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Rushita H Kotadiya
Assistant Research Scientist, Soil
and Water Management Research
Unit, Navsari Agricultural
University, Navsari, Gujarat, India

Krishna A Kachhiyapatel
Assistant Research Scientist, Soil
and Water Management Research
Unit, Navsari Agricultural
University, Navsari, Gujarat, India

Mohit Kumar
Assistant Professor, Directorate of
Research, Navsari Agricultural
University, Navsari, Gujarat, India

MP Ramani
Assistant Research Scientist,
Medicinal and Aeromantic Plants
Research Station, Anand
Agricultural University, Anand,
Gujarat, India

AS Bhanvadia
Associate Research Scientist, Bidi
and Tobacco Research Station,
Anand Agricultural University,
Anand, Gujarat, India

KV Ram
Assistant Professor, College of
Agriculture, Junagadh Agricultural
University, Junagadh, Gujarat,
India

DM Patel
Assistant Professor, College of
Agriculture, Anand Agricultural
University, Jabugam, Gujarat,
India

Corresponding Author:
Rushita H Kotadiya
Assistant Research Scientist, Soil
and Water Management Research
Unit, Navsari Agricultural
University, Navsari, Gujarat, India

Cumulative impact of plant geometry and foliar spray of growth retardant on economics of cotton under high density planting system

Rushita H Kotadiya, Krishna A Kachhiyapatel, Mohit Kumar, MP Ramani, AS Bhanvadia, KV Ram and DM Patel

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Abstract

Cotton, an essential cash crop both globally and in India, is economically vital, ranking just behind food grains in India. This research examines how plant growth regulators (PGRs) and plant density affect cotton yield and economic outcomes in high-density planting systems (HDPS). The study was carried out at Regional Research Station, Anand Agricultural University, Gujarat, during the *kharif* seasons of 2022-2023 and 2023-2024. A Randomized Block Design (Factorial) with three replications were used, encompassing twelve treatment combinations of four plant geometries and three PGR treatments. Statistical analysis of seed cotton yield data showed that the 30-90-30 × 20 cm paired row spacing with 200 ppm Chlormequat chloride produced the highest seed cotton yield (2923 kg/ha), net return and benefit-cost ratio (2.69). The findings suggest that paired row spacing and CCC application enhance plant architecture, resource efficiency and boll number and size, resulting in better economic returns. The study demonstrates that high-density planting, combined with the appropriate use of PGRs, can substantially increase cotton productivity and profitability.

Keywords: Cotton, plant density, plant growth regulators, economics

Introduction

The production of fiber and oilseeds makes cotton the world's most important cash crop. (Dong *et al.*, 2010) ^[5]. It is an important cash crop that is second only to food grains in terms of importance to the Indian economy. (Patel *et al.*, 2016) ^[11]. Among cash crops, cotton is highly valuable and is known as the "King of Fiber Crops" in India. Global cotton production estimates for the 2022–2023 year, as reported by the US Department of Agriculture, point to a 35.5 million hectare cultivated area and 115.7 million bales produced (Anonymous, 2023a) ^[2]. With 13.0 million hectares under cultivation, India is notable for having the greatest cotton farming area during the same time period.

The environment and methods of seasonal management have a big influence on cotton's growth and development (O'Berry *et al.*, 2008) ^[9]. Maintaining a suitable plant population is one tactic to maximize output per unit area; this element differs throughout cotton cultivars (Ali *et al.*, 2009) ^[1]. Appropriate plant spacing is essential for reaching the optimal plant density according to the variety's requirements, especially for increasing cotton yield. (Nadeem *et al.*, 2010) ^[8]. Plants used in the High-Density Planting System (HDPS) must have a compact, determinate growth pattern with short fruiting branches and no vegetative branches on the main stem. (Venugopalan *et al.*, 2013) ^[14]. The performance of the cotton crop under various spacing configurations must thus be carefully examined in order to understand the effects of plant density on crop development, seed production and quality (Basanagouda and Patil, 2007) ^[3]. Plant growth regulators or PGRs, are used to reduce negative effects and alter the architectural features of cotton plants (Echer and Rosolem, 2012) ^[6]. Plants with a shorter, more compact and open canopy as well as a higher ratio of vegetative to reproductive dry matter may be the outcome of applying plant growth regulators (Sawan, 2017) ^[13]. Therefore, the purpose of the study was to investigate how plant growth regulators and plant density affect cotton yield and economics.

Materials and Methods

The current study was conducted at the Regional Research Station, Anand Agricultural University, Anand (Gujarat), during the *khari*f seasons of 2022–2023 and 2023–2024. Three replications with a Randomized Block Design (Factorial) layout were used for the experiment. Three levels of plant growth regulators and four levels of plant geometry were used in twelve (12) treatment combinations. Thirty-six plots were comprised of twelve treatment combinations: P₁ - 60 × 20 cm, P₂ - 30-90-30 × 20 cm (paired row), P₃ - 75 × 20 cm and P₄ - 45-105-45 × 20 cm (paired row). Additionally, there were three treatments for plant growth regulators: G₁ - Control, G₂ - Chlormequat chloride 200 ppm at 60 and 75 DAS and G₃ - Paclobutrazol 23% SC at 60 and 75 DAS. Both years' experiments employed the GTHV 13/28 variety of cotton. Without altering the treatments' randomization, the experiment was carried out at the same location in both seasons. The soil in experimental field had loamy sand texture. The nutrients (NPK) application was done as per the recommended dose (240-00-00 kg NPK ha⁻¹). The data on seed cotton were recorded in accordance with established protocols and Gomez and Gomez (1984) [7] analysis of variance technique for randomized block design (Factorial) design was used to conduct a statistical analysis of the data relevant to seed cotton yield. A few formulas were employed to compute the economics, as explained below.

Gross return

Using the current local market pricing and the seed cotton yield from each treatment, the gross revenue, expressed in rupees per hectare, was computed.

Net returns

To calculate net returns, the whole cost of cultivation was deducted from each treatment's gross yields.

Benefit: cost ratio (B:C)

The benefit-cost ratio was determined by subtracting all costs from the total revenue from the total yield of seed cotton, accounting for the costs of all inputs required for different treatments as well as the current rates of the product market.

$$\text{B:C ratio} = \frac{\text{Gross returns (₹/ha)}}{\text{Total cost of cultivation (₹/ha)}}$$

Results and Discussion

The maximum economic return on a treatment determines how adaptable agronomic procedures are on a regional level for any given crop. Thus, for a reliable comparison of agronomic approaches and competent advice, the economics of various treatments must be determined. The current market price of seed cotton, together with several variable and non-variable inputs, were used to compute the cost of production, gross return, net return and BCR for various treatments. The plant geometry and plant growth regulators (average of both years) individual component yield and economics are shown in Table 1. Data presented in Table 1 clearly indicated that paired row spacing of 30-90-30 × 20 cm and application of chlormequat chloride 200 ppm at 60 and 75 DAS (P₂G₂) recorded maximum seed cotton yield (3028 kg/ha), net return of ₹ 1,22,359 /ha with BCR 3.06 followed by P₁G₂ (60 × 20 cm and application of chlormequat chloride 200 ppm at 60 and 75 DAS) seed cotton yield (2923 kg/ha), net return of ₹ 1,11,020 /ha with BCR 2.73 and P₂G₃ (paired row spacing of 30-90-30 × 20 cm and application of paclobutrazole 23% SC at 60 and 75 DAS) seed cotton yield of 2693 kg/ha, net return of ₹ 1,01,437 /ha with BCR 2.69. The combination of paired row spacing and CCC application optimizes plant architecture and resource use, leading to higher boll numbers and larger boll size, thus increasing the overall yield, net return and benefit cost ratio. The narrower spacing of 90 × 30 cm resulted in significantly higher net return of ₹38,603 per hectare (Biradar *et al.* 2010) [4]. Reddy (2012) [12] reported that maximum net returns and returns per rupee of investment were achieved with higher planting density than other lower planting density. The gross monetary returns (₹ 124320/ha) and net monetary returns (₹ 85076/ha) were significantly the highest with 2.22 lakh plant population per hectare (Paslawar *et al.* 2015) [10]. While minimum seed cotton yield of 1715 kg/ha, net return of ₹ 43,582 /ha with 1.73 BCR was noticed with plant geometry P₃ (75 × 20 cm) with plant growth regulators G₁ (Control).

Table 1: Economics of different treatments on cotton (Average of both years)

Treatments		Seed cotton yield kg/ha	Cost of cultivation ₹/ha	Gross return ₹/ha	Net return ₹/ha	B:C ratio
P ₁ G ₁	60 × 20 cm + Control	2027	63585	121640	58055	1.91
P ₁ G ₂	60 × 20 cm + Chlormequat chloride 200 ppm at 60 and 75 DAS	2923	64350	175370	111020	2.73
P ₁ G ₃	60 × 20 cm + Paclobutrazole 23% SC at 60 and 75 DAS	2542	65132	152500	87368	2.34
P ₂ G ₁	30-90-30 × 20 cm (Paired row) + Control	2032	58566	121920	63354	2.08
P ₂ G ₂	30-90-30 × 20 cm (Paired row) + Chlormequat chloride 200 ppm at 60 and 75 DAS	3028	59331	181690	122359	3.06
P ₂ G ₃	30-90-30 × 20 cm (Paired row) + Paclobutrazole 23% SC at 60 and 75 DAS	2693	60113	161550	101437	2.69
P ₃ G ₁	75 × 20 cm + Control	1715	59298	102880	43582	1.73
P ₃ G ₂	75 × 20 cm + Chlormequat chloride 200 ppm at 60 and 75 DAS	1885	60063	113080	53017	1.88
P ₃ G ₃	75 × 20 cm + Paclobutrazole 23% SC at 60 and 75 DAS	1919	60845	115140	54295	1.89
P ₄ G ₁	45-105-45 × 20 cm (Paired row) + Control	1916	54280	114940	60660	2.12
P ₄ G ₂	45-105-45 × 20 cm (Paired row) + Chlormequat chloride 200 ppm at 60 and 75 DAS	2187	55045	131240	76195	2.38
P ₄ G ₃	45-105-45 × 20 cm (Paired row) + Paclobutrazole 23% SC at 60 and 75 DAS	1855	55827	111270	55443	1.99

Selling price of seed cotton: ₹ 60/kg

Conclusion

The study demonstrates that using a 30-90-30 × 20 cm paired row spacing with 200 ppm Chlormequat chloride greatly increases cotton yield, net return and benefit-cost ratio. The results indicate that integrating high-density planting with the proper application

of PGRs, particularly CCC, can significantly improve cotton productivity and profitability, presenting an efficient agronomic strategy for maximizing yields.

Conflict of Interest: None

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