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Response of *Bt* cotton under different dates of sowing with weed management

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ABSTRACT : Cotton plays an important role in textile industries and livelihood for millions of farmers, those concerned with its trade, processing, manufacturing and other allied sectors. It is mainly used in the manufacturing of cloth for mankind to all over the world. Introduction of *Bt* cotton hybrids targeting on cotton bollworms substantially brought down the cost of cultivation and has been a boon as the technology is eco friendly and acceptable to farmers. In cotton, improper time of sowing and weed management practices significantly influences the weed growth and cotton development at initial stages and it leads to reduce yield up to 60-80 per cent. Hence, pre and post emergence herbicides were evaluated with objective of weed control efficacy, growth and productivity under different dates of sowing of *Bt* cotton. Recent approach of herbicides has a greater role in managing weeds as well easy, efficient methods and economical way. The experimental result showed that early sowing of *Bt* cotton hybrid on 1st August combination with pre emergence application of pendimethalin 38.7 per cent CS @ 0.68 kg/ha followed by post emergence pyrithiobac sodium (5% EC) @ 62.5 g/ha significantly reduce the weeds density, dry weight and increase growth, yield attributes, seed cotton yield and economics.

Key words: *Bt* cotton, pre and post emergence herbicides, time of sowing

Cotton is one of the major commercial crops in India and is popularly called as 'White Gold'. It plays an important role in textile industries and is a means of livelihood for millions of farmers and those concerned with its trade, processing, manufacturing and other allied sectors. Cotton seed contains 15 to 20 per cent oil and it is used as vegetable oil and in soap industries. Introduction of *Bt* cotton hybrids targeting on cotton bollworms substantially brought down the cost of cultivation and has been a boon as the technology is eco friendly and acceptable to farmers. Concomitant with the steep increase in adoption of *Bt* cotton hybrids between 2002 and 2007, average lint yield of cotton in India increased from 308 kg/ha to 560 kg/ ha (Anonymous, 2009). Improper time of sowing influences the weed infestation and makes the weeds compete more for the nutrients, moisture, light and space and severely affects the growth and development of cotton. Greater competition of weeds usually occurs at the early stage of cotton. Traditional method of weed management *i.e.,* hand weeding effectively reduces the weed competition and enhanced the yield of cotton. However, hand weeding is not economic, time consuming and labour intensive operation. Recent approach of herbicides have a greater role in managing weeds in *Bt* cotton hybrid as well easy, as efficient and economical

method (Owen *et al.*, 2015). Optimum time of sowing combined with suitable weed management methods resulted in early elimination of weed competition which favoured a suitable environment to the *Bt* cotton.

MATERIALS AND METHODS

Field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore during the winter season of 2015-2016 and 2016-2017. The field was situated at 11° North latitude and 77° East longitude at an altitude of 426.72 m above Mean Sea Level. The mean annual rainfall of Coimbatore is 670.6 mm distributed in 47 rainy days. The mean maximum and minimum temperatures are 30.6 and 20.9°C respectively. The soil of the experimental field was sandy clay loam in texture with low in available nitrogen, medium in available phosphorus and high in available potassium. For the experiment of *Bt* cotton hybrid (Uttam BG II) was selected to carry out the study during both the years. In the experiment main plots consisted of four dates of sowing 1stAugust (M_1), 15th August (M_2), 1st September (M_3) and 15th September (M_4) and sub plots were chemical weed management (pendimethalin 38.7% CS @ 0.68 kg/ha PE followed by (1b) one hand weeding at 40 DAS (S_1), pendimethalin 38.7% CS @ 0.68 kg/ha PE *fb* POE pyrithiobac sodium 5% EC @ 62.5 g/ha (S_2), pendimethalin 38.7% CS @ 0.68 kg/ha PE *fb* POE quizolofop ethyl 5% EC @ 50 g/ha (S_3), pendimethalin 30% EC @ 1.0 kg/ha PE *fb* hand weeding at 40 DAS (S_4), two hand weeding on 20 and 40 DAS (S_5) and weedy check (S_6). The experiment laid out in split plot design with three replications.

RESULTS AND DISCUSSION

Weed interference : Distinctive time of sowing in *Bt* cotton hybrids impacted the weeds and cotton development during both years of the experiment (2015-2016 and 2016-2017). Total weed density (80.6 and 101.7) Nos./m^2) and weed dry weight (46.1 and 61.1 g/m^2) at 40 days after sowing (DAS) were lesser in advance sowing of cotton done on 1st August (Table 1 and 2) as compared to late sown cotton (15th September) having total weed density (113.3 and 120.7 Nos./m^2) and weed dry weight (48.58 and 92.2 g/m^2) at 40 DAS. It might be due to the fact that, optimum time of sowing provided better vigour to crop and encountered lesser weed competition consequently resulting into higher productivity. Similar results were reported by Malik and Yadav (2014) who found that density of weeds increased significantly with delayed sowing in pigeon pea.

Among the weed management methods, pre emergence application of pendimethalin (38.7%) CS @ 0.68 kg/ha followed by post emergence pyrithiobac sodium (5%) EC @ 62.5 g/ha recorded significantly lower weed density (48.0 and 99.9 Nos./m^2), weed dry weight (21.68 and 69.0 g/m^2) respectively, during 2015-2016 and 2016-2017(Table 1). Higher total weed density (205.2 and 273.4 Nos. /m^2) and weed dry weight (104.2 and 202.1g/m^2) were recorded in weedy check during both the year of study. It is mainly due to sequential application of pre emergence herbicides followed by post emergence herbicides could be attributed to weed free situation during initial stages and thus, reducing the weed competition during critical initial to peak growth period of *Bt* cotton. The results are in corroboration with the findings of

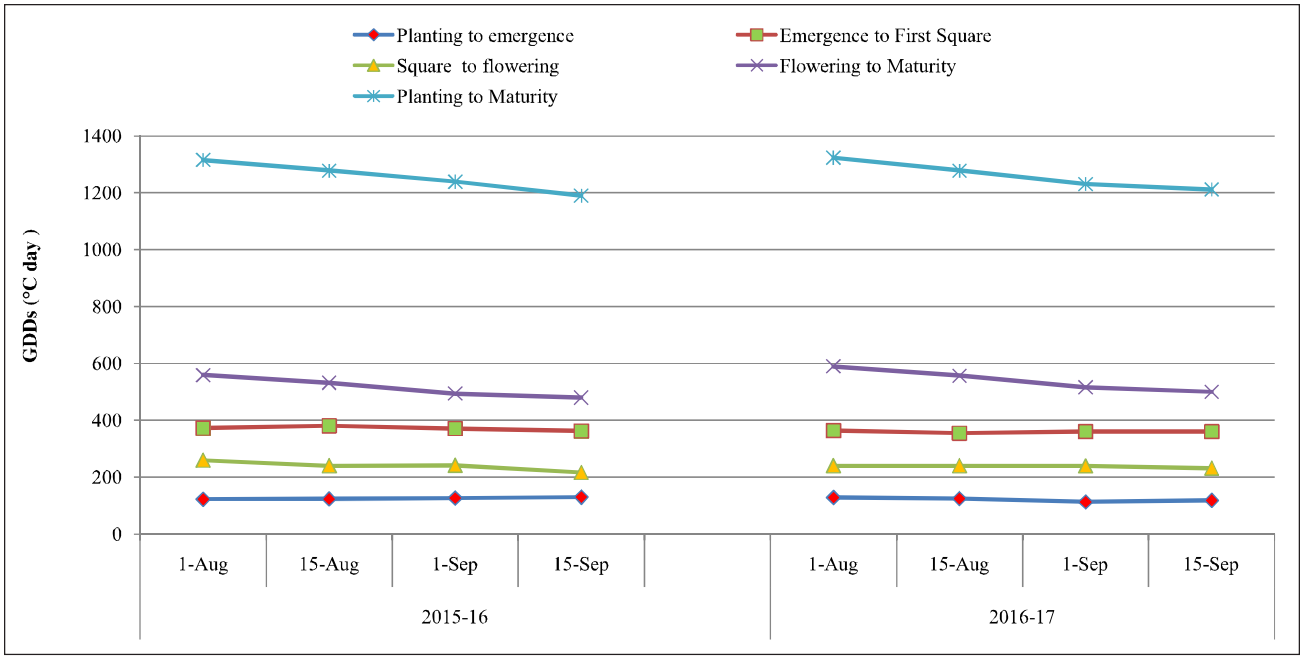

Fig 1. GDDs *Bt* cotton at various growth stage under different time of sowing

Hiremath *et al.*, (2013) who found that pre emergence application of pendimethalin 38.7 per cent CS @ 1.5 kg /ha *fb* pyrithiobac sodium 10 per cent EC @ 1.25 kg/ ha with inter culture at 60 DAS registered low weed dry matter, weed index in cotton.

Nutrient depletion by weeds : Nutrient depletion from the soil is a function of dry weight and nutrient content in the weeds and plants. Weeds usually grow faster than crop plants and thus absorb the available nutrients quickly resulting in inadequate supply of the nutrients to the crop. Slow growth of cotton crop might have favoured competition by heavy weed infestation. Early sown cotton on 1st August combined with PE herbicide application could save nutrient loss appreciably by decreasing the nutrients (nitrogen, phosphorus and potassium) depletion by weeds at all the stages of cotton growth as compared to weedy check (Table 2).

Cotton sown on 1st August with PE pendimethalin 37.8 CS @ 0.68 kg/ha *fb* POE pyrithibac sodium 5 per cent EC @ 62.5 g/ha recorded lower nitrogen, phosphorus and potassium removal by weeds at 40 DAS, which was comparable with hand weeding twice at 20 and 40 DAS. This might be due to lower weed density and dry weight (Table 1 and 2). Some of the sceintists here reported that weed consumed 5 to 6 times nitrogen, 5 to 12 times phosphorus and 2 to 5 times potash than cotton crop at the early growth stages and thus reduced seed cotton yield from 54 to 85 per cent.

Nutrients (nitrogen, phosphorus and potassium) removal by weeds were lower in hand weeding twice at 20 and 40 DAS and PE pendimethalin 37.8 CS @ 0.68 kg/ha *fb* POE pyrithibac sodium 5 per cent EC @ 62.5 g/ha. This might be due to the weed free environment created by the weed management methods, which reduced the weed dry matter production.

Table 1. Response of time of sowing and weed management methods on total weed density, dry weight and weed control efficiency (%) in *Bt* cotton hybrid at 40 DAS

Treatment	Total weed density* (Nos./ m^2)		**Mean (Pooled)**	Total weed dry weight* (g/m^2)		**Mean (Pooled)**	WCE (%)		**Mean (Pooled)**
	2015-2016	2016-2017		2015-2016	2016-2017		2015-2016	2016-2017	
Date of sowing									
1st August	9.01	10.18	**9.65**	6.47	7.94	**7.17**	61.10	63.70	**61.10**
	(80.6)	(101.70)	**(91.15)**	(39.80)	(61.10)	**(49.45)**			
15th August	8.94	10.19	**9.62**	6.62	8.51	**7.63**	53.40	61.70	**57.60**
	(79.4)	(101.80)	**(90.60)**	(41.90)	(70.50)	**(56.20)**			
1st September	9.26	10.60	**9.99**	7.30	9.26	**8.32**	55.20	62.30	**58.80**
	(85.3)	(110.30)	**(97.80)**	(51.30)	(83.80)	**(67.15)**			
15th September	10.67	11.08	**10.91**	7.37	9.71	**8.62**	52.50	60.60	**56.60**
	(113.3)	(120.70)	**(117.00)**	(52.30)	(92.20)	**(72.25)**			
SEd	0.18	0.21	**0.16**	0.14	0.15	**0.16**	-	-	-
CD (p=0.05)	0.37	0.43	**0.32**	0.29	0.36	**0.34**	-	-	-
Weed management methods									
Pendimethelin 0.68 *fb* one	7.34	10.09	**8.87**	5.82	8.43	**7.24**	69.00	63.50	**66.30**
hand weeding	(53.4)	(99.90)	**(76.70)**	(31.90)	(69.00)	**(50.45)**			
Pendimethelin 0.68 *fb*	6.96	6.32	**6.70**	4.79	5.15	**4.97**	80.20	88.60	**84.40**
pyrithiobac Na	(48.0)	(37.90)	**(42.95)**	(20.90)	(24.50)	**(22.70)**			
pyrithiobacNa 0.68 *fb*	7.08	6.51	**6.86**	5.41	5.30	**5.35**	73.80	87.40	**80.60**
quizalofob ethyl	(49.6)	(40.40)	**(45.00)**	(27.20)	(26.10)	**(26.65)**			
quizalofob ethyl 1.0 *fb* one	7.71	11.20	**9.65**	6.54	9.15	**7.93**	60.50	58.40	**59.50**
hand weeding	(59.0)	(123.40)	**(91.20)**	(40.00)	(81.80)	**(60.90)**			
Two Hand weeding	11.09	9.24	**10.23**	7.41	7.74	**7.55**	49.80	65.90	**57.90**
	(122.4)	(83.40)	**(102.70)**	(52.90)	(57.90)	**(55.05)**			
Weedy check	14.35	16.59	**15.54**	10.31	14.29	**12.46**	0.00	0.00	**0.00**
	(205.4)	(273.40)	**(239.00)**	(104.20)	(202.10)	**(153.20)**			
SEd	0.16	0.19	**0.17**	0.13	0.14	**0.15**	-	-	-
CD (p=0.05)	0.33	0.38	**0.34**	0.26	0.28	**0.26**	-	-	-
M x S	0.71	0.76	**0.70**	0.55	0.62	**0.57**	-	-	-
S x M	0.66	0.65	**0.61**	0.51	0.49	**0.49**	-	-	-

*Transformed value (Figures in parenthesis are original values)

Table 2. Response of time of sowing and weed management methods on nutrient removal by weeds (kg ha^{-1}) in *Bt* cotton hybrid at 40 DAS

Treatment	Nitrogen		**Mean**	Phosphorus		**Mean**	Potassium		**Mean**
	2015-2016	2016-2017	**(Pooled)**	2015-2016	2016-2017	**(Pooled)**	2015-2016	2016-2017	**(Pooled)**
Date of sowing									
1st August	6.0	10.5	**8.7**	3.8	5.5	**4.7**	8.5	12.2	**10.4**
15th August	6.8	11.7	**8.9**	4.1	6.3	**5.2**	9.2	14.1	**11.7**
1st September	9.3	13.8	**11.6**	4.6	7.5	**6.1**	10.2	16.8	**13.5**
15th September	11.1	14.8	**13.0**	5.9	8.3	**7.1**	13.1	18.4	**15.8**
SEd	0.2	0.4	**0.3**	0.1	0.2	**0.1**	0.2	0.3	**0.2**
CD (p=0.05)	0.5	0.9	**0.9**	0.2	0.4	**0.3**	0.4	0.7	**0.5**
Weed management									
Pendimethelin 0.68 *fb* one hand weeding	8.3	12.7	**10.5**	2.9	6.2	**4.6**	6.5	13.8	**10.2**
Pendimethelin 0.68 *fb* pyrithiobac Na	7.6	7.8	**7.7**	2.7	2.2	**2.5**	6.0	4.9	**5.5**
Pendimethelin 0.68 *fb* quizalofob ethyl	8.4	10.4	**9.4**	2.9	2.4	**2.7**	6.5	5.2	**5.9**
Pendimethelin 1.0 *fb* one hand weeding	9.1	13.9	**11.5**	3.2	7.4	**5.3**	7.1	16.4	**11.8**
Two Hand weeding	18.4	15.9	**17.2**	6.5	5.2	**5.9**	14.4	11.6	**13.0**
Weedy check	26.9	56.8	**41.9**	9.5	18.2	**13.9**	21.0	40.4	**30.7**
SEd	0.3	0.5	**0.4**	0.1	0.2	**0.2**	0.2	0.4	**0.3**
CD (p=0.05)	0.6	1.0	**0.9**	0.2	0.3	**0.4**	0.4	0.7	**0.6**
M x S	1.1	2.0	**1.8**	0.4	0.7	**0.8**	0.9	1.5	**1.2**
S x M	1.0	1.8	**1.4**	0.3	0.6	**0.6**	0.7	1.3	**1.0**

Table 3. Response of time of sowing and weed management methods on seed cotton yield, net return and BCR in *Bt* cotton hybrid

Treatment	Seed cotton yield (kg/ha)		**Mean (Pooled)**	Net return (Rs/ha)		**Mean (Pooled)**	BCR		**Mean (Pooled)**
	2015-2016	2016-2017		2015-2016	2016-2017		2015-2016	2016-2017	
Time of sowing									
1st August	1454	1401	**1428**	39227	36067	**37647**	1.81	1.74	**1.78**
15th August	1322	1296	**1307**	31 337	29757	**30547**	1.65	1.61	**1.63**
1st September	1234	1158	**1196**	26017	21507	**23762**	1.54	1.44	**1.49**
15th September	1129	1114	**1122**	19737	18867	**19302**	1.41	1.39	**1.40**
SEd	59	46	**24**	-	-	**-**	-	-	**-**
CD (p=0.05)	108	93	**58**	-	-	**-**	-	-	**-**
Weed management									
Pendimethelin 0.68 *fb* one hand weeding	1299	1273	**1286**	28302	26772	**27537**	1.57	1.54	**1.56**
Pendimethelin 0.68 *fb* pyrithiobac Na	1640	1413	**1527**	52340	38705	**45523**	2.14	1.84	**1.99**
Pendimethelin 0.68 *fb* quizalofob ethyl	1261	1218	**1240**	29832	27282	**28557**	1.65	1.60	**1.63**
Pendimethelin 1.0 *fb* one hand weeding	1194	1254	**1223**	21084	24789	**22937**	1.42	1.49	**1.46**
Two Hand weeding	1517	1510	**1510**	36708	36258	**36483**	1.68	1.67	**1.68**
Weedy check	799	782	**793**	6213	5493	**5853**	1.15	1.13	**1.14**
SEd	63	58	**30**	-	-	-	-	-	-
CD (p=0.05)	126	116	**60**	-	-	-	-	-	-
M x S	236	115	**123**	-	-	-	-	-	-
S x M	216	235	**106**	-	-	-	-	-	-

Weedy check recorded higher nutrient removal by weeds due to higher weed density and weed dry weight, which might have depleted maximum nutrients compared to other weed management methods as a result of more weed competition and biomass production. This finding is in line with the reports of Chander *et al.*, (1994), who inferred that application of pendimethalin @ 1.25 kg/ha followed by hand weeding reduced the nutrient removal by weeds. The results are also in line with findings of Wanjari *et al.*, (2001) who observed higher nutrient removal by the weeds in the weedy check and higher nutrient uptake by the crop in weed free condition throughout cropping period.

Seed cotton yield, net return and BCR : Higher seed cotton yield (1454 and 1401 kg/ha) was the recorded with cotton sown on 1st August and was significantly superior to other dates of sowing (15thAugust, 1st and 15th September) during 2015-2016 and 2016-2017. There was a progressive reduction in seed cotton yield for every successive fortnightly shift in sowing dates from 1st August to 15th September during in both years. Seed cotton yield of *Bt* cotton was reduced drastically when the sowing was delayed beyond 15th August (Table 3). It might be due to the reduction of cumulative GDDs under delayed sowing in all the phenological stages (Fig. 1). Advance sowing of cotton (1st August) recorded higher cumulative GDD_S of 1314 and 1323 compared to its sowing on 15th September (GDDs 1189 and 1212). Optimum heat unit system (GDDs) facilitated cotton to higher photosynthesis, which might have led to higher plant height, dry matter production, sympodial branches, bolls/plant and seed cotton yield as compared to late sown *Bt* cotton hybrid. Buttar *et al.,* (2010) also reported, higher seed cotton yield was obtained in early sown American cotton *(G. hirsutum)* as compared to late sown crop in Punjab.

In weed management, first year study (2015-2016), pre-emergence application of pendimethalin 38.7 per cent CS @ 0.68 kg/ha *fb* post emergence pyrithiobac sodium 5 per cent EC @ 62.5 g/ha recorded higher seed cotton and it was comparable with hand weeding twice at 20 and 40 DAS. During winter 2016-2017, higher seed cotton yield was observed in hand weeding on 20 and 40 DAS and it was *on par* with pendimethalin 38.7 per cent CS @ 0.68 kg/ha *fb* pyrithiobac sodium 5 per cent EC @ 62.5 g/ha (Table 1). Advance sowing of cotton on 1st August combined with PE pendimethalin 38.7 per cent CS @ 0.68 kg/ha *fb* POE pyrithiobac sodium 5 per cent EC @ 62.5 g/ha recorded maximum net return (Rs. 52340 and 38705/ ha) and B: C ratio (2.14 and 1.84), respectively, during 2015-2016 and 2016-2017. Whereas, minimum B: C ratio (1.15 and 1.13) was recorded in weedy check with delayed sowing of cotton (Table 3). It might be due to increased seed cotton yield due to least weed competition throughout growing season under the influence of sequential use of PE and POE herbicides with one inter culture. The results are in line with the findings of Prabhu *et al.* (2012) and Hiremath *et al.,* (2013), who reported that pre emergence application of pendimethalin 38.7 per cent CS @ 1.5 kg/ha *fb* pyrithiobac sodium 5 per cent EC @ 1.25 kg/ha with inter cultivation at 60 DAS recorded higher seed cotton yield, gross and net returns.

CONCLUSION

From the experimental results it could be concluded that early sowing of *Bt* cotton hybrid on 1st August decreased weed interaction and its combination with integrated weed management practices of pre emergence application of pendimethalin 38.7 per cent CS @ 0.68 kg/ha followed by post emergence application pyrithiobac sodium 5 per cent EC @ 62.5 g/ha resulted in minimum weed interference with enhanced the productivity and profitability in western zone of Tamil Nadu.

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