,c - An over view of crop in different crop geometry with growth patern of individual plant at 60 DAS

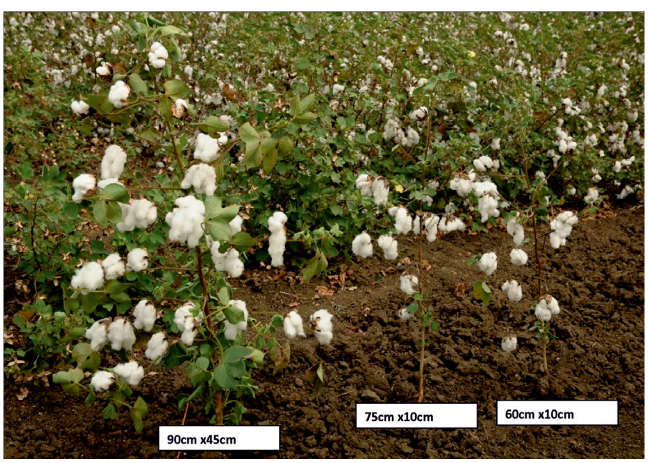

Plate 2. Growth patern of individual plant in different crop geometry at harvest

mulation and seed cotton yield. Therefore, long-term studies required to further explore the role of different crop geometry on the cotton productivity under sufficient amounts of nitrogen fertilizers.

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