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Studies on Seed Vigour in Bt Cotton Hybrids

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Studies on seed vigour tests in Bt and non Bt cotton hybrids were taken up during 2007 at Seed Research and Technology Centre, Rajendranagar, Hyderabad. Irrespective of Bt and Non Bt cotton hybrids, TP (87%), S methods (85%) recorded higher germination than BP (83%) and soil method (82%). Among the vigour tests, first count (78%), final count (86%), brick gravel test (81%) and cold test (79%) recorded higher germination in all the Bt cotton hybrids than Non Bt hybrids which recorded superior values for speed of germination (74%), field emergence (76%), paper exhaustion test (68%) and tetrazolium test for viability. Bt cotton hybrids especially TCH 9 and PRCH 31 recorded higher germination in all germination testing methods as well as vigour tests. Germination and seedling vigour gradually declined with an increase in period of accelerated ageing from 0 to 30 days. Such decline was more in Non Bt cotton hybrids when compared to Bt cotton hybrids. Among different Bt cotton hybrids, PRCH 31 and TCH 9 have shown higher values in all vigour tests as against the other hybrids. There was a rapid decline in germination and vigour in NCS 145, NCS 207, Rudra and Sandeep.

Key words: Bt and Non Bt cotton hybrids, germination and vigour tests.

Cotton popularly known as 'white gold' is an important commercial crop vis-a-vis commodity and plays an important role in agrarian and industrial activities of the nation.India stands third in world production, albeit substantially low productivity. Cotton production in India witnessed a quantum leap during last five years with the introduction of transgenic technology and inter and intra specific hybrids with high yield potential. Presently it is cultivated over an area of 11.96 m. ha with a production of 36.10 m. tonnes in 2011. Monsanto, in collaboration with Mahyco introduced Bt cotton technology in India, which carries a gene derived from soil bacterium *Bacillus thuringiensis* var. *kurstaki* that confers resistance to the bollworm complex. Bt cotton has increased yield up to 50 per cent, reduced insecticide sprays by half, with accrued environmental and health benefits and has contributed to social benefits and alleviation of poverty. Seed vigour is an important aspect of quality, which predicts the plant stand, establishment and field performance. Problems associated with establishing vigorously growing cotton seedlings are often related to poor seed quality. High quality cotton seeds have the capacity to provide vigorous seedlings over a wide range of environments. Hence, an attempt was made to study the seed vigour of six Bt and non-Bt cotton counter parts. Keeping in view the meager research in this field, the present study was undertaken to study the seed vigour of Bt and non Bt cotton hybrids.

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Materials and Methods

The present experiment was carried out at Seed Research and Technology Centre, Rajendranagar, Hyderabad during the year 2007-2008. Seeds of twelve varieties of cotton hybrids both Bt and Non Bt in three replications using factorial RBD were assessed for seed germination by different methods such as top of paper method, between paper method, sand method, soil method and various seed vigour assessment techniques like seedling length (cm), seedling dry weight (mg), cold test, germination percentage (first and final count), accelerated ageing, field emergence index, speed of germination, seed leacheate, brick gravel, tetrazolium and paper exhaustion tests.

Results and Discussion

Irrespective of cotton hybrids, Bt cotton hybrids recorded significantly higher germination percentage than non-Bt counter parts by top of paper method (Table 1). Among the cotton hybrids, PRCH 31 recorded maximum germination (91%) followed by Rudra and TCH 9 (89% and 88%, respectively) which were significantly superior to the other cotton hybrids except Rudra and Sandeep recorded the minimum germination (82%). PRCH 31 recorded maximum germination in both Bt (93%) and non Bt (89%) categories among the six cotton hybrids in top of paper method.

In between paper method (Table 2), PRCH 31 recorded the maximum germination (93% and 87%)

Table 1. Effect of different germination methods on germination (%) in six Bt and Non Bt cotton hybrids

Treatment	Top of paper method			Between paper method			Sand method			Soil method		
	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean
NCS 145	85.25	82.75	84.00	81.75	81.75	81.75	90.50	82.75	86.60	76.75	77.50	77.12
NCS 207	83.50	86.50	85.00	89.50	77.35	83.62	76.50	76.50	76.50	81.50	76.50	74.08
TCH9	93.25	82.50	87.75	91.75	83.25	87.50	91.75	86.75	89.27	90.00	83.25	*86.62*
RUDRA	89.75	88.25	89.00	82.35	78.25	80.50	89.25	81.50	85.37	80.75	76.75	78.75
PRCH 31	93.25	89.25	91.25	93.25	86.50	90.00	94.50	91.75	93.12	92.75	88.08	90.37
SANDEEP	87.25	77.00	82.12	77.25	76.25	77.00	77.50	76.25	76.87	78.00	76.25	77.17
MEAN	88.70	84.33	86.52	86.08	80.71	83.40	86.67	82.58	84.62	83.29	79.71	81.50
	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I
SE ±	1.31	0.25	1.84	1.33	0.77	1.88	0.994	0.57	1.41	1.82	1.05	2.58
C.D @ 5%	2.65	1.53	3.74	2.71	1.56	3.80	2.02	1.16	2.85	3.69	2.13	*5.22*

V = Varieties,I = Interaction between Varieties x Bt vs. non Bt

followed by TCH 9 (92 % and 83%) for Bt and Non Bt types, respectively. By sand method, PRCH 31 (95% and 92%) recorded the maximum germination, followed by TCH 9 (92% and 87%) in both Bt and non-Bt types, respectively. These results indicated

Table 2. Effect of total seedling length (cm) in six Bt and Non Bt cotton hybrids

Treatment	First count			Final count		
	BT	NBT	Mean	BT	NBT	Mean
NCS 145	11.50	9.07	10.68	23.49	22.50	22.99
NCS 207	11.50	9.75	10.62	23.16	22.82	22.99
TCH 9	12.00	10.12	11.06	21.26	19.94	20.60
RUDRA	10.37	9.12	9.75	22.05	20.50	21.27
PRCH 31	11.12	10.50	10.91	22.64	24.75	23.69
SANDEEP	11.37	8.75	10.06	23.14	18.67	20.97
Mean	11.35	12.81	12.08	22.62	21.53	22.08
	VBt x Non Bt		I	VBt x Non Bt		I
S.E±	5.42	3.13	7.67	1.11	0.64	1.58
C.D @ 5%	11.0	6.36	15.50	2.20	1.31	3.21

V = Variety,I = Interaction between V x Bt x Non Bt

that significantly higher germination percentage in sand method and in between paper method, when compared to soil media. It might be due to the large seed size nature of cotton**.** Similar results have been reported by various workers in medicinal plants (Bahaguna et al., 1987 and Parihar et al., 2006). According to Axay Kumar (2008), highest germination was observed in sand where as lowest germination was recorded on top of paper method in *jatropa*. This clearly indicates that sand is the best substrata for conducting germination tests because seed is covered fully there by maintaining the required level of moisture necessary for germination and seedling development. The lowest germination was observed on top of paper method which may be attributed to unavailability of sufficient moisture for seed germination. Similar results were also reported by Uppar et al., (2006) in dicoccum wheat. Coming to soil method, the germination percentage differed significantly due to hybrids of Bt and non Bt. All the Bt cotton hybrids gave higher germination compared to their non-Bt counter parts except NCS 145. Among the cotton hybrids, PRCH 31 recorded maximum germination (93% and 88%) in both Bt and Non-Bt types, respectively. Among the

Table 3. Effect of germination methods on seedling length (cm) in six Bt and Non-Bt cotton hybrids

Treatment	Top of paper method			Between paper method			Sand method			Soil method			Brick gravel test		
	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean
NCS 145	7.30	6.75	7.02	20.11	17.87	18.99	13.33	12.70	13.02	13.36	11.31	12.24	13.27	11.90	12.59
NCS 207	7.20	6.75	6.97	19.65	17.48	18.56	13.27	12.23	12.76	13.67	13.70	12.59	13.80	13.79	13.80
TCH9	7.80	7.22	7.51	17.92	16.27	17.10	12.87	11.49	12.18	13.91	11.96	12.93	13.89	11.80	12.84
RUDRA	7.35	6.87	7.11	17.60	8.67	13.13	13.49	12.00	13.15	14.05	11.63	12.04	14.43	13.13	13.78
PRCH31	7.87	7.19	7.53	19.18	17.87	18.52	16.00	14.20	15.14	14.45	14.27	14.35	14.42	15.33	14.88
SANDEEP	7.37	6.80	7.08	14.80	7.80	11.30	13.03	12.12	12.57	13.37	11.98	12.67	13.40	11.84	12.62
MEAN	7.48	6.93	7.20	18.21	14.32	16.27	13.60	12.59	13.40	13.80	12.47	13.14	13.87	12.97	13.42
	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I
S.E ±	0.24	0.139	0.34	0.51	0.29	0.72	0.18	0.10	0.26	0.21	0.12	0.30	0.35.	0.20	0.50
CP@5%	0.491	0.283	0.695	1.04	0.60	1.47	0.37	0.21	0.53	0.43	0.28	0.61	0.72	0.41	1.02

V = Variety, I= Interaction between V x Bt x Non Bt

cotton hybrids, Bt hybrids recorded maximum germination than other non-Bt counter parts. It might be due to genetic makeup. Similar results were reported by Frietas et al., 2002 in cotton, Gowda and Shobha in 2003 in soybean.

With respect to evaluation of seedling vigour on seedling length basis (Table 2), TCH 9 recorded the maximum seedling length (11.06 cm) during the first count. In the final count, PRCH 31 recorded the maximum seedling length (23.69 cm) irrespective of Bt and Non Bt cotton hybrids.

Comparison of effect of different methods of testing of germination percentage on seedling length (Table 3) revealed that the seedling length in top of the paper method, between paper method, sand method, soil method and brick gravel method has also shown similar trend like germination percentage. The cotton hybrid PRCH 31 recorded the maximum seedling length of 7.53 cm, 15.14 cm, 14.35 cm and 14.88 cm in TP method, sand method, soil method and brick gravel methods, respectively while NCS 145 recorded the maximum seedling length (18.99 cm) in BP method.

Seedling vigour index on seedling length basis, revealed that, the cotton hybrid PRCH 31 recorded the maximum SV I in both Bt and Non Bt categories

Table 4. Seedling vigour index-I on seedling length basis for six Bt and Non Bt cotton hybrids

Treatment	Top of paper method			Between paper method			Sand method			Soil method			First count			Final count		
	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean
NCS 145	623	558	590	1689	1495	1592	1205	829	1017	1092	866	979	875	763	819	2015	1867	1941
NCS 207	642	580	611	1693	1507	1599	983	938	961	1114	1048	1081	914	745	830	1951	1890	1920
TCH9	709	594	652	1649	1355	1502	1181	997	1089	1247	993	1120	950	786	868	1946	1726	1836
RUDRA	659	607	633	1455	714	1084	1203	1041	1122	1268	947	1108	820	693	757	1935	1692	1813
PRCH31	730	640	685	1794	1596	1695	1519	1255	1387	1338	1255	1297	897	834	866	2071	2055	2063
SANDEEP	655	524	589	1148	596	872	1010	924	966	1042	908	975	880	669	774	1908	1487	1697
MEAN	670	584	627	1571	1210	1391	1183	997	1090	1184	1003	1093	889	748	819	1971	1786	1878
	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I
S.E±	19.83	11.45	28.04	43.47	26.83	65.72	73.20	42.20	103.50	26.61	15.36	37.63	37.88	21.87	53.57	98.99	57.15	139.99
CD@5%	40.25	23.24	56.93	94.34	54.46	133.41	148.60	85.50	210.10	54.02	31.19	76.40	76.90	44.39	108.75	200.95	116.02	284.19

V = Variety, I= Interaction between V x Bt x Non Bt

in TP method (730 and 640), BP method (1794 and 1596), sand method (1519 and 1255), soil method (1338 and 1255) and even in final count (2071 and 2055) as shown in Table 4.

Bt cotton hybrids recorded highest SVI II compared to the Non Bt cotton hybrids (Table 5). Highest seedling vigour index I on dry weight basis was recorded in the cotton hybrid PRCH 31 of 62,

Table 5. Seedling vigour index-I on dry weight basis in six Bt and noin Bt cotton hybrids

Treatment	Top of paper method			Between paper method			Sand method			Soil method			First count			Final count		
	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean
NCS 145	43	40	42	55	52	54	50	46	48	53	49	51	48	46	47	58	54	56
NCS 207	53	43	48	60	58	59	56	53	54	58	54	56	54	51	52	61	58	59
TCH 9	62	59	61	67	61	54	65	60	62	66	60	63	53	59	61	78	62	66
RUDRA	60	44	47	61	59	60	56	51	53	57	53	55	49	46	48	63	60	61
PRCH 31	64	59	62	71	65	68	66	61	64	69	61	65	65	58	61	75	64	70
SANDEEP	46	41	43	54	51	52	50	47	48	53	51	52	47	44	45	56	52	54
MEAN	53	48	50	61	58	59	57	53	55	59	55	57	54	51	52	64	58	61
	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I
S.E ±	1.74	1.0	2.48	1.38	0.79	1.95	1.86	1.07	2.65	2.07	1.20	2.94	1.27	0.73	1.80	1.20	0.69	1.70
CD@5%	3.54	2.04	5.0	2.80	1.61	3.96	3.77	2.18	5.34	4.22	.2.43	5.96	.2.59	1.49	3.66	2.44	1.41	3.46

V = Variety, I= Interaction between V x Bt x Non Bt

68, 64, 65 and 70 in TP method, BP method, sand method, soil method and final count, respectively. These variations observed may be due to the fact of using different testing media and hybrids and their interaction effect between them. The highest seedling vigour index I and II was due to the seedling length and seedling dry weight, respectively and the germination potentiality of the cotton hybrids. Similar results were reported by Parvathamma et al., (1991) in sorghum and Rohini (2005) and Siva Jyothi (2008) in medicinal plants.

Coming to vigour tests, the germination percentage of PRCH 31 recorded maximum in both Bt (80%) and Non Bt (79%) cotton hybrids by using first count method of germination (Table 6). In final count of germination method, PRCH 31 recorded the maximum germination (92% and 90%)

Table 6. Effect of different vigour tests on germination(%) in six Bt and Non-Bt cotton hybrids.

Treatment	First count			Final count			Speed of germination			Field emergence		
	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean
NCS 145	78	77	78	87	84	85	76	13	74	80	75	78
NCS 207	79	77	78	84	82	83	75	72	73	74	68	71
TCH 9	79	77	78	92	87	89	78	75	77	89	75	82
RUDRA	79	76	78	88	83	85	71	68	70	73	69	71
PRCH 31	80	79	80	92	90	91	78	73	76	84	77	80
SANDEEP	77	76	77	83	79	81	78	69	74	79	74	76
MEAN	79	77	78	87	84	86	76	72	74	80	73	76
	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I
SE ±	0.95	0.55	1.34	1.4	0.81	1.99	1.64	0.95	2.32	1.64	0.94	2.32
CD@5%	1.93	1.11	2.7	2.86	1.65	4.04	3.34	1.92	4.72	3.33	1.92	4.72

V = Variety, I= Interaction between V x Bt x Non Bt

followed by TCH 9 (92% and 87%) in both Bt and Non Bt categories, respectively. The germination rate was higher in case of PRCH 31 (76%) while lowest was recorded for Rudra (70%). First count of germination and speed of germination also serve as effective indicators for vigour tests for obtaining maximum germination and similar results were also reported by Zode et al. (1994). The field emergence was found to be higher in TCH 9 (82%) followed by PRCH 31 (80%). Field emergence ability is the major aspect of seed quality that concern growers and a higher percentage of germination serves as a pre requisite for seeds to be sown. Similar reports were also reported by Pieto Filho and Ellis (1991) and Siva Jyothi (2008).

Among different stress tests evaluated, PRCH 31 recorded maximum germination i.e. 87% and 85% by using brick gravel method and cold test, respectively. Martin et al., (1988) reported that the

Table 7. Effect of different vigour tests on germination(%) in six Bt and Non-Bt cotton hybrids.

Treatment	Brick Gravel Test			Cold test			Paper exhaustion test			Tetrazolium test			Electrical conductivity		
	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean	BT	NBT	Mean
NCS 145	79.25	77.00	78.12	77.25	75.35	76.50	75.25	78.50	71.85	84.50	84.25	84.37	542.50	522.50	533.87
NCS 207	77.75	77.50	76.62	78.25	75.50	76.87	77.50	76.00	76.75	84.25	78.50	81.37	664.50	482.50	573.50
TCH 9	88.25	81.50	84.87	87.50	82.75	85.00	76.25	61.00	68.75	100.00	100.00	100.00	612.50	610.75	611.62
RUDRA	87.25	78.50	82.87	77.75	76.50	76.87	81.25	37.50	59.37	100.00	90.00	95.00	451.50	583.50	507.50
PRCH 31	90.50	82.75	86.62	87.75	83.00	85.25	85.50	57.50	71.50	100.00	100.00	100.00	442.00	585.75	513.87
SANDEEP	76.00	75.75	75.87	71.25	75.35	76.50	55.00	71.25	63.12	74.00	85.50	79.75	612.00	568.00	590.37
MEAN	83.17	78.83	81.00	80.87	78.12	79.50	74.45	62.66	68.56	90.46	89.71	90.08	554.17	559.42	556.79
	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I	V	Bt x Non Bt	I
S.E ±	1.22	0.70	1.72	0.97	0.56	1.37	2.83	1.63	4.01	1.45	0.84	2.05	84.24	4.75	11.65
CD@5%	2.47	1.43	3.50	1.97	1.14	2.79	5.75	3.32	8.14	2.95	1.70	4.17	16.73	9.66	23.66

V = Variety, I= Interaction between V x Bt x Non Bt

cold test was a superior predictor of field emergence in corn. In case of paper exhaustion test, the seed germination was higher in NCS 207 (77%). The tetrazolium test revealed that the viability of the seeds of cotton hybrids, PRCH 31 and TCH 9 were 100 percent w.r.t both Bt and non Bt cotton hybrids. The electric conductivity of seed lechates was lower for PRCH 31 (442.00) in case of Bt hybrid and NCS 207

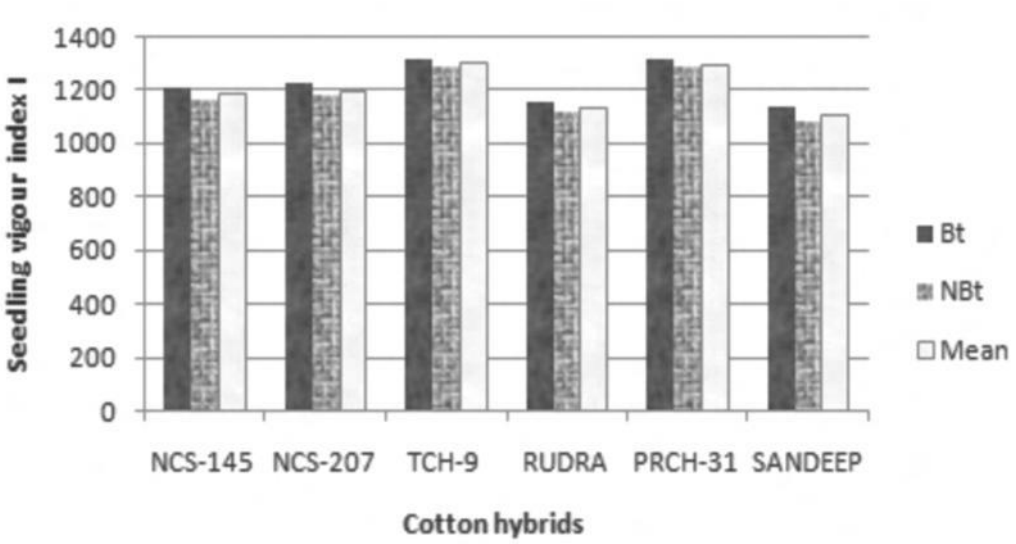

Fig. 1. Effect of accelerating ageing on seedling vigour index I of six Bt and Non-Bt cotton hybrids at 30 days.

(482.50) in case of Non Bt cotton hybrids while it was higher for TCH 9 (611.62) in the non Bt hybrids and NCS 207 (664.50) for Bt hybrids. Lower the electrical conductance better will be the germination and quality of seeds. Similar results were also reported by several researchers (Rohini, 2005). Khan et al. (2005) observed that turnip seed showed a gradual reduction in seedling vigour as accelerated ageing duration increased.

With respect to accelerated ageing test, the germination percentage declined with the duration of accelerated ageing test. According to Raj Kumar (2011), standard germination, tetrazolium test and accelerated ageing could be the most suitable predictors for seedling establishment in coriander. Torres et al., (2004) concluded that accelerated ageing test is the best vigour test for estimating the field emergence in soybean. PRCH 31 followed by TCH 9 had shown higher germination at all periods of accelerated ageing and significantly superior to other hybrids. The decline in germination (%) after accelerated ageing was less in PRCH 31 (88.60% in 0 days and 82.12% after 30 days). The accelerated ageing on SVI I basis revealed that TCH 9 recorded the highest SVI (1703 initially and 1318 after 30 days) among the Bt cotton hybrids. The Non Bt hybrids, NCS 145 and PRCH 31 recorded the maximum SVI initially (1605) while PRCH 31 maintained the same trend at 30 days of accelerated ageing (1290) (Fig 1). The increased duration of accelerated ageing decreased, the percent germination and after 15 days of ageing there has been sharp decline to the extent of 27 % in rice seeds (Gangwar and Kanaujia, 2006).

The data on effect of AAT on SVI II (Fig 2) revealed that the Bt cotton hybrids recorded high SVI II as compared to Non Bt cotton hybrids. The seedling vigour index II was found to be higher in TCH 9 (59 initially and 38 after 30 days) among the Bt hybrids. Within the Non Bt hybrids, TCH 9 (51) followed by

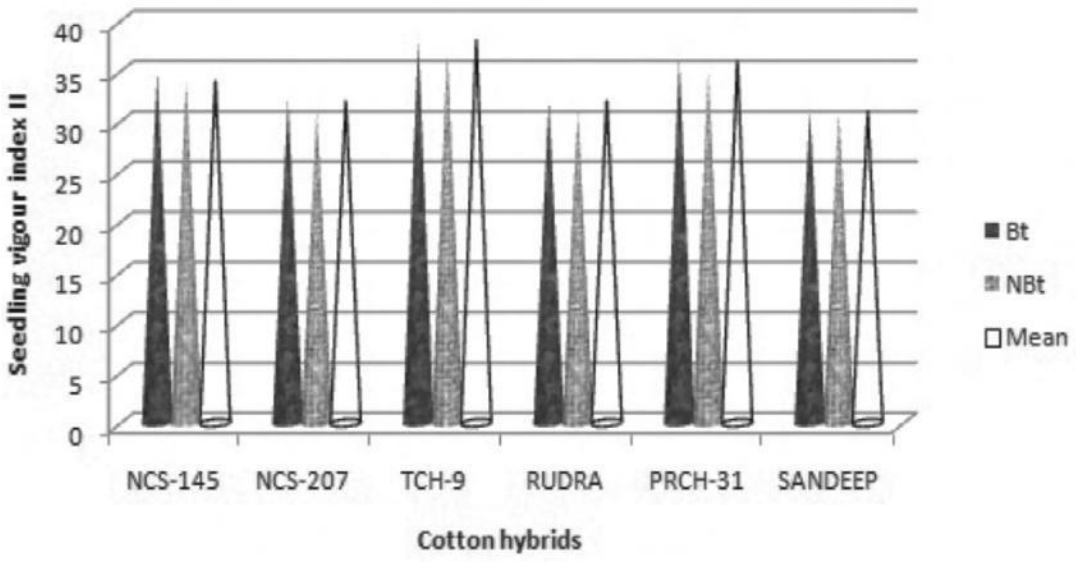

Fig. 2. Effect of days of accelerating on seedling vigour index (SVI -II) on dry weight (g) basis of six Bt and Non-Bt cotton hybrids at 30 days

PRCH 31 (50) recorded the maximum SVI-II initially, and finally (37 and 35, respectively).

Conclusion

Bt cotton hybrids especially PRCH 31 recorded higher germination in all the germination testing methods as well as vigour tests. Germination and seedling vigour gradually declined with an increase in period of accelerated ageing from 0 to 30 days. Such decline was more in Non Bt cotton hybrids when compared to Bt cotton hybrids. However, TCH 9 and PRCH 31 have shown reduced declinein germination and seedling vigour. These varieties were shown to posses resistance to seed deterioration against adverse factors and considered as resistant varieties under stress conditions.

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