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HIGH-DENSITY PLANTING SYSTEM (HDPS) FOR TRANSFORMING COTTON CULTIVATION IN INDIA

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ABSTRACT

The High-Density Planting System (HDPS) represents a significant advancement in cotton cultivation in India, aimed at improving productivity and sustainability. This system involves cultivating early-maturing, compact cotton hybrids at closer spacing, thereby increasing plant population per unit area. HDPS has demonstrated yield advantages of 30–40% in several cotton-growing states while reducing labour dependency and enabling mechanization. The approach integrates improved agronomic practices, including nutrient management, canopy regulation, and pest control. By enhancing resource-use efficiency and supporting rainfed agriculture, HDPS offers a viable pathway to strengthen farmer livelihoods and boost India's competitiveness in the global cotton sector.

KEYWORDS: Bt cotton, Cotton productivity, HDPS, Precision farming, Sustainable agriculture

INTRODUCTION

Cotton is one of the most important fibre and cash crops in India, playing a crucial role in the global textile industry and supporting the livelihoods of millions of farmers. India contributes approximately 19.35% of global cotton production, with an estimated output of 294.25 lakh bales (about 5.0 million metric tonnes). Despite having the largest area under cotton cultivation—nearly 40% of the global acreage—India ranks relatively low in productivity (Ministry of Textiles, 2025). This disparity highlights the urgent need for innovative production strategies that can enhance yield while ensuring sustainability.

The High-Density Planting System (HDPS) has emerged as a promising solution to address these challenges. By optimizing plant population, utilizing compact hybrids, and adopting improved crop management practices, HDPS aims to increase productivity, reduce labour requirements, and improve resource-use efficiency. This system is particularly relevant under rainfed conditions, where variability in rainfall and limited resources often constrain yields.

CONCEPT OF HDPS

The High-Density Planting System (HDPS) is an advanced agronomic approach in which cotton is cultivated at a higher plant population using narrow row spacing and compact plant architecture. Unlike conventional cotton cultivation, which typically accommodates 7,000–8,000 plants per acre with wider spacing, HDPS increases plant density to approximately 21,000–22,000 plants per acre through closer spacing arrangements.

This system relies on early-maturing, semi-compact cultivars characterized by shorter plant height, reduced leaf size, and a pyramidal canopy structure. Such traits allow better light interception, improved resource utilization, and suitability for mechanical harvesting. Growth regulators such as mepiquat chloride are often used to manage plant height and prevent excessive vegetative growth.

HDPS is particularly suitable for rainfed regions, where optimal plant population helps maximize yield under limited moisture conditions (Dandu et al., 2025; Ingle et al., 2024). The adoption of spacing such as 90 × 15 cm or 90 × 30 cm depends on soil depth and moisture availability, ensuring flexibility across diverse agro-ecological conditions.

SELECTION OF SUITABLE CULTIVARS

The success of HDPS largely depends on the selection of appropriate cotton cultivars. Ideal varieties should possess traits such as compact growth habit, short fruiting branches, and high boll retention at the first fruiting position. Early maturity and synchronous boll development are also desirable to facilitate uniform harvesting.

In addition, cultivars suitable for HDPS should have larger boll size (greater than 4 g), small leaves, and tolerance to major pests and diseases. Resistance to sucking pests is particularly important, as dense planting can create favourable conditions for pest proliferation.

Several Bt cotton hybrids have been developed specifically for HDPS, including those released under coordinated research programs. Private sector initiatives, such as the development of hybrids by seed companies in collaboration with research institutions, have further accelerated the adoption of HDPS in states like Maharashtra, Gujarat, Telangana, and Tamil Nadu (CICR, 2025).

Table 1. Cotton varieties and *Bt* hybrids released for HDPS (Source: Central Institute of Cotton research, Regional Station, Coimbatore).

Name	Year	Type	Institution	Bt/Non-Bt	Suitable Regions & Soil Types	Remarks
F 2383	2016	State	PAU, Faridkot	Non-Bt	Punjab; suitable for medium to deep loamy soils under irrigated conditions.	Compact plant type; suitable for HDPS.
CSH 3075	2017	Central	CICR, Sirsa	Not specified	North Zone (Punjab, Haryana, Rajasthan); adaptable to sandy loam to loamy soils under irrigated conditions.	Tolerant to major biotic stresses; suitable for HDPS with a yield potential of 25 q/ha.
Cotton CO 15 (TCH 1705)	2018	Central	TNAU, Coimbatore	Not specified	Tamil Nadu; thrives in black cotton soils under both rainfed and irrigated conditions.	Developed for high-density systems; semi-compact growth habit.
F 2381	2016	Central	PAU, Faridkot	Not specified	Punjab; suitable for medium to deep loamy soils under irrigated conditions.	Early maturing variety; potential for HDPS.
ARBC 19	2016	Central	UAS, Dharwad	Not specified	Karnataka; adaptable to red loamy soils under rainfed conditions.	Compact plant type; suitable for HDPS.
CO 17	2020	State	TNAU, Coimbatore	Not specified	Tamil Nadu (Perambalur, Ariyalur districts); performs well in black cotton soils	Short duration (125-130 days); high yielding; suitable for HDPS and mechanical harvesting.

					under rainfed conditions.	
RS 2818	2020	Central	SKRAU, Sriganganagar	Not specified	North-West Rajasthan; thrives in sandy loam soils under irrigated conditions.	Suitable for HDPS; consistent yield performance.
ARBC 1601	2020	Central	UAS, Dharwad	Not specified	Karnataka; adaptable to red loamy soils under rainfed conditions.	Compact growth habit; suitable for HDPS.
ARBC 1651	2020	Central	UAS, Dharwad	Not specified	Karnataka; suitable for red loamy soils under rainfed conditions.	Compact plant type; suitable for HDPS.
DSC 1651	2020	Central	UAS, Dharwad	Not specified	Karnataka; adaptable to red loamy soils under rainfed conditions.	Possibly similar to ARBC 1651; suitable for HDPS.
PKV 081-Bt	-	-	ICAR-CICR	Bt	Maharashtra; performs well in shallow to medium black soils under rainfed conditions.	Compact Bt variety; suitable for HDPS.
Suraj Bt	-	-	ICAR-CICR	Bt	Maharashtra; adaptable to shallow to medium black soils under rainfed conditions.	Compact Bt variety; suitable for HDPS.
Rajat Bt	-	-	ICAR-CICR	Bt	Maharashtra; thrives in shallow to medium black	Compact Bt variety; suitable for HDPS.

					soils under rainfed conditions.	
GJHV 374 Bt	-	-	ICAR-CICR	Bt	Maharashtra; suitable for shallow to medium black soils under rainfed conditions.	Compact Bt variety; suitable for HDPS.
CICR- H Bt Cotton 63 (Samrat Bt / CICR-183059-2)	2022	-	ICAR-CICR	Bt	Rainfed conditions of South Zone (Karnataka, Tamil Nadu, Andhra Pradesh and Telangana)	Early maturing, medium staple Bt cotton variety amenable for HDPS (Average Yield – 13.73 q/ha; Potential yield -24.14 q/ha)
CICR- H Bt Cotton 62 (Namami Bt / CICR 19-32 Bt)	2022	-	ICAR-CICR	Bt	Rainfed conditions of Central Zone (Maharashtra, Madhya Pradesh and Gujarat)	Early maturing, medium staple Bt cotton variety amenable for HDPS (Average Yield – 11.49 q/ha; Potential yield – 20.72 q/ha)
CICR- H Bt Cotton 61 (Tejas Bt / Bt - 183059-4)	2022		ICAR-CICR	Bt	Rainfed conditions of Central Zone (Maharashtra, Madhya Pradesh and Gujarat)	Early maturing, medium staple *Bt* cotton variety amenable for HDPS (Average Yield- 11.63 q/ha; Potential yield – 20.5 q/ha)
CICR- H Bt Cotton 60 (Yugank Bt / CICR-183059- 5)	2022		ICAR-CICR	Bt	Rainfed conditions of Central Zone (Maharashtra, Madhya Pradesh and Gujarat)	Early maturing, medium staple *Bt* cotton variety amenable for high density planting (Average Yield – 12.65 q/ha; Potential yield – 22.1 q/ha)

LAND PREPARATION, SOWING, AND NUTRIENT MANAGEMENT

Proper land preparation is essential for successful HDPS cultivation. Deep ploughing is recommended periodically to improve soil structure, followed by harrowing and incorporation of organic manures such as farmyard manure. A well-prepared seedbed ensures uniform germination and crop establishment.

Timely sowing is critical, with the optimal window in central and southern India generally falling between mid and late June. Precision sowing using manual methods or pneumatic planters ensures accurate spacing and depth, which are crucial for maintaining the desired plant population.

Nutrient management in HDPS requires a balanced and split application approach. A recommended fertilizer dose of nitrogen, phosphorus, and potassium is applied in stages to match crop demand at different growth phases. Micronutrients such as zinc and boron are also included to support plant growth and boll development. Foliar nutrition may be used under stress conditions or high yield potential situations to enhance productivity.

A field view of cotton crop

CANOPY AND WATER MANAGEMENT

Canopy management plays a vital role in HDPS due to the increased plant density. The use of plant growth regulators, particularly mepiquat chloride, helps control plant height, reduce internodal length, and improve boll retention. Proper canopy architecture ensures better light penetration and reduces the risk of pest and disease incidence.

Water management is equally important, especially under rainfed conditions. Practices such as earthing up, furrow opening, and moisture conservation techniques help maintain soil moisture and improve water-use efficiency. In irrigated systems, controlled irrigation can further enhance crop performance and support higher yields.

WEED MANAGEMENT

Weed control is critical during the early stages of crop growth in HDPS. The rapid canopy closure associated with high plant density helps suppress weed growth at later stages. Pre-emergence application of herbicides such as pendimethalin effectively controls weeds during the initial growth period.

Subsequent weed management includes mechanical methods such as hoeing and hand weeding, along with post-emergence herbicides targeting specific weed types. Integrated weed management ensures minimal competition for nutrients, water, and light, thereby supporting optimal crop growth.

INSECT PEST MANAGEMENT

Pest management is a key component of HDPS due to the dense canopy, which can favour pest multiplication. An integrated pest management approach is essential for maintaining crop health and productivity.

Monitoring tools such as pheromone traps are used to detect pest populations, particularly pink bollworm. Biological control measures, including the release of beneficial insects, complement chemical control strategies. Neem-based products and selective insecticides are applied based on economic threshold levels to minimize damage while reducing environmental impact.

Timely management of sucking pests, bollworms, and whiteflies is crucial to prevent yield losses. The adoption of IPM practices ensures sustainable pest control and reduces reliance on chemical pesticides.

ADVANTAGES OF HDPS

The High-Density Planting System offers several advantages over conventional cotton cultivation. It significantly increases productivity, with yield gains of 20–40% reported in various regions, particularly under rainfed conditions (CICR, 2025). The system also enables early crop maturity, reducing exposure to late-season pest infestations such as pink bollworm.

HDPS supports mechanization, including machine harvesting, which addresses labour shortages and reduces production costs. Improved resource-use efficiency, including better utilization of nutrients and water, contributes to sustainability. Additionally, the system allows for crop diversification, as early harvest enables the cultivation of subsequent crops in the same field.

The incorporation of crop residues into the soil further enhances soil health, improves organic matter content, and supports long-term productivity.

ADOPTION AND IMPACT IN INDIA

The adoption of HDPS in India has gained momentum in recent years, particularly in states such as Maharashtra, Andhra Pradesh, Gujarat, Karnataka, Telangana, and Tamil Nadu. Collaborative efforts involving research institutions, extension agencies, and private sector organizations have played a crucial role in promoting this technology.

Initiatives such as farmer demonstrations and training programs have helped build awareness and confidence among farmers. Reports indicate substantial improvements in yield and profitability, making HDPS an attractive option for cotton growers. The system aligns with national goals of enhancing agricultural productivity and strengthening the textile sector.

CONCLUSION

The High-Density Planting System represents a transformative approach to cotton cultivation in India, addressing key challenges of low productivity, labour scarcity, and resource inefficiency. By increasing plant density and adopting improved agronomic practices, HDPS enables farmers to achieve higher yields and better economic returns. Its compatibility with mechanization, suitability for rainfed conditions, and contribution to sustainable farming make it a promising strategy for the future. As adoption expands and technological innovations continue, HDPS has the potential to significantly enhance India’s position in the global cotton market. Ultimately, this system not only improves farm-level productivity but also supports the broader goals of agricultural sustainability and economic development.

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