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Effect of transplanting and seedling age on growth, yield attributes and seed cotton yield of *Bt* cotton (*Gossypium hirsutum*)

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ABSTRACT

An experiment conducted during *kharif* 2008 and 2009 laid out in RBD replicated thrice had 10 treatments in which 20 and 30 days old *Bt* cotton (*Gossypium hirsutum* L.) seedlings raised in two different kinds of media, i e cocopeat or FYM: Soil (1:1 mixture) grown in polythene bags and plastic trays were transplanted in the field on April 24 and May 5, respectively. Direct sowing was also done on these dates to ascertain the comparison of growth and yield dynamics. Twenty days old seedlings resulted better yield and other attributes. FYM: Soil (1:1) was found superior than cocopeat for raising seedling. Yield and yield contributing characters of cotton grown from seedlings reared in polythene bags were higher than plastic trays owing to better dry matter and LAI indices. Among transplanting treatments, 20 days old polythene bag nursery grown in FYM: Soil (1:1 mixture) recorded highest yield (3 336.6 kg/ha) and was statistically comparable with direct sown crop on April 24 (3 521.2 kg/ha) and May 5 (3 390.6 kg/ha). Pooled data on net returns and B:C ratio also revealed the possibility of transplanting cotton to raise a profitable crop under compelling circumstances as a potentially exploitable technology.

Key words: B: C ratio, *Bt* cotton transplanting, Cocopeat, FYM, Growth and yield attributes, Seed cotton yield, Seedlings age

The cotton (*Gossypium hirsutum* L.) crop is primarily grown in south-western zone of Punjab which is characterized by brackish underground water and poor soil fertility. Here, canal water is the sole source of irrigation for crops. However, its availability during the recommended sowing time (i e April-mid May) is often meager because of ongoing repair work required for safe flow during upcoming *kharif* season. As a result, timely sowing of cotton is severely hampered. Consequently, crop sown after pre-sowing irrigation with brackish underground water results in poor emergence owing to high sensitivity of germinating cotton seed to accumulated salts in the soil. Kent and Lauchli (1985) observed reduced germination, and also reduced fresh weight with addition of salts (200 mol/m^3 NaCl) in the presence of a complete nutrient medium. Kumari and Gill (2007) also reported similar findings. The situation is further deteriorated when such seedlings are exposed to continuously rising temperature often exceeding 40°C resulting in high seedling mortality due to burning. Ultimately poor plant stand of the crop results in huge reduction in seed cotton yield. Generally, flat bed method is used for sowing cotton. But under such circumstances, raising crop by growing seedlings in the nursery and later transplanting them at an appropriate time has an exploitable potential. Transplanting of cotton has been tried not only in India (Pundarikakshudu *et al.* 1992, Sarkar and Malik 2004) but also in countries like Iran (Sarvestani and Kordi 2001) and China (Dong *et al.* 2007) from where better response has been obtained than direct sowing. Though, transplanting is a costly process as compared to direct sowing but if practiced at an appropriate time, may result in equivalent/increased yield by performing better crop growth (Salakinkop *et al* 2010). Since *Bt* seed is costly, transplanting technology of raising hybrid cotton seedlings in polybags, well in advance of planting is generating interest (Rajakumar and Gurumurthy 2008). Debit ridden cotton growers are keen to improve profit margins by adopting such practices while maintaining yield. High cost of *Bt* seed coupled with poor germination and establishment under such situations has paved the way for contingency technique. Transplanting as a method for crop establishment has potential to realize aforesaid benefits. Keeping view of these points, an experiment was formulated to explore the feasibility of raising cotton crop by transplanting of seedlings previously grown in nursery and to evaluate the performance of

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transplanted *Bt* cotton under the site-specific agro-climatic conditions of Faridkot.

MATERIALS AND METHODS

The experiment was conducted during *kharif* 2008 and 2009 at PAU, Regional Research Station, Faridkot (30°40'N and 74°44'E) which typically represents Zone IV (South-Western Zone) of Punjab situated at 200 m above MSL. The soil of the experimental field was sandy loam, slightly high in pH (8.6), normal EC (0.43), low in OC (0.39 %), medium in available P (21 kg/ha) but high in available K (480 kg/ha). The experiment was conducted in randomized block design with three replications. There were 10 treatments including transplanting and direct sowing methods. Among transplanting, 20 and 30 days old seedlings of *Bt* hybrid (RCH-134) were raised in polythene bags and plastic trays during April and later on transplanted in the field on April 24 and May 5, respectively. Direct sowing was also done on these dates by dibbling 2 seeds per hill and later on thinned to one plant. Nursery was raised by sowing single seed either in cocopeat or in a mixture of FYM: soil (1:1) in polythene bags (4" × 6") as well as plastic trays after moisturizing them to field capacity. Soil moisture in poly bags and trays was maintained by water sprays on regular basis. Right from seeding, poly bags and trays were kept exposed to direct sunlight. Total amount of rainfall was 561.1 and 475.5 mm for the year 2008 and 2009, respectively. No. of rainy days (47) were higher during 2008 as compared to only 31 days in the year 2009. A maximum temperature of 39.4°C was recorded in May 2008,while June (40.7°C) was the hottest month in 2009.All other agronomic practices were followed as per recommended package of practices. Data on growth and yield attributes were recorded from 5 randomly selected plants in each treatment plot. Seed cotton yield (kg/ha) was recorded from whole plot. The data were analyzed statistically as per the standard procedure proposed by Cheema and Singh (1991).

RESULTS AND DISCUSSION

Effect of transplanting and source of nursery

The results indicated that the nursery raised in polythene bags performed significantly better than plastic trays. Improved seedling survival (Table 1), LAI, dry matter and consequently higher number of bolls/plant in polythene bags as compared to plastic trays resulted in higher seed cotton yield (Table 2). The number of sympods/plant though non-significant among the individual years, but pooled values indicated statistically highest values for direct sown (T_9 and T_{10}) treatments except for T_3 (Table 3). Lint yield also exhibited the similar trend.Net returns of nursery raised under polythene bags were also significantly better as compared to tray nursery treatments (Table 4). Irrespective of age of nursery, there was an improvement in the yield by 20.8, 23.1 and 0.5 and 7.5% for polythene bags as compared to plastic tray nursery treatments in otherwise same treatment (Table 5). The mean of two year study revealed 11.8% higher (3 150.8 kg/ha) seed cotton yield under polythene bags was as compared to plastic trays (2 817.6 kg/ha). Highest seed cotton yield was recorded under directly sown cotton on

Table 1 Effect of different planting treatments on the seed cotton yield and other characters of *Bt* Hybrid (RCH 134) at Faridkot

Treatment	Seedling survival (%)			Plant height (cm) at maturity			Dry matter at 50% boll opening (q/ha)		
	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
T_1 20 days old TN (cocopeat)	76.3	74.3	75.3	165.8	111.7	138.7	87.2	68.3	77.6
T_2 30 days old TN (cocopeat)	64.6	71.0	67.8	166.6	106.6	136.6	78.7	65.3	72.0
T_3 20 days old PN (cocopeat)	80.0	82.3	81.1	186.6	115.0	150.8	96.0	99.0	97.5
T_4 30 days old PN (cocopeat)	75.3	78.0	76.6	182.5	115.8	149.1	92.4	80.3	86.3
T_5 20 days old TN (FYM/Soil 1:1 mixture)	78.6	79.0	78.8	173.3	119.9	146.6	97.9	79.3	88.6
T_6 30 days old TN (FYM/Soil 1:1 mixture)	71.6	74.0	72.8	169.8	115.8	142.8	97.2	69.3	83.2
T_7 20 days old PN (FYM/Soil 1:1 mixture)	85.6	90.0	87.8	195.0	125.0	160.0	101.0	91.3	96.1
T_8 30 days old PN (FYM/Soil 1:1 mixture)	79.6	85.6	82.6	190.8	112.5	151.6	99.3	74.6	87.0
T_9 Direct sowing on 24 April	95.6	98.0	96.8	196.6	132.5	164.6	111.0	97.0	104.0
T_{10} Direct sowing on 5 May	98.0	90.0	94.0	193.3	121.7	157.5	105.9	95.0	100.4
CD (P=0.05)	6.3	8.4	5.0	NS	NS	17.1	15.8	12.7	9.7
CV(%)	4.6	5.9	5.3	9.9	8.5	9.7	9.5	9.0	9.4

TN, Tray nursery; PN, poly bag nursery

Table 2 Effect of different planting treatments on the seed cotton yield and other characters of *Bt* Hybrid (RCH 134)

Treatment	Bolls/plant			Boll weight (g)			Seed cotton yield (kg/ha)			Lint yield (kg/ha)		
	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
T_1 20 days old TN (cocopeat)	50.5	41.6	46.1	3.56	3.63	3.59	3 024.6	2 167.0	2 596.0	1 093.3	753.3	923.3
T_2 30 days old TN (cocopeat)	47.2	43.1	45.1	3.61	3.65	3.63	2 835.0	1 916.0	2 375.8	1 034.6	683.7	859.2
T_3 20 days old PN (cocopeat)	57.9	55.0	56.4	4.16	3.82	3.99	3 596.3	2 677.0	3 136.6	1 288.8	958.8	1123.8
T_4 30 days old PN (cocopeat)	60.6	49.6	55.1	3.80	3.58	3.69	3 252.6	2 600.0	2 926.4	1 174.4	925.6	1050.0
T_5 20 days old TN (FYM/Soil 1:1 mixture)	55.7	52.0	53.8	3.53	3.80	3.66	3 859.0	2 780.0	3 319.6	1 383.9	1000.4	1192.1
T_6 30 days old TN (FYM/Soil 1:1 mixture)	63.0	46.8	54.9	3.39	3.75	3.57	3 468.0	2 490.0	2 979.0	1 241.6	901.9	1071.7
T_7 20 days old PN (FYM/Soil 1:1 mixture)	65.7	50.3	58.0	4.04	3.75	3.89	3 616.3	3 056.0	3 336.6	1 271.9	1107.6	1189.7
T_8 30 days old PN (FYM/Soil 1:1 mixture)	63.2	49.6	56.4	3.68	3.57	3.62	3 443.6	2 963.0	3 203.6	1 262.1	1034.9	1148.5
T_9 Direct sowing on 24 April	69.5	59.8	64.6	4.20	4.18	4.19	3 889.3	3 153.0	3 521.2	1 415.7	1127.6	1271.6
T_{10} Direct sowing on 5 May	61.5	52.6	57.0	4.07	3.60	3.83	3 765.6	3 015.0	3 390.6	1 341.6	1066.8	1204.2
CD (P=0.05)	9.8	7.5	5.9	0.43	NS	0.30	561.8	708.4	436.4	229.5	251.3	164.2
CV(%)	9.6	8.8	9.3	6.6	7.1	6.8	9.4	15.4	12.1	10.7	15.3	12.7

TN, Tray nursery; PN, poly bag nursery

Table 3 Effect of different planting treatments on the seed cotton yield and other characters of *Bt* Hybrid (RCH 134)

Treatment	Monopods/plant			Sympods/plant			LAI		
	2008	2009	Pooled	2008	2009	Pooled	2008	2009	Pooled
T_1 20 days old TN (cocopeat)	2.33	1.8	2.0	26.50	22.5	24.5	2.9	3.2	3.0
T_2 30 days old TN (cocopeat)	2.00	2.2	2.3	26.66	24.4	25.5	2.6	3.0	2.8
T_3 20 days old PN (cocopeat)	2.66	1.8	2.2	31.16	26.2	28.7	3.3	3.8	3.5
T_4 30 days old PN (cocopeat)	2.43	2.4	2.2	32.50	24.2	28.3	3.1	3.3	3.2
T_5 20 days old TN (FYM/Soil 1:1 mixture)	2.16	2.0	2.3	29.50	22.6	26.0	3.0	4.0	3.5
T_6 30 days old TN (FYM/Soil 1:1 mixture)	2.16	2.8	2.4	28.50	22.9	25.7	2.9	3.7	3.3
T_7 20 days old PN (FYM/Soil 1:1 mixture)	2.66	2.6	2.3	33.16	23.4	28.3	3.4	4.2	3.8
T_8 30 days old PN (FYM/Soil 1:1 mixture)	2.16	3.0	2.5	32.33	24.0	28.2	3.1	3.9	3.5
T_9 Direct sowing on 24 April	2.83	3.3	3.0	35.33	29.2	32.3	3.9	4.4	4.1
T_{10} Direct sowing on 5 May	2.50	2.9	2.6	33.33	27.8	30.6	3.6	4.1	3.8
CD (P=0.05)	0.37	0.45	0.28	NS	NS	3.9	0.6	NS	0.5
CV(%)	9.1	10.6	9.9	10.9	13.5	12.1	12.0	14.7	13.7

TN, Tray nursery; PN, poly bag nursery

Table 4 Effect of different planting treatments on the monetary parameters and B:C ratio on *Bt* Hybrid (RCH 134)

Treatment	Net returns (₹/ha)			B:C ratio		
	2008	2009	Pooled	2008	2009	Pooled
T_1 20 days old TN on 24 April (cocopeat)	53 524	35 824	44 674	1.72	1.2	1.47
T_2 30 days old TN on 5 May (cocopeat)	48 688	28 928	38 807	1.59	1.0	1.29
T_3 20 days old PN on 24 April (cocopeat)	68 008	49 717	58 862	2.08	1.6	1.84
T_4 30 days old PN on 5 May (cocopeat)	59 244	47 604	53 424	1.86	1.5	1.71
T_5 20 days old TN on 24 April (FYM/Soil 1:1 mixture)	75 380	53 310	64 345	2.31	1.7	2.02
T_6 30 days old TN on 5 May (FYM/Soil 1:1 mixture)	65 409	45 329	55 369	2.06	1.5	1.79
T_7 20 days old PN on 24 April (FYM/Soil 1:1 mixture)	73 160	65 265	69 212	2.60	2.4	2.53
T_8 30 days old PN on 5 May (FYM/Soil 1:1 mixture)	68 757	62 699	65 728	2.48	2.3	2.42
T_9 Direct sowing on 24 April	82 953	70 861	76 907	3.20	2.9	3.08
T_{10} Direct sowing on 5 May	79 800	67 077	73 438	3.11	2.8	2.98
CD (P=0.05)	14 328	19 483	11 673	0.37	0.5	0.32
CV(%)	12.3	21.5	16.6	9.4	17.1	13.2

TN, Tray nursery; PN, poly bag nursery

Table 5 Individual effect of planting material, seedling age and planting media on seed cotton yield (simple mean of two years)

	Seed cotton yield (kg/ha)								
	Planting material			Seedling age			Planting media		
	Polythene bag	Plastic tray	% increase over tray	20 days	30 days	% increase over 30 days	FYM	Cocopeat	% increase over cocopeat
	3 136.6 (T_3)	2 596.0 (T_1)	20.8	2 596.0 (T_1)	2 375.8 (T_2)	9.2	3 319.6 (T_5)	2 596.0 (T_1)	27.8
	2 926.4 (T_4)	2 375.8 (T_2)	23.1	3 136.6 (T_3)	2 926.4 (T_4)	7.1	2 979.0 (T_6)	2 375.8 (T_2)	25.3
	3 336.6 (T_7)	3 319.6 (T_5)	0.5	3 319.6 (T_5)	2 979.0 (T_6)	11.4	3 336.6 (T_7)	3 136.6 (T_3)	6.3
	3 203.6 (T_8)	2 979.0 (T_6)	7.5	3 336.6 (T_7)	3 203.6 (T_8)	4.1	3 203.6 (T_8)	2 926.4 (T_4)	9.4
Mean	3 150.8	2 817.6	11.8	3 097.2	2 871.2	7.8	3 209.7	2 758.7	16.3

TN, Tray nursery; PN, poly bag nursery; * Abbreviations in the parenthesis indicate the treatment symbol; **Unanalyzed mean values for each factor have been calculated after averaging upon the other two factors.

April 24 (3 521.2 kg/ha), though it was at par with some of the transplanting treatments such as T_3 and T_5 (i e 20 days old poly bag nursery grown either in cocopeat or FYM and also with 20 or 30 days old poly bag nursery grown in FYM: Soil mixture (T_7 and T_8, respectively). Seed cotton yield under direct sowing on May 5 (3390.6 kg/ha) was at par with direct sowing on 24 April and also with 20 or 30 days old poly bag nursery grown in FYM : Soil mixture (T_7 and T_8). Studies revealed that equivalent yield as that of direct sown crop can be realized by growing cotton through transplanting. Sarvestani and Kordi (2001) in Tehran (Iran) reported improved sympodia in transplanted cotton than direct seeded one, though there was no effect on yield, earliness, bolls per plant and boll size. However, Dong *et al.* (2005a, 2005b and 2007) in China found that transplanted cotton performed better as compared to direct seeded. Rajakumar and Gurumurthy (2008) at Coimbatore observed improved boll number and weight under polybag transplanting than direct sowing. Sarkar and Malik (2004) in India also recorded improved growth, yield attributes and 16.5 and 12.7% higher seed cotton and lint yield, respectively in transplanted crop as compared to direct sown cotton. Transplanting resulted in increased net returns and per day productivity by 22.5 and 16.9%, respectively over direct sown cotton. These results are in conformity with the findings of Deshmukh *et al.* (1987). Pooled means for growth indices such as LAI and

dry matter in few of the transplanting treatments was comparable with direct sown crop. As a result, seed cotton yield in these treatments, i e T_3, T_5, T_7 and T_8 was statistically comparable with direct seeded cotton.Kamel *et al.* (1994) also observed improvement in growth indices in raised plants. Salakinkop *et al.* (2010) also reported significantly higher seed cotton yield (3 828 to 4 266 kg/ha) in transplanting of seedlings compared to farmer's practice of hand dibbling (3 277 kg/ha). Despite higher cost of cultivation in transplanting, the gross returns were higher which ranged from ₹ 95 700 and 106 650/ha with monetary advantage to the tune of 12.5 to 32% compared to dibbling (₹ 57 625/ha). However, net returns in directly sown cotton on 24 April were significantly higher than all the transplanting treatments except for T_7 and T_8. Except for year 2009, the B:C ratio was significantly highest for direct sown treatments (T_9 and T_{10}), which indicated overall superiority of direct sown crop. The more expenditure incurred on labour engaged for transplanting treatments was mainly responsible for low values. However, as a contingent measure, values of B:C ratio closely approaching direct sown crop indicates the feasibility of growing cotton by transplanting seedlings.

Effect of seedling age

Age of seedling for transplanting had significant effects on yield and yield contributing characters of *Bt* cotton. Transplanting of 20 day old seedlings grown either in plastic trays or polythene bags resulted in higher seed cotton yield as compared to 30 days old seedlings irrespective of the planting media, i e cocopeat or FYM: Soil (Table 2). This might be due to the fact that yield contributing characters such as sympods, bolls/plant and boll weight exhibited decline with increase in age of seedlings from 20 to 30 days. Growth indices, i e plant height, dry matter and LAI also followed similar trend. Unanalyzed data of two years also indicated yield improvement in the range of 4.1-11.4% for 20 days as compared to 30 days old nursery within otherwise same treatment combination (Table 5). Mean seed cotton yield of four 20 day old nursery treatments was 7.8% higher (3 097.2 kg/ha) than respective 30 day old nursery (2 871.2 kg).There was a decline in lint yield as the age of the seedlings increased (Table 2). Seedlings of 20 days age performed better as compared to old seedlings (30 days) because of their better ability to withstand transplanting shock. This might be due to certain unfavorable effects on root growth experienced in 30 days old seedlings resulting into their less efficiency as compared to 20 days old seedlings. Such seedlings, when transplanted on 20 April, exhibited improved seed cotton yield primarily due to better leaf area indices, which helped in more sink production, i e resulted in more bolls/plant and eventually yield was increased. Initially healthy seedlings coupled with vigorous growth in case of FYM: Soil (1:1) as compared to cocopeat resulted in higher seed cotton yield and yield attributes. Comparatively poor nutrient supplying capacity of cocopeat during early seedling growth and development thus reflected into reduced yield. Kaul *et al.* (2010) also reported higher seed cotton yield in 3 week old as compared to two or four week old cotton seedlings. As the age of the seedlings increased, decline in lint yield was observed.

Effect of planting media

Among the two planting media, i e cocopeat or FYM: Soil (1:1), there were clear cut differences for most of the characters under study including seed cotton yield. However, no. of bolls/plant was significantly improved under FYM: Soil mixture as compared to cocopeat. Irrespective of age of nursery, there was an improvement in the yield by 27.8, 25.4 and 6.4 and 9.4% for FYM: Soil (1:1) as compared to cocopeat treatment in otherwise same treatments with an overall increase of 16.34% seed cotton yield than cocopeat plots under FYM: Soil plots, thereby indicating the superiority of the latter (Table 5).

Present studies revealed that 20 days old nursery is suitable for transplanting under north Indian conditions to get same seed cotton yield as that of normal timely sown crop. Polythene bags (4×6') have proved better than plastic trays as media for growing nursery. Similarly, mixture of FYM (1:1) proved better over cocopeat for establishment of nursery plants in the field. Risk of crop failure can be minimized by adopting this technology as direct sown crop is prone to crust formation if early rain occurs (3-4 DAS),which is quite common during sowing periods. Since, canal water supply is erratic during sowing period, such technology can be exploited to get equivalent yield as that of direct sown cotton.

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