Development and evaluation of tractor drawn inclined cell plate type Bt cotton planter

VINEET KUMAR SHARMA, D.N. SHARMA AND DINESH KUMAR

Received : 05.07.2013; **Revised :** 10.09.2013; **Accepted :** 10.10.2013

See end of the Paper for authors' affiliation

Correspondence to :

VINEET KUMAR SHARMA
Department of Farm Machinery and Power Engineering, C.C.S. Haryana Agricultural University, HISAR (HARYANA) INDIA
Email : sharmavineet9@gmail.com

ABSTRACT : The performance evaluation of seed metering inclined cell plate under laboratory conditions was carried out on existing Bt cotton planter in term seed rate, cell fill percentage, seed to seed distance and soil cover over the seed. The seed rate obtained with seed hopper in level position and at speed ratio of 3:1 were 1.75kg/ha, 2.40kg/ha and 2.65kg/ha in large medium and small seed size categories, respectively. These seedrate are quite close to the recommended seed rates of Bt cotton varieties.Based on the results of lab study the optimum speed ratio of 3:1, seed release height of 30 cm inclined cell plate type metering roller and shoe type furrow opener were selected and improved prototype of Bt cotton planter was developed. The development and evaluation of improved prototype Bt cotton planter was carried out under field condition and compared with existing inclined plate type cotton planter. The effective field capacity of both machines was 0.73 and 0.71 ha/h at average operating speeds of 4.1 and 3.8 km/h, respectively. Time lost in turning of both planters was 35 and 37 sec/turn and the field efficiency was 59.34 and 58.77%, respectively. The germination of seed was recorded after 21 days of planting and it was 16-19 plants in case improved Bt Cotton planter and 12-16 in existing planter. The distribution of plants in row and crop response at farmer's field indicated that mean plant spacing was 71 .8 cm and quality of feeding index was 75.57% in case of improved Bt Cotton planter whereas, the mean spacing of 77.6 cm and quality feeding index 68.81 % was recorded in existing cotton planter. The missing index and multiple index recorded in improved Bt cotton planter were 15.45 % and 8.88%, respectively, whereas it was 22.86% and 8.33% in existing cotton planter.

KEY WORDS : Improved Bt Cotton planter, Seed rate, Cell fill percentage, Missing index, Multiple index

HOW TO CITE THIS PAPER : Sharma, Vineet Kumar, Sharma, D.N. and Kumar, Dinesh (2013). Development and evaluation of tractor drawn inclined cell plate type Bt cotton planter. *Internat. J. Agric. Engg.*, **6**(2) : 329-334.

Cotton' the white gold is one of the most important commercial crops playing a key role in the economical and social affairs of the country. India is the third largest producer of cotton in the world. Our production levels of this crop satisfactory increased five folds since independence. But still our yield is 307 kg/ha low as compared to 783 kg/ha in USA, 659 kg/ha in China and 988 kg/ha in Egypt (Anonymous, 2013). The current yields tend to linger on lower averages, which has been a matter of concern and a national challenge. The low yields of cotton are attributed to inadequate inputs, untimely field operation, lack of irrigation (70 % area under rainfed conditions), lack of mechanised farm operation and inefficient crop production technologies. Lack of mechanisation of various farm operations like seed bed preparation, sowing or planting, intercultural and harvesting, is one of the main reasons for low production and productivity of cotton. Traditional cotton cultivation had recently become uneconomic in many parts of the country due to the high cost of pesticides and the low yields. Under this background the introduction of Bt cotton took place in India in2002. Sowing is very important operation, if it mechanised as per the requirement of agronomic practices our production and productivity may increase. Seed rate of Bt (*BacillusThuringiensis)* Cotton is low as compared to our traditional cotton. At present sowing or planting of Bt cotton has been performed by conventional seed drill used for traditional cotton, but the performance of these seed drill are not very good, as seed rate is comparatively high in these seed drill recommended in package and practices of Bt cotton. The higher seed rate not only require extra seed but also increase cost of labour for thinning and extra time for desired crop establishment in the field. It is difficult to maintain the desired spacing and depth by using existing seed drill. Precise planting of cotton saves seed, utilized fertilizer for best advantage and increase yield by enabling good cultivation practices. The use of precision planting technique results in uniform plant spacing and depth and helps for further mechanization of intercultural farming operation that reduces the total cost of cultivation. Inclined plate planter can serve the purpose of precise planting of Bt Cotton by using suitable size of cell plate, adjustment of seed hopper height and suitable furrow opener. So, there exist a need to develop a tractor drawn inclined cell plate planter for precise planning of Bt Cotton.

METHODOLOGY

Location :

The laboratory study was conducted at farm machinery lab of department of Farm Machinery and Power Engineering, CCSHAU Hisar in 2009 and 2010. Field study was carried out at research area of College of Agricultural Engineering and Technology and at farmer's field, village Gorakhpur of Fatehabad District in 2009 and 2010.

Crop and varieties :

Three different varieties of Bt cotton namely, Tulasi-45(seed small), IT-905 (medium) and KDCHH-441 (large) categories were used for laboratory study. Rasi-134 (large seed size at par with KDCHH-441) identified for Haryana region was used for field experiments.

Variables undertaken during study :

The major objectives of the study were to determine the optimum values for the functional components of an inclined cell plate type Bt cotton planter in laboratory and modify the planter as per the optimum values. Field evaluation of modified planter was carried out at farmers field on the optimum values. The variables of the study were grouped into two categories namely independent and dependent variables. All the variables have interaction among each other and their effects were evaluated to determine optimum performance parameters for development of the inclined cell plate type Bt cotton planter.

Independent parameters:

Crop parameters:

Three different varieties Tulasi-45(seed small), IT-905 (medium) and KDCHH-441 (large)) with different seed sizes were selected for the lab study. Rasi-134 (large seed size) identified for Haryana region was used for field experiments at farmer's field.

Machine parameters:

Four levels of seed levels in hopper (full,3/4,1/2 and 1/4), five levels of hopper inclination (5° F/W & B/W, level and 10° F/W & B/W), three levels of speed ratio(R1= 2.1:1,R2= 2.4:1&R3= 3.0:1), three levels of height of seed release (H1=30cm, H2=60cm and H3= 90 cm) and three type of furrow opener (shoe type, T-type and shovel type) were selected for lab study. Optimum machine parameters were taken for the field studies based on the outcome of the lab studies.

Dependant parameters:

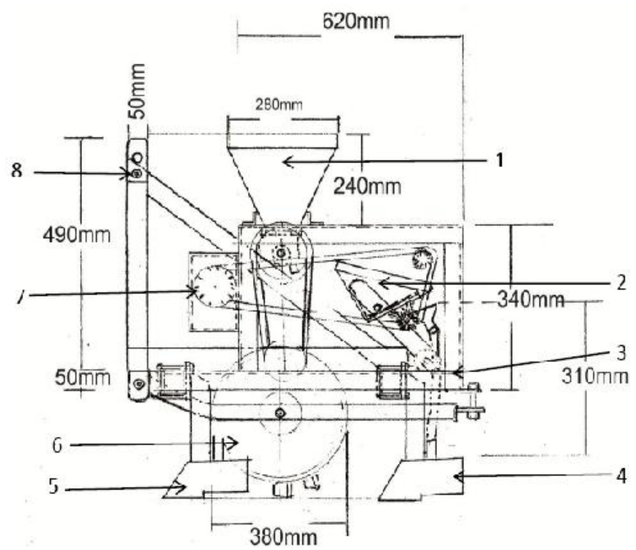
Seed rate, kg/ha, volumetric cell fill percentage (%), seed distribution pattern (cm), seed to seed distance (cm) and depth of soil cover over the seed (cm) were the dependent parameters selected for the lab study. Field studies were carried out based on the outcome of the lab studies. Field capacity, field efficiency, speed of operation, fuel consumption, hill to hill distance, depth of planting and germination of seed were the parameters selected for the field study. The laboratory and field parameter were measured as per the procedure given in BIS standard (IS: 6316-1971) (Anonymous, 1971). The sowing uniformity of the horizontal distribution pattern (missing index, multiple index, quality of feeding index and precision of spacing) was recorded as per the procedure described in Kachman and Smith (1995). The cost of operation of the machine was computed by using the BIS Standard procedure (IS: 9164-1979).

Analysis of the data:

The data were subjected to the statistical analysis by the analysis of variance technique/ programme.

Brief description of developed machine:

The constructional details of the modified tractor drawn inclined cell plate type Bt cotton planter are given in Fig. A. The main frame (2250×630 cm) of the unit is made by using a mild steel channel section of size (60×60) mm. The seed hopper, fertilizer box and speed reduction unit are mounted on the main frame. Three point hitch assembly is provided on the frame so as to hitch the unit to prime mover. A power transmission assembly made of chain and sprockets is used to transmit the drive from ground wheel to seed and fertilizer metering units. The speed ratio of ground wheel to fertilizer metering shaft is 2:1, while ground wheel to the seed metering unit can be taken as2.1:1, 2.4:1 and 3:1 as per requirements. The triangular shaped seed box frame is fabricated from M.S. sheet and its rear side was fitted with three inclined cell plates at proper spacing. Around each cell plate a circular box made from M.S. sheet is provided. The circular box diameter is 160 mm and height of seed in the box is 80 mm. Every inclined cell plate is having five U shape cell constructed around its periphery at equal distance. The fertilizer metering mechanism (flutted roller) is fitted at the bottom of fertilizer box. Three number of flutted rollers



(1-Fertilizer box, 2- Seed box, 3- Main frame,4- Furrow opener of seed, 5- Furrow opener of fertilizer, 6- Ground Wheel, 7-Speed reduction box and 8- hitching point)

Fig. A : A view of improved prototype Bt cotton planter

having 12 flutes with aluminum cups are fitted on a shaft for metering the fertilizer. The depth of planting can be adjusted by varying the height of ground wheels from the ground level with the help of suitable mechanism provided.

RESULTS AND DISCUSSION

The results of the present study as well as relevant discussions have been presented under following sub heads:

Laboratory studies:

Effect of selected machine and crop parameters on seed rate:

The linear relationship was found between seed level in hopper and seed rate in inclined seed metering plate at all the hopper inclinations and speed ratios. It is also clear from Table 1 that the seed rate decreased with the corresponding decrease in seed level in hopper. When, seed level in hopper was decreased, the chances of seed entering the cell decreased. Moreover, some seeds fall down due to gravity. There was significant effect of seed levels in hopper on seed rates recorded in all the speed ratios and all seed size. The seed rate increase with corresponding decrease in speed ratios because the revolution of metering plate was increased. It is clear from the table that, there was significant difference in seed rates at different hopper inclinations and speed ratios. When seed hopper was inclined 5° to 10° in backward with vertical line the angle of seed release point decreased correspondingly. The seed rate was increased with correspond decrease in angle of seed release point. Similarly, when hopper inclinations were changed in 5° to 10° forward inclinations, seed rates were reduced considerately. The highest seed rate was recorded in small seed size Bt cotton crop variety. The lowest seed rate was metering in largest seed size variety. There was significant interaction between the inclinations and speed ratios of cell plate in all varieties of Bt cotton. Similar results were reported by Singh *et al.* (2006)

Table 1 : Effect of selected machine and crop parameters on seed rate

	CD/ Factor		
Parameters	Small	Medium	Large
L	0.03	0.03	0.07
R	0.02	0.03	0.05
D	0.02	0.03	0.06
L x R	0.05	0.05	0.12
R x D	0.04	0.05	N.S.
L x D	0.06	0.06	0.13
L x R x D	0.10	0.11	0.23

where L= Hopper angle, R= Speed ratio, and
D = Different seed level in hopper

Effect of selected machine and crop parameters on volumetric cell fill percentage :

It is evident from Table 2 that volumetric cell fill percentage of seed metering unit varied with the different speed ratios, height of seed level in hopper and seed hopper inclinations. The cell fill percentage in all the three seed size (large, medium and small) of Bt cotton increased with increase in hopper inclination from 10^0 forward to 10^0 backward as well as with the increase in seed column height in the seed box. The maximum average volumetric cell fill percentage was recorded with L_5 (10° B/W) hopper inclination at full level of seed in hopper in all three varieties of Bt cotton. There was significant effect of hopper inclination on cell fill percentage at 5 per cent level of significance. The optimum cell fill percentages were found at L_3 and L_4 hopper inclinations in small and medium size Bt

Table 2 : Effect of selected machine and crop parameters on volumetric cell fill percentage

	CD/ Factor		
Parameters	Small	Medium	Large
L	0.92	0.94	1.89
R	0.71	0.73	NS
D	0.82	0.84	1.69
L x R	1.59	1.63	3.27
R x D	1.42	1.46	3.27
L x D	1.84	1.89	3.78
L x R x D	3.18	3.27	6.55

NS=Non-significant

cotton seed, respectively. For large seed size, optimum cell fill percentage was recorded in L_5 hopper inclination, at R_1 (2.1:1) and R_2 (2.4:1) speed ratios. At hopper inclinations L_3, L_4 and L_5 in small, medium and large seed sizerespectively were obtained 2-3 seeds/cell and least seed rates were achieved, which is a desirable feature from seed economy point of view because Bt cotton seed is very costly. Singh *et al.* (2006) reported that volumetric cell percentage of seed metering unit was affected by crop variety due to difference in seed dimensions and other physical characteristics.

Effect of selected machine and crop parameters on hill to hill distance :

There was non-significant effect of combination of seed sizes and speed ratios on hill to hill distance as shown in Table 3. It is also clear from the table that there was significant effect of speed ratios on hill to hill distance in each category of seed size.The average hill-to-hill distance increased from 52.8 cm to 75.5 cm with decrease in speed ratio from 2.1:1to 3:1inlarge seed size (KDCHH-441) variety of Bt cotton Similar trends were observed for small (Tulsi-45) and medium (IT-905) size of Bt cotton. Similar results were reported by Karayel *et al.* (2006) and Parish and Bracy (2003), according to them the seed spacing uniformity of seed drill was affected by the speed of the roller and speed of operation of the planting machine.

Table 3 : Hill to hill distances at different seed varieties and speed ratios

Varieties	Speed ratio	Mean@ (Hill to Hill to distance)
Tulasi-45	2.1:1	54.7
	2.4:1	60.7
	3.0:1	76.0
IT-905	2.1:1	53.4
	2.4:1	60.0
	3.0:1	74.4
KDCHH-441	2.1:1	52.8
	2.4:1	61.2
	3.0:1	75.5

@ Averages of ten samples

Factors	C.D. (P=0.05)	SEM
Bt. cotton varieties	N.S.	1.41
Speed ratios	3.95	1.41
Bt cotton varieties x Speed ratios	NS	2.43

Performance of furrow openers:

The main purpose of sowing a crop is to place the seed at certain spacing and desired depth in the seedbed. To obtain maximum cotton yield, the seed placement must be close to optimum sowing depth and adequate soil cover over the seed. The required depth of planting is 12 cm for Bt cotton crop at desired moisture content and soil cover over the seed between 4-6cm. In Haryana region cotton crop is sown in last week April to mid of May having very high temperature in this region, which required more depth of seed placement and desire soil cover over the seed. Where at the deeper depth of seed placement soil moisture content retain long time around the seed that results to number plant germinate at this stage. Comparative performance results of three different types of furrow openers are given in Table 4. Shoe type furrow opener gave better performance as compared to shovel type and T-type opener (Table 4). It is also clear from table that average draft of the machine fitted with six shoe type furrow openers was 310 kgf with average depth of sowing as 11.6 cm and average soil cover of 7.1 cm over the cotton seed, followed by shovel type furrow opener with 325 kgf draft, 12.26 depths of sowing and 9.8 cm soil cover over the seed. Deviation was minimum in case of shoe type furrow opener. Similar, results were observed by was found Karayel and Ozmerzi (2007) and they reported that the most uniform sowing depth was obtained with shoe type furrow opener.

Development of planter:

Based on the results of laboratory study the optimum speed ratio of 3:1, seed release height of 30 cm inclined cell plate type metering roller and shoe type furrow opener were selected. According to these results, the necessary modifications in the existing planter were carried out in the work shop of Farm Power and Machinery Department.

Field performance of Bt cotton planter:

The field performance results of both the machines are presented in Table 5. The effective field capacities of both machines were 0.73 ha/h and 0.71 ha/h, respectively and the corresponding field efficiencies were 59.34% and 58.77%, respectively. The time losses per turn under improved and existing Bt cotton planters were 35 sec and 37 sec, respectively, however, widths of planting of both the machines under field condition was 300 cm. Low efficiency of the planter was found due to more time consume during turning, as we have to change marker in every turn. This is in agreement with the findings of Kathirvel *et al.* (2005) where quite low field efficiency was obtained while testing ridger seeder, pneumatic planter and cultivator seeders in the field conditions.

The actual seed rates were 2.35 and 3.05 kg/ha in T_1 and T_2 treatment, respectively and corresponding fertilizer rates were 79.19 and 89.00 kg/ha, respectively. The average depth of furrow and soil cover over the cotton seed were 12.4 cm and 5.4 cm, respectively in the crop planted by the improved Bt cotton planter. While, in case of crop planted by the existing planter the average depth of furrow and average soil cover over the seed recorded were 12.6 cm and 5.9 cm, respectively.

The crop response of both the machines is reported in

Table 6. It is evident from the table that the distribution of plants in row was quite satisfactory as mean plant spacing observed was 71.8 cm with a quality of feeding index 75.57 per cent with the use of improved Bt cotton planter compared to 77.6 cm mean plant spacing in existing cotton planter with quality of feeding index as 68.81 per cent. The missing index and multiplying index recorded in improved Bt cotton planter were 15.55 per cent and 8.88 per cent, respectively, while

Table 4 : Comparative performances of furrow openers

Sr. No.	Parameters		Shoe type	T- type	Shovel type
1.	Draft*, kgf		310.00	340.00	325.00
2.	Depth of sowing	Mean*, cm	11.60	12.53	12.26
		SE (mean)	0.26	0.52	0.32
		CV, %	8.78	23.79	8.66
3.	Soil cover over the seed	Mean*, cm	7.13	6.53	9.80
		SE (mean)	0.29	0.47	0.34
		CV, %	16.08	40.90	3.50

*Average of five samples

Table 5 : Comparative field performance of Bt. cotton planters

Sr. No.	Particulars	Improved Bt. cotton planter, (T_1)	Existing planter (T_2)
1.	Speed of operation, km/h	4.10	3.80
2.	Fuel consumption, l/h	2.54	2.20
3.	Row to spacing, cm	100.00	100.00
4.	Time lost in per turn, sec.	35.00	37.00
5.	Theoretical field capacity, ha/h	1.23	1.14
6.	Actual field capacity, ha/h	0.73	0.71
7.	Field efficiency, per cent	59.34	58.77
8.	Seed rate, kg/ha	2.35	3.05
9.	Fertilizer rate, kg/ha NPK (12:32:16)	79.19	89.00
10.	Average depth furrow, cm	12.40	12.60
11.	Average Depth of soil cover over the seed, cm	5.40	5.90

Table 6 : Plant distribution in rows and crop response

Sr. No.	Particulars	Improved Bt. cotton planter	Existing planter
1.	Average plant spacing after germination, cm	71.8	77.6
2.	Missing index, %	15.55	22.86
3.	Multiple index, %	8.88	8.33
4.	Quality of feeding index, %	75.57	68.81
5.	Precision of spacing	14.73	17.97
6.	Average number of plant in 10m length		
	7DAS	10-19	11-14
	15DAS	16-21	12-17
	21DAS	12-19	12-16

Table 7 : Economics of Bt. cotton planters

Sr. No.	Particulars	Improved Bt. cotton planter	Existing planter
1.	Labour requirement, man-h/ha	1.34	1.40
2.	Cost of operation Rs./h	304.00	304.00
	Rs./h	416.00	428.00
3.	Breakeven point, ha*	17.04	17.52
4.	Payback period, years*	2.05	2.17

*compared to custom hire cost, Rs 625/ha these were 22.86 per cent and 8.33 per cent, respectively in existing cotton planter. Lower values in improved machine are due to decreased seed release height. These performance parameters clearly indicate the better performance of developed planter.

The plant population was counted 21 days after planting of crop. The plant population observed in the field planted by improved inclined cell plate type Bt cotton planter was 12-19 plants/10 m row length. This is higher than the plant population of 8-10 plants/ 10 m row length observed by Anonymous (2008) and Kumaraj and Kathirvel (2008). Higher plant population of Bt cotton crop planted by improved machine in comparison to existing planter was obvious as the machine was developed based on optimum machine performance parameters.

Cost of operation of both the machines *i.e.* improved Bt cotton planter and existing cotton planter was calculated and reported in Table 7. It is evident from the table that on the basis of custom hiring charges by the owner saving in cost of operation in improved Bt cotton planter was 33.44 per cent implanting Bt cotton crop. Similar results were reported by Anonymous (2008) and Kumaraj and Kathirvel (2008). The improved Bt cotton planter has economic feasibility over existing planting machine used in Bt cotton crop as with annual use in 17.04 ha area, the payback period of machine is only 2.05 years.

Authors' affiliations:
D.N. SHARMA AND DINESH KUMAR, Department of Farm Machinery and Power Engineering, C.C.S. Haryana Agricultural University, HISAR (HARYANA) INDIA
Email : dn60sharma@gmail.com; dkjangra21@yahoo.co.in

REFERENCES

Anonymous (1971). Test code for seed-cum-fertilizer drill.IS: 6316-1971.Bureau of Indian Standards, New Delhi (INDIA).

Anonymous (2008).Q.R.T. Report of AICRPM on FIM scheme. Deptt.of Farm Power and Machinery, College of Agriclture Engineering and Technology, C.C.S. Haryana Agricultural University, Hisar (HARYANA) INDIA.

Anonymous (2013). Mechanisation of cotton production in India.Technical Bulletin, Central Institute for Cotton Research, Nagpur (M.S.) INDIA.

Kachman, S.D. and Smith, J.A. (1995). Alternative measures of accuracy in plant spacing for planters using single seed metering. *Trans. ASAE*, **38**(2):379–387.

Kamaraj, P. and Kathirvel, K. (2008). Development and evaluation of tractor operated belt type cotton planter. *J. Agric. Engg., ISAE,* **45**(1):69-72.

Karayel, D. and Ozmerzi, A. (2007). Comparison of vertical and lateral seed distribution of furrow openers using a new criterion. *Soil & Tillage Res*., **95**(1-2):69-75.

Karayel, D., Wiesehoff, M., Ozmerzi, A. and Muller, J. (2006). Laboratory measurement of seed drill seed spacing and velocity of fall ofseeds using high-speed camera system. *Comput. Electron. Agric.*, **50** (2): 89–96.

Kathirvel, K., Reddy, A., Manian, R and Senthilkumar, T. (2005). Performance evaluation of planters for cotton crops. *Agricultural Mechanization in Asia Africa & Latin America*, **36** (1) : 61-65.

Parish, R.L. and Bracy, R.P. (2003). At attempt to improve uniformity of a Gaspardo precision seeder. *Hort. Technol.*, **13** (1) : 100-103.

Singh, S., Sharma, D.N., Dixit, J. and Vatsa, D.K. (2006). Development and performance evaluation of a test rig for mechanical metering of sunflower seeds.*Agric. Mechanization in Asia Africa & Latin America*, **37** (1):18–24.

6th Year
★★★★★ of Excellence ★★★★★