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Performance of cotton under different spacings and fertilizer levels on growth, yield, nutrient uptake and economics in high density planting system

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Abstract

Adopting a high-density planting system in cotton cultivation has resulted in increased yields compared to traditional methods. Despite the clear benefits, farmers face various challenges throughout the cultivation process, from sowing to harvesting. However, selecting appropriate plant spacings, fertilizer levels and implementing tailored cultivation techniques can significantly enhance productivity. A field experiment entitled “Performance of cotton under different spacings and fertilizer levels in High Density Planting System” was carried out during *kharif*, 2023 on sandy loam soil at Siddapur Research Farm, Regional Agricultural Research Station, Warangal to examine the effects of various spacings and fertilizer levels on growth, yield, nutrient uptake and profitability within high density planting system. The study used the factorial concept with three replications. Twelve treatment combinations were taken with three levels of plant spacings (S1: 80 x 20 cm; 62,500 plants ha^{-1}, S2: 90 x 15 cm;74,074 plants ha^{-1}, S3: 90 x 60 cm;18,518 plants ha^{-1}) and four fertilizer levels (F1: 100% RDF, F2: 125% RDF, F3:100% RDF + Microbial consortia, F4: Control (no fertilizers) in factor II. The results revealed that higher plant height, more number of sympodial branches per plant, number of bolls m^{-2}, seed cotton yield (kg ha^{-1}) and higher profits were obtained with the spacing 90 x 15 cm (74,074 plants ha^{-1}). Among the different levels of fertilizer, 125% RDF recorded highest plant height, number of monopodial and sympodial branches per plant, no. of bolls m^{-2} and seed cotton yield (2362 kg ha^{-1}) and higher returns. Nutrient uptake (kg ha^{-1}) was higher significantly in closer spacing 90 x 15 cm compared to other spacings and higher in the treatment with 125% RDF with respect to fertilizer levels.

Keywords: High density planting system, cotton, nutrient uptake, profitability

Introduction

Cotton (*Gossypium hirsutum* L.) is a major cash crop and fiber source with global significance, grown in more than seventy countries. Known as "White Gold" or the "King of Fibers," it is a vital economic resource, contributing to employment and foreign exchange earnings.

According to the United States Department of Agriculture (USDA), globally, cotton area and production are projected as 35.5 million hectares and 115.7 million bales during 2022-23” (PJTSAU, 2023) [1]. “India has the largest area under cotton cultivation with 13.0 million hectares with the production and productivity of 34.3 million bales and 447 kg ha^{-1}, respectively during 2022-23. In Telangana, the area of cotton during 2021-22 was 1.8 million hectares with the production and productivity of 4.8 million bales and 439 kg ha^{-1}, respectively (Indiastat, 2023) [2]. The average lower productivity of cotton in India in general or Telangana state in particular can be primarily attributed to the fact that a majority of the cotton-growing zones are reliant on rainfed conditions. Most of the research findings revealed that heavy soils are more suitable for cotton cultivation” (Kavya *et al*., 2022) [13]. However, in the state of Telangana, most of the farmers are cultivating cotton as a rainfed crop on light textured soils characterized by shallow depth, poor fertility, vulnerable to water and soil erosion, producing notably low yields. Further, monocropping, low plant population, imbalanced application of fertilizers and delayed sowing due to late onset of rainfall, intermittent and terminal dry spells.

Nearly 95% of Indian cotton farmers grow genetically modified Bt cotton, yet they are encountering stagnant yields.

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This is largely due to rising labour demands, labour costs and increased expenses for cotton picking and nutrient inputs. These challenges highlight the urgent need for sustainable practices. To maintain productivity, implementing high-density planting systems with narrow or ultra-narrow spacing, especially in rainfed areas and developing effective management strategies to enhance yields and improve input use efficiency have become essential (Madhavi *et al.*, 2017) [15].

In cotton cultivation, wider intra-row spacing often leads to issues with plant gaps, particularly when the plant stand is affected by heavy rainfall or high temperatures combined with prolonged or intermittent dry spells during seedling development. These poor plant stands result in lower seed cotton yields. To achieve optimal plant populations, it's crucial to reduce intra-row spacing and cultivate short, compact genotypes that yield more in closer spacing (Basavanneppa *et al.*, 2000) [4] and (Mert *et al.*, 2006) [17]. A potential strategy for enhancing cotton productivity is to manipulate row spacing to increase plant density and optimize their spatial arrangement, a practice known as the high-density planting system (HDPS) in cotton.

In cotton production, both plant density and fertilizer dosage are critical factors. While plants may exhibit strong growth and high yields per plant, the overall yield per unit area may be limited if the plant population is too low. Therefore, achieving optimal spacing is crucial for maximizing economic yield.

Management practices such as plant density and nutrient management are crucial for maximizing cotton productivity. Establishing the right plant density is essential for achieving higher yields, as a lower density can lead to resource wastage, while a higher density may restrict individual plant growth.

This research has the potential to refine crop management practices, increase productivity, and enhance fiber quality, which are essential for the sustainable advancement of the cotton industry. The insights gained will assist farmers in choosing the most effective planting densities and fertilizer applications to optimize yields and maintain economic viability, thus improving the overall efficiency and competitiveness of cotton production.

“Balanced fertilization is a crucial factor for boosting cotton yields”. To achieve the maximum yield potential of Bt cotton hybrids, it is essential to use proper agronomic practices, including optimal plant spacing and balanced fertilization, whether in irrigated or rainfed conditions. With the expansion of Bt cotton cultivation and the need for farmer-specific trials with different plant geometries, this study was designed to identify the best plant geometry and fertilizer levels. Therefore, the current research aims to determine the most effective plant spacing and fertilizer application for high-density planting systems.

Materials and Methods

The present investigation was carried out during the *kharif*, 2023 at Siddapur Research farm, Regional Agricultural Research Station (RARS), Warangal. The farm is geographically located at18°05'33.7"N latitude and 79°35'45.4"E longitude at an altitude of 266 m above mean sea level, in the Central Telangana Agro-climatic zone of Telangana. According to Troll’s climatic classification it falls under semi-arid tropics (SAT). The soil at the experimental site was sandy loam in texture, with low available nitrogen (250 kg ha^{-1}), medium available phosphorus (21.3 kg ha^{-1}), and organic carbon content (0.52%), high available potassium (361.2 kg ha^{-1}) and a pH of 7.3. A total of 873.8 mm of rainfall was recorded during the cropping season.

The study used a randomized block design (factorial concept) with three replications, consisting of 12 treatment combinations. These included three plant spacings: S_1: 80 x 20 cm (62,500 plants ha^{-1}), S_2: 90 x 15 cm (74,074 plants ha^{-1} and S_3: 90 x 60 cm (18,518 plants ha^{-1}) as Factor I and four fertilizer levels as Factor II: F_1: 100% RDF, F_2: 125% RDF, F_3: 100% RDF + Microbial consortia, F_4: Control (no fertilizers). The cotton hybrid, RCH-665, was sown by dibbling according to the treatments on July 6, 2023. A full dose of phosphorus was applied as a basal application at the time of sowing, while the required amounts of nitrogen and potassium were applied to the soil surface via band placement at 20, 40, 60, and 80 days after sowing (DAS) as per the treatments.

The microbial consortia, including Azotobacter (500 gm), Phosphorous Solubilizing Bacteria (PSB) (500 gm), and Potassium Releasing Bacteria (KRB) (500 gm), were mixed with 50 kg of vermicompost and applied to the soil in the respective treatments. All recommended agronomic practices and need-based plant protection measures were followed to ensure a healthy crop. Growth and yield observations were recorded according to standard procedures.

Plant height (cm): Five tagged plants were used for recording plant height. Plant height (cm) was measured from the ground surface to the topmost growing point by using a linear meter scale.

No. of monopodial branches plant^{-1}: The average number of monopodial branches plant^{-1} was determined by counting the branches formed at the base of the labelled plants. Monopodial branches are exact replicas of the main stem and do not bear flowers and bolls. Fruiting bodies are formed on further branches that extend from the monopodial branches.

No. of sympodial branches plant^{-1}: The branches formed above the growing shoots which bear flowers at each node and grow horizontally are called sympodial branches. These were counted from the labelled plants and average no. of sympodial branches plant^{-1} was worked out. The branches which arose from the monopodia also counted as no. of sympodial branches plant^{-1}.

Number of bolls plant^{-1}: The total number of bolls which are present in boll development and opened bolls at picking from the five tagged plants from the net plot were counted, averaged and expressed as no. of bolls plant^{-1}.

Number of bolls m^{-2}: The number of bolls were counted from one square meter area of the net plot in each treatment before the harvest and expressed as number of bolls m^{-2}.

Seed cotton yield (kg ha^{-1}): After picking, seed cotton obtained from each treatment in net plot was weighed on an electronic balance. The seed cotton obtained from net plots in each treatment was weighed in g plot^{-1} and yield was converted to kg ha^{-1}.

Nitrogen uptake (kg ha^{-1}): The plant samples collected for dry matter estimation were utilized for chemical analysis. The dried samples were powdered together and used for analysis. The total nitrogen content was estimated by following micro-kjeldahl method (Jackson, 1967) [11]. The nutrient uptake (g plant-1) by crop at harvest were worked out by multiplying the percent nutrient content with dry matter of the respective treatments. Total N was calculated for each treatment separately by using the following formula.

$$\text{Nitrogen uptake (kg ha}^{-1}\text{)} = \frac{\text{Percentage of nitrogen x Total dry matter production (kg ha}^{-1}\text{)}}{100}$$

Phosphorous uptake (kg ha^{-1}): The phosphorus content in the extract was determined by using a Spectrophotometer (Elico SL-177) at a wavelength of 420 nm, following the Vanado-Molybdo phosphoric yellow colour method as described by (Piper,1966) [20] and the phosphorus content was expressed in percentage. The nutrient uptake (g plant-1) by crop at harvest were worked out by multiplying the percent nutrient content with dry matter of the respective treatments. Total P was calculated for each treatment separately by using the following formula.

$$\text{Phosphorous uptake (kg ha}^{-1}\text{)} = \frac{\text{Percentage of Phosphorous x Total dry matter production (kg ha}^{-1}\text{)}}{100}$$

Potassium uptake (kg ha^{-1})

The potassium content in the extract was then determined using a Flame photometer (Elico CL 378) following the method described by (Jackson,1967) [11]. The potassium content was expressed in percentages. The respective potassium uptake was calculated from the plant samples using the following formula and then converted into kilograms per hectare (kg ha^{-1}).

$$\text{Phosphorous uptake (kg ha}^{-1}\text{)} = \frac{\text{Percentage of Phosphorous x Total dry matter production (kg ha}^{-1}\text{)}}{100}$$

Gross monetary returns (GMR) were calculated by multiplying the seed cotton yield and stalk yield with their respective prevailing market price. Net returns were calculated by subtracting the cost of cultivation from gross returns for each treatment. Benefit cost ratio was calculated by dividing gross returns with cost of cultivation for each treatment.

Data on different characters *viz*., growth, yield, nutrient uptake were subjected to analysis of variance procedures as outlined for Randomized Block Design, factorial concept (Gomez and Gomez, 1984) [10]. Statistical significance was tested by F- value at 0.05 level of probability and critical difference was worked out wherever the effects were significant.

Results and Discussion

The results obtained from the present study as well as discussions have been summarized under following heads:

Plant height (cm)

Plant height is an important morphological characteristic in cotton that provides locations for nodes and internodes, from which sympodial branches emerge and play a crucial role in determining the morphological framework relating to productivity. Significantly more plant height (100 cm) was recorded with spacing of 90 x 15 cm (74,074 plants ha^{-1}) and followed by 80 x 20 cm (62,500 plants ha^{-1}) (95 cm). While significantly lower plant height (85 cm) was recorded with spacing of 90 x 60 cm (18,518 plants ha^{-1}). Plant height was found to be superior with application of 125% RDF (96cm) and followed by 100% RDF + Microbial consortia (93.4 cm) and it was comparable to 100% RDF (93.3 cm). However, a shorter plant height was recorded with control treatment(F_4) (90.7 cm)

The availability of horizontal space for individual plant in narrow rows reduced due to which intense inter plant competition for nutrient and light suppressed node appearance and plants grew taller in respect of vertical space. (Venugopalan *et al.*, 2013) [22]. also endorsed that inter-plant competition for nutrients and light produced taller plants at higher plant density. Shorter plants are preferred in narrow row cotton to avoid late maturity. Increase in plant height with higher level of fertilizer may be attributed to increased cell division and cell elongation promoted through the application of 125% RDF. This was in accordance with (Basha *et al.*, (2017) [5]. (Kanchana *et al.*, (2019) [12]. noticed that plant height increased linearly with each increment of nitrogen from 0 to 150 kg ha^{-1} whereby each higher dose was significantly greater than the preceding level.

No. of monopodial branches plant^{-1}

The number of monopodia per plant were significantly influenced by varied plant spacings and higher number of monopodial branches plant^{-1}was observed with plant spacing of S_3 (18,518 plants ha^{-1}) followed by S_1 (62,500 plants ha^{-1}) and were significantly superior over S_2 (74,074 plants ha^{-1}). Significantly higher monopodia plant^{-1} (1.7) were noticed with 125% RDF followed by 100% RDF+ microbial consortia (1.1) and 100% RDF (0.8). While significantly lower monopodia plant^{-1} were recorded with control treatment.

Less availability of horizontal space for individual plants in narrow rows leads to intense inter-plant competition for light and other resources. This competition suppresses node appearance and causes the plants to grow taller to maximize their use of vertical space. Effective cotton crop management involves maintaining a balance between vegetative and reproductive growth. Fertilizer application has been essential in enhancing agricultural productivity. However, higher plant density increases the demand for nutrients to support overall growth and development. These observations are in close conformity with Dadgale *et al.*, (2014) [8].

No. of sympodial branches plant^{-1}

Higher sympodia plant^{-1} were registered with wider spacing of 90 x 60 cm (18,518 plants ha^{-1}) followed by 80 x 20 cm spacing (62,500 plants ha^{-1}). While significantly lower sympodia plant^{-1} were recorded with closer spacing of 90 x 15 cm (74,074 plants ha^{-1}). Significantly higher sympodia plant^{-1} were recorded with application of 125% RDF followed by 100% RDF + microbial consortia and it was comparable to 100% RDF and lower sympodia recorded in control treatment.

Sympodial branches are a crucial part of the cotton plant's structure, as they are where the fruiting bodies develop. Plants under wider spacing, there will be an availability of more space for lateral expansion of branches and chance to enhance auxiliary buds of plants compared to closer spacing resulted in more branches per plant. These results are consistent with (Baig *et al.*, (2021) [3], (Maheshwari *et al.*, (2019) [16]. Fertilization increases the availability of nutrients in readily accessible forms, leading to optimal growth and development, and resulting in an increase in lateral branches. The increase in the number of sympodia plant^{-1} with higher fertilizer levels is supported with the findings of (Liaquat *et al.*, (2018) [14] and Kanchana *et al.*, (2019) [12].

Number of bolls plant^{-1}

A perusal of data on number of bolls plant^{-1} reported that significantly higher bolls plant^{-1} was recorded in wider spacing S_3- 90 x 60 cm (18,518 plants ha^{-1}) which was significantly superior to the other plant spacings. Whereas lower no. of bolls per plant was recorded in closer spacing S_2- 90 x 15 cm (74,074 plants ha^{-1}) spacing. Significantly higher no. of bolls plant^{-1} (22.7) was recorded with application of 125%RDF (F2) which was comparable with the application of 100%RDF+microbial consortia (F3) (20.5) and followed by 100%RDF (F1) (18.5). Further, lower no. of picked bolls plant^{-1} (8.4) was recorded in the control treatment(F4).

The higher no. of bolls per plant was observed in wider spacing which can be attributed to the ample space for growth, consistent availability of water, nutrients and improved photosynthetic efficiency. This ultimately results in significantly more no. of sympodia per plant. Such an increase in bolls plant^{-1} was a direct consequence of more sympodial branches plant^{-1}. Similar results were substantiated by Munir *et al.*, (2015) [18]. The reduction in the no. of bolls plant^{-1} in closer spacing can be attributed to the shading effect on lower leaves and bolls caused by interplant competition. This shading results in unopened bolls and reduced transfer of assimilates to the reproductive parts. The increase in the number of picked bolls plant^{-1} with higher doses of fertilizer may be attributed to greater nutrient availability and uptake, enhanced leaf formation, improved photosynthesis, and better translocation of assimilates to reproductive parts, leading to improved square and boll formation. These results are supported by Gadage *et al.*, (2015) [9] and Devi *et al.*, (2018) [7].

No. of bolls m^{-2}

Scrutiny of data disclosed that significantly higher no. of bolls m^{-2} (112.3) was noted with closer spacing of S_2- 90 x 15 cm (74,074 plants ha^{-1}) was due to more no. of plants allocated per unit area and followed by S_1- 80 x 20 cm spacing (62,500 plants ha^{-1}) (108.8). While lower bolls m^{-2} were recorded in 90 x 60 cm (18,518 plants ha^{-1}) (40.1). Significantly higher no. of bolls m^{-2} (105.4) were recorded with application of 125%RDF (F_2) and followed by 100%RDF + Microbial consortia (F_3) (93.5) and 100%RDF (84.7). Further, lower no. of bolls m^{-2} (64.4) were recorded in control treatment(F_4).

Seed cotton yield (kg ha^{-1})

Data regarding seed cotton (kapas) yield (kg ha^{-1}) showed that significantly higher seed cotton yield (2433 kg ha^{-1}) was registered with S_2- 90 x 15 cm (74,074 plants ha^{-1}) spacing and followed by S_1-80 x 20 cm (62,500 plants ha^{-1}) (2040 kg ha^{-1}). Whereas lower kapas yield was recorded in wider spacing S_3-90 x 60 cm (18,518 plants ha^{-1}). Among the fertilizer levels, significantly higher seed cotton yield (2362 kg ha^{-1}) was recorded with 125% RDF (F_2), compared to 100% RDF + Microbial consortia (2113 kg ha^{-1}) (F_3) and yield was comparable to the 100% RDF (1942 kg ha^{-1}) (F_1) while lower yield was observed in the control treatment(F_4).

Kapas yield is ultimately determined by the total biomass produced and how it is distributed into reproductive parts during various stages of crop growth. Optimizing plant population can be an effective strategy to increase yields, boost profits, and enhance input utilization efficiency. Similar observations were substantiated by (Pandagale *et al.*, 2020) [19]. and (Sankarnarayana *et al.*, 2004) [21]. The variation in yield under different spacings might be due to differences in growth and yield characteristics.

The wider spacing- 90 x 60 cm (18,518 plants ha^{-1}) resulted in significantly higher yield components. This was due to improved plant growth and development, which facilitated a more even distribution of plants. Moreover, the wider spacing promoted efficient utilization of moisture, solar energy, and nutrients by reducing both inter- and intra-plant competition. These conditions favoured for growth in wider plant spacing, but these higher yield components were compensated through higher density per unit area with closer spacing of 90 x 15 cm (74,074 plants ha^{-1}), it resulted in higher kapas yield over others and also lead to the higher nutrients uptake per unit area. These results are consistent with findings of Venugopalan *et al.* (2011). In cotton plants, nutrient requirements vary across different stages rather than being uniform. Applying fertilizers according to the specific crop growth periods enhances nutrient uptake, promotes plant growth and development and ultimately supports higher seed cotton yields.

According to (Dadgale *et al.*, 2014) [8]., the beneficial impact of mineral nutrient supply on the number of sink organs is not solely due to increased nitrogen (N) supply, but also due to enhanced supply of photosynthates to the sink sites. These results are in line with the findings of Bharathi *et al.*, (2018) [6] and Kanchana *et al.*, (2019) [12].

Nutrient uptake (kg ha^{-1})

An appraisal of data reported that N, P and K uptake was affected significantly by varied plant spacings where significantly higher nutrient uptake was recorded with closer spacing S_2-90 x 15 cm and it was followed by S_1- 80 x 20 cm over wider spacing S_3- 90 x 60 cm. Among fertilizer levels them, significantly higher nutrient uptake was recorded with application of125%RDF (F_2), compared to 100%RDF + Microbial consortia (F_3) and 100%RDF(F_1) and lower nutrient uptake was recorded in the control treatment(F_4).

The variation in nutrient uptake by cotton plants across different spacings can be attributed to the differences in dry matter accumulation at various crop stages and final seed cotton yield. The growth, development and yield were determined by the presence of mineral nutrients in the soil and in their readily available form for plant uptake. The uptake of the plant mineral nutrients was closely associated with the nutrient concentration in the soil solution. Where the application of fertilizers leads to an increase in concentration of the nutrient ions in the soil solution and availability of sufficient amounts of nutrients might have helped in higher uptake of the nutrient by the plants.

The study revealed a non-significant interaction was found between plant spacings and different levels of fertilizers on growth, yield and nutrient uptake.

Table 1: Growth, Yield attributes and Seed Cotton Yield (kg ha^{-1}) of cotton under varied plant densities and fertilizer levels during kharif, 2023

Treatments	Plant height (cm)	No. of monopodia plant^{-1}	No. of sympodia plant^{-1}	No. of bolls plant^{-1}	No. of bolls m^{-2}	Seed Cotton Yield (kg ha^{-1})
Spacings						
S1: 80 cm X 20 cm (62,500 plants ha^{-1})	95	1.58	19.5	19.6	108.8	2040
S2: 90 cm X 15 cm (74,074 plants ha^{-1})	100	0.85	16.7	16.2	112.3	2233
S3: 90 cm X 60 cm (18,518 plants ha^{-1})	85	2.67	21.1	22.2	40.1	1841
SEm ±	0.66	0.1	0.59	0.38	2.2	4.91
CD (P=0.05)	1.95	0.31	1.74	1.11	6.45	14.41
Fertilizer Levels						
F_1: 100%RDF	93.3	1.3	19.6	18.5	84.7	1942
F_2: 125% RDF	96	3.0	21.7	22.7	105.4	2362
F_3: 100% RDF+ microbial consortia	93.4	2.0	19.2	20.5	93.5	2113

F$_4$: Control	90.7	0.4	15.5	15.4	64.4	1737
SEm ±	0.77	0.12	0.69	0.44	2.54	5.67
CD (P=0.05)	2.25	0.36	2.01	1.28	7.45	16.64
Interaction						
SEm ±	1.33	0.21	1.19	0.76	4.4	9.82
CD (P=0.05)	NS	NS	NS	NS	NS	NS

*NS- Nonsignificant

Table 2: Nutrient uptake (kg ha^{-1}) of cotton under varied plant densities and fertilizer levels during kharif, 2023

Treatments	Nitrogen uptake (kg ha^{-1})	Phosphorous uptake (kg ha^{-1})	Potassium uptake (kg ha^{-1})
Spacings			
S1: 80 cm X 20 cm (62,500 plants ha^{-1})	98.5	26.5	112.7
S2: 90 cm X 15 cm (74,074 plants ha^{-1})	106.4	29.0	117.9
S3: 90 cm X 60 cm (18,518 plants ha^{-1})	80.6	19.9	90.8
SEm ±	2.52	0.8	1.7
CD (P=0.05)	7.7	2.4	5.1
Fertilizer Levels			
F1: 100%RDF	94.2	22.4	104.5
F2: 125% RDF	101.2	26.6	114.4
F3: 100% RDF+ microbial consortia	98.4	25.8	110.3
F4: Control	84.1	17.0	94.1
SEm ±	0.88	0.23	1.3
CD (P=0.05)	2.7	0.7	4.0
Interaction			
SEm ±	5.0	4.2	1.9
CD (P=0.05)	NS	NS	NS

Table 3: Economics of cotton as influenced by varied plant spacings and fertilizer levels under HDPS

Treatments	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net Returns (₹ ha^{-1})	B:C ratio
Spacings				
S1: 80 cm X 20 cm (62,500 plants ha^{-1})	96242	144863	48627	1.5
S2: 90 cm X 15 cm (74,074 plants ha^{-1})	98508	158560	60052	1.6
S3: 90 cm X 60 cm (18,518 plants ha^{-1})	89675	130776	41101	1.4
SEm ±	-	348	348	-
CD (P=0.05)	-	1023	1023	-
Fertilizer levels				
F1: 100%RDF	96216	137850	41634	1.4
F2: 125%RDF	98159	167702	69542	1.7
F3: 100%RDF+ Microbial consortia	97841	150023	52131	1.5
F4: Control	87016	123358	36342	1.3
SEm ±	-	403	403	-
CD (P=0.05)	-	1181	1181	-
Interaction				
SEm ±	-	698	697	-
CD (P=0.05)	-	NS	NS	-

Economics

The economic indicators such as cost of cultivation (Rs. ha^{-1}), gross return (Rs. ha^{-1}), net return (Rs. ha^{-1}) and B: C ratio was worked out and these indicators were analyzed statistically and presented in the Table 3. Significantly higher gross returns (₹ 1,58,560 ha^{-1}), net returns (60,052 Rs. ha^{-}1) and B:C ratio (1.6) was recorded with closer spacing 90 x 15 cm when compared to wider spacing 90 x 60 cm. While, highest gross returns (1,67,702 Rs. ha^{-1}), net returns (69542 Rs. ha^{-1}) and B:C ratio (1.7). However lowest returns were recorded in the control treatment.

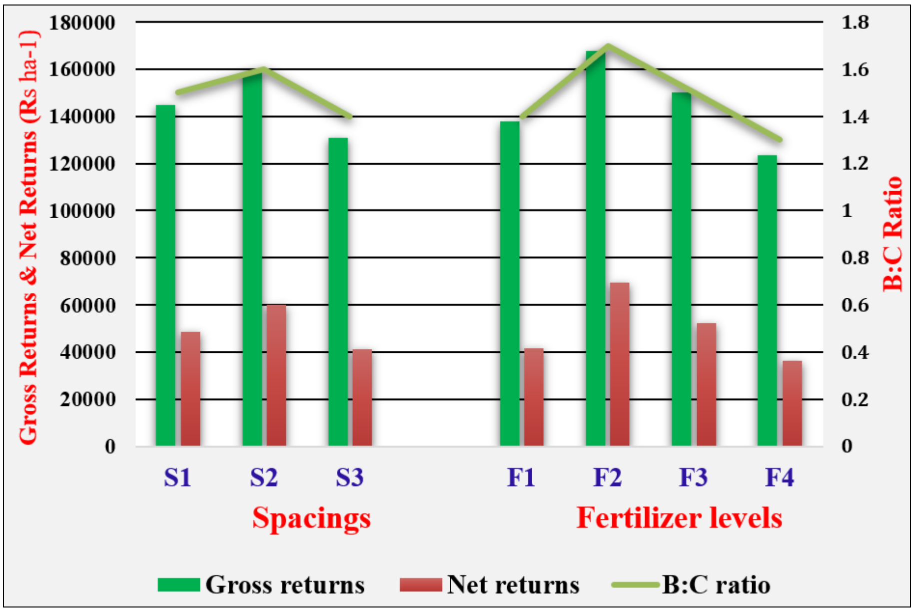

Fig 1: Economics of cotton as influenced by different spacings and fertilizer levels

Conclusion

Based on the results of present study the following conclusions are drawn:

- Adoption of 90 x 15 cm (74,074 plants ha^{-1}) and 80 x 20 cm (62,500 plants ha^{-1}) recorded higher kapas yield per unit area over traditional planting at 90 x 60 cm (18,518 plants ha^{-1}).
- Among the fertilizer levels, 125% RDF application yielded the greatest seed cotton output and monetary returns.
- Significantly higher gross returns (₹ 1,58,560 ha^{-1}), net returns (₹ 60,052 ha^{-1}) and B:C ratio (1.6) were achieved with the closer spacing 90 x 15 cm in comparison to wider spacing 90 x 60 cm. Among the fertilizer levels 125% RDF resulted in higher gross, net returns and B:C ratio.

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