



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
© Agronomy
NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; 9(7): 356-359
Received: 24-05-2026
Accepted: 28-06-2026

Durgam Venkatesh
College of Agriculture, PJTAU,
Rajendranagar, Hyderabad,
Telangana, India

C Sudha Rani
Agricultural Research Station
Tandur, Vikarabad, Telangana,
India

C Sudhakar
Agricultural Research Station
Tandur, Vikarabad, Telangana,
India

T Ram Prakash
College of Agriculture, PJTAU,
Rajendranagar, Hyderabad,
Telangana, India

K Supriya
College of Agriculture, PJTAU,
Rajendranagar, Hyderabad,
Telangana, India

Corresponding Author:
Durgam Venkatesh
College of Agriculture, PJTAU,
Rajendranagar, Hyderabad,
Telangana, India

Crop growth rate and relative growth rate of high-density cotton in pigeonpea-based intercropping systems in Vertisols

Durgam Venkatesh, C Sudha Rani, C Sudhakar, T Ram Prakash and K Supriya

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i7e.5952>

Abstract

The study was conducted to study the performance of the paired row pigeonpea cotton intercropping system and to assess the growth and yield of paired row pigeonpea, which is intercropped with high-density cotton. The space between the two paired rows of Pigeonpea is effectively utilized for growing high-density cotton. This experiment was conducted at Agricultural Research Station (ARS) Tandur, Vikarabad during *Kharif* 2023-24 and 2024-25. The experiment was laid out in split-plot design with three replications. Among the main plots 60 cm x 15 cm (M₁) recorded the maximum crop growth rate, 100 cm x 15 cm (M₃) recorded the maximum relative growth rate during 2023-24, 2024-25 and mean results. Among the sub plots highest crop growth rate and relative growth rate was recorded with application of 125% RDN + Mepiquat chloride 50 ppm at square formation and flowering stage (S₃), however it was performing on par with treatments received 100% RDN + Mepiquat chloride 50 ppm at square formation and flowering stage (S₂) and with application of (125% RDN + Cycocel 60 ppm at square formation and flowering stage) (S₆) during 2023-24, 2024-25 and mean data.

Keywords: Paired row pigeonpea, high-density cotton, growth regulators, nitrogen management, Mepiquat chloride, Cycocel

Introduction

Pigeonpea (*Cajanus cajan* L.) is India's second most important pulse crop after chickpea. Pigeonpea is one of the most crucial rainy season (*kharif*) grain legume crop, grown predominantly under rainfed conditions in India. In India, Pigeonpea is growing in an area of 50.02 lakh ha with production of 4.34 million tonnes and productivity of 877 kg ha⁻¹.

In the paired row Pigeonpea cotton intercropping system, the space between the two paired rows of Pigeonpea is effectively utilized for growing high-density cotton. Paired row planting system allows for better light interception by the crop and resource sharing for harvesting better yields (Rani *et al.*, 2019) ^[9]. In addition to that, the paired row of Pigeonpea intercropping system enriches the soil by adding nitrogen, improving the soil physico-chemical and biological properties. Intercropping of Pigeonpea with other crops like cotton provides farmers with additional returns as a commercial crop. Pigeonpea improves soil quality, reduces climatic risks and chance of crop failure, enhances biodiversity, and ensures greater use of resources and land area (Maitra *et al.*, 2001; Maitra and Ray, 2019) ^[5,6]. Pigeonpea is suitable for inter-cropping with different crops like cotton, sorghum, pearl millet, greengram, blackgram, maize, soybean and groundnut to increase production, resource use efficiency and maintain soil fertility. Paired row pigeonpea-based intercropping systems with high-density cotton represent a strategically designed cropping pattern that integrates the complementary growth habits of pigeonpea and cotton to maximize land productivity and resource use efficiency (Potdar *et al.*, 1996) ^[8]. In these systems, pigeonpea is sown in paired rows with adequate intra-pair spacing, often with the wider spaces between pairs utilized to accommodate high-density cotton rows. This arrangement allows for cultivating two crops simultaneously on the same land, leveraging the vertical structure and deep rooting ability of pigeonpea alongside the rapid canopy development and economic yield potential

of high-density cotton. (Bhardwaj *et al.*, 2023) ^[1].

Materials and Methods

The experimental plot was clay loamy soil, slightly alkaline in reaction, medium organic carbon, low available nitrogen, high available phosphorus and medium available potassium, respectively. The experiment was laid out in a split-plot design with three replications and 18 treatments and conducted during *kharif* 2023-24 and 2024-25. The main plot treatments consisted of high density cotton spacings in paired row pigeonpea viz., M₁: Paired row of pigeonpea intercropped with high density planting of cotton at 60 cm x 15 cm (1,11,111 plants ha⁻¹), M₂: Paired row of pigeonpea intercropped with high density planting of cotton at 75 cm x 20 cm (66,666 plants ha⁻¹), M₃: Paired row of pigeonpea intercropped with normal planting of cotton at 100 cm x 15 cm (66, 666 plants ha⁻¹) and sub plot treatments were consists of growth regulators and nitrogen management (S₁: 100% RDN + Mepiquat chloride 50 ppm at square initiation, peak square formation and flowering stage, S₂: 100% RDN + Mepiquat chloride 50 ppm at square formation and flowering stage, S₃: 125% RDN + Mepiquat chloride 50 ppm at square formation and flowering stage, S₄:100% RDN + Cycocel 60 ppm at square initiation, peak square formation and flowering stage, S₅:100% RDN + Cycocel 60 ppm at square formation and flowering stage, S₆: 125% RDN + Cycocel 60 ppm at square formation and flowering stage are replicated thrice.

ADB-39 cotton variety and TDRG 59 pigeonpea variety were selected for the experiment and sown by dibbling at different spacings of high-density cotton. First paired row of pigeonpea was sown with spacing of 45 cm and the space between the two paired rows of pigeonpea was 3 metres and in between the two paired rows of pigeonpea, 60 cm x 15 cm (5 rows of high density cotton), 75 cm x 20 cm (4 rows of high density cotton), and 100 cm x 15 cm (3 rows of high-density cotton) of high density cotton were grown during both years of the experiment. Recommended dose of fertilizers (RDF) of pigeonpea is 20:50:00 NPK kg ha⁻¹. Pigeonpea RDF of 20 kg of N and 50 kg of P₂O₅ were applied as urea and single super phosphate respectively as basal dose to the all the plots of pigeonpea as per treatments. Weeds were controlled by spraying pre-emergence herbicide, pendimethalin @ 0.75 kg a.i. ha⁻¹ second day of sowing followed by manual weeding at 40 and 70 DAS during both years of study (*kharif*, 2023-24 and 2024-25). The incidence of sucking pests was controlled by spraying Fipronil 5% SC @ 4 ml lit⁻¹. Later stages Imidacloprid @ 0.45 ml L⁻¹. To check the incidence of bollworms (*Pectinophora gossypiella*), spraying was done with Chlorantraniliprole (10%) + Lambda cyhalothrin 5% ZC @ 0.5 ml lit⁻¹ at boll development stage in 2023-24. Emamectin benzoate 5% SG @ 0.5 g L⁻¹ was sprayed against bollworms at 105 DAS and 120 DAS in 2024-25.

Statistical Analysis

Data on different characters, viz., growth, yield attributes, yield, soil and plant analysis, and economics, were subjected to analysis of variance procedures as outlined for split-plot design (Gomez and Gomez, 1984). Statistically significance was tested by F-value at p=0.05 (5%) level of probability and critical difference was worked out wherever the effect was significant. Non-significant treatment differences were denoted as NS.

Results and Discussion

Crop growth rate (CGR) (g m⁻² day⁻¹)

At 0-30 DAS and 30-60 DAS Among main plots, data indicated that high density cotton in paired row of pigeonpea was not

significantly influenced the CGR recorded during 2023-24, 2024-25 and in the average over years results. Among sub-plots, growth regulators and nitrogen management exert non-significant influence on CGR recorded during 2023-24, 2024-25 and in the average over years results.

Among main plot treatments, significantly highest CGR (2.79, 2.69 and 2.74) at 60-90 DAS, CGR (2.34, 2.21 and 2.27) at 90-120 DAS and CGR (1.9, 1.7 and 1.8) at 120 DAS-harvest was recorded with high density cotton spacing of 60 cm x 15 cm (M₁) during 2023-24, 2024-25 and in the average over years data results, respectively. The rest of the treatments, with high density cotton spacing of 75 cm x 20 cm (M₂) and 100 cm x 15 cm (M₃) performed on par with each other at 60-90 DAS and significantly the lowest CGR (2.10, 1.91 and 2.01) at 90-120 DAS and CGR (1.5, 1.4 and 1.5) at 120 DAS- harvest was obtained with high density cotton spacing of 100 cm x 15 cm (M₃) during both years and in the average over years data results, respectively.

Among sub-plots, growth regulators and nitrogen management had significantly influenced the CGR of high-density cotton in paired row of pigeonpea. Application 125% RDN + mepiquat chloride 50 ppm at square formation and flowering stage (S₃) recorded significantly highest CGR (2.82, 2.70 and 2.76) at 60-90 DAS, CGR (2.34, 2.21 and 2.27) at 90-120 DAS and Crop growth rate (2.0, 1.8 and 1.9) at 120 DAS- harvest, however it was comparable with application of 100% RDN + mepiquat chloride 50 ppm at square formation and flowering stage (S₂) and with application of 125% RDN + cycocel 60 ppm at square formation and flowering stage (S₆) during 2023-24, 2024-25 and in the average over years data results respectively. In contrast, significantly the lowest CGR (2.30, 2.24 and 2.27) at 60-90 DAS, CGR (1.89, 1.81 and 1.85) at 90-120 DAS and Crop growth rate (1.3, 1.2 and 1.3) at 120 DAS -harvest was noted with 100% RDN + cycocel 60 ppm at square initiation, peak square formation and flowering stage (S₄) during both years and in the average over years results, respectively.

Results revealed that among main plots, high density cotton spacing of 60 cm x 15 cm (M₁) recorded significantly more CGR. This might be due to more plants per unit area are utilizing available resources more efficiently it results in potentially increasing total biomass and yield up to an optimal density. The combined photosynthetic activity and resource capture by all the plants can exceed that of lower densities, leading to a higher CGR per unit area. Similar findings are reported by Hu *et al.* (2023) ^[2] and Sapkota *et al.* (2023) ^[11]. The CGR was increased with the increase in plant density as reported by Patel *et al.* (2021) ^[7].

Among the sub-plots, the highest CGR was recorded with application of 125% RDN + mepiquat chloride 50 ppm at square formation and flowering stage (S₃). This is due to the application of higher doses of nitrogen, its role in enhancing vegetative growth results in increasing dry matter production. Spraying of growth regulators (mepiquat chloride) can optimize plant architecture, reduce excessive vegetative growth, improve light penetration within the canopy, supporting efficient photosynthesis and higher CGR. Similar results were reported by Kumar *et al.* (2022) ^[4] and Wei *et al.* (2024) ^[12].

Relative Growth Rate (RGR) (g g⁻¹ day⁻¹)

Among main plot treatments, significantly highest RGR (0.018, 0.015 and 0.017) at 90-120 DAS and highest RGR (0.010, 0.010 and 0.010) at 120 DAS to harvest was observed with high-density cotton spacing of 100 cm x 15 cm (M₃) in paired row of pigeonpea as compared to the rest of the treatments. In contrast, the lowest RGR was recorded with high density cotton spacing of 60 cm x 15 cm (M₁) during both years and in the average over years

results, respectively.

Among the sub-plots, application of 125% RDN + mepiquat chloride 50 ppm at square formation and flowering stage (S_3) recorded the highest RGR (0.0198, 0.0147 and 0.0170 $\text{g g}^{-1} \text{day}^{-1}$) at 90-120 DAS and highest Relative growth rate (0.01, 0.009 and 0.011) at 129 DAS to harvest, however it was on par with application of 100% RDN + mepiquat chloride 50 ppm at square formation and flowering stage (S_2) and with application of 125% RDN + cycocel 60 ppm at square formation and flowering stage (S_6) during both the years and in the average over years data results, respectively.

Results revealed that RGR was not significantly influenced by high density cotton spacing in paired row of pigeonpea. However, among main plots high density cotton spacing of 100 cm $\times$ 15 cm (M_3) recorded the higher RGR. This might be due to wider spacing allowed for each plant so as to have greater access to light, water and nutrients, thereby enhancing photosynthesis and faster growth per plant. Similar findings were reported by Ibrahim *et al.* (2022) [3].

Among the sub-plots, highest RGR was recorded with application of 125% RDN + mepiquat chloride 50 ppm at square formation and flowering stage (S_3). The increase in RGR after application of growth regulators could be attributed to increased photosynthetic efficiency as a result of increased leaf thickness, higher chlorophyll content and efficient translocation of photosynthates. These results were in agreement with the findings of Sabale *et al.* (2017) [10]. Higher N availability increases leaf area, dry matter accumulation, directly boosting RGR and it declined at later stages of crop growth, which might be due to partitioning of extra photosynthates towards the developing sink during reproductive development. Similar findings were reported by Kumar *et al.* (2022) [4].

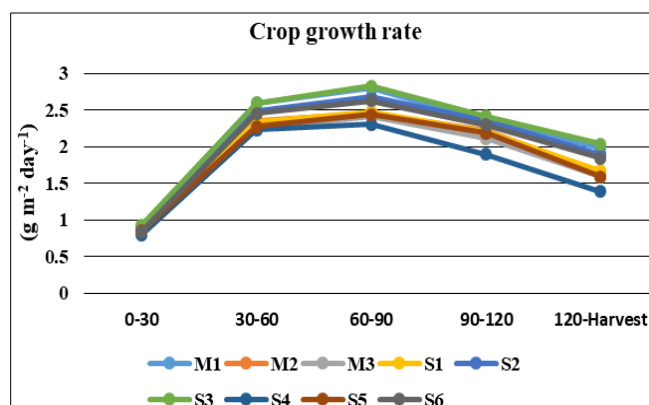
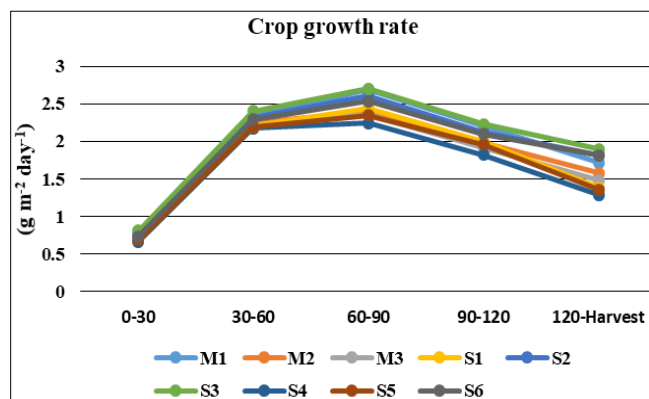


Fig 1: Crop growth rate ($\text{g m}^{-2} \text{day}^{-1}$) of high-density cotton in pigeonpea-based intercropping system as influenced by growth regulators and nitrogen management during *kharif* 2023-24 and 2024-25

M_1 : Paired row of pigeonpea intercropped with high density planting of cotton at 60 cm $\times$ 15 cm (111,111 plants ha^{-1}). M_2 : Paired row of pigeonpea intercropped with high density planting of cotton at 75 cm $\times$ 20 cm (66,666 plants ha^{-1}). M_3 : Paired row of pigeonpea intercropped with high density planting of cotton at 100 cm $\times$ 15 cm (66,666 plants ha^{-1}). S_1 : 100% RDN + mepiquat chloride 50 ppm at square initiation, peak square formation and flowering stage. S_2 : 100% RDN + mepiquat chloride 50 ppm at square formation and flowering stage. S_3 : 125% RDN + mepiquat chloride 50 ppm at square formation and flowering stage. S_4 : 100% RDN + cycocel 60 ppm at square initiation, peak square formation, and flowering stage. S_5 : 100% RDN + cycocel 60 ppm at square formation and flowering stage. S_6 : 125% RDN + cycocel 60 ppm at square formation and flowering stage.

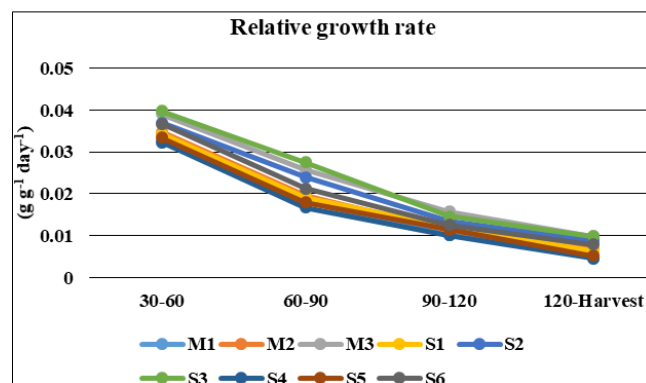
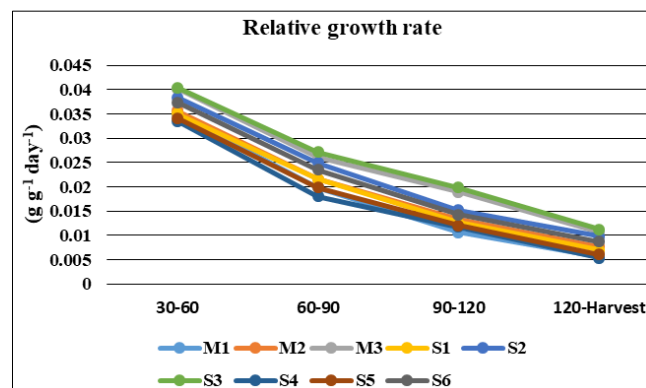


Fig 2: Relative growth rate ($\text{g g}^{-1} \text{day}^{-1}$) of high-density cotton in pigeonpea-based intercropping system as influenced by growth regulators and nitrogen management during *kharif* 2023-24 and 2024-25

M_1 : Paired row of pigeonpea intercropped with high density planting of cotton at 60 cm $\times$ 15 cm (111,111 plants ha^{-1}). M_2 : Paired row of pigeonpea intercropped with high density planting of cotton at 75 cm $\times$ 20 cm (66,666 plants ha^{-1}). M_3 : Paired row of pigeonpea intercropped with high density planting of cotton at 100 cm $\times$ 15 cm (66,666 plants ha^{-1}). S_1 : 100% RDN + mepiquat chloride 50 ppm at square initiation, peak square formation and flowering stage. S_2 : 100% RDN + mepiquat chloride 50 ppm at square formation and flowering stage. S_3 : 125% RDN + mepiquat chloride 50 ppm at square formation and flowering stage. S_4 : 100% RDN + cycocel 60 ppm at square initiation, peak square formation, and flowering stage. S_5 : 100% RDN + cycocel 60 ppm at square formation and flowering stage. S_6 : 125% RDN + cycocel 60 ppm at square formation and flowering stage.

Conclusion

It is concluded that high-density cotton spacing of 60 $\times$ 15 cm (M_1) in paired row pigeonpea recorded the highest crop growth

rate while 100 x 15 cm recorded the highest relative growth rate. Among the subplots, application of 125% RDN + Mepiquat chloride 50 ppm at square formation and flowering stage (S₃) recorded the highest crop growth rate and relative growth rate as compared to the rest of the treatments during both 2023-24, 2024-25 and in mean data. The lowest was observed with the application of 100% RDN + Cycocel 60 ppm at square initiation, peak square formation and flowering stage (S₄). It is concluded that high density cotton in paired row pigeonpea was performing well with the application of growth regulators and the recommended dose of nitrogen during both years of the experiment.

References

1. Bhardwaj R, Kushwaha HS, Birla J, Turkar Y, Patidar K. Studies on nutrient management in pigeon pea [*Cajanus cajan* (L.) Millsp.] based intercropping system. Legume Res. 2023;46(8):1048-1053.
2. Hu T, Liu Z, Jin D, Chen Y, Zhang X, Chen D. Effects of growth regulator and planting density on cotton yield and N, P and K accumulation in direct-seeded cotton. Agronomy. 2023;13(2):501.
3. Ibrahim IA, Yehia WM, Saleh FH, Lamlom SF, Ghareeb RY, El-Banna AA, *et al.* Impact of plant spacing and nitrogen rates on growth characteristics and yield attributes of Egyptian cotton (*Gossypium barbadense* L.). Front Plant Sci. 2022;13:916734.
4. Kumar R, Pareek NK, Kumar U, Javed T, Al-Huqail AA, Rathore VS, *et al.* Coupling effects of nitrogen and irrigation levels on growth attributes, nitrogen use efficiency and economics of cotton. Front Plant Sci. 2022;13:890181.
5. Maitra S, Ghosh DC, Sounda G, Jana PK, Roy DK. Productivity, competition and economics of intercropping legumes in finger millet at different fertility levels. Indian J Agric Sci. 2001;70(12):824-828.
6. Maitra S, Ray DP. Enrichment of biodiversity, influence in microbial population dynamics of soil and nutrient utilization in cereal-legume intercropping systems: a review. Int J Bio-resource Sci. 2019;6(1):11-19.
7. Patel BR, Chaudhari PP, Chaudhary MM, Patel KN. Effect of mepiquat chloride on growth parameters and yield of Bt cotton (*Gossypium hirsutum*) under high-density planting system. Indian J Agron. 2021;66(1):67-73.
8. Potdar MV, Anders MM, Sharma M. Yield advantages and economic returns from pigeonpea/cotton strip intercropping rotations on a vertisol in the Indian semi-arid tropics. Series Int Agric Res. 1996:58-72.
9. Rani CS, Sudhakar C, Rani SK. Effect of different spacing within a pair and between pairs on growth and productivity of pigeonpea crop (*Cajanus cajan* (L.) Millsp.) in a paired row planting system. Int J Agric Sci Res. 2019;1(10):1-6.
10. Sabale SS, Lahane GR, Dhakulkar SJ. Effect of various plant growth regulators on growth and yield of cotton (*Gossypium hirsutum*). Int J Curr Microbiol Appl Sci. 2017;6(11):978-989.
11. Sapkota BR, Adams CB, Kelly B, Rajan N, Ale S. Plant population density in cotton: addressing knowledge gaps in stand uniformity and lint quality under dryland and irrigated conditions. Field Crops Res. 2023;290:108762.
12. Wei K, Wang Q, Deng M, Lin S, Guo Y. Response of cotton growth, yield, and water and nitrogen use efficiency to nitrogen application rate and ionized brackish water irrigation under film-mulched drip fertigation. Front Plant Sci. 2024;15:1361202.