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# COMPARATIVE FIELD EVALUATION OF PNEUMATIC PLANTER AND MANUAL SOWING UNDER HIGH DENSITY PLANTING SYSTEM IN RAINFED COTTON

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## ABSTRACT

High density planting system (HDPS) offers an opportunity to improve cotton productivity through optimum plant population and efficient utilization of available resources. However, timely and uniform crop establishment is essential for successful adoption of HDPS, particularly under rainfed conditions. A two-year comparative field demonstration was conducted during kharif 2024 and kharif 2025 in farmers' fields of Nalgonda district, Telangana, India to evaluate pneumatic planter sowing against manual sowing in HDPS cotton. The cotton hybrid RASI 929 was cultivated at a spacing of 90 × 15 cm under purely rainfed conditions on shallow red sandy loam soils. Two sowing methods, viz., manual sowing and pneumatic planter sowing were compared in three paired farmer fields during each year. Across six paired observations pneumatic planter sowing recorded a mean seed cotton yield of 29.02 q ha$^{-1}$ compared with 26.32 q ha$^{-1}$ under manual sowing, representing a 10.26% increase. Mean net returns were ₹1,30,835 ha$^{-1}$ under pneumatic planter sowing compared with ₹1,10,225 ha$^{-1}$ under manual sowing. Pneumatic planter sowing also reduced operational time from 75 to 40 minutes acre$^{-1}$, representing a 46.67% reduction. The results indicate the potential of pneumatic planter technology to improve crop establishment, operational efficiency and economic performance of HDPS cotton under rainfed conditions.

**KEYWORDS:** Cotton, HDPS, pneumatic planter, manual sowing, rainfed agriculture, mechanization, seed cotton yield, economic returns.

## 1. INTRODUCTION

Cotton (Gossypium hirsutum L.) is an important commercial fibre crop contributing significantly to agricultural income and the textile industry. Enhancing cotton productivity requires efficient utilization of land, water, nutrients and other production resources. High density planting system (HDPS) has emerged as an important production strategy for improving area-based productivity through optimum plant population, suitable crop geometry and effective canopy management (Gauthami *et al.,* 2023)

Under HDPS, a relatively higher plant population is maintained per unit area compared with conventional cotton cultivation. Appropriate planting geometry helps improve canopy development, light interception and resource utilization. Research conducted in Telangana has demonstrated the importance of planting geometry and genotype selection in determining seed cotton yield under HDPS (Reddy *et al.,* 2023).

Successful implementation of HDPS particularly under rainfed and shallow deep soil conditions depends considerably on timely and uniform crop establishment. Rainfed cotton cultivation in shallow red sandy loam soils is often associated with limited soil moisture availability and a narrow window for sowing operations following the onset of monsoon rainfall (Santhosh and Ramesh, 2023). Delays in sowing and uneven crop establishment may adversely affect plant population and crop productivity (Blaise *et al.,* 2021).

Manual sowing is labour intensive and may require considerable time particularly when sowing operations need to be completed within a limited period. Variations in seed placement, spacing and sowing depth may also influence crop establishment and plant population (Senthilkumar *et al.,* 2020).

Mechanization of cotton sowing through pneumatic planters offers an opportunity to improve operational efficiency, seed placement and sowing timeliness. Precision planting equipment can potentially improve uniformity of seed distribution and reduce labour requirements. These advantages are particularly relevant for HDPS cotton where maintaining the desired plant geometry and population is important (Singh *et al*., 2005 and Verma *et al.,* 2024)

Although HDPS is being promoted in different cotton-growing regions, comparative information on pneumatic planter and manual sowing under similar rainfed HDPS management is useful for understanding their relative agronomic and economic performance.

Therefore, the present study was undertaken during kharif 2024 and kharif 2025 in Nalgonda district of Telangana to compare pneumatic planter sowing with manual sowing under HDPS cotton, with particular emphasis on seed cotton yield, operational efficiency, cultivation cost, net returns and benefit-cost ratio.

## 2. MATERIALS AND METHODS

### 2.1 Experimental location and duration

The comparative field demonstrations were conducted during kharif 2024 and kharif 2025 in farmers' fields of Nalgonda district, Telangana State, India.

The experimental fields were characterized by shallow red sandy loam soils under purely rainfed conditions. The study was conducted during two consecutive kharif seasons to evaluate the performance of pneumatic planter and manual sowing under prevailing farmers' field conditions.

### 2.2 Crop and planting geometry

The cotton hybrid RASI 929 was used for the demonstrations. The crop was established under a high-density planting system with a row-to-row spacing of 90 cm and plant-to-plant spacing of 15 cm.

The demonstrations were conducted under purely rainfed conditions without supplementary irrigation. The crop depended entirely on seasonal rainfall for its moisture requirement.

### 2.3 Treatments and field arrangement

Two sowing methods were evaluated:

- T1: Manual sowing ( 90 X 15 cm)
- T2: Pneumatic planter sowing (90 X 15 cm).

Three farmer fields were considered during each year. Both sowing methods were demonstrated side by side within the same farmer fields to facilitate comparison under similar soil and climatic conditions. Thus, six paired field observations were considered over the two years, with three paired demonstrations during each year. The recommended HDPS planting geometry of 90 × 15 cm was followed under both sowing methods. Other crop-management practices, including fertilizer application, weed management and plant protection, were maintained similarly between the two sowing methods, wherever applicable.

### 2.4 Observations recorded

The following observations were considered for evaluating the performance of the two sowing methods.

**Crop establishment and yield parameters**

- Germination percentage.
- Plant population per square metre.
- Seed cotton yield (q $ha^{-1}$).

**Operational parameters**

- Time required for sowing (minutes $acre^{-1}$).
- Sowing charges.
- Animal-drawn gorru charges.
- Basal fertilizer application charges.

**Economic parameters**

- Cost of cultivation (₹ $ha^{-1}$).
- Gross returns (₹ $ha^{-1}$).
- Net returns (₹ $ha^{-1}$).
- Benefit-cost ratio.

### 2.5 Economic analysis

Gross returns were calculated based on the value of seed cotton produced. Net returns were calculated by subtracting the total cost of cultivation from gross returns.

Net returns = Gross returns − Cost of cultivation.

The benefit-cost ratio was calculated using the method followed in the original field records. The calculation convention should be specified consistently in the final manuscript.

### 2.6 Statistical analysis

The data were subjected to combined analysis considering year, sowing method and farmer field nested within year.

The statistical model was:

$Yijk = \mu + Yi + Fj(i) + Tk + (YT)ik + \varepsilon ijk$

Where Yijk is the observed value, μ is the overall mean, Yi is the year effect, Fj(i) is the farmer field within year, Tk is the sowing method, (YT)ik is the year × treatment interaction and εijk is the residual error Pagliari *et al.* (2022)

The farmer field was considered the matching/blocking unit because both sowing methods were demonstrated side by side within the same farmer field.

Treatment means, standard error of mean, standard error of difference, critical difference at 5% probability and coefficient of variation were calculated from the pooled error mean square.

As the study involved comparative field demonstrations rather than a formally randomized replicated field experiment, the statistical findings were interpreted as evidence from the observed matched farmer fields.

## 3. Results and Discussion

The results obtained in the present investigation was depicted in table 1 to table 3 and Fig. 1 to Fig. 3

### 3.1 Seed cotton yield

Pneumatic planter sowing recorded higher seed cotton yield than manual sowing during both years of study.

During kharif 2024, pneumatic planter sowing recorded 29.83 q $ha^{-1}$ compared with 26.97 q $ha^{-1}$ under manual sowing. Similarly, during kharif 2025, the corresponding yields were 28.20 and 25.67 q $ha^{-1}$, respectively.
The pooled mean seed cotton yield was 29.02 q $ha^{-1}$ under pneumatic planter sowing compared with 26.32 q $ha^{-1}$ under manual sowing, representing a 10.26% increase.
The combined paired field analysis indicated a significant treatment effect (P = 0.00047), whereas the year × treatment interaction was not significant (P = 0.553).
The higher yield under pneumatic planter sowing may be associated with improved crop establishment and plant population. The recorded plant population was 6 plants $m^{-2}$ under pneumatic planter sowing compared with 5 plants $m^{-2}$ under manual sowing. The pneumatic planter recorded higher seed cotton yield than manual sowing. The yield advantage may be attributed to improved seed placement, more uniform crop establishment and better maintenance of the desired plant population. Senthilkumar *et al.* (2020) reported better seed metering performance of the pneumatic planter under HDPS cotton, with a higher quality of feed index and lower miss index, supporting its potential for precision sowing. Thus, improved crop establishment through mechanized precision sowing could have contributed to the higher seed cotton yield observed in the present study.

**3.2 Effect on operational efficiency**

Operational efficiency is an important consideration in rainfed cotton cultivation, particularly during the monsoon sowing period.
Manual sowing required approximately 75 minutes $acre^{-1}$, whereas pneumatic planter sowing required only 40 minutes $acre^{-1}$. Thus, pneumatic planter sowing reduced the operational time by approximately 46.67% compared with manual sowing.
The pneumatic planter considerably reduced the time required for sowing compared with manual sowing. The operation required 40 minutes per acre with the pneumatic planter, compared with 75 minutes per acre under manual sowing, representing a 46.67% reduction in sowing time. This improvement can be attributed to the higher field capacity and continuous seed-metering mechanism of the pneumatic planter. Similar advantages of mechanized cotton sowing in reducing operational time compared with traditional manual planting have been reported by Kamaraj and Kathirvel (2008) and Pandey *et al.* (2022). The reduction in sowing time can facilitate timely completion of sowing operations to reduce dependence on manual labour and enable farmers to cover larger areas within a shorter period with tractor operated pneumatic planter in shallow soils. These advantages are particularly relevant in rainfed regions of Telangana, where timely sowing is important for utilizing available seasonal rainfall.

**3.3 Effect on crop establishment**

The recorded germination percentage was 85% under pneumatic planter sowing compared with 75% under manual sowing. Similarly, plant population was 6 plants $m^{-2}$ under pneumatic planter sowing compared with 5 plants $m^{-2}$ under manual sowing (Table 4).
The higher recorded germination and plant population under pneumatic planter sowing indicate its potential to improve crop establishment under HDPS conditions.
Uniform seed placement and timely sowing may contribute to improved establishment. These findings are in line with results obtained by Senthilkumar *et al.,* 2020. Balas *et al.,* 2024 also reported the efficiency of machinery in HDPS cotton.

**3.4 Effect on gross and net returns**

The economic performance of pneumatic planter sowing was superior to manual sowing during both years. Pooled gross returns were ₹2,17,168 $ha^{-1}$ under pneumatic planter sowing compared with ₹1,97,009 $ha^{-1}$ under manual sowing.
Similarly, pooled net returns were ₹1,30,835 $ha^{-1}$ under pneumatic planter sowing, while manual sowing recorded ₹1,10,225 $ha^{-1}$. The improvement in net returns under pneumatic planter sowing was approximately 18.70%. The combined analysis indicated significant treatment differences for gross returns and net returns. The year × treatment interaction was not significant for either parameter.
The higher economic returns under pneumatic planter sowing could be attributed primarily to higher seed cotton yield and associated gross income. These findings indicate that mechanized sowing may offer economic benefits in addition to operational advantages under HDPS cotton cultivation. Similarly, Pandey et al. (2022) reported reduced operational costs with mechanical cotton sowing compared with traditional sowing.

**3.5 Effect on BC ratio**

The pooled BC ratio was 2.56 under pneumatic planter sowing compared with 2.29 under manual sowing. The pneumatic planter recorded a higher B:C ratio in both years. However, the year × treatment interaction was significant (P = 0.0395), indicating that the magnitude of the economic advantage varied between years. The observed differences may be associated with variations in cultivation costs, sowing charges and returns between the two seasons.
Therefore, the economic advantage of pneumatic planter sowing should be interpreted considering local machinery hiring charges, availability of equipment and prevailing input and output prices.

**3.6 Overall implications under rainfed conditions**

The two year field demonstrations indicate that pneumatic planter sowing has potential to improve the efficiency of HDPS cotton cultivation through reduced sowing time, higher recorded plant population and improved seed

cotton yield. These benefits are particularly relevant under shallow red sandy loam soils of Nalgonda district, where cotton production depends entirely on seasonal rainfall.

Timely sowing and efficient utilization of available soil moisture are important components of successful rainfed cotton production. Pneumatic planter technology may help farmers complete sowing operations within a shorter period and establish the desired crop geometry.

Nevertheless, the results should be interpreted in the context of the limited number of paired farmer fields. Further validation involving more farmers, locations and seasons would strengthen the recommendations.

## 4. CONCLUSION

Pneumatic planter sowing under HDPS cotton recorded higher seed cotton yield, gross returns, net returns and benefit cost ratio compared with manual sowing during both years of field demonstrations conducted in Nalgonda district, Telangana. The pneumatic planter recorded a pooled seed cotton yield advantage of 10.26% and a net return advantage of 18.70%. It also reduced sowing time by approximately 46.67%. The results indicate that pneumatic planter sowing is a promising mechanization option for improving operational efficiency and economic performance under HDPS cotton cultivation in shallow red sandy loam soils under purely rainfed conditions. Larger multi location demonstrations and randomized field experiments are recommended to validate these findings under diverse agroecological conditions.

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**Table 1. Year-wise and pooled performance of pneumatic planter and manual sowing of HDPS cotton**

| Parameter | Year | T1 Manual | T2 Pneumatic |
|---|---|---|---|
| Seed cotton yield (q/ha) | 2024 | 26.97 | 29.83 |
| | 2025 | 25.67 | 28.20 |
| | Pooled | 26.32 | 29.02 |
| Gross returns (₹/ha) | 2024 | 191250 | 211556 |
| | 2025 | 202767 | 222780 |
| | Pooled | 197009 | 217168 |
| Cost of cultivation (₹/ha) | 2024 | 76100 | 74150 |
| | 2025 | 97467 | 98517 |
| | Pooled | 86783 | 86333 |
| Net returns (₹/ha) | 2024 | 115150 | 137406 |
| | 2025 | 105300 | 124263 |

| | | | |
|---|---|---|---|
| | Pooled | 110225 | 130835 |
| B:C ratio | 2024 | 2.51 | 2.85 |
| | 2025 | 2.08 | 2.26 |
| | Pooled | 2.29 | 2.56 |

**Table 2. Combined analysis of variance for yield and economics**

| Parameter | Treatment F-value | P-value | Year × Treatment P-value |
|---|---|---|---|
| Seed cotton yield | 109.81 | 0.00047 | 0.5530 |
| Gross returns | 114.01 | 0.00044 | 0.9419 |
| Cost of cultivation | 6.75 | 0.06017 | 0.0010 |
| Net returns | 132.75 | 0.00032 | 0.4095 |
| B:C ratio | 98.28 | 0.00058 | 0.0395 |

**Table 3. Statistical parameters for yield and economics**

| Parameter | SEm ± | SEd | CD (5%) | CV (%) |
|---|---|---|---|---|
| Yield | 0.182 | 0.258 | 0.715 | 1.61 |
| Gross returns | 1335.02 | 1888.01 | 5241.95 | 1.58 |
| Cost of cultivation | 122.47 | 173.21 | 480.89 | 0.35 |
| Net returns | 1264.83 | 1788.73 | 4966.32 | 2.57 |
| B:C ratio | 0.0188 | 0.0266 | 0.0737 | 1.90 |

**Table 4: Comparative operational costs ( Rs. acre$^{-1}$) of HDPS cotton under pneumatic planter and manual sowing**

| Parameter | Pooled data | |
|---|---|---|
| | Manual sowing | Pneumatic planter |
| Time (min) | 75 | 40 |
| Sowing charges (Rs) | 850 | 1200 |
| Gorru (animal drawn) charges (Rs) | 800 | - |
| Basal fertilizer application charges (Rs) | 330 | - |
| Germination (%) | 75 | 85 |
| No of plants m$^{-2}$ | 05 | 06 |

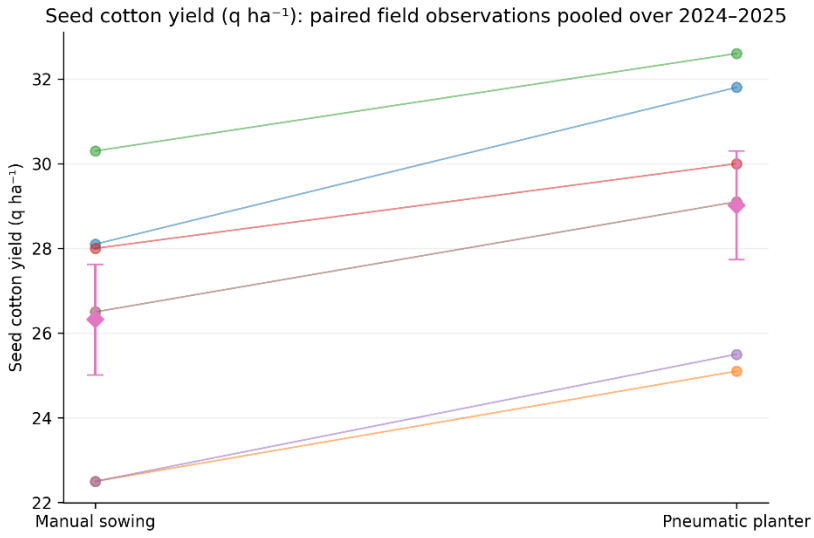
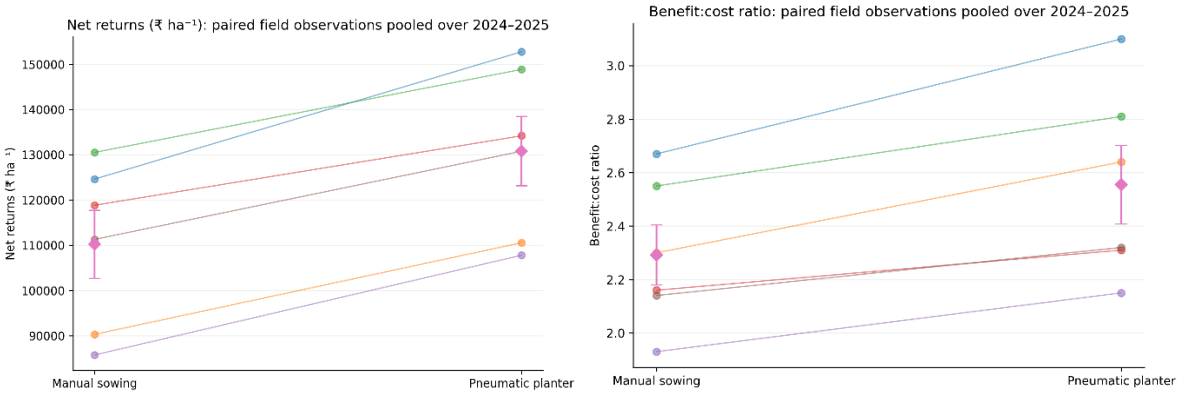



Fig 1: Seed cotton yield (q ha$^{-1}$) : paired field observations over 2024-2025




a) b)

Fig 2: a) Net returns ( Rs. ha-1) and b) BC ratio: paired field observations pooled over 2024-2025