

Demonstration of the Technology of High-Density Planting of Bt cotton on Shallow Soils under Rainfed Situation in Vidarbha region of Maharashtra

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ABSTRACT

For the first time a mega demonstration of a technology was conducted for showcasing the benefits of high density planting system (HDPS) in Bt cotton hybrids specially developed for the new agronomy. Three newly developed Bt cotton hybrids viz.; Rasi THCT-5380, Ankur Kirti 3060 and Mahyco-7399 were planted each on three acres in a sequence at four locations in farmers' field at villages Lakhori, Metpanjara (Nagpur dist.), Talegaon (Wardha dist.) and Kanshivani (Akola dist.) at 90 cm x 15 cm. All the hybrids produced better growth in HDPS plots in respect of height, branches, squares, and green bolls as compared to the non-HDPS plots. The best growth suitable for the technology was observed in Rasi THCT-5380 as it remained compact suiting to the close planting. However, all the hybrids out yielded and gave 31 to 44 % higher yield in HDPS plots than the respective non-HDPS fields where planting was done at 90 cm x 60 cm or 120 cm x 75 cm. The yield of Rasi hybrid (2100 kg ha⁻¹) was slightly superior to other two hybrids viz. Ankur (1848 kg ha⁻¹) and Mahyco (1942 kg ha⁻¹). The location influence was visible as the yields obtained at Talegaon and Kanshivani were of high order in all the hybrids than plots raised in Nagpur dist. Analysis of weather data revealed that Nagpur dist. villages received nearly double the rainfall during crop season as compared with Akola and Wardha villages.

Keywords: HDPS, Bt Cotton technology, Rainfed Cotton

INTRODUCTION

With the advent of Bt technology made available in cotton hybrids and released commercially on large scale after 2002, cotton production gained a momentum and peaked the productivity at around 600 kg lint/ha. However, since 2013-14, cotton yield is either stagnant (around 450 kg lint per ha) or declining when the best national average yield was 565.72 kg lint per ha obtained ten years ago (Mayee and Chaudhari, 2019). Within the country Maharashtra has the highest area under cotton (4.0 to 4.3 m/ha); nearly 1/3rd of the country, but it has lowest productivity (320-350 kg lint /ha). Being one of the major cash crops of Vidarbha farmers, cotton productivity has been a matter of great concern as average yield is hardly 8-10 q per ha or 1.8-2.0 bales of 170 kg lint per ha. There are several reasons of low productivity of cotton in Vidarbha. The declining treasure of soil nutrient and improper use of fertilizer skewed towards macro nutrients are considered very important factors for this situation. Long duration Bt cotton hybrids unsuitable for light soils are

frequently grown because of unavailability of compact, short duration Bt hybrid (Panchbhai *et al.* 2023). Many cotton countries were able to enhance yields by increasing planting density and plant geometry. In India also, the High-Density Planting System (HDPS) has been researched and experimented in farmer's field using varieties. In the last few years nearly 11-12 varieties were released for cultivation developed by various cotton centers. Though the technology suits well to shallow and medium Vertisol soils in Vidarbha region, it has not found favor with the farmers. Government of Maharashtra in collaboration with ICAR-CICR carried nearly 1660 demos between 2012-13 to 2016-17. However, the technology adoption did not happen mainly due to the use of non-Bt cultivars like, *Anjali*, *Suraj*, *NH165*, *PKV 081* from amongst the *G. hirsutum* and *AKA07*, *Phule Dhanwantary* from *G. arboreum*. However, in recent years due to declining yield and facing acute shortages of raw material to cotton industries there is renewed interest in HDPS technologies specifically using short duration, compact Bt hybrids suitable for shallow soils under

rainfed conditions in Vidarbha. In fact, nearly 35 per cent of the 1.6 million ha cotton area in Vidarbha region is under shallow to medium soils with very poor nutrient status and dependent on monsoon rains. Majority traits that define genotypes fitting HDPS include shy branching with 10-12 bolls of 4-5 g mainly closer to main stem so that these are synchronous bursting within 3-4 days with short duration; 120-130 days crop (Kumar *et al.* 2020). Government of India through Nagpur-based Cotton Institute has also commenced a massive program on HDPS demos in Maharashtra under PPP mode from 2023-24. To supplement their efforts, the present large scale demonstration was undertaken of HDPS technology directly in farmer's fields.

MATHODOLOGY

During Kharif season 2023-24, four demos of HDPS using three newly developed Bt hybrids viz., Rasi THCT-5380, Mahyco-7399 and Ankur Kirti-3066 were carried out on three-acre area of each plot per hybrid in farmers field in four Villages; Metpanjara and Lakhori (District: Nagpur), at Kanshivani (District: Akola) and Talegaon (District: Wardha). The names of the farmers who participated in this demo are given in Table 1. The area selected has shallow depth light soil. After the pre-cultivation operations such as ploughing, harrowing, the soil was made ready for planting. Sowing was done at 90cm x 15 cm between rows and

plants. One acre control plot was sown at distance of 1.5 m where the sowing was done as per farmer's practice with 90 cm x 60 cm or 120 cm x 60 cm distance between rows and plants. The schedule of nutrient application of NPK (100:50:50)/ha was given; nitrogen (N) fertilizer in 3 equal splits at the sowing, squaring, and flowering stages, remaining phosphorous (P) at sowing and potassium (K) in two splits at sowing and squaring stage in 40-50 DAS. Weed and Integrated pest management was adopted as per the recommendations given by Dr PDKV, Akola (Anonymous, 2023), except for Mepiquat chloride (Chamatkar) application which was sprayed @ 60 ppm at the onset of squaring and subsequent spray @ 60 ppm based on need at 65-70 days of crop stage. For prevention of square shedding neem-based spray of 40 ppm was applied.

Being exceptionally large demo plots (3 acres each hybrid), the HDPS area of each hybrid was marked into three segments. Cotton growth ancillary observations were recorded by tagging 40 random plants in each segment of one acre. Thus, observation were recorded on total of 120 plants for each hybrids on the number of branches, squares, flowers, and bolls per plant along with the height of plants at 90 days after planting. Green boll damage and sucking pest incidence at 10 days interval were recorded periodically and highest incidence was compared.

Table 1
Participating farmers in mega demonstration of HDPS technology in three districts of Vidarbha region

Sl. No	District	Village	Name of Farmers	Date of sowing			
				Rasi THCT-5380	Mahyco MRC-7399	Ankur KIRTI-3066	Total Rainfall
1	Nagpur	Lakhori	1. Shri. Narendra Boratkar	29 th June2023	30 th June2023	1 st July 2023	1244
			2. Sau. Sushma Gokhale				
			3. Sau. Savita Bhojne				
		Metpanjara	1. Shri. Govind Rathod	4 th July 2023	5 th July 2023	7 th July 2023	
			2. Shri. Prakash Meghe				
			3. Sau. Nilima Meghe				
2	Wardha	Talegaon	1. Shri. Diliprao Nimbhorkar	1 st July 2023	2 nd July 2023	2 nd July 2023	779
			2. Sau. Padmabai Nimbhorkar				
			3. Shri. Pravin Nimbhorkar				
3	Akola	Kanshivani	1. Shri. Shriram Malthane	27 th June 2023	28 th June 2023	28 th Jun 2023	695
			2. Shri. Mukunda Waghmare				
			3. Shri. Diliprao Waghmare				

(Soils range from light soil at Talegaon to medium deep at Kanshivani and Nagpur; PH ranged from 8.1 to 8.3)

RESULTS AND DISCUSSION

Growth of cotton hybrids in high density planting

The data were recorded on the branching per plant as well as highest average height of the Bt hybrids in high density system. The data are presented in Table 2. It was revealed that the number branches in general were more in the hybrids grown in high density. Amongst the hybrids Rasi -5380 exhibited lowest number followed by Ankur Kirti-3066. As against the combined control

the number branches were nearly 3-5 more in HDPS. The location also showed some variation as at Kanshivani the number of branches were much less than other locations. The data in Table 2 compiled for the plant height also exhibited large variations in height in plots of HDPS grown at 3 locations. In general Rasi-5380 was dwarf than other hybrids but all of them were shorter than the combined control. The hybrids at Talegaon location were little taller than at other locations.

Table 2
Branching number and plants height of Bt cotton in high density planting system

Hybrid	No. of branches					Plant height (cm)				
	Lakhori	Metpanjra	Talegaon	Kanshivni	Mean	Lakhori	Metpanjra	Talegaon	Kanshivni	Mean
Rasi-5380	15	13	16	10	14	72	74	109	90	81
Mahyco-7399	17	16	20	12	16	98	102	119	106	106
Ankur Kirti-3066	17	16	15	11	15	104	97	116	93	102
Control	12	12	13	09	12	106	105	120	107	110
Location Mean	15	14	16	11	14	95	94	116	99	100

The data on actual squares per plant and the retained green bolls per plant are given in Table 3. Interestingly the square number was markedly high in all the hybrids grown in HDPS (14-17 per plant) than the combined control plots where the square per plant was limited to just 06 showing clearly that close planting distance favored better square retention. The location influence on the square retention was negligible. From the data on green boll

retention, it was revealed that the hybrids grown in HDPS retained better than when the hybrids grown in traditional planting at 90cm x 60 cm. The control plots exhibited just average 10 green boll per plant as against the 15-17 green bolls per plant in HDPS. Like what was observed about square retention, Talegaon plots showed high number of green boll retention than at other locations.

Table 3
Square number and green bolls per plant in Bt cotton in high density planting system

Hybrid	No. of Squares/plant					No. of Green bolls/plant				
	Lakhori	Metpanjra	Talegaon	Kanshivni	Mean	Lakhori	Metpanjra	Talegaon	Kanshivni	Mean
Rasi-5380	15	10	19	12	14	15	10	20	15	15
Mahyco-7399	20	15	12	16	16	15	10	21	15	15
Ankur Kirti-3066	12	15	22	17	17	16	11	20	15	17
Control	06	04	06	06	06	09	08	16	08	10
Location Mean	13	11	15	13	13	14	11	18	14	14

Pest incidence in cotton hybrids in high density planting

Periodical observations were recorded on the incidence of sucking pests at all locations in all the three hybrids grown in HDPS and the summarized data on the highest incidence are presented in Table 4. Because regular schedule of integrated pest management was followed, in

general the incidence of aphids, jassids, thrips and white flies were under control and most of the time below ETL. However, maximum incidence of sucking pests was noticed in control plots than the HDPS plots. When the data of locations was scrutinized, it was revealed that the incidence of all sucking pests was higher at Talegaon followed by Metpanjra.

Table 4
Sucking pest population in Bt hybrids grown in high density system

Location	Pest population @ peak level															
	Aphid/ 3leaves				Jassid/3 leaves				Thrips/ 3leaves				Whitefly/ 3leaves			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
Lakhori	3	3	2	4	2	2	2	5	4	3	2	7	2	2	2	5
Metpanjra	2	2	3	7	2	3	3	7	6	5	6	6	1	2	3	6
Talegaon	4	4	11	12	3	4	6	8	3	3	4	6	4	3	3	7
Kanshivni	3	2	2	5	3	3	2	7	1	1	3	4	2	4	2	6
Mean	3	3	5	7	3	3	3	7	4	3	4	6	2	3	3	6

A- Rasi-5380, B- Mahyco-7399, C- Ankur Kirti-3066, D-Control

Square and Boll formation in HDPS grown hybrids

The data on the square formation and number of green boll formation per plant was recorded in all the three hybrids at all four locations at periodical intervals. The data revealed that early square formation was common in Rasi-5380 and conversion of square to green boll was nearly 90 percent and above. When these were compared with Mahyco-7399 hybrid, the conversion of square to boll was also to the tune 85 to 95 per cent. HDPS technology appears to favor more retention of squares and green bolls irrespective of the hybrid used when compared with non-HDPS grown cotton. Amongst the hybrids Rasi-5380 which appears genetically compact suits better to HDPS

planting. Further when the square and green boll damages were counted, it was found that the square damage largely due to American bollworm as negligible at all location and in all the hybrids. However lowest incidence was noted at Kanshivani and in Rasi 5380. However, the pink bollworm damage showed significant differences. High incidence was noted in non-HDPS plots but the location influence was more characteristic as highest attack of PBW was seen at Kanshivani followed by Talegaon. The incidence of PBW at Lakhori and Metpanjara was absent. Therefore the assumption that HDPS planting may enhance the incidence of cotton pest is not so as observed in the current mega-demo pots

Table 5
Square and Green boll damage due to bollworms in Bt cotton grown in high density planting system

Hybrid	% Square damage					% Green boll damage				
	Lakhori	Metpanjra	Talegaon	Kanshivni	Mean	Lakhori	Metpanjra	Talegaon	Kanshivni	Mean
Rasi-5380	2.4	2.4	4.0	0.5	2.3	0	0	15	27	11
Mahyco-7399	3.0	3.4	3.9	0.5	2.7	0	0	10	30	10
Ankur Kirti-3066	4.5	3.4	2.9	1.0	3.0	0	0	10	20	8
Control	4.1	4.0	4.3	2.7	3.8	2	3	20	35	15
Location Mean	3.5	3.3	3.8	1.2	3.0	0.5	0.5	13.8	28	11

Seed cotton yield of Bt hybrids in high density planting

The harvesting of all the plots was done using three pickings and the total yield has been expressed based on per ha yield (Table 6). There were large variations between the locations. Highest yield was obtained in Rasi-5380 at all the

locations except Kanshivani where an acre of the demo plot was submerged due to heavy rains. This was followed by Mahyco -7399 and Ankur Kirti-3066. When the yield data were compared for each hybrid with their respective control plots, it was found that the increase in yield in Rasi hybrid ranged from 20 to 90 per cent with an average of 44

per cent increase. In Mahyco hybrid the mean increase was 40% and in Ankur hybrid, it was 31%. All the three hybrids by and large gave higher yield at Kanshivani village; particularly Ankur Kirti-3066 (3426 kg/ha), while Rasi-5380 (2280 kg/ha) yielded best at Talegaon followed by Metpanjara. Mahyco-7399 (2383 kg/ha) gave higher

yield at Talegaon followed by Kanshivani. At all the locations HDPS grown hybrids gave higher yield than their respective control plots. Highest increase in yield in all three hybrids was observed at Kanshivani. It is also since this center received modest rainfall which was suitable for cotton growth.

Table 6
Seed cotton yield (Kg/ha) of Bt hybrids at four locations in HDPS demos

Hybrid	Locations									
	Lakhori	% increase over non-HDPS	Metpanjara	% increase over non-HDPS	Talegaon	% increase over non-HDPS	Kanshivani	% increase over non-HDPS	Mean	% increase
Ankur Kirti-3066	1216 (850)	43	1250 (1000)	25	1500 (800)	88	3426 (1800)	90	1848 (1113)	40
Rasi THCT-5380	1544 (900)	72	1869 (1560)	20	2280 (1200)	90	2710 (1050)	72	2100 (1178)	44
Mahyco MRC-7399	1438 (1040)	38	1800 (1050)	71	2383 (2000)	19	2148 (1300)	65	1942 (1348)	31

Figures in parenthesis are for non-HDPS control plots

Lower output at Lakhori and Metpanjara can be attributed to unusually high rains during the boll formation stages. Nagpur Dist. rain fall of cotton season was 1244 mm as against the rain 695 mm received at Kanshivani and 779 mm of Talegaon.

Several reports on the beneficial influence of high-density planting are available. Parihar *et al.* 2018; and Padangale *et al.* 2020 concluded that the high-density planting of cotton cultivars whether varieties or hybrids showed less monopodial branching, reduced height, more square retention, and less incidence of pests. Pest management in HDPS occasionally showed high initial incidence of sucking pests and bollworms (Naik *et al.* 2018) but that was more in non Bt cultivars. All studies in the past few years have pointed out clearly that the seed cotton yield increases from 25-40 per cent in HDPS grown hybrids (Kavya *et al.* 2022; Gouthami *et al.* 2023). The present study is unique in many respects; large demos with three newly developed hybrids grown on three acres of plot each at four different locations in Vidarbha cotton growing districts was never attempted earlier. The current results also support the mass scale demos recently carried out by ICAR-CICR in Vidarbha region as pilot project under PPP mode. Over 550 farmers from Nagpur and Wardha have recorded three times jump in

production under HDPS technology pilot project implemented in the State (The Times of India, Nagpur, 24 March 2024).

CONCLUSION

Based on the demonstrations in three cotton growing districts of Vidarbha it is concluded that the HDPS technology is useful for the rainfed cotton cultivation in Vidarbha region of Maharashtra. It can be a tool to improve the productivity of cotton, irrespective of rainfall. The three locations selected for the demo had rainfall ranging from 695 to 1244 mm during the crop season but still the HDPS raised plots of cotton yielded more than the traditional way of growing cotton at 95cm x 60cm or 120cm x 90cm.

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