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Optimization of functional components of the developed planters for high-density cotton

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ABSTRACT

High-density planting of cotton at recommended spacing of 60×10 cm facilitates mechanical harvesting of cotton since the system increases the height of lowest boll. Considering the non-availability and poor penetration of planters in the high-density cotton farms in the country which is tedious and labourious, a study was undertaken to optimize the functional components of the existing five planters so as to enhance availability of the planter for high-density planting of cotton. Observations were taken on intra-row spacing at a strip of 8 m length for each treatment. From the results, it was concluded that the CIAE tractor operated pneumatic planter and CIAE inclined plate planter were the ideal planters among the selected ones for high-density planting system of cotton.

Key words: Cotton, High-density planting, Planter, Seeder

High-density planting system (HDPS) is more relevant to India to establish sustainable production systems. A narrow-row cotton production system shares same agronomic benefits as that of ultra-narrow-row cotton. Close row spacing (19 to 25 cm) and high plant populations in ultra-narrow rows lead to more rapid canopy closure than in wide rows (Robinson 1993).The indeterminate habit of the cotton plant enables it to compensate its fruiting patterns in response to plant populations, allowing it to be grown at a wide range of populations depending on soil, climate and cultivar (Silvertooth *et al.* 1999).Early maturing compact plant types with shorter sympodia such as Suraj, Supriya, PKV-081, NH-615, AKA07 and D-123 have been identified for high-density planting system of cotton. By increasing plant population to 150000 to 220000 plant/ha it is possible to obtain yields of more than 1.8 t/ha in marginal soils under rainfed conditions as was observed in experimental farms at Central Institute of Cotton Research, Regional Station, Coimbatore and farmers field during 2012 (Anonymous 2012).

Cotton is cultivated under rain-fed conditions over 60% area in the country and the productivity of cotton in these regions is low. This HDPS can be improved significantly by adopting Central Institute of Cotton Research, Regional Station, Coimbatore demonstrated technologies such as suitable variety (Anjali/Suraj), certified seeds, line planting by animal-drawn inclined plate planer, soil moisture conservation practices. The seed-drills or planters available are mostly used for wider-row cotton cultivation and other bold seeds for narrow-spaced planting. High-density planting of cotton in recommended spacing of 60 × 10 cm also increases the height of lowest boll thus facilitating mechanical harvesting of cotton.

In Ultra Narrow Row (UNR) systems, cotton is produced in row spacing of less than 51 cm and is planted at higher populations than conventional cotton. Under these conditions, bolls per plant may be decreased, but yield is maintained through higher plant population. If not counteracted by factors such as reduced rates of boll setting or maturation, the reduction in bolls per plant may result in earlier crop maturity (Ernest *et al.* 2006). A narrow-row cotton production system can provide early canopy closure similar to an ultra-narrow-row cotton system without increased seed cost. Studies in North Carolina (Wilson 2006) demonstrated that plant populations for cotton in 38 cm rows were similar to wide-row cotton. Narrow or ultra narrow- row production system has been suggested as an alternative strategy instead of conventional spacing in order to increase yield and to reduce cotton input cost (Darawsheh *et al.* 2009).

High-density planting systems is a highly technical system and practising this system needs careful planning, timely planting, rigorous monitoring and timely interventions. Several, management related issues are yet to be resolved.

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Since large scale adoption of this system would involve substantial alternations in the way cotton is produced today there is a need for end to end package of practices along with do's and don'ts.

High-density cotton planting system is a new initiative from CICR, Nagpur in collaboration with the State Agriculture Departments and KVKs to improve the productivity of rainfed cotton on marginal (shallow to medium deep) soils of Vidarbha region of Maharashtra. Three varieties, viz. Suraj, PKV 081 and NH 615 amenable to high-density planting at 45 × 10-15 cm spacing were identified for this purpose.The inclined plate planter, cotton planter, cultivator mounted seed-drill, pneumatic planter and animal-drawn seed-drill were compared with manual sowing and broadcast method. Among the planters, inclined plate planter was the best as it maintained row to row spacing of 45 cm and mean plant to plant spacing of 15.4 cm with a seed rate of 19.2 kg/ha. The highest yields were obtained with manual sowing and were similar to those with inclined plate planter (Anon 2014).

The seed-drills or planters available are mostly used for wider-row cotton cultivation and other bold seeds for narrow-spaced planting. Hence, a study was conducted to evaluate the five different models of planters for suitability of high-density planting of cotton in recommended spacing of 60 × 10 cm.

MATERIALS AND METHODS

Five models of available planters namely, TNAU animal-drawn seed-drill, TNAU tractor drawn cultivator mounted seed-drill, TNAU Tractor drawn ridger seeder, CIAE tractor drawn pneumatic planter and CIAE tractor drawn inclined plate planter were used for high-density planting of cotton. The entire seed planters selected for this study was modified to sow the seeds at a row spacing of 60 cm. The seed plates and metering system were modified to sow the seeds with 10 cm spacing. The seed planters were calibrated in laboratory to calculate the seed rate by standard procedure with cotton seed variety Anjali.

Field trials were carried out at the fields of Central Institute for Cotton Research -Regional Station, Coimbatore with the six treatments in three replications by following Randomized Block Design, viz. TNAU animal-drawn seed-drill (T1), TNAU tractor-drawn cultivator-mounted seed-drill (T2), TNAU tractor-drawn ridger seeder (T3), CIAE tractor-drawn pneumatic planter (T4), CIAE tractor-drawn inclined plate planter (T5) and manual sowing (T6 as control).The measurements for evaluation of planters were depth of seed placement, seed spacing and plant stand. The data measured were used to calculate the following indices of planter performance. After the germination in field, observations were taken on the spacing between two adjacent plants at a strip of 8 meter length for each treatment.

Performance indices

Multiple index: Multiple index (D) is an indicator of more than one seed dropped within a desired spacing. It is the percentage of spacing that are less than or equal to half of the theoretical spacing.

$$D = n_1/N$$

where, N is total number of observations, and n_1 is number of spacings in the region less than or equal to 0.5 times of the theoretical spacing.

Quality of feed index: Quality of feed index (A) is the measure of how often the seed spacings were close to the

a) TNAU animal-drawn seed-drill (T1)

b) TNAU tractor-drawn cultivator-mounted seed-drill(T2)

c) TNAU tractor-drawn ridger seeder (T3)

d) CIAE tractor-drawn pneumatic planter (T4)

e) CIAE tractor-drawn inclined plate planter (T5)

theoretical spacing (Kachman and Smith 1995). It is the percentage of spacings that are more than half, but not more than 1.5 times the theoretical spacing. The quality of feed index is mathematically expressed as follows.

$$A = n_2/N$$

where, N is total number of observations, and n_2 is number of spacing's between 0.5 times the theoretical spacing and 1.5 times of the theoretical spacing

Miss index: Miss index (M) is an indicator of how often a seed skips the desired spacing. It is the percentage of spacing greater than 1.5 times the theoretical spacing, and expressed as

$$M = n_3/N$$

where, N is total number of observations, and n_3 is number of spacing's in the region >1.5 times of the theoretical spacing.

Precision: Precision (C) is a measure of the variability in spacing after accounting for variability due to both multiples and skips. The degree of variation is the coefficient of variation of the spacing's that are classified as singles, and expressed as

$$C = S_2/Xref$$

where, S_2 is sample standard deviation of the n_2 observations, and X_{ref} is theoretical spacing.

RESULTS AND DISCUSSION

Planting depth: The average value of cotton seed placement depths with manual, TNAU Animal-drawn seed-drill, TNAU tractor drawn cultivator mounted seed-drill, TNAU tractor drawn ridger seeder, CIAE tractor drawn pneumatic planter and CIAE tractor drawn inclined plate planter were found to be 55, 62, 75, 53,65 and 45 mm respectively. This indicated that seed placement with inclined plate planter is within the range of target depth of 45 mm (Anon 2014). Also, more uniform depth of seed placement was obtained with the inclined plate planter.

Mean seed spacing: The mean value of the cotton seed spacing measured along each planted row was about 96, 141, 152, 148, 136 and 115 mm with manual, TNAU animal-drawnseed-drill, TNAU tractor drawn cultivator mounted seed-drill, TNAU tractor drawn ridger seeder, CIAE tractor drawn pneumatic planter and CIAE Tractor drawn inclined plate planter . The mean seed spacing of manual planting and inclined plate planter is within range of the optimal seed spacing of 100 mm (Anon 2014).

Performance indices: The distance between plants within a row is influenced by a number of factors including multiple index, miss index, failure of a seed to emerge, and variability around the drop point. Miss, multiple and quality of feed index were highly influenced by all the three design variables at 5% level of significance.The different seed-drill performance indices calculated for all the treatments are shown in Table 3.

Miss index: The average miss index of the cotton seed for the data taken along the planted rows were 0.34, 0.70, 0.68, 0.21 and 0.196 with TNAU animal-drawn seed-drill, TNAU tractor drawn cultivator mounted seed-drill, TNAU tractor drawn ridger seeder, CIAE tractor drawn pneumatic planter and CIAE tractor drawn inclined plate planter respectively. It was observed that, the lowest miss index (0.19) for inclined plate planter followed by pneumatic planter (0.21) and the highest miss index (0.70) for tractor drawn seed-drill. This level of miss index could be due to a number of factors including the design of seed plate, failure of the metering plate to be filled with seeds, failure in dropping seed holes and any possible clogging of seeds along the boot and/or drop tube.

Multiple index: The average multiple index of the cotton seed for the data taken along the planted rows were 0.22, 0.08, 0.08, 0.02 and 0.04 with TNAU animal-drawn seed-drill, TNAU tractor drawn cultivator mounted seed-drill, TNAU tractor drawn ridger seeder, CIAE tractor drawn pneumatic planter and CIAE Tractor drawn inclined plate planter respectively. The highest multiple index (0.21) was obtained for animal-drawn seed-drill and the lowest multiple index (0.024) for pneumatic planter.

Quality of feed index: The average feed index of the cotton seed were 0.44, 0.22, 0.24, 0.76 and 0.76 with TNAU animal-drawn seed-drill, TNAU tractor drawn cultivator mounted seed-drill, TNAU tractor drawn ridger seeder, CIAE tractor drawn pneumatic planter and CIAE tractor drawn inclined plate planter respectively. Highest feed index (0.76) tractor drawn inclined planter and Pneumatic planter and the lowest feed index was observed for tractor drawn seed-drill (0.21).

Precision index: The average precision index of the

Table 1 Seed-drill calibration data

Treatment	Calibration	Field performance				
	Seed rate, kg/ha	Mean planting depth, mm	Mean seed spacing, mm	Multiple index	Feed index	Miss index
T1	15.76	62	141	0.216[a]	0.442[b]	0.342[b]
T2	16.80	75	152	0.078[b]	0.218[b]	0.704[a]
T3	14.60	53	148	0.076[b]	0.237[b]	0.687[a]
T4	19.40	65	136	0.025[b]	0.757[a]	0.218[b]
T5	17.40	45	115	0.044[b]	0.759[a]	0.197[c]
T6	-	55	96	0.015[b]	0.932[a]	0.053[c]
LSD (5%)	-	-	-	0.115	0.232	0.163

cotton seed were 0.22, 0.31, 0.16, 0.18 and 0.15 with TNAU animal-drawn seed-drill, TNAU tractor drawn cultivator mounted seed-drill, TNAU tractor drawn ridger seeder, CIAE tractor drawn pneumatic planter and CIAE tractor drawn inclined plate planter respectively. Highest precision index of 0.31 was observed with TNAU tractor drawn cultivator mounted seed-drill and the lowest precision index of 0.15 (Shiddanagouda *et al.* 2013) was observed with CIAE tractor drawn inclined plate planter as showed in Table 1.

The above results show that the CIAE inclined plate planter and pneumatic planter are performing better than other three planters for high-density planting cotton seeds. This can be explained with the reference to the design of the inclined plate and pneumatic seed metering mechanism most suitable for accommodating the cotton seeds properly and delivered directly to the furrow opener. However, the depth sowing is mainly depend on the experience of the tractor operator and the same time the inclined planter planter maintaining the uniform depth of sowing throughout the trail. The results summarized that, the mechanical sowing reduced cost of labour by 62.5 % when compared with the manual planting of cotton.

Conclusion

A study was conducted to compare the performance of five different planter as well manual sowing for high density planting of cotton seed The following conclusions were drawn:The optimum depth of planting was obtained with inclined plate planter (45 mm) which is very closer to the recommend depth planting of 50 mm. Highest feed index (0.75) tractor drawn inclined planter and Pneumatic planter and the lowest feed index was observed for tractor drawn seed-drill (0.21). The lowest miss index (0.19) for inclined plate planter followed by pneumatic planter (0.21) and the highest miss index (0.70) for tractor drawn seed-drill. The highest multiple index (0.21) was obtained for animal-drawn seed-drill and the lowest multiple index (0.024) for Pneumatic planter. From the result, it was found that the tractor operated Pneumatic planter and inclined plate planter are the most suitable planters for high-density planting of cotton.

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