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Exploring the impact of High-density planting system (HDPS) technology in cotton under light soils

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Abstract
A field experiment was carried out to assess the influence of spacing on growth and yield parameters of cotton at farmers field under KVK, Bellampalli of Mancherial district, Telangana during *Kharif* 2023-24. The treatments included High Density Planting System (HDPS) @90X15cm, Closer Spacing @90x30cm and the Conventional method@90x60 cm. Plant height was recorded at 30, 60, 90 and 120 days after sowing (DAS) while yield attributing traits such as number of sympodial branches per plant, dry matter accumulation, number of bolls per plant and seed cotton yield (q/acre) were evaluated at harvest. Results revealed that the conventional method led to significantly highest plant height throughout all growth stages, attaining a maximum of 118.67 cm at 120 DAS. In contrast, HDPS recorded the lowest plant height (96.33 cm at 120 DAS) indicating that denser planting reduced plant height due to interplant competition. Regarding yield attributes, the conventional method produced the highest number of sympodial branches (18.33) and dry matter accumulation (161.00 g/plant) but it resulted in a lower boll count per acre and ultimately the lowest yield (9.90 q/acre). HDPS despite having fewer bolls per plant achieved the highest seed cotton yield (13.07 q/acre) suggesting superior yield efficiency per unit area in high-density planting. The findings highlight the individual plant performance and overall yield per unit area suggesting that HDPS is a promising strategy for maximizing yield in cotton cultivation under light to medium soils.

Keywords: Closer spacing, high density, monopodial, sympodial branches

Introduction
Cotton is one of the most significant commercial crops in India and is cultivated widely in tropical and subtropical regions across the globe. It serves as the foundation of the textile industry and contributes nearly 25% of global cotton production (OECD-FAO, 2020) [11]. Owing to its substantial economic value, cotton is often referred to as “white gold.” The crop plays a crucial role in India’s economy by generating foreign exchange through the export of raw cotton, semi-processed products such as yarn and fabrics, and finished goods including garments (PIB, 2025). Therefore, enhancing sustainability and productivity in cotton cultivation is essential to meet the growing global demand. During the 2024-25 season, the area under cotton cultivation in India declined to 112.94 lakh hectares compared to 123.70 lakh hectares in 2023-24. Maharashtra ranks first in cotton acreage with 40.86 lakh hectares, followed by Gujarat (23.66 lakh ha), Telangana (17.70 lakh ha), Karnataka (6.84 lakh ha), and Madhya Pradesh (6.14 lakh ha) (Cotton Outlook - January 2025). Cotton is predominantly a kharif crop and performs best in clay-rich soils particularly black cotton soils, due to their superior water-holding capacity. In terms of production, Maharashtra leads with 84.80 lakh bales followed by Gujarat (80.01 lakh bales) Telangana (48.95 lakh bales) Rajasthan (20.42 lakh bales) and Karnataka (18.56 lakh bales) (Cotton Outlook - January 2025).
Despite having a large area under cotton cultivation, India’s productivity per unit area remains considerably lower than that of several other cotton-producing countries. The declining production trends highlight the urgent need for adopting advanced technologies to improve yields. Black cotton soils generally produce higher yields than lighter soils because of their deep, fertile profile, rich nutrient content and excellent moisture retention which support the deep-rooted growth habit of cotton plants. The high clay content helps conserve moisture, while

nutrients such as calcium carbonate, magnesium, potash and lime contribute to better crop growth. Conversely, lighter soils like sandy or loamy types suffer from poor water retention and higher nutrient losses demanding intensive management practices (FAO, 2021). These limitations often result in reduced yield and inferior fiber quality making medium to heavy textured soils more suitable for cotton cultivation.

Cotton is a long-duration crop that requires multiple pickings which often leads to deterioration in lint quality and lower market prices. Additionally, the scarcity and rising cost of labor for manual picking pose serious challenges as cotton harvesting in India is still entirely dependent on manual labor. In this context, the High-Density Planting System (HDPS) has emerged as an innovative and promising approach to enhance cotton productivity particularly in light soils (Mayee *et al.*, 2021) [3]. The ICAR-Central Institute for Cotton Research (CICR), Nagpur, has standardized HDPS, which involves closer plant spacing (90 × 15 cm) compared to the conventional spacing of 90 × 60 cm (Prasad Y.G., 2023) [6]. This system improves land-use efficiency and optimizes resource utilization. Plant population density significantly influences light interception, soil moisture availability, air circulation, plant architecture, boll development, maturity and overall crop yield (Khan *et al.*, 2019; Fahad *et al.*, 2021) [9, 10]. Studies have demonstrated that HDPS can increase yields, lower production costs, and enable mechanized harvesting, making it a viable strategy for both irrigated and rainfed cotton production systems.

Materials and Methods

A field experiment was conducted during the *kharif* season of 2023-24 at farmers field in the Mancherial district of Telangana to evaluate the effect of different planting geometry on growth and yield attributes of cotton at Bellampalli and Luxettipet clusters which is situated in between 18.1124° N latitude and 79.0193° E longitudes. Telangana is a semi-arid region has a predominantly hot and dry climate. Summers start in March and peak in mid-April with average high temperatures in the 37-38 °C (99-100 °F) range. The monsoon arrives in June and lasts until Late-September with about 755 mm (29.7 inches) of precipitation. Monthly meteorological data including maximum temperature, minimum temperature, total rainfall (mm), and the number of rainy days were recorded from June to December 2023 and presented graphically in Fig 2. The observed weather data revealed that July 2023 received the highest rainfall (approximately 570 mm) and the maximum number of rainy days followed by September (around 290 mm). The months of October to December recorded minimal precipitation. Maximum temperatures ranged between 28°C to 36°C during the cropping season while minimum temperatures varied from 12°C to 26°C. Light Soils with homogenous fertility, good drainage was selected for HDPS technology and Medium-deep black soils were selected to cultivate cotton by closer spacing and conventional method.

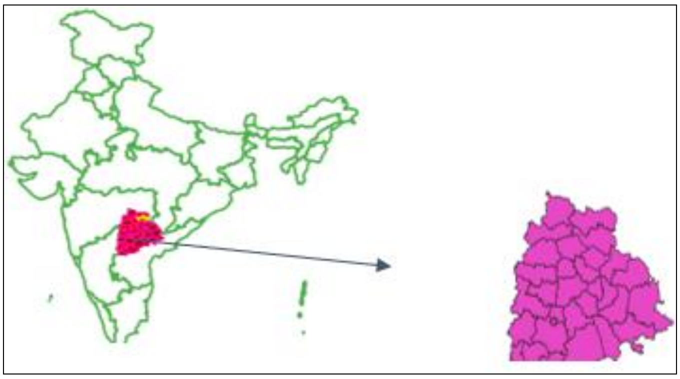

Fig 1: Pictoral representation of study area

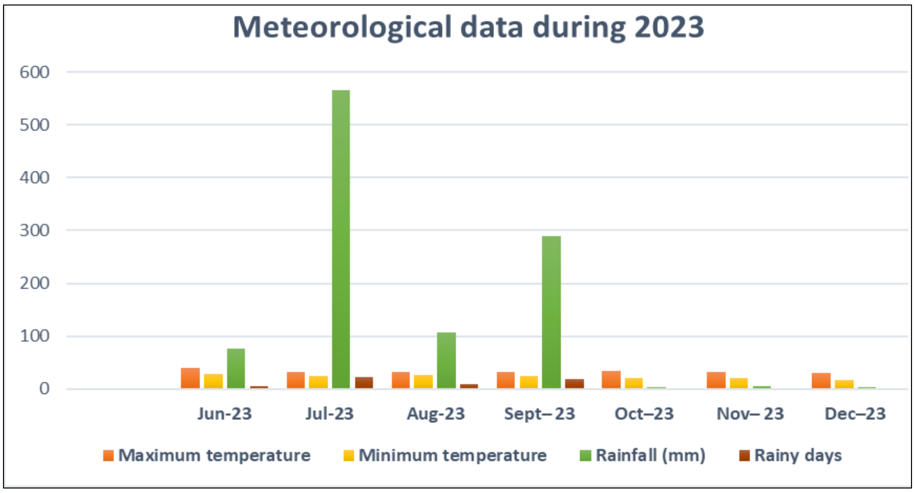

Fig 2: illustrates meteorological parameters during crop season, 2023-24

Experimental materials, design and methods

The fields were thoroughly prepared for sowing using disc plough, by end of May two harrowings were done. Field was cleared of weeds and trash of previous crop. The treatments consists of T_1 High Density Planting System (HDPS) at 90 cm × 15 cm spacing, T_2 Closer Spacing at 90 cm × 30 cm spacing and T_3 Conventional Method at 90 cm × 60 cm spacing. The cotton hybrids used in these trials were RCH-929 for HDPS, Veda platinum for CS and Armita for conventional method. Sowing of cotton was done in last week of June after the onset of monsoon. Sowing was done manually by adopting accurate spacing. All recommended agronomic practices such as application of nutrients such as required amount of Nitrogen, phosphorus and potassium was applied in field in the form of urea, DAP and MOP as basal dose at the time of sowing, irrigation and plant protection measures were uniformly applied to all plots as per the recommended package of practices for cotton cultivation.

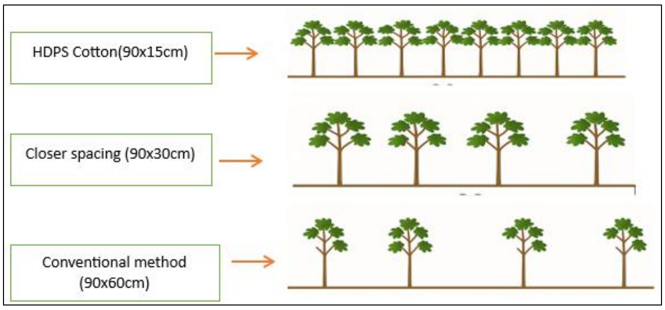

Fig 3: illustrates the spacing adopted under different methods of cotton cultivation

Biometric observations

Plant height was measured at 30, 60, 90 and 120 days after sowing (DAS). Five representative plants from the net plot area of each treatment were selected and the height was measured from the base of the plant at the soil surface to the terminal growing point using a measuring scale. The mean value was recorded and expressed in centimeters (cm). Sympodial branches were counted manually at harvest from five randomly selected plants per plot. Only mature and well formed sympodial branches were considered. The average of five plants was computed and used for statistical analysis. At the time of harvest, five randomly selected plants from each plot were uprooted carefully and partitioned into stem, leaves and reproductive parts. These were oven-dried at 65°C until a constant weight was achieved. The total dry matter of each plant was calculated and expressed in grams per plant (g/plant).

Yield parameters

Bolls were counted manually at harvest from the same five tagged plants used for other biometric observations. Only fully developed and mature bolls were considered. The mean value was calculated and used for treatment comparison. All bolls from the net plot area of each treatment were hand-picked at full maturity. The seed cotton was sun-dried, weighed per-acre basis. The yield was expressed in quintals per acre (q/acre).

Statistical Analysis

The data collected for various parameters were subjected to Analysis of Variance (ANOVA) using the method described by Gomez and Gomez (1984) [2]. Treatment means were compared using the Critical Difference (CD) at a 5% level of significance. The standard error of mean (SEm) were also computed to assess experimental precision and data reliability.

Results and Discussion

Growth attributes

Plant population increases with decrease in spacing It has also been reported by Brar *et al*. (2002) [1]. The effect of plant spacing was significant which recorded that the conventional method (T_3) with the highest plant height (43.33 cm) followed by closer spacing (T_2; 39.67 cm) and HDPS (T_1; 37.00 cm). This trend continued throughout the crop period with T_3 maintaining significantly higher values up to 120 DAS (118.67 cm) compared to T_2 (107.67 cm) and T_1 (96.33 cm). The consistent increase in plant height under the conventional method may be attributed to reduced intra-specific competition, allowing better access to light, nutrients and moisture. Conversely, the reduced height in HDPS could be due to greater plant density leading to resource competition and restricted vertical growth.

Table 1: Effect of Different Plant Spacings on growth Parameters of Cotton

Treatments	Plant height@30DAS	Plant height@60DAS	Plant height@90DAS	Plant height@120DAS
HDPS(T_1)	37.000	59.667	89.000	96.333
Closer spacing(T_2)	39.667	65	99.000	107.667
Conventional method(T_3)	43.333	68.333	108.667	118.667
C.D.	3.556	4.142	3.994	3.994
SE(m)	0.882	1.027	0.991	0.991

Yield attributes

The yield attributing parameters were significantly influenced by different spacing as shown in Table 2. With increase in spacing under conventional method (T_3) the number of sympodial branches per plant (18.33) and maximum dry matter accumulation (161.00 g/plant) also increased followed by closer spacing (T_2) and HDPS (T_1). This can be attributed to reduced plant density under wider spacing which allowed better canopy development and resource utilization per plant reducing competition among plants and more space available under increased spacing (Alfaqeih's (2002) [4]. Number of bolls plays an important role in increasing yield. The bolls per plant in HDPS recorded less this might be due to increase in density. It is evident from the data,Despite producing fewer bolls per plant (12.33) HDPS (T_1) recorded the highest seed cotton yield (13.07 q/acre) significantly outperforming both T_2 (11.83 q/acre) and T_3 (9.90 q/acre).The higher productivity must be due to compact sympodial branches that are well-suited for high density planting (Latha *et al.* 2011) [5]. This highlights the efficiency of higher plant population in compensating for lower individual plant productivity resulting in greater yield per unit area. Although, T_3 had the highest number of bolls per plant (38.00), the wider spacing led to fewer plants per acre, thereby reducing total yield.

Table 2: Effect of Different Plant Spacings on Yield Parameters of Cotton

Treatments	Sympodial branches per plant	Dry matter accumulation(g/plant)	bolls per plant	Yield(q)
HDPS(T_1)	13.000	94.667	12.333	13.067
Closer spacing(T_2)	16.000	141.333	18.333	11.833
Conventional method(T_3)	18.333	161.000	38.000	9.900
C.D.	2.262	8.339	5.754	1.075
SE(m)	0.561	2.068	1.427	0.267

Conclusion

The study demonstrated that planting geometry has a significant impact on the growth and yield performance of cotton. While the conventional method favored individual plant growth by producing highest plant height, more sympodial branches and higher dry matter accumulation, it resulted in lower yield due to reduced plant population per unit area. In contrast, the High Density Planting System (HDPS) produced shorter plants with fewer bolls per plant but achieved the highest seed cotton yield (13.07 q/acre) highlighting its superior efficiency in maximizing productivity per unit area. Therefore, HDPS emerges as a promising approach for enhancing cotton yield under optimal agronomic management in the agro-climatic conditions of Mancherial district, Telangana.

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