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Balwinder Singh Dhillon
Senior Research Fellow, Krishi Vigyan Kendra, Bathinda, Punjab, India

Jitender Singh Brar
Associate Director (Trg.), Krishi Vigyan Kendra, Bathinda, Punjab, India

Harinder Singh
Senior Extension Specialist (Agronomy), Farm Advisory Service Centre, Bathinda, Punjab, India

Correspondence
Balwinder Singh Dhillon
Senior Research Fellow, Krishi Vigyan Kendra, Bathinda, Punjab, India

Influence of different planting methods on growth, productivity and root characteristics of BT cotton in south-west Punjab

Balwinder Singh Dhillon, Jitender Singh Brar and Harinder Singh

Abstract
Field experiment was conducted during *Kharif* 2016-17 and 2017-18, at the *Krishi Vigyan Kendra*, Bathinda, Punjab Agricultural University, Ludhiana to study the growth, productivity and quality and root characteristics of Bt Cotton under different planting methods *viz.* T_1: Cotton sowing drill (Three tynes), T_2: Cotton sowing drill (Four tynes), T_3: Ridge sowing and T_4: Bed maker Bt sowing machine. The results concluded that bed maker Bt sowing machine treatment showed significantly higher plant height, dry matter accumulation, number of monopodial branches/plant, number of sympodial branches/plant, number of bolls/plant and average boll weight over cotton sowing drill (Three tynes) and cotton sowing drill (Four tynes) and it was at par with ridge sowing. Bed maker Bt sowing machine treatment gave significantly higher cotton yield (12.3%) over cotton sowing drill (Three tynes) but it was statistically similar with ridge sowing. Maximum ginning out turn (GOT), seed index and lint index was noticed in bed maker Bt sowing machine treatment.

Keywords: Bt cotton, Ginning out turn, Lint index, Monopodial, Ridge sowing, Sympodial

1. Introduction
Cotton accounts nearly 44% of world fibre and 10% of world's edible oil production. It is not cultivated in all parts of the world. Certain tropical conditions are needed for cultivation of cotton. At present, cotton is being cultivated in some 80 countries in the world of which the top five countries are China, India, USA, Pakistan and Brazil. India has the largest cotton area in the world with about 11 million hectares accounting for one-fourth of the global cotton area. Among many agronomic factors responsible for cotton growth and yield, the planting method has prime importance because it not only helps in establishing the appropriate crop stand but also facilitates the conversion of light energy by balancing plant to plant competition in order to produce maximum crop yield (Ali *et al.* 2012) [2].

The productivity of rainfed farming is low as compared to the irrigated crop production. The crop yield in the rainfed farming is often reduced due to the lack of soil moisture. It is necessary to adopt suitable technology to conserve the rain water in-situ to ensure adequate moisture during the various growing stages of the crop in rainfed farming. Animal drawn broad bed-furrow planter are available but their efficiency is very less therefore it is necessary to develop suitable tractor operated BBF planter to overcome this problem (Srinivas, 2005) [17]. At present various types of BBF (Broad Bed Furrow) planters are available in which only the ridger is used for formation of broad beds. If the field is not well prepared, then this will result in the formation of cloddy seed-bed so sowing becomes difficult. Available BBF markers are used only for BBF formation and sowing is done separately which is costly. BBF farming has many advantages in regard to water saving, mechanical weeding, fertilizer placement, available moisture conservation, less lodging and better crop stand (Astatke *et al.*, 2002) [4]. *In-situ* water conservation makes the moisture available for the sown crop. Use of BBF can have several benefits depending on its use. Raised beds are primarily a field drainage tool aimed at decreasing water logging and increasing crop yield. BBF farming is a new idea developed for conservation of water for dry land farming. The placement of seed at correct depth is very important for proper germination and for obtaining optimum plant population per unit area of the crop especially under dry land farming where soil moisture is at greater depth (Khambalkar *et al.*, 2010) [13].

In India, ridge sowing and sowing of cotton with drill is practiced in most of the cotton growing areas which may result in poor seed germination and patchy plant population. Some times after planting and before emergence of cotton seedlings, a light shower of rain results in crust formation which restricts the emergence of seedlings and causes poor plant population.

Uniform plant population is the most important factor to harvest more profitable yield of all crops. Sowing of cotton on raised beds or ridges ensures adequate plant population due to better seed germination and emergence of seedlings even during unusual rains. Khan and Ullah (1991) [14] after studying various planting methods of cotton concluded that ridge sowing out yielded by producing 2582 kg per hectare seed cotton whereas Bridge *et al.* (1973) [8] observed no significant influence of planting methods on seed cotton yield. Planting on bed and furrow is the most appropriate and efficient method to fetch good seed germination and emergence of seedlings (Gill, 1999) [11]. Anwar *et al.* (2003) [3] reported that 33% higher seed cotton yield was observed from bed-furrow planting as compared with flat planting. Similarly, Hussain *et al.* (2003) [12] concluded that ridge sowing produced significantly higher seed cotton yield (1729 kg/ha) than flat sowing (1683 kg/ha). Flat planted cotton was lower yielding than cotton planted on raised beds (Boquet, 2005) [6, 7]. Ali and Ehsanullah (2007) [1] concluded that flat planting with each row earthing up gave higher seed cotton yield than bed and ridge plantings. Bed sowing method was significantly superior to flat sowing method with 35% higher seed cotton yield in cotton-wheat rotation (Chauhan, 2007) [9]. Similarly furrow-bed seeded cotton increased lint yield by 25% compared with flat seeded cotton (Dong *et al.*, 2008) [10]. The present study was undertaken to find out the most suitable planting method for improving cotton production.

2. Materials and methods

The field experiment was conducted at Krishi Vigyan Kendra, Bathinda, Punjab Agricultural University (PAU), Ludhiana during *Kharif* 2016-17 and 2017-18. Bathinda is located in Transgangetic agro-climatic zone and represents the Indo-Gangetic alluvial plains. The experimental site was sandy loam in texture, with pH 7.2 and electrical conductivity (0.25 dS/m), low in organic carbon (0.18%) and available nitrogen (175.2 kg/ha) and medium in available phosphorus (12.8 kg/ha) and potassium (138 kg/ha). Cotton var. RCH 773 was sown on 14th April and 13th April during 2016-17 and 2017-18 respectively using 2.25 kg seed/ha by different planting methods viz. T_1: Cotton sowing Drill (three tynes) keeping plant to plant distance of 75 cm and row to row distance of 67.5 cm, T_2: Cotton sowing Drill (four tynes) keeping plant to plant distance of 75 cm and row to row distance of 67.5 cm, T_3: Ridge sowing keeping plant to plant distance of 50 cm and row to row distance of 67.5 cm, and T_4: Bed maker Bt sowing machine keeping plant to plant distance of 50 cm and row to row distance of 60.0 cm and replicated thrice. The trial was laid out in strip plot design having plot size of 20m × 15m. All the package of practices was followed as recommended by PAU, Ludhiana for raising a healthy crop.

Data regarding growth parameters *viz.* plant height (cm) at harvest, dry matter (g/plant) at 120 days after sowing (DAS) and 160 DAS, and yield attributes *viz.* number of monopodial and sympodial branches/plant and root parameters viz. root length (cm), root radius (mm) and root dry weight (g/plant) were collected from randomly selected ten plants. Leaf area index was recorded at 120 DAS and 160 DAS by using the Sun Scan Canopy Analyzer. Average weight of boll (g) was measured by collecting ten opened bolls from the selected plants and measured with an electric balance. The seed cotton obtained from all the pickings was mixed and subjected to roller type laboratory ginning machine. The 100-cotton seed weight was measured by counting and weighing 100 cotton seeds collected after ginning from each replication. Seed cotton yield was determined by weighing the seed cotton from each replication and converted to kg/ha. The ginning out turn (GOT) was calculated using the formula of Singh (2004) [16].

The collected data were statistically analyzed by using Fisher's ANOVA technique and least significant difference (LSD) test at 5% probability level was used to compare differences among treatment means (Steel *et al.*, 1997).

3. Results and discussion

3.1 Growth parameters of Bt cotton

The results showed that plant height at 160 days after sowing (DAS) and dry matter accumulation at 120 DAS and 160 DAS by cotton were affected significantly by the influence of different sowing methods (Table 1). Bed maker Bt sowing machine treatment resulted highest plant height and dry matter accumulation but were statistically at par with ridge sowing and significantly higher than other planting methods. Leaf area index of cotton not affected significantly by different planting methods, while maximum leaf area index was observed under ridge sowing. Similar results were also reported by Anwar *et al.* (2003) [3], Boquet (2005) [6, 7], Chauhan (2007) [9], Dong *et al.* (2008) [10] and Iqbal *et al.* (2002).

3.2 Root radius, length and dry weight of Bt cotton

Root length (22.4 cm), root dry weight (0.710 g/plant) and root radius (0.365 mm/plant) of Bt cotton were observed higher in bed maker Bt sowing machine treatment followed by ridge sowing (root length (21.6 cm), root dry weight (0.692 g/plant) and root radius (0.352 mm/plant) (Figure 1). Root length, root dry weight and root radius of cotton sowing with Drill (Four tynes) treatment (19.0 cm, 0.592 g/plant and 0.303 mm/plant respectively) were higher than cotton sowing with Drill (Three tynes) treatment (18.5 cm, 0.588 g/plant and 0.292 mm/plant respectively. Bengough *et al.* (2011) [5] reported that well developed root system with sufficient root elongation is imperative for better plant growth particularly with limited water and nutrient supply, whereas roots elongate with slower rate due to water stress and mechanical impedance in dry soils.

3.3 Yield and yield attributes of Bt cotton

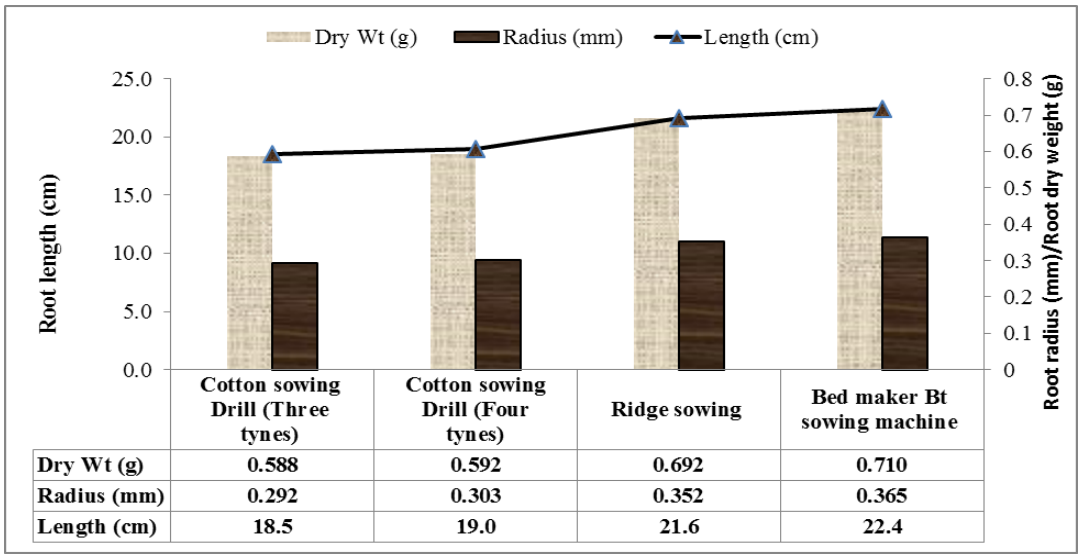
There was a significant effect of different sowing methods on yield and yield components of cotton (Table 2). Highest number of monopodial branches was observed when the crop was sown on ridges (4.6) but it was statistically at par with bed maker Bt sowing machine (4.1) during first year, but during 2nd year, bed maker Bt sowing machine gave higher number of monopodial branches and it was statistically at par with ridge sowing and significantly higher than other planting methods. Number of sympodial branches/plant, number of bolls/plant and average boll weight were significantly higher bed maker Bt sowing machine treatment but were statistically at par with ridge planting treatment and significantly higher than other planting methods during both the years. Bed maker Bt sowing machine treatment gave higher seed cotton yield but it was statistically at par with ridge planting and significantly higher than other planting methods during both the years. Minimum cotton yield was produced under cotton sowing Drill (Three tynes) planting method.

Increase in plant height, number of monopodial and sympodial branches per plant, boll weight and seed cotton yield of cotton by sowing the crop with bed maker Bt sowing machine may be due to improved soil moisture content and better light penetration in the crop plants which enhanced the

plant growth and development. The higher cotton yield under bed maker Bt sowing machine treatment also might be due to more root length, root radius and root dry weight (Figure 1) which causes more uptake of the plant nutrients and moisture content from the soil which enhanced the plant growth and development which leads to more synthesis of photosynthates and their translocation to the sink. Similar results were also reported by Anwar *et al.* (2003) [3], Boquet (2005) [6, 7], Chauhan (2007) [9], Dong *et al.* (2008) [10] and Iqbal *et al.* (2002) who observed that bed sowing method was superior to flat sowing, while Hussain *et al.* (2003) [12] observed that ridge sowing produced significantly higher seed cotton yield than flat sowing. This is in contrast to the findings of Ali and Ehsanullah (2007) [1] who reported that flat planting gave higher seed cotton yield than bed planting and ridge planting.

3.4 Fibre quality of Bt cotton

Ginning out turn and seed index in cotton not affected significantly by different planting methods while maximum ginning out turn and seed index were observed under bed maker Bt sowing machine treatment (Table 3). There was a significant effect of different sowing methods on the lint index of cotton. Highest lint index was observed when the crop was sown with bed maker Bt sowing machine but it was statistically at par with ridge sowing and significantly higher than other plant methods during both the years. Siebert *et al.* (2006) [15] observed a non-significant effect of different planting configurations on fiber quality characteristics.



	Cotton sowing Drill (Three tynes)	Cotton sowing Drill (Four tynes)	Ridge sowing	Bed maker Bt sowing machine
Dry Wt (g)	0.588	0.592	0.692	0.710
Radius (mm)	0.292	0.303	0.352	0.365
Length (cm)	18.5	19.0	21.6	22.4

Fig 1: Root parameters of cotton as influenced by different planting methods (Means of two years)

Table 1: Growth parameters of cotton as influenced by different planting methods

Treatments	Plant height (cm)	Dry matter (g/plant)		Leaf area index	
		120 DAS	160 DAS	120 DAS	160 DAS
2016-17					
Cotton sowing Drill (Three tynes)	185.2	128.3	180.0	3.38	1.58
Cotton sowing Drill (Four tynes)	191.4	130.3	182.5	3.50	1.62
Ridge sowing	202.1	133.1	183.3	3.56	1.64
Bed maker Bt sowing machine	204.2	133.9	183.9	3.45	1.60
LSD (p=0.05)	4.5	1.2	1.1	NS	NS
2017-18					
Cotton sowing Drill (Three tynes)	190.4	130.7	182.0	3.45	1.60
Cotton sowing Drill (Four tynes)	197.5	134.6	184.2	3.55	1.64
Ridge sowing	206.9	138.5	185.6	3.60	1.65
Bed maker Bt sowing machine	208.7	139.2	186.1	3.48	1.62
LSD (p=0.05)	3.4	1.5	1.4	NS	NS

Table 2: Yield attributes and seed cotton yield of cotton as influenced by different planting methods

Treatments	Monopodial branches/plant	Sympodial branches/plant	No of bolls/plant	Boll weight (g)	Seed cotton yield (q/ha)
2016-17					
Cotton sowing Drill (Three tynes)	3.5	31.2	45.5	4.1	21.2
Cotton sowing Drill (Four tynes)	3.7	31.3	47.3	4.5	22.1
Ridge sowing	4.6	32.5	49.2	4.6	23.1
Bed maker Bt sowing machine	4.1	33.2	50.5	4.9	24.4
LSD (p=0.05)	0.7	1.1	1.5	0.3	1.5
2017-18					
Cotton sowing Drill (Three tynes)	3.4	28.5	47.2	4.0	22.5
Cotton sowing Drill (Four tynes)	3.8	30.2	48.1	4.2	23.0
Ridge sowing	4.3	32.6	51.9	4.5	24.3
Bed maker Bt sowing machine	4.4	33.5	52.5	4.6	25.8
LSD (p=0.05)	0.5	1.2	0.9	0.2	1.6

Table 3: Ginning out turn (GOT), seed index and lint index of cotton as influenced by different planting methods

Treatments	GOT (%)		Seed index		Lint index	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Cotton sowing Drill (Three tynes)	34.7	34.2	9.3	9.4	4.94	4.89
Cotton sowing Drill (Four tynes)	35.2	34.5	9.4	9.4	5.11	4.95
Ridge sowing	35.5	34.8	9.5	9.6	5.32	5.12
Bed maker Bt sowing machine	35.8	35.2	9.8	9.7	5.46	5.27
LSD (p=0.05)	NS	NS	NS	NS	0.19	0.22

4. Conclusion

It was concluded that bed maker bed maker Bt sowing machine treatment recorded significantly higher cotton yield (12.3% and 11.1%) over cotton sowing drill (Three tynes) and cotton sowing drill (Four tynes), respectively, but it was statistically similar with ridge sowing.

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