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Effect of seed enhancement treatments and plant spacing on the field performance of hybrid cotton

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ABSTRACT Seed enhancement is a widely used technique to improve field emergence, uniformity and final plant establishment under wide range of environmental conditions. Field experiments were conducted during *kharif* 2010 and 2011 to find out effective seed enhancement treatment and suitable spacing for Bt Express and non Bt Express cotton hybrids. A total of 17 seed quality enhancement treatments were attempted for enhancing the field performance of cotton hybrids. Significantly higher field emergence and final plant stand establishment were observed in the seeds treated with azotobacter + microphos (10g each/kg of seed) followed by thiram+ imidacloprid (2.0 g/kg seed + 7.5ml/kg seed) treatment. These two treatments also resulted in early initiation of flowering, 50% flowering and 50% boll opening over all other treatments. Therefore, these presowing seed treatments are recommended before sowing in the field. Among the three, spacing of 75×60cm was found to be significantly superior over 75×75cm and 75×30cm, thus it may be followed to obtain their better field performance.

Keywords: Cotton, pre-sowing, seed enhancement treatment, spacing, field performance

Cotton is a major fibre crop of global importance with high commercial value playing important role in the economic, political and social affairs. India occupies the place of pride in the global cotton scenario due to distinct features such as largest cotton growing area and cultivation of all the 4 cultivated species. It is the second largest producer of cotton, the productivity of 493kg/ha is much lower than the world productivity of 725kg/ha [1]. About 70 per cent cotton cultivation in India is under rainfed conditions [2]. To increase the cotton production in the country, it is necessary to increase cultivation of hybrid cotton under irrigated as well as rainfed areas and for this, supply of good quality seed is essential. Uniform as well as vigorous crop stand is the major milestone in successful and economic cotton production. Numerous biotic and abiotic stresses adversely affect cotton plant from the germination till maturity. The growth during the seedling establishment phase plays an important role in yield realization. However, during this stage it is susceptible to damping-off primarily caused by *Rhizoctonia solani* (Kuhn), *Colletotrichum gossypii* and *C. gossypii* var. *cephalosporioides* [3]. Application of chemical treatments to the seeds helps in controlling seed borne pathogens.

Seed enhancement comprises of post harvest or pre sowing treatments such as priming, coating or dry dressing with fungicides, insecticides, polymers etc., which improves germination, seedling growth and/or plant stand. In film coating, additives are dissolved in a solution of sticky polymers allowing minimal application of pesticides or growth promoting substances, whereas in priming a controlled hydration process initiates the earliest stage of germination, activating the metabolic activities and cellular repair of membranes and organelles damaged during seed storage [4] and thus resulting in rapid and uniform emergence. The pre sowing seed enhancement also helps in coping up the adversity caused by hostile environmental conditions at the time of seedling growth and stand establishment.

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Among various cultural practices, the spacing is a crucial factor which influences the field performance of cotton. When optimum level of plant density in cotton exceeds, yield reduction occurs due to excessive vegetative growth [5], increased boll shedding, delayed maturity and increased boll rot [6]. Hence, there is a need to standardize the plant spacing to obtain the higher yield with better seed quality. Therefore, the present investigation was conducted to compare the effect of different seed enhancement treatments as well as spacing for improving the field performance of cotton.

MATERIALS AND METHODS

Seeds of Bt cotton (*G. hirsutum* L.) and non Bt cotton (*G. hirsutum* L.) Express hybrids were procured from Nath bio-genes Limited, Aurangabad, Maharashtra. These two hybrids were used during present investigation for studying field performance after giving 16 seed enhancement treatments. The treatments given were: T1- Control (Untreated); T2- Cruiser (5ml/kg seed); T3- Fulvic acid + KCl (0.3% + 0.2%); T4- Fulvic acid + KNO_3(0.3% + 0.2%); T5- Hydro-priming (16hr soaking in 30ml water (wt./vol) at 20^0C); T6- Imidacloprid (6ml/kg seed); T7- Incotec red (10ml/kg seed); T8- Magnetic Enhancement (2500 G for 1 hr); T9- Neem oil (6ml/kg seed); T10- Incotec red + Seaweed powder (6ml/kg seed+0.3%); T11- Royalflo (5ml/kg seed); T12- Thiram (2.0g/kg seed); T13- Thiram+ Imidacloprid (2.0g/kg seed + 7.5ml/kg seed); T14- Vitavax power (3.0g/kg seed); T15- Polymer (5ml/kg seed); T16- Azotobacter + Microphos (10g/kg seed +10g/kg seed) and T17- Kaveri (1.0kg/kg soil). The field experiments were conducted during *kharif* 2010 and 2011 at IARI Experimental farm, Division of Seed Science and Technology, New Delhi. The experiment was laid out in factorial randomized block design consisting of 17 treatments and 3 levels of spacing (D1=75×75cm, D2=75×60cm, D3=75×45cm). The treatment combinations were replicated twice in paired rows so as to form four replications.

The observations on field emergence were recorded on alternate day till 15th day of sowing the seeds in three spacing in two replications of paired rows in the field for both Bt and non Bt cotton hybrid. The seedling emergence was expressed in percentage. Final plant stand was recorded after twenty one days of sowing. The seedling establishment was expressed in percentage. Days to; initiation of first flowering, 50 percent flowering, termination of flowering, 50 percent boll opening were also recorded and calculated from the day of sowing. The mean seed yield obtained from five plants of each treatment and replication combinations was recorded after ginning and expressed in grams per plant.

The data from field experiments were analyzed as per Panse and Sukhatme [7] following Randomized Block Design (RBD). The percentage data were arcsine transformed. The analysis of data was done by using the SAS package (version 9.3).

RESULTS AND DISCUSSION

Effect on field emergence and final plant stand (%)

The results on the field emergence as influenced by Bt and non Bt hybrids, seed treatments and spacing have been presented in table 1.There was significant difference in the field emergence of the two hybrids, the Bt Express hybrid showed significantly higher field (80.3 %) emergence than the non Bt Express hybrid (74.3%). Field emergence was numerically higher in 2010 (78.2 %) than 2011 (76.4%).The field emergence percent was significantly influenced by seed treatments, all the treatments proved to be significantly better than the control (64.0%). It was found highest in seeds treated with azotobacter + microphos (T16, 80.8 %), followed by thiram + imidacloprid (T13, 80.3%), thiram (T12, 77.7%), imidacloprid (T6, 79.5%), though plant spacing too had significant influence on field

Table 1. Effect of seed quality enhancement treatments on field emergence (%) with respect to spacing in cotton hybrids over the years

Treatment	H1				H2				Y1			Y2					
	D1	D2	D3	Mean (H1XT)	D1	D2	D3	Mean (H2XT)	D1	D2	D3	D1	D2	D3	Mean (TXY1)	Mean (TXY2)	Mean
T1	54.8 (47.8)	67.8 (55.5)	61.0 (51.4)	61.2 (51.5)	66.0 (54.4)	67.0 (55.0)	67.8 (55.5)	66.3 (54.5)	58.3 (49.8)	66.0 (54.4)	61.3 (57.6)	62.5 (52.3)	71.8 (58.0)	67.5 (55.3)	61.8 (57.9)	66.3 (54.5)	64.0 (53.2)
T2	72.0 (58.1)	74.8 (59.9)	70.3 (57.0)	72.0 (58.1)	75.3 (60.2)	80.5 (63.8)	83.0 (65.7)	78.3 (62.3)	69.0 (56.2)	78.3 (62.3)	72.8 (58.6)	78.3 (62.3)	79.0 (62.8)	80.5 (63.8)	73.3 (58.9)	78.3 (62.3)	75.8 (60.6)
T3	74.0 (59.4)	71.0 (57.4)	72.5 (58.4)	72.5 (58.4)	77.3 (61.6)	75.5 (60.4)	72.5 (58.4)	74.1 (59.4)	73.0 (58.7)	75.0 (60.0)	72.5 (58.4)	78.3 (62.3)	74.5 (59.7)	72.5 (58.4)	73.5 (59.0)	74.1 (59.4)	73.8 (59.2)
T4	69.0 (56.2)	72.3 (58.3)	74.3 (59.6)	72.5 (58.4)	74.8 (59.9)	78.8 (62.6)	74.0 (59.4)	72.1 (58.1)	70.3 (57.0)	78.0 (62.1)	77.5 (61.7)	72.5 (58.4)	76.0 (60.7)	70.8 (57.3)	75.3 (60.2)	72.1 (58.1)	73.7 (59.2)
T5	71.8 (58.0)	75.0 (60.0)	79.3 (63.0)	75.0 (60.0)	83.3 (65.9)	86.3 (68.3)	83.0 (65.7)	77.5 (61.7)	79.3 (63.0)	85.5 (67.7)	83.3 (65.9)	75.8 (60.6)	81.8 (64.8)	78.0 (62.1)	82.7 (65.5)	77.5 (61.7)	80.1 (63.5)
T6	73.0 (58.7)	76.8 (61.2)	76.8 (61.2)	76.5 (61.0)	82.3 (65.2)	86.8 (68.7)	78.3 (62.3)	78.3 (62.3)	76.5 (61.0)	84.3 (66.7)	81.3 (64.4)	78.8 (62.6)	85.3 (67.5)	73.8 (59.2)	80.7 (64.0)	78.3 (62.3)	79.5 (63.1)
T7	74.3 (59.6)	76.3 (60.9)	70.8 (57.3)	74.8 (59.9)	80.0 (63.5)	86.5 (68.5)	79.3 (63.0)	77.7 (61.9)	72.0 (58.1)	85.8 (67.9)	79.3 (63.0)	82.3 (65.2)	83.0 (65.7)	70.8 (57.3)	79.0 (62.8)	77.7 (61.9)	78.3 (62.3)
T8	72.3 (58.3)	71.0 (57.4)	71.8 (58.0)	72.7 (58.5)	76.5 (61.0)	87.3 (69.2)	77.8 (61.9)	74.8 (59.9)	71.5 (57.8)	83.8 (66.3)	79.8 (63.3)	77.3 (61.6)	80.5 (63.8)	69.8 (56.7)	78.3 (62.3)	74.8 (59.9)	76.6 (61.1)
T9	80.5 (63.8)	74.5 (59.7)	72.0 (58.1)	75.7 (60.5)	76.5 (61.0)	85.0 (67.2)	81.3 (64.4)	77.3 (61.6)	76.0 (60.7)	82.8 (65.5)	80.3 (63.7)	81.0 (64.2)	80.8 (64.0)	73.0 (58.7)	79.3 (63.0)	77.3 (61.6)	78.3 (62.3)
T10	77.0 (61.4)	79.0 (62.8)	74.3 (59.6)	76.8 (61.2)	80.8 (64.0)	88.3 (70.0)	82.3 (65.2)	78.5 (62.4)	77.3 (61.6)	84.0 (66.5)	84.8 (67.1)	78.5 (62.4)	86.3 (68.3)	71.8 (58.0)	82.0 (64.9)	78.5 (62.4)	80.3 (63.7)
T11	71.8 (58.0)	78.8 (62.6)	73.0 (58.7)	74.5 (59.7)	81.3 (64.4)	86.3 (68.3)	79.8 (63.3)	78.6 (62.5)	73.3 (58.9)	83.8 (66.3)	78.0 (62.1)	79.8 (63.3)	84.3 (66.7)	74.8 (59.9)	78.3 (62.3)	78.6 (62.5)	78.5 (62.4)
T12	78.3 (62.3)	84.5 (66.8)	75.3 (60.2)	79.3 (63.0)	82.3 (65.2)	81.3 (64.4)	82.5 (65.3)	77.7 (61.9)	82.0 (64.9)	89.0 (70.7)	83.0 (65.7)	78.5 (62.4)	79.8 (63.3)	74.8 (59.9)	84.7 (67.0)	76.7 (61.2)	80.7 (64.0)
T13	75.0 (60.0)	79.8 (63.3)	75.8 (60.6)	76.8 (61.2)	87.0 (68.9)	83.0 (65.7)	81.5 (64.6)	79.9 (63.4)	80.0 (63.5)	83.5 (66.1)	78.8 (62.6)	82.0 (64.9)	82.3 (65.2)	78.5 (62.4)	80.8 (64.0)	79.9 (63.4)	80.3 (63.7)
T14	74.0 (59.4)	80.0 (63.5)	75.8 (60.6)	76.6 (61.1)	80.8 (64.0)	87.8 (69.6)	80.5 (63.8)	78.5 (62.4)	76.0 (60.7)	87.5 (69.3)	79.8 (63.3)	78.8 (62.6)	83.3 (65.9)	76.5 (61.0)	81.1 (64.3)	78.5 (62.4)	79.8 (63.3)
T15	75.0 (60.0)	73.8 (59.2)	69.0 (56.2)	72.6 (58.5)	79.5 (63.1)	73.8 (59.2)	78.5 (62.4)	73.1 (58.8)	80.3 (63.7)	75.3 (60.2)	74.8 (59.9)	74.3 (59.6)	75.3 (60.2)	72.8 (58.6)	75.8 (60.6)	73.1 (58.8)	74.9 (60.0)
T16	80.0 (63.5)	80.0 (63.5)	77.3 (61.6)	79.1 (62.8)	79.3 (63.0)	86.0 (68.1)	82.3 (65.2)	73.9 (59.3)	83.5 (66.1)	85.5 (67.7)	82.0 (64.9)	75.8 (60.6)	83.5 (66.1)	77.5 (61.7)	83.7 (66.2)	77.9 (62.0)	80.8 (64.0)
T17	75.0 (56.2)	78.5 (62.4)	74.5 (59.7)	74.0 (59.4)	78.8 (62.6)	88.8 (70.5)	83.8 (66.3)	81.2 (64.3)	68.0 (55.6)	81.3 (64.4)	83.5 (66.1)	79.8 (63.3)	89.0 (70.7)	74.8 (59.9)	77.6 (61.8)	80.2 (63.6)	78.9 (62.7)
Mean (HXD)	73.0 (58.7)	76.7 (61.2)	73.1 (58.8)		78.9 (62.7)	82.9 (65.6)	79.3 (63.0)										
Mean (H)	74.3 (59.6[b])	80.3 (63.7[a])															
Mean (D)	75.9 (60.6[b])	79.8 (63.3[a])	76.2 (60.8[b])														
Mean (YXD)									74.5 (59.7[c])	81.6 (64.6[a])	78.4 (62.3[b])	77.4 (61.6[b])	77.9 (62.0[ab])	74.0 (59.4[bc])			
Mean (Y)										78.2 (62.2[a])			76.4 (61.0 [a])				
CD (p=0.05)	H = 0.73, D= 0.72, Y= NS, T= 0.89, HXD= 1.18, YXD=2.13, YXH=NS YXT= NS, YXHXT= NS, YXHXDXT= NSYXD=NS, HXT=NS, YXHXD= NS, HXDXT = NS, YXHXT= NS																

Means with the same superscript are statistically non significant (NS)
Year of sowing (Y): Y1= 2010, Y2= 2011
Hybrid (H): H1= Non Bt Express hybrid, H2= Bt Express hybrid

Values within the parenthesis are arcsine transformed values
D1-75 cm ×75 cm, D2-75 cm ×60 cm, D3-75cm × 45cm
T= Treatment

emergence. Out of the three spacing, the spacing D2 gave significantly higher field emergence (79.8%), while D3 (76.2%) and D1 (75.9%) were at par. The interaction due to plant spacing and year (D×Y) showed significant difference on the field emergence. In both 2010 and 2011 spacing D2 gave significantly higher field emergence recording 78.6% and74.9% respectively. However, in 2011 spacing D1 (77.4%) was at par with D2 (77.9%).

The results on the effect of seed quality enhancement treatments on final plant stand with respect to spacing in cotton hybrids over the years have been depicted in table 2. The effects of the treatments revealed that except T3 (fulvic acid + KCl; 53.1%) and T15 (polymer; 50.5%) the performance of all the treatments were significantly superior to the control (53.6%). Amongst these, the best treatment was T13 (thiram + imidacloprid, 67.4%) followed by T16 (azotobacter + microphos, 65.6%) and T14 (vitavax, 67.4%).The final plant stand was significantly higher in 2011(63.7%) than 2010 (59.1%). The interaction between hybrid and year showed that non Bt hybrid performed consistently in both the years while, final plant stand of the Bt hybrid differed significantly over the years. Overall Bt hybrid (69.4%) had higher plant stand than the non Bt hybrid (66.3%). There was significant effect of spacing on final plant stand, spacing D1 gave the highest plant stand of 64.3% followed by D2 (62.1%) and D3 (57.8%). The final plant stand was recorded higher in 2011 (63.7%) than 2010 (59.1%).

The interaction due to hybrid and spacing (H×D) was found significant, in both Bt and non Bt hybrid the spacing D1 resulted in highest plant stand recording 71.0% and 67.8% respectively. In Bt hybrid the spacing D2 (64.3%) and D3 (63.7%) were at par while in non Bt hybrid D2 (60.1) was significantly higher than D3 (53.1). no significant difference for plant stand establishment was noticed in other interactions *viz.*, hybrid × treatment, spacing × year, treatment × year, spacing × treatment, year × hybrid × spacing, hybrid × spacing × treatment, year × spacing × treatment.

All the invigoration treatments significantly enhanced the field emergence over control in both the hybrids. The positive effect of seed treatment with fungicides, insecticides, biological agents and polymer was reflected by significantly higher field emergence and final plant establishment in both the hybrids. The seeds treated with thiram alone increased the field emergence and final plant stand by 27.4% and 21.3% other control. The beneficial effect of thiram treatment is attributed to its role in reducing the fungal infection, control of pre and post mortality [8] on the germinating seeds. Raj *et al.*[9] reported that soybean seeds treated with thiram (2.00 g/kg seeds) were effective in controlling *Aspergillus flavus, A. niger and Alternaria alternate* thus, resulting in better crop performance. The improvement in field emergence and final plant stand due to royalflo was attributed to its thiram base [10]. The improvement in field emergence due to thiram application is in conformity with the results of Vijaykumar *et al.*[11] in cotton. The insecticides *viz.*, cruiser and imidacloprid increased final plant stand by 11.0% and 20.0% respectively, their pronounced effect may be due to their effectiveness in controlling leaf hopper [12] and jassids [13]. In cotton seed treatment with cruiser was effective as the population of sucking pests remained low up to 56 days after sowing [14]. Earlier Gupta *et al.* [15] observed that seeds treated with imidacloprid even at lower dose of 3 g per kg of seed treatment proved to be effective against leaf hoppers up to 61-76 days in cotton. It was further confirmed by Pathare [16] who found that incidence of leaf minors, jassids, and thrips was least on cruiser treated plants. Muthuraj*et al.* [17] reported higher field emergence in polycoated seeds, due to increase in the rate of imbibition where the fine particles in the coating act as moisture

Table 2. Effect of seed quality enhancement treatments on final plant stand (%) with respect to spacing in cotton hybrids over the years

Treatment	H1				H2				Y1			Y2					
	D1	D2	D3	Mean H1XT)	D1	D2	D3	Mean (HXT)	D1	D2	D3	D1	D2	D3	Mean (TXY1)	Mean (TXY2)	Mean
T1	51.1 (45.7)	55.0 (47.9)	48.7 (44.3)	51.6 (45.9)	59.4 (50.4)	56.0 (48.5)	51.4 (45.8)	55.6 (48.2)	55.8 (48.4)	56.3 (48.6)	51.0 (45.6)	54.7 (47.7)	54.8 (47.8)	49.1 (44.5)	54.4 (47.5)	52.9 (46.7)	53.6 (47.1)
T2	63.7 (53.0)	60.5 (51.1)	53.5 (47.0)	59.2 (50.3)	62.2 (52.1)	60.0 (50.8)	69.7 (56.6)	59.7 (50.6)	52.8 (46.6)	55.0 (47.9)	66.2 (54.5)	63.4 (52.8)	55.5 (48.2)	61.0 (51.4)	58.0 (49.6)	60.0 (50.8)	57.0 (49.0)
T3	57.1 (49.1)	49.7 (44.9)	51.5 (55.9)	52.7 (46.6)	53.6 (47.1)	55.0 (47.9)	51.5 (45.9)	53.4 (47.0)	50.1 (45.1)	55.0 (47.9)	51.6 (45.9)	60.6 (51.1)	49.7 (44.9)	52.5 (46.5)	52.2 (46.3)	54.3 (47.5)	53.1 (46.8)
T4	71.4 (57.7)	53.0 (46.7)	55.4 (48.1)	59.9 (50.7)	53.4 (47.0)	55.0 (47.9)	54.5 (47.6)	54.0 (47.3)	58.6 (50.0)	55.0 (47.9)	58.3 (49.8)	66.3 (54.5)	53.0 (46.7)	53.6 (47.1)	57.3 (49.2)	57.6 (49.4)	57.0 (49.0)
T5	69.3 (56.4)	58.3 (49.8)	58.3 (49.8)	60.3 (51.0)	60.0 (50.8)	66.3 (54.5)	74.6 (59.8)	67.0 (55.0)	61.5 (51.7)	66.5 (54.7)	58.0 (49.6)	73.4 (59.0)	67.0 (55.0)	60.9 (51.3)	62.0 (52.0)	67.1 (55.0)	63.7 (53.0)
T6	70.9 (57.4)	65.4 (54.0)	52.5 (46.5)	62.9 (52.5)	63.9 (53.1)	65.3 (53.9)	67.8 (55.5)	65.6 (54.1)	65.4 (54.0)	63.3 (54.5)	59.3 (50.4)	73.4 (59.0)	67.4 (55.2)	60.9 (51.3)	62.7 (52.4)	67.2 (55.1)	64.3 (53.3)
T7	71.3 (56.9)	60.7 (51.2)	48.7 (44.3)	60.9 (51.3)	64.1 (53.2)	68.8 (56.1)	63.1 (52.6)	65.3 (53.9)	61.0 (51.4)	63.8 (53.0)	58.3 (49.8)	74.4 (59.6)	70.7 (57.3)	70.5 (57.1)	61.1 (51.4)	71.9 (58.0)	63.1 (52.6)
T8	70.1 (56.9)	60.6 (51.1)	52.5 (46.5)	61.1 (51.4)	58.4 (49.9)	62.5 (52.3)	61.2 (51.5)	60.7 (51.2)	67.7 (55.4)	57.5 (49.3)	59.3 (50.4)	56.3 (48.6)	66.9 (54.9)	57.3 (49.2)	61.5 (51.7)	60.2 (50.9)	60.9 (51.3)
T9	73.3 (58.9)	58.4 (49.9)	52.5 (46.5)	61.4 (51.6)	57.8 (49.5)	72.5 (58.4)	63.1 (52.6)	64.5 (53.5)	56.1 (48.5)	57.5 (49.3)	57.0 (49.0)	75.0 (60.0)	73.4 (59.0)	61.2 (51.5)	56.9 (49.0)	69.9 (56.8)	62.9 (52.5)
T10	75.4 (60.3)	62.2 (52.1)	53.5 (47.0)	63.7 (53.0)	59.9 (50.7)	59.0 (50.2)	60.1 (50.9)	59.7 (50.6)	62.9 (52.5)	56.8 (48.9)	59.3 (50.4)	73.4 (59.0)	62.4 (52.2)	57.3 (49.2)	59.6 (50.6)	64.4 (53.4)	61.7 (51.8)
T11	70.8 (57.3)	60.3 (51.0)	56.3 (48.6)	62.5 (52.3)	61.6 (51.7)	68.8 (56.1)	60.2 (50.9)	63.5 (52.9)	59.8 (50.7)	60.0 (50.8)	55.4 (48.1)	72.5 (58.4)	69.0 (56.2)	71.2 (57.6)	58.4 (49.9)	70.9 (57.4)	63.0 (52.6)
T12	66.1 (54.4)	67.3 (55.1)	54.4 (47.5)	62.6 (52.3)	64.3 (53.3)	66.5 (54.7)	69.9 (56.8)	66.9 (54.9)	62.6 (52.3)	60.3 (51.0)	61.3 (51.6)	67.8 (55.5)	63.1 (52.6)	61.9 (51.9)	61.4 (51.6)	64.2 (53.3)	65.0 (53.8)
T13	70.8 (57.3)	69.9 (56.8)	53.5 (47.0)	64.7 (53.6)	65.4 (54.0)	71.3 (57.6)	73.2 (58.9)	70.0 (56.8)	62.5 (52.3)	64.3 (53.3)	64.2 (53.3)	78.7 (62.5)	75.9 (60.6)	67.5 (55.3)	63.7 (53.0)	74.0 (59.4)	67.4 (55.2)
T14	72.3 (58.3)	66.5 (54.7)	59.0 (50.2)	65.9 (54.3)	60.6 (51.1)	75.0 (60.0)	71.9 (58.0)	69.2 (56.3)	61.5 (51.7)	71.5 (57.8)	64.0 (53.2)	73.4 (59.0)	70.0 (56.8)	66.9 (54.9)	66.5 (54.7)	70.1 (56.9)	62.7 (52.4)
T15	57.9 (49.6)	47.2 (43.4)	40.9 (39.8)	48.7 (44.3)	51.3 (45.8)	48.8 (44.3)	56.4 (48.7)	52.2 (46.3)	54.9 (47.1)	49.0 (44.4)	58.0 (49.6)	65.3 (53.9)	58.9 (50.2)	57.3 (49.2)	54.0 (47.3)	60.5 (51.1)	50.5 (45.3)
T16	72.4 (58.3)	63.0 (52.6)	56.7 (48.9)	64.0 (53.2)	61.6 (51.7)	75.0 (60.0)	64.7 (53.6)	67.1 (55.0)	62.5 (52.3)	65.8 (54.2)	58.3 (49.8)	72.5 (58.4)	72.2 (58.2)	63.1 (52.6)	62.2 (52.1)	69.3 (56.4)	65.6 (54.1)
T17	68.9 (56.1)	64.0 (53.2)	54.4 (47.5)	62.4 (52.2)	58.4 (49.9)	67.5 (55.3)	68.9 (56.1)	64.9 (53.0)	53.6 (47.1)	64.3 (53.3)	65.7 (54.2)	61.8 (51.9)	61.3 (51.6)	66.7 (54.8)	61.2 (51.5)	63.3 (52.7)	63.7 (53.0)
Mean(HXD)	67.8	60.1 (55.5)	53.1 (50.9)	(46.8)	71.0	64.3 (57.4)	63.7 (53.3)	(53.0)									
Mean(H)	69.4 (54.6[b])	66.3 (54.5[a])															
Mean(D)	64.3	62.1 (53.3[a])	57.8 (52.0[b])	(49.5[c])													
Mean(YXD)									60.0 (50.8[c])	60.1 (50.9[c])	57.2 (49.2[c])	68.6 (55.9[a])	64.0 (53.2[b])	58.5 (49.9[c])			
Mean(Y)										59.1 (50.3[b])			63.7 (53.0[a])				

Means with the same superscript are statistically non significant (NS)
Year of sowing (Y): Y1= 2010, Y2= 2011
Hybrid (H): H1= Non Bt Express hybrid, H2= Bt Express hybrid

Values within the parenthesis are arcsine transformed values
D1-75 cm ×75 cm, D2-75 cm ×60 cm, D3-75cm × 45cm
T= Treatment

attracting material which improves seed soil interphase. Coating with hydrophilic polymer regulates the rate of water uptake, reduce imbibition damage and improve the emergence of soybean seeds [18]. Padamanabhan and Mustaffa [19] also suggested the use of 0.01% imidacloprid for the control of red rust thrips. Overall, highest plant stand recorded an increase of 25.7%in seeds treated with thiram + imidacloprid as it was able to overcome both the insects as well as fungal attack.

Effect on flowering and boll opening

The results on days to initiation of flowering as influenced by hybrid, spacing, treatment, year of planting and interaction among these factors have been illustrated in table 3. There was significant difference between hybrid, Bt hybrid took longer duration (72.0 days) than the non Bt hybrid (63.2 days). Seed treatments had significant effect on the flower initiation as well. All the treated seeds required less time for flower initiation except in seed treated with cruiser T2 (70.5 days), which was at par with control (71.8 days). Plant spacing too significantly influenced initiation of flowering, D3required least time (66.7 days)whereas,D1 (68.3 days)was at par with D2 (67.8 days).Other interactions *viz.*, hybrid × treatment, spacing × treatment, year × hybrid × spacing, hybrid × spacing × treatment, year × hybrid × treatment were found to be non significant.

The data on days to 50% flowering have been portrayed in table 4. There was significant effect of hybrid, spacing, year and interaction between year and spacing on days to 50% flowering. The Bt hybrid required longer duration (89.2 days) than the non Bt hybrid (84.5 days) for 50% flowering. It was observed that spacing D1 (85.9 days) and D2 (85.7 days) were at par but D3 (89.0) took longer duration. Over the year, in 2010 plants required 92.9 days for 50 % flowering while in 2011 it was achieved in lesser duration (80.8 days). The effect of spacing over year revealed that in the years 2010, D1 (91.3 days) and D2 (91.3 days) were at par but in spacing D3 took longer duration (96.1 days) while in year 2011 there was no effect of this interaction. Remaining of the interactions were observed to be non significant with respect to days to 50% flowering.

The results on days to termination of flowering as influenced by hybrids, seed treatments, spacing and their interaction over year have been presented in table 5. The Bt hybrid required longer duration (131days) for flowering than the non Bt hybrid (128 days). The seed treatments had significant effect on days to termination of flowering. The treatments with polymer (T15) and solid matrix priming with kaveri (T17) took significantly longer duration i.e. 132 days, remaining treatments were found at par with the control (129 days). The spacing D3 needed longer duration (131 days) followed by D1 (130 days) and D2 (129 days). The interaction between hybrid and spacing was observed significant. In the non Bt hybrid the spacing D2 took least number of days (127 days), whereas D1 (129 days) and D3 (129 days) were noticed at par. On the other hand in the Bt hybrid D3 recorded flowering for longest duration (133 days) followed by D2 (131 days) and D1 (130 days). The other interactions *viz.*, year × spacing, year × treatment, spacing × treatment had no significant effect on days to termination of flowering.

The results on effect of seed enhancement treatments on days to 50% boll opening in cotton hybrids with respect to plant spacing in hybrids over the years have been depicted in table 6. There was significant difference between the two hybrids in days to 50 % boll opening, the Bt hybrid required longer duration (152 days) than the non Bt hybrid (146 days). Plant spacing was found to have significant influence, the spacing D1 (147days) and D2 (147 days) were at par but D3 required longer duration (152 days). In the year 2010 it required longer duration (155

Table 3. Effect of seed quality enhancement treatments on days to initiation of flowering with respect to spacing in cotton hybrids over the years

Treatment			H1				H2				Mean (DXT)			Y1			Y2	Mean
	D1	D2	D3	Mean	D1 (H×T)	D2	D3	Mean	D1 (H×T)	D2	D3	D1	D2	D3	D1	D2	D3	
T1	69.5	68.3	65.8	67.8	75.5	76.5	75.3	75.8	72.5	72.4	70.5	73.0	71.5	70.3	72.0	73.3	70.8	71.8^{a}
T2	67.5	67.0	67.5	67.3	72.8	74.8	73.3	73.6	70.1	70.9	70.4	70.8	72.3	72.8	69.5	69.5	68.0	70.5^{ab}
T3	64.5	64.3	61.5	63.4	74.8	73.8	73.8	74.1	69.6	69.0	67.6	72.3	71.0	68.0	67.0	67.0	67.3	68.8^{bc}
T4	62.5	63.3	62.5	62.8	76.0	73.8	70.3	73.3	69.3	68.5	66.4	72.8	70.3	65.8	65.8	66.8	67.0	68.0^{bc}
T5	65.0	63.8	62.8	63.8	73.3	74.5	72.3	73.3	69.1	69.1	67.5	71.5	70.3	68.0	66.8	68.0	67.0	68.6^{bc}
T6	61.5	62.0	63.5	62.3	72.8	69.5	72.0	71.4	67.1	65.8	67.8	67.0	66.0	69.3	67.3	65.5	66.3	66.9^{c}
T7	60.8	63.0	61.3	61.7	73.0	69.5	66.3	69.6	66.9	66.3	63.8	69.5	66.0	62.0	64.3	66.5	65.5	65.6^{c}
T8	60.8	62.5	59.5	60.9	73.3	73.5	70.3	72.3	67.0	68.0	64.9	68.0	69.5	64.8	66.0	66.5	65.0	66.6^{c}
T9	63.8	63.3	61.5	62.8	72.8	72.3	70.0	71.7	68.3	67.8	65.8	70.3	68.5	65.3	66.3	67.0	66.3	67.3^{bc}
T10	63.3	62.5	62.0	62.6	72.3	71.5	69.0	70.9	67.8	67.0	65.5	69.5	67.0	64.5	66.0	67.0	66.5	66.8^{c}
T11	63.0	62.8	61.3	62.3	72.0	71.5	71.0	71.5	67.5	67.1	66.1	69.3	67.8	65.8	65.8	66.5	66.5	66.9^{c}
T12	61.0	60.8	62.8	61.5	73.8	72.0	71.8	72.5	67.4	66.4	67.3	70.5	68.0	70.3	64.3	64.8	64.3	67.0^{c}
T13	62.0	61.5	62.8	62.1	71.3	71.3	68.5	70.3	66.6	66.4	65.6	70.5	68.0	68.3	62.8	64.8	63.0	66.2^{c}
T14	63.5	63.0	64.5	63.7	73.8	72.5	68.8	71.7	68.6	67.8	66.6	71.0	69.0	68.0	66.3	66.5	65.3	67.7^{bc}
T15	63.3	65.5	66.0	64.9	68.5	66.3	73.3	69.3	65.9	65.9	69.6	70.5	66.5	73.5	61.3	65.3	65.8	67.1^{bc}
T16	63.5	62.3	62.8	62.8	73.5	71.8	68.8	71.3	68.5	67.0	65.8	74.0	69.0	65.5	63.0	65.0	66.0	67.1^{c}
T17	61.3	62.3	62.0	61.8	75.8	72.8	64.3	70.9	68.5	67.5	63.1	72.0	70.3	65.5	65.0	64.8	60.8	66.4^{c}
Mean(H×S)	63.3^{c}	63.4^{c}	62.9^{c}		73.2^{a}	72.2^{ab}	70.5^{c}											
Mean (H)			63.2^{b}	72.0^{a}														
Mean (D)	68.3^{a}	67.8^{a}	66.7^{b}															
Mean(Y×D)													70.7^{a}	68.9^{ab}	67.5^{bc}	65.8^{c}	66.7^{c}	65.9^{c}

CD (p=0.05) H=0.88, D=1.07, Y=NS, T=2.56, YXH=NS, HXD=NS, YXT= NS, YXHXT= NS, YXHXDXT= NSYXD=NS, HXT=NS, YXHXD= NS, HXDXT = NS, YXHXT= NS

Means with the same superscript are statistically non significant (NS)
D1-75 cm ×75 cm, D2-75 cm ×60 cm, D3-75cm × 45cm
Hybrid (H): H1= Non Bt Express hybrid, H2= Bt Express hybrid
Year of sowing (Y): Y1= 2010, Y2= 2011
T= Treatment

days) than in 2011 when it took 143 days for 50 % boll opening. No significant differences were observed for 50 % boll opening in the other interactions studied.

Higher and faster field emergence result in better crop establishment and ultimately early flowering and maturity. The seeds invigorated by halopriming, hydropriming, biopriming, insecticides, fungicides took less number of days for initiation of flowering compared to control. Pre sowing hydration treatments have been found to prepone flowering in maize [20-21]. In the present study days to initiation of flowering was advanced by 3-5 days (table 6), days to 50 per cent flowering was also early by two to five days (table 7). Flowering is a trait which is significantly influenced by genotype [22] as well as environmental factors. The results indicated the varietal difference in days to initiation of flowering, days to 50% flowering, 50% boll opening, days to termination of flowering, the Bt hybrid required longer duration for all the three parameters.

Effect on seed yield per plant (g)

The results on effect of seed quality enhancement treatments on yield per plant with respect to spacing in cotton hybrids over the year have been portrayed in table 7. There was no significant effect of seed treatment as well as hybrid on yield per plant. Plant spacing had significant influence on yield per plant. The plant spacing D2 gave significantly higher yield (193g) followed by D1 (183g) and D3 (170g). The effect of spacing over the year was also found significant. In the year 2010 there was no significant difference among the 3 spacing while in 2011 D2

Table 4. Effect of seed quality enhancement treatments on days to 50% flowering with respect to spacing in cotton hybrids over the years

Treatment	H1				H2				Y1 (2010)			Y2 (2011)			Mean(T)
	D1	D2	D3	Mean D1 (H1×T)	D1	D2	D3	Mean D1 (H2×T)	D1	D2	D3	D1	D2	D3	
T1	88.3	85.0	86.8	86.7	91.3	89.5	93.8	91.5	93.8	91.3	98.8	85.8	83.3	81.8	89.1
T2	85.5	83.5	86.0	85.0	86.5	83.3	91.3	87.0	91.5	92.0	96.5	80.5	74.8	80.8	86.0
T3	83.0	84.0	88.0	85.0	89.5	87.8	97.5	91.6	92.3	91.5	101.5	80.3	80.3	84.0	88.3
T4	85.0	84.8	89.5	86.4	92.8	87.0	91.0	90.3	94.0	91.3	98.5	83.8	80.5	82.0	88.3
T5	85.3	84.8	87.5	85.8	89.8	88.5	92.8	90.3	93.5	92.0	97.3	81.5	81.3	83.0	88.1
T6	83.3	83.5	85.8	84.2	88.0	86.8	95.0	89.9	90.8	90.3	97.5	80.5	80.0	83.3	87.0
T7	82.3	83.5	87.8	84.5	87.3	88.3	90.0	88.5	90.3	91.8	93.3	79.3	80.0	84.5	86.5
T8	81.8	82.0	84.8	82.8	88.3	88.3	89.3	88.6	90.0	90.3	93.8	80.0	80.0	80.3	85.7
T9	84.0	85.5	87.0	85.5	87.5	91.5	86.5	88.5	89.3	92.5	91.8	82.3	84.5	81.8	87.0
T10	82.8	82.3	83.3	82.8	85.8	87.5	91.5	88.3	89.0	89.5	94.0	79.5	80.3	80.8	85.5
T11	82.8	82.3	84.5	83.2	86.8	85.3	89.5	87.2	90.0	88.5	95.0	79.5	79.0	79.0	85.2
T12	83.5	82.0	86.8	84.1	88.8	85.0	90.5	88.1	90.8	88.5	96.5	81.5	78.5	80.8	86.1
T13	83.3	82.0	84.8	83.3	87.0	87.3	90.5	88.3	91.0	90.8	96.8	79.3	78.5	78.5	85.8
T14	83.5	82.3	85.5	83.8	85.0	89.0	93.5	89.2	91.5	91.3	97.0	77.0	80.0	82.0	86.5
T15	83.0	81.5	91.8	85.4	87.5	92.3	91.3	90.3	89.3	92.8	98.5	81.3	81.0	84.5	87.9
T16	83.3	82.0	85.3	83.5	84.3	89.8	89.0	87.7	91.5	93.0	91.8	76.0	78.8	82.5	85.6
T17	83.8	82.3	87.3	84.4	91.5	93.8	90.0	91.8	94.0	94.3	95.8	81.3	81.8	81.5	88.1
Mean(H×D)	83.8	83.1	86.6	88.1	88.3	91.3									
Mean(Y×D)									91.3[b]	91.3[b]	96.1[a]	80.5[c]	80.1[c]	81.8[c]	
Mean(H)				84.5[b]				89.2[a]							
Mean(D)		85.9[b]	85.7[b]	89.0[a]											
Mean(Y)												92.9[a]	80.8[b]		
CD (p=0.05)	H=0.96, D=1.18, Y=0.96, T=NS, Y×D=1.67, YXH=NS, HXD=NS, YXT= NS, YXHXT= NS, YXHXDXT= NSHXT=NS, YXHXD= NS, HXDXT = NS, YXHXT= NS														

Means with the same superscript are statistically non significant (NS)
D1-75 cm ×75 cm, D2-75 cm ×60 cm, D3-75cm × 45cm
Hybrid (H): H1= Non Bt Express hybrid, H2= Bt Express hybrid

Year of sowing (Y): Y1= 2010, Y2= 2011
T= Treatment

Table 5. Effect of seed enhancement treatments on days to termination of flowering with respect to spacing in cotton hybrids

Treatment	V1				V2				Mean (DXT)			Y1			Y2			Mean
	D1	D2	D3	Mean (VT)	D1	D2	D3	Mean (VT)	D1	D2	D3	D1	D2	D3	D1	D2	D3	
T1	129	122	127	126	128	131	136	132	128	127	132	130	127	132	127	127	131	129^{cd}
T2	130	125	128	128	130	132	135	132	130	129	132	131	129	133	129	129	130	130^{cd}
T3	130	125	127	127	128	131	135	131	129	128	131	129	128	132	129	128	130	129d
T4	128	125	127	127	132	131	131	131	130	128	129	130	128	129	130	128	129	129^{cd}
T5	130	128	129	129	130	132	133	132	130	130	131	131	130	131	129	130	131	130^{c}
T6	129	127	129	128	131	129	137	132	130	128	133	130	128	133	130	128	133	130^{c}
T7	129	128	127	128	129	128	133	130	129	128	130	130	128	130	128	128	130	129^{cd}
T8	129	128	127	128	129	129	134	130	129	128	130	129	128	130	129	128	130	129^{cd}
T9	131	128	127	129	129	129	130	129	130	128	129	130	128	129	130	128	129	129^{cd}
T10	131	128	129	129	130	129	131	130	130	128	130	130	128	130	130	128	130	129^{cd}
T11	131	128	129	129	132	132	130	131	131	130	130	131	130	130	131	130	130	130^{b}
T12	126	129	130	128	132	133	133	133	129	131	131	129	131	134	129	131	129	130^{b}
T13	126	128	128	127	130	131	133	131	128	129	131	128	129	133	128	129	129	129^{cd}
T14	126	128	131	128	129	132	133	131	127	130	132	127	130	133	127	130	131	130^{d}
T15	132	135	135	134	128	129	130	129	130	132	133	129	132	132	132	132	134	132^{a}
T16	128	128	130	129	130	132	133	132	129	130	132	129	130	132	129	130	131	130^{b}
T17	131	128	131	130	135	133	133	134	133	130	132	135	131	134	131	130	130	132^{a}
Mean (VD)	129^{d}	127^{e}	129^{d}		130^{c}	131^{b}	133^{a}											
Mean(D)	130^{b}	130^{b}	131^{a}															
Mean(V)	128^{b}				131^{a}													
Mean(YD)												130^{b}	129^{c}	131^{a}	129^{c}	130^{b}	130^{b}	
CD (p=0.05)	H=0.34,D=0.42, Y= NS, T=1.00, H×T=1.42, H×D=0.60, YXH=NS, YXT= NS, YXHXT= NS, YXHXDXT= NSYXD=NS, YXHXD= NS, HXDXT = NS, YXHXT= NS																	

Means with the same superscript are statistically non significant (NS)
D1-75 cm ×75 cm, D2-75 cm ×60 cm, D3-75cm × 45cm
Hybrid (H): H1= Non Bt Express hybrid, H2= Bt Express hybrid

Year of sowing (Y): Y1= 2010, Y2= 2011
T= Treatment

Table 6. Effect of seed quality enhancement treatments on days to 50% boll opening with respect to spacing in cotton hybrids over the years

Treatment	H1				H2				Mean(D×T)			Y1			Y2		
	D1	D2	D3	Mean (H1×T)	D1	D2	D3	Mean	D1 (H2×T)	D2	D3	D1	D2	D3	D1	D2	D3
T1	147	146	152	148	154	151	156	154	150	148	154	155	153	165	146	144	144
T2	146	144	150	147	146	152	155	151	146	148	152	152	155	160	141	142	145
T3	145	145	153	148	152	149	163	155	148	147	158	156	153	169	141	142	147
T4	146	149	151	148	154	149	153	152	150	149	152	155	155	162	145	143	142
T5	146	145	150	147	152	151	158	153	149	148	154	155	153	162	143	142	146
T6	145	143	146	145	148	150	163	153	146	146	155	152	151	162	141	141	147
T7	145	144	151	147	150	151	153	151	147	147	152	154	154	158	141	141	147
T8	145	142	146	144	148	150	151	150	146	146	148	151	150	154	141	142	143
T9	145	147	147	146	147	154	149	150	146	150	148	150	156	152	142	144	144
T10	144	142	143	143	146	147	155	149	145	144	149	150	148	155	140	141	143
T11	145	144	145	145	147	148	155	150	146	146	150	152	150	159	140	142	141
T12	145	144	150	146	149	148	159	152	147	146	154	152	150	164	142	142	145
T13	146	144	146	145	147	150	157	151	147	147	151	153	153	162	140	141	141
T14	145	144	149	146	146	150	157	151	146	147	153	153	152	165	138	142	141
T15	144	142	156	147	148	153	159	153	146	147	158	150	154	166	142	141	149
T16	145	143	149	146	148	155	152	152	146	149	151	154	156	155	139	142	147
T17	145	143	150	146	153	159	155	156	149	151	152	155	159	161	142	144	144
Mean(H×D)	145^{abc}	144^{abc}	149^{ab}	149^{ab}	151^{a}	156^{a}											
Mean(D)									147^{b}	147^{b}	152^{a}						
Mean(H)			146^{b}					152^{a}									
Mean(Y×D)												153^{a}	153^{a}	160^{a}	141^{b}	142^{b}	144
Mean(Y)													155^{a}			143^{b}	
CD(p=0.05)	H=1.17, D=1.44, Y=1.17, T=NS, YXH=NS, HXD=NS, YXD=NS, YXT= NS, YXHXT= NS, YXHXDXT= NSHXT=NS, YXHXD= NS, HXDXT = NS, YXHXT= NS																

Means with the same superscript are statistically non significant (NS)
D1-75 cm ×75 cm, D2-75 cm ×60 cm, D3-75cm × 45cm

Hybrid (H): H1= Non Bt Express hybrid, H2= Bt Express hybrid

Year of sowing (Y): Y1= 2010, Y2= 2011
T= Treatment

Table 7. Effect of seed enhancement treatments on yield per plant (g) with respect to spacing in cotton hybrids over the years

Treatment	H1 D1	H2 D2	M(DXT) D3	M (HXT)	Y1 D1	Y2 D2	D3	M (HXT)	D1	D2	D3	D1	D2	D3	D1	D2	D3
T1	158	192	173	174	171	184	154	170	165	188	163	174	205	177	155	171	150
T2	175	189	178	181	167	181	166	171	171	185	172	185	189	178	157	181	166
T3	175	192	165	178	236	170	166	191	205	181	166	215	172	170	195	191	162
T4	171	203	171	182	187	183	181	184	179	193	176	182	180	179	176	206	173
T5	174	220	164	186	197	192	170	186	185	206	167	188	194	178	183	218	157
T6	184	225	170	193	188	228	189	202	186	227	179	180	188	185	192	265	173
T7	166	164	169	166	173	176	176	175	169	170	172	183	157	184	156	183	160
T8	171	186	197	185	189	184	159	177	180	185	178	185	174	205	175	196	151
T9	183	243	170	199	173	194	163	176	178	218	167	176	180	183	180	256	151
T10	167	196	168	177	180	193	163	179	174	194	166	170	170	173	177	219	158
T11	167	195	170	177	182	165	166	171	174	180	168	172	168	177	177	193	159
T12	191	225	164	193	191	179	178	182	191	202	171	177	171	170	205	233	172
T13	196	205	173	192	168	183	187	179	182	194	180	168	193	198	196	196	163
T14	176	212	146	178	174	174	180	176	175	193	163	170	169	172	180	216	154
T15	161	155	153	156	196	163	175	178	179	159	164	189	169	178	168	149	149
T16	196	199	163	186	213	165	185	188	205	182	174	212	175	189	198	189	160
T17	195	213	156	188	223	219	173	205	209	216	164	211	188	178	206	245	151
M(HXD)	177	201	168		189	184	172										
M(H)		181 [a]				183 [a]											
M(D)	183[b]	193[a]	170[c]														
M(YXD)												185 [b]	179 [b]	181 [b]	181 [b]	206 [a]	159 [c]
CD(p=0.05)	H=NS,D=7.67, Y=NS, T=NS, Y×D=10.85, YXH=NS, HXD=NS, YXT= NS, YXHXT= NS, YXHXDXT= NSHXT=NS, YXHXD= NS, HXDXT = NS, YXHXT= NS																

Means with the same superscript are statistically non significant (NS)
D1-75 cm ×75 cm, D2-75 cm ×60 cm, D3-75cm × 45cm
Hybrid (H): H1= Non Bt Express hybrid, H2= Bt Express hybrid
Year of sowing (Y): Y1= 2010, Y2= 2011
T= Treatment

(206g) produced higher yield (206g) than D1 (181g) and D3(159g).There were no significant differences in the other interactions *viz.*, treatment × hybrid, spacing × treatment, hybrid × spacing × treatment and year × spacing× treatment were observed for per plant yield. Plant spacing plays critical role in determining the seed yield and seed quality in cotton as in several other crops [23]. Spacing between and within the rows has greater influence on the growth pattern. Earlier Bhalerao *et al.* [24] reported that closer spacing of 60×30cm resulted in significantly higher seed cotton yield than wider spacing (60×45cm). Mohapatra and Nanda [25] found that seed cotton yield was better in closer spacing (60×30cm), while yield contributing characters performed significantly better in60×45cm spacing.

Our results also exhibit that yield per plant was highest in intermediate spacing 75×60cm (D2) compared to closer 75×30cm (D3) and wider spacing 75×75cm (D1). It was also found that spacing 75×60cm *i.e.* D2 gave significantly earlier initiation of flowering, 50% flowering and 50% ball opening along with higher yield per plant. It is in agreement with studies of Farrukhsaleem *et al.* [26] on row spacing. It was concluded from the above that the Bt Express hybrid had significantly higher field emergence than the non Bt Express hybrid. The seed treatment with thiram (@2.0g/kg seed) + imidacloprid (@7.5ml/kg seed) or azotobacter (@10g/kg seed) + microphos (@10g/kg seed) resulted in significantly higher emergence and highest plant stand. It was also deduced that an intermediate spacing of 75×60cm could be adopted for ensuring higher seed yield.

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