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EFFECT OF HIGH-DENSITY PLANTING (HDPS) AND CLOSER ROW SPACING (CS) ON GROWTH, YIELD AND PROFITABILITY OF COTTON (*GOSSYPIMUM HIRSUTUM* L.) IN KURNOOL DISTRICT OF ANDHRA PRADESH, INDIA

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ABSTRACT

Cotton (*Gossypium hirsutum* L.) is a key cash crop in India, yet its productivity remains low at 487 kg/ha, compared to global averages exceeding 1500 kg/ha. To address this gap, the Central Institute for Cotton Research (CICR) recommended the adoption of High-Density Planting System (HDPS) and Closer Spacing (CS) techniques. During the *Kharif* 2024–25 season, Krishi Vigyan Kendra (KVK), Banavasi, conducted frontline demonstrations across 11 villages in Kurnool district, Andhra Pradesh. A total of 22 farmers participated, using compact and early-maturing varieties such as CCH-369, Rasi Swift and Siri. Planting was done at spacings of 90×15 cm and 90×30 cm, in contrast to the conventional 100×45 cm. Canopy management using Mepiquat chloride (Chamatkar) was applied to control vegetative growth. Comparative data from four farmers indicated a notable increase in plant population, boll number and seed cotton yield, with an average increase of 1.8–2.2 kg per 5m row over traditional practices. Economic analysis revealed higher input costs but significantly improved profitability, with net returns rising by Rs. 20,000– Rs. 30,000 per acre and a B:C ratio between 1.65 and 2.20. The study concludes that HDPS & CS offer a viable, profitable solution for improving cotton productivity under rainfed conditions. These systems ensure better space utilization, enhanced yield and higher profitability, making them highly recommended for wider adoption in similar agro-ecological zones.

Key words: Special project on Cotton, HDPS, CS, Productivity, Yield enhancement, Profitability, Kurnool district

Introduction

Cotton (*Gossypium hirsutum* L.) is one of the most significant fiber and cash crops grown worldwide. It holds immense economic importance, particularly in the textile sector. Due to its high commercial value and the livelihoods, it supports, cotton is often referred to as “white gold”. As per the USDA Foreign Agricultural Service (2023–24), global cotton production is projected at 112.98 million bales. Among the leading producers, China tops the list with 27.35 million bales, followed by India with 25.4 million bales. Brazil (14.57 million bales) and the United States (12.07 million bales) also play significant roles in global cotton production. However, despite having a vast cultivation area, India faces a notable productivity challenge.

India accounts for over one-third of the world's cotton area, cultivating cotton on approximately 13.4 million hectares. In contrast, China produces nearly the same quantity of cotton from just 3.25 million hectares. According to the 2021 census, India's average productivity is only 487 kg/ha - far below the global average of 775 kg/ha. Several countries, including Brazil, China, Turkey, and Australia, report productivity levels exceeding 1,500 kg/ha (Kumar *et al.*, 2020). This indicates a critical need for improving cotton productivity in India through advanced agronomic practices.

Andhra Pradesh stands 8th in the country in both area and production, cultivating cotton on 4.27 lakh hectares with an output of 11.58 lakh bales during 2023–24 (Cotton Advisory Board, cotcorp.org.in). Despite this,

the state's productivity remains at 461.03 kg/ha, which ranks 5th among Indian states. In Andhra Pradesh, the area under cotton cultivation has decreased compared to the previous year. As of January 9, 2024, cotton was sown on 4.27 lakh hectares, which is much less than the 7.04 lakh hectares recorded the previous year (apagrisnet.gov.in). Most of the cotton in the state is grown in six main districts - Kurnool, Palnadu, Ananthapuramu, Prakasam, YSR and NTR. These districts together cover 85% of the total cotton-growing area and produce 83% of the state's cotton. Among them, Kurnool district ranks first in both area and productivity, making it an important region for taking up steps to improve cotton yields (AP Agricultural Statistics, 2022–23).

In response to India's productivity concerns, the Central Institute of Cotton Research (CICR), Nagpur, has introduced and advocated the High-Density Planting System (HDPS) and closer spacing (CS) techniques. These innovative systems are already widely adopted in countries like Brazil, China, Australia, Spain, Uzbekistan, Argentina, the USA, and Greece (Rossi *et al.*, 2004). HDPS is designed to increase plant population per unit area, thereby enhancing resource-use efficiency and overall productivity.

Unlike traditional methods with wider spacing and lower plant densities, HDPS allows for early canopy closure, improved light interception, better moisture conservation and weed suppression (Narayana and Prasad, 2018). These benefits collectively lead to higher photosynthetic activity and improved yield potential. However, HDPS success relies on precise crop management, including the selection of suitable plant architecture, efficient nutrient application and timely pest and disease control measures (Anbarasan *et al.*, 2023).

Thus, adopting HDPS and closer spacing methods presents a promising strategy for boosting cotton productivity, especially in key regions like Kurnool district of Andhra Pradesh, where conditions are conducive for such technological interventions.

Materials and Methods

The project study was carried out by Krishi Vigyan Kendra (KVK), Banavasi during the Kharif season of 2024–2025 in Kurnool district, Andhra Pradesh. Demonstrations were conducted in five cluster locations, covering 11 villages, where the predominant soil types were light to medium and the farming system was predominantly rainfed, with an annual rainfall range of 700–900 mm. A total of 22 farmers participated in the demonstration trials. The objective was to evaluate the

effectiveness of High-Density Planting System (HDPS) and Closer Spacing (CS) techniques in enhancing cotton productivity, compared to the conventional spacing method. In demonstration plots, spacing patterns of 90 cm × 15 cm and 90 cm × 30 cm were used, while control plots followed the traditional 100 cm × 45 cm spacing. The cotton varieties selected for the trial were short-duration and compact types, namely Crystal CCH–369, Rasi Swift and Nuziveedu Siri, as per recommendations. Seed rate in HDPS plots was increased by 2–3 times to accommodate higher plant density. Canopy management was implemented through foliar application of Mepiquat chloride (Chamatkar) at 1 ml/liter, first at 40–45 days after sowing (DAS) and a second time at 60–65 DAS, based on the condition that the average length of the top five internodes exceeded 20 cm.

For performance evaluation, data were collected from the fields of four selected farmers, representing both demonstration and conventional plots. Agronomic observations were recorded from a standard 5-meter row length, which included parameters such as plant height, number of plants, number of opened and green bolls and total kapas (seed cotton) yield (in grams). In addition, a cost-benefit analysis was conducted to assess the economic viability of HDPS and CS practices. Key economic indicators included gross expenditure, gross income, net returns and the benefit-cost (B:C) ratio. This systematic approach provided insights into the impact of planting geometry on yield potential and profitability, helping to validate HDPS and CS as effective, scalable solutions for cotton production in rainfed agro-ecological zones.

Results and Discussion

The crop cut and crop estimation at the open boll stage under the Special Project on Cotton was conducted for four different farmers. The findings reveal significant differences in plant population, boll count, and seed cotton weight between CS plots and Conventional plots.

Key Observations:

1. Higher Plant Population in CS Plots:

- The CS plots consistently had a greater number of plants per 5m row length across all farmers. The average number of plants in CS plots ranged from 77 to 79, whereas in conventional plots, it ranged from 37 to 45.

2. Increased Boll Count in CS Plots:

- The total number of bolls in CS plots was significantly higher. The difference in total boll count between CS and conventional plots was

Table 1: Crop cutting and yield estimation at the open boll stage (5×5 m plot) conducted under the Special Cotton Project 2024-25.

First Picking data								
Farmer 1		Intervention						
	CS plots				Conventional plots			
No. of rows	Total no. of plants in 5 m row length	Total no. of bolls in 5 m row length	Total no. of green bolls in 5 m row length	Total seed cotton (Kapas) weight (g) in 5m row length	Total no. of plants in 5 m row length	Total no. of bolls in 5 m row length	Total no. of green bolls in 5 m row length	Total seed cotton (Kapas) weight (g) in 5m row length
Row 1	15	260	198	1350	7	208	128	905
Row 2	17	295	200	1417	12	250	163	1050
Row 3	16	282	188	1400	7	205	120	890
Row 4	16	280	173	1395	9	223	136	926
Row 5	15	265	178	1380	10	238	150	975
Total	79	1382	937	6942	45	1124	697	4746

Farmer 2		Intervention						
	CS plots				Conventional plots			
No. of rows	Total no. of plants in 5 m row length	Total no. of bolls in 5 m row length	Total no. of green bolls in 5 m row length	Total seed cotton (Kapas) weight (g) in 5m row length	Total no. of plants in 5 m row length	Total no. of bolls in 5 m row length	Total no. of green bolls in 5 m row length	Total seed cotton (Kapas) weight (g) in 5m row length
Row 1	17	271	172	1348	9	215	160	976
Row 2	16	296	198	1450	9	230	180	995
Row 3	15	250	166	1283	8	210	125	965
Row 4	16	281	190	1320	7	197	180	903
Row 5	15	240	152	1250	7	194	122	890
Total	79	1338	878	6651	40	1046	767	4729

Farmer 3		Intervention						
	CS plots				Conventional plots			
No. of rows	Total no. of plants in 5 m row length	Total no. of bolls in 5 m row length	Total no. of green bolls in 5 m row length	Total seed cotton (Kapas) weight (g) in 5m row length	Total no. of plants in 5 m row length	Total no. of bolls in 5 m row length	Total no. of green bolls in 5 m row length	Total seed cotton (Kapas) weight (g) in 5m row length
Row 1	14	264	210	1254	7	201	134	870
Row 2	15	263	168	1250	8	214	136	910
Row 3	17	315	240	1510	9	235	178	990
Row 4	15	269	204	1275	7	206	148	920
Row 5	16	272	209	1290	6	184	120	765
Total	77	1383	1031	6579	37	1040	716	4455

Farmer 4		Intervention						
	CS plots				Conventional plots			
No. of rows	Total no. of plants in 5 m row length	Total no. of bolls in 5 m row length	Total no. of green bolls in 5 m row length	Total seed cotton (Kapas) weight (g) in 5m row length	Total no. of plants in 5 m row length	Total no. of bolls in 5 m row length	Total no. of green bolls in 5 m row length	Total seed cotton (Kapas) weight (g) in 5m row length
Row 1	16	260	210	1274	7	203	185	835
Row 2	15	254	174	1235	7	204	203	830
Row 3	15	259	180	1242	8	228	150	885
Row 4	16	262	209	1290	9	235	175	950
Row 5	15	249	185	1240	7	197	180	827
Total	77	1284	958	6281	38	1067	893	4327

Table 2: Pooled mean performance of CS plots and Conventional plots across four farmers under the Special Cotton Project (2024–25).

Treatment	Mean No. of Plants (per 5 m row)	Mean No. of Bolls (per 5 m row)	Mean No. of Green Bolls (per 5 m row)	Mean Seed Cotton Weight (g per 5 m row)
HDPS-CS Plot	78	1346.75	951	6613.25
Conventional Plot	40	1069.25	768.25	4564.25
SEd (±)	1.354	26.678	57.570	66.073
CD (P=0.05)	4.309	84.903	NS	210.274
*NS – Non significant at P=0.05				

observed across all farmers:

- ◆ Farmer 1: 1382 (CS) vs. 1124 (Conventional)
- ◆ Farmer 2: 1338 (CS) vs. 1046 (Conventional)
- ◆ Farmer 3: 1383 (CS) vs. 1040 (Conventional)
- ◆ Farmer 4: 1284 (CS) vs. 1067 (Conventional)

3. Higher Green Boll Count in CS Plots:

- The CS plots had a greater number of green bolls, which indicates a potential for additional yield in subsequent pickings. For example:
 - ◆ Farmer 1: 937 (CS) vs. 697 (Conventional)
 - ◆ Farmer 2: 878 (CS) vs. 767 (Conventional)
 - ◆ Farmer 3: 1031 (CS) vs. 716 (Conventional)
 - ◆ Farmer 4: 958 (CS) vs. 893 (Conventional)

4. Higher Seed Cotton Weight in CS Plots:

- The most significant observation was the difference in total seed cotton weight (kapas weight). The CS plots consistently yielded more seed cotton compared to the conventional plots.
 - ◆ Farmer 1: 6942g (CS) vs. 4746g (Conventional)
 - ◆ Farmer 2: 6651g (CS) vs. 4729g (Conventional)
 - ◆ Farmer 3: 6579g (CS) vs. 4455g (Conventional)
 - ◆ Farmer 4: 6281g (CS) vs. 4327g (Conventional)

The data strongly supports the effectiveness of CS plots over Conventional plots in terms of plant population, boll formation, and seed cotton yield. Several factors contribute to these results:

1. Higher Plant Density Leads to Increased Productivity:

Table 3: Economics.

Parameters	Farmer - 1		Farmer - 2		Farmer - 3		Farmer - 4	
Methods	HDPS & CS	Conventional method	HDPS & CS	Conventional method	HDPS & CS	Conventional method	HDPS & CS	Conventional method
Yield	18 q	14 q	15 q	10 q	15 q	11 q	14 q	09 q
Gross expenditure	40960/-	35450/-	39360/-	32870/-	40900/-	35600	39050/-	34350/-
Gross income	131140/-	105,000/-	114600/-	76000	111600/-	82,500	103800/-	67500
Net returns	90180/-	69,550/-	76040/-	43,130	70700/-	46,900	64750/-	33150
B: C Ratio	2.2:1	1.96:1	1.9:1	1.76:1	1.81:1	1.31:1	1.65:1	1.3:1

- The CS method optimizes space utilization, allowing for a greater number of plants per unit area, resulting in higher total boll production.

2. Better Boll Development in CS Plots:

- The CS plots consistently had a higher number of bolls per plant, indicating improved plant vigor and better resource utilization.

3. Increased Seed Cotton Weight in CS Plots:

- The CS method resulted in a significantly higher kapas weight across all four farmers. This directly correlates with increased yield and profitability.

4. Future Yield Potential:

- The presence of a higher number of green bolls in CS plots suggests that subsequent pickings will also yield a higher quantity of cotton compared to conventional methods.

The pooled mean data across four farmers presented in Table 2 clearly demonstrates the superiority of the High-Density Planting System with Closer Spacing (HDPS-CS) plots over the conventional planting system in terms of plant population, boll production and seed cotton yield. The average number of plants per 5 m row was substantially higher in CS plots (78) compared to conventional plots (40), indicating effective utilization of space under the HDPS system. This increased plant density led to a higher boll count, with CS plots recording a mean of 1346.75 bolls, which was significantly greater than the 1069.25 bolls in conventional plots.

The number of green bolls was also higher in CS plots (951) compared to conventional plots (768.25),

although the difference was not statistically significant (NS) at the 5% level, as indicated by the critical difference (CD) values. However, the total seed cotton (kapas) weight per 5 m row was significantly greater in the CS plots (6613.25 g), reflecting a clear advantage over the conventional system (4564.25 g). This improvement in kapas yield can be attributed to better crop canopy, efficient nutrient use and more uniform boll distribution under HDPS conditions.

Discussion on the Comparative Performance of HDPS & CS vs Conventional Method

The study compares the yield, economic returns, and cost-benefit analysis of the High-Density Planting System & Crop Spacing (HDPS & CS) against the Conventional Method across four different farmers. The results indicate a consistent trend favoring HDPS & CS in terms of productivity and profitability.

Yield Comparison

The yield obtained under HDPS & CS is significantly higher across all four farmers compared to the conventional method. The increase ranges between 4 to 5 quintals, indicating the effectiveness of HDPS & CS in enhancing crop production. The higher plant population density and optimized spacing likely contribute to better resource utilization, leading to improved yields.

Economic Analysis

1. Gross Expenditure:

- The gross expenditure for HDPS & CS is higher than that of the conventional method. The difference ranges between Rs. 3,000 to Rs. 6,000 across different farmers. This could be due to increased input requirements, such as seeds, fertilizers, and labor, associated with higher-density planting.

2. Gross Income:

- The revenue generated from HDPS & CS is significantly higher than the conventional method. Farmers using HDPS & CS experienced an increase in gross income ranging from Rs. 21,000 to Rs. 38,000 compared to those following the conventional approach.

3. Net Returns:

- The net returns obtained from HDPS & CS are considerably higher, with an increase of Rs. 20,000 to Rs. 30,000 over the conventional method. This demonstrates the superior profitability of HDPS & CS despite the slightly higher input costs.

Benefit-Cost Ratio (B: C Ratio)

The B:C ratio, which reflects the return on investment, is consistently higher for HDPS & CS in all cases. The ratios for HDPS & CS range from 1.65:1 to 2.2:1, whereas the conventional method lags at 1.3:1 to 1.96:1. This indicates that for every rupee invested, farmers using HDPS & CS gain a higher return compared to those using the conventional method.

Conclusion

The present study clearly establishes that the High-Density Planting System (HDPS) combined with Closer Row Spacing (CS) significantly enhances the productivity and profitability of cotton under rainfed conditions in Kurnool district, Andhra Pradesh. Across all four farmers, CS plots recorded a higher plant population, increased boll number, greater green boll retention and substantially higher seed cotton yield compared to conventional plots. Despite slightly higher input costs, the economic analysis revealed notably improved net returns (Rs. 20,000– Rs. 30,000 per acre) and higher benefit-cost ratios (1.65 to 2.20) in HDPS & CS plots, indicating a strong return on investment. The higher green boll counts also suggest better yield potential for subsequent pickings. These results confirm that HDPS & CS not only optimize space and resource use but also provide a scalable and profitable alternative to traditional cotton cultivation practices. Therefore, wider adoption of this system is strongly recommended to bridge the yield gap and enhance farmer income in rainfed agro-ecological zones. The findings confirm that CS plots outperform conventional methods in terms of productivity and economic benefits. Farmers are encouraged to adopt this system for better resource utilization and increased returns on investment. Further studies can focus on optimizing input costs in CS plots while maintaining their high productivity to make them even more beneficial for farmers.

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