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Integrated weed management for *Bt* cotton hybrid

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ABSTRACT

Time of sowing and canopy density influence the interaction between weeds and cotton however, little is known about time of sowing response to weed interference in cotton productivity. A field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore during 2015 and 2016 to quantify the influence of time of sowing and weed management methods on weeds interference and seed cotton yield. Crop growth response to weed interference in different time of sowing with weed management was determined in Bt cotton hybrid. Results revealed that, cumulated thermal time (GDDs) was maximum in early sown cotton (1st August) beyond 15th August sowing experienced minimum cumulative GGDs in 15th September. Higher weed density and weed dry weight drastically increased in delayed sowing time from 1st August to 15th September. Pre-emergence pendimethalin 38.7 per cent CS followed by post-emergence pyrithiobac sodium 5% EC 62.5 g ha^{-1} recorded lower weed density,dry weight and higher weed control efficiency at 40 DAS. Better growth, higher yield parameters and seed cotton yield were recorded when sowing was done on August.

Keywords : Bt cotton hybrid, GDDs, time of sowing, weed management

Cotton (*Gossypium hirsutum* L.) is a important commercial crop of India; it sustains the cotton textile industry which perhaps the largest segment of organized industries in the country. Cotton is highly sensitive to environmental conditions and grown in a wide range of ecological zones. In cotton, 60 per cent of the yield losses are due to climate as compared to 30 per cent recorded in other crops like cereals, oilseeds and pulses (Dason, 1996). Temperature is the driving force of all cellular reactions. Optimum temperature range promotes plant health through active growth. Undesirable temperatures can slow growth and lead to declining affects. In addition, temperature can influence the competitive outcome between desirable cotton and weeds. Weeds primarily compete during the early crop growth period for solar radiation, moisture and nutrients. The critical period of weed competition in cotton was found to be 15 to 60 days (Sharma, 2008). Since, the cotton has long development cycle; it needs to go through incessant downpours and along these lines weeds additionally represent a difficult issue. Losses caused by weeds in cotton ranges from 50 to 85 per cent depending upon the nature and intensity of weeds. Sowing time plays an important role to realize maximum seed cotton yield as the potential optimizing yield is directly influenced by the accumulation of heat units and thermal time (Zhang *et al*., 2008). It is essential to study the quantitative relationships which account for the effects of plant and environmental factors on reproductive allocation. In Central India, if sowing is delayed beyond July 15th , the peak lowering and boll development period will coincide with cool day and night temperatures (Hebbar *et al*., 2007). Hence, in order to manage the crop better, it is worthwhile to understand the effect of sowing dates on phenology and weeds interference of *Bt* cotton hybrid.

Field experiment was conducted at Tamil Nadu Agricultural University, Coimbatore. The farm is situated in Western Agro climatic zone of Tamil Nadu. It located with 11°N longitude and 77° E latitude at an altitude of 426.7 m above mean sea level and the farm receives the normal total annual rainfall of 674.2 mm in 45.8 rainy days. Trial was conducted with sandy clay loam type of soil and it was medium in organic carbon content and the available nutrient status was low in nitrogen, medium in phosphorus and high in potassium.

MATERIALS AND METHODS

Experiment consisting four dates of sowing (1st Aug, 15th Aug, 1st Sept and 15th Sept) in the main plots and six weed control treatments (pre-emergence pendimethalin 30% EC and 38.7% CS of 1.0 and 0.68 kg ha^{-1} followed by post-emergence pyrithiobac sodium 5% EC 62.5 kg ha^{-1} and quizalofop ethyl 5% EC 50 kg ha^{-1} at 2-3 leaf stages of weeds, Hand weeding on 20 and 40 DAS and weedy check in the sub-plots. Trail was laid out in split plot design with three replications. The land was prepared for cotton by giving two dry ploughings with disc plough followed by clod crushing to achieve fine seed bed. Cotton was sown manually keeping the distance of 90 × 60 cm in different time of sowing after sowing the seed, immediately a light irrigation was given to the crop for uniform germination. Pre-emergence herbicide are sprayed on 3 DAS and post-emergence herbicides are sprayed at 2-3 leaf stages of weeds in respect of treatment using hand operated knapsack sprayer fitted with a flat fan type nozzle with

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spray volume of 500 L $ha^{-1.}$ Metrological data were recorded during the cropping season 2015-16 and Growing Degree Days (GDDs) were calculated as per the formula developed by Jones and Wells (1998).

GDDs (°C day) = $(T_{max} + T_{min})/2 - T_b$

Whereas,

T_{max} : Daily maximum temperature (^{0}C)

T_{min} : Daily minimum temperature (^{0}C)

T_b : Base temperature as 15.5 ^{0}C

Densities of grasses, sedges and broad leaved weeds were counted using 0.5 × 0.5 m quadrat from four randomly fixed places in each plot and collected; the weeds were after shade drying, dried in hot-air oven at 80°C for 72 hrs. The weed density (Nos./m^{-2}) and dry weight (g m^{-2}) were recorded separately. Weed control efficiency (WCE) was calculated as per the procedure given by Main *et al.* (2007).

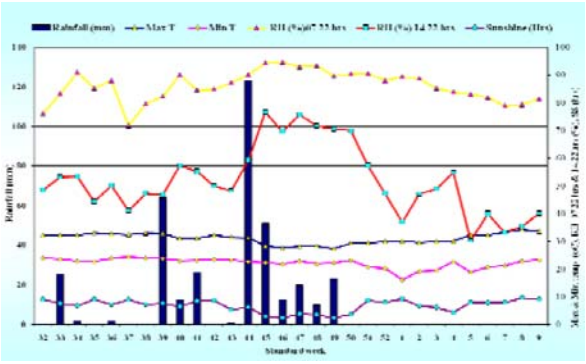
WCE = 100*(WDc – WDt)/ WDc

Whereas,

WCE : weed control efficiency (%), WDc : weed dry weight (g m^{-2}) in control plot

WDt: weed dry weight (g m^{-2}) in treated plot.

Data were statistically analysed following the procedure (Gomez and Gomez. 2010) for split plot design. Data pertaining to weeds were transformed to square root scale $\sqrt{(X+2)}$ whenever significant variation existed, critical .difference was assembled at five per cent probability level.

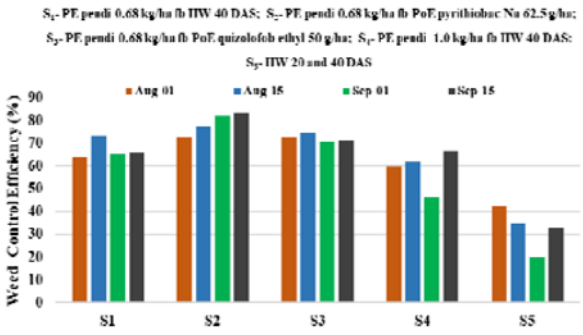


Weather parameters prevailed during the cropping period (August 2015-March 2016)

RESULTS AND DISCUSSION

Influence of growing degree days (GDDs) on Bt cotton hybrid

Growing Degree Days consumed for completion of different phenological stages of Bt cotton are significantly influenced under varied date of sowing time. The cumulated thermal time was maximum in 1st August sown crop followed by 15th August sown crop at all phonological stages. GDDs values at planting to maturity (up to 1st picking) were 1315, 1278, 1239 and 1189 °C day for 1st Aug , 15th Aug, 1st Sept. and 15th Sept) respectively. The cotton crop sown on August 1



Time of sowing and weed management on WCE (%) of *Bt* cotton at 40 DAS

accumulated higher thermal units as compared to 1st September and 15th Sept. sown crops because early sown crop took more days to mature as compared to late sown crops. Similar types of results were observed by Young *et al*. (1980) and Hebbar *et al*. (2007). Prakash *et al*. (2010) also confirmed that early sown cotton experienced the maximum cumulative GDDs whereas the late sown crop experienced the minimum GDDs.

Influence of time of sowing and weed management on weeds interference in Bt cotton hybrid

Weed flora of the experimental field consisted of eleven species of broad leaved weeds, seven species of grasses and a sedge weed. Dominant among grassy weeds was *Cynodon dactylon* (L.) Pers. and *Trianthema portulacastrum* (L.) and *Digera arvensis* (Forsk.) were the dominant among the broad leaved weeds. *Cyperus rotundus* (L.) was the only sedge present in the experimental fields. Distinctive time of sowing in cotton impact the weeds development. Lower total weed density (80.6 Nos. m^2) and weed dry weight (46.1 g m^2.) were recorded when sowing was done on 1stAugust (Table 1and 2) and it on par with August 15 sowing. Late sown cotton (Sept. '15) recorded higher total weed density (113.3 Nos. m^2) and weed dry weight (65.2 g m^{-2}) compared to early sown *Bt* cotton hybrid (1st August). It might be, optimum time of sowing provided better vigour to crop and encountered lesser weeds competition. Similar results were earlier reported by Malik and Ashok Yadav (2014).

In weed management, pre-emergence pendimethalin 38.7% CS 0.68 kg ha^{-1} followed by post emergence pyrithiobac sodium 5% EC 62.5 g ha^{-1} significantly recorded lower total weed density (48.0 and 37.9 Nos. m^2) total weed dry weight (20.9 and 29.7.g m^{-2}) and higher weed control efficiency (86%). Higher total weed density and weed dry weight**)** are recorded in weedy check. It is mainly due to sequential application of herbicides along with inter cultivation could be attributed to weed free situation during initial stages and further control of new flush of weeds by application of post emergence herbicides at 30-35 DAS followed by inter cultivation at 60 DAS and thus, reducing the weed

Table 1: Effect of time of sowing and weed management practices on total weed density, weed dry weight of *Bt* cotton hybrid at 40 DAS (2015-16)

Treatment	Total weed density (Nos. m^2)					Total weed dry weight (g m^{-2})				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
S_1	7.01	6.57	7.30	8.36	7.34	4.73	6.26	5.54	6.58	5.82
	(48.7)	(42.7)	(52.8)	(69.4)	(53.4)	(20.4)	(37.2)	(28.7)	(41.3)	(31.9)
S_2	7.31	6.88	7.46	6.14	6.96	4.65	3.95	4.96	5.47	4.79
	(52.9)	(46.9)	(55.1)	(37.2)	(48.0)	(19.6)	(13.6)	(22.6)	(27.9)	(20.9)
S_3	6.47	6.00	5.17	9.79	7.08	4.83	5.52	6.15	5.03	5.41
	(41.4)	(35.5)	(26.2)	(95.4)	(49.6)	(21.3)	(28.5)	(35.8)	(23.3)	(27.2)
S_4	7.93	7.93	7.24	7.73	7.71	5.76	6.80	6.53	7.00	6.54
	(62.4)	(62.4)	(51.9)	(59.2)	(59.0)	(31.2)	(44.3)	(40.6)	(47.0)	(40.0)
S_5	9.91	10.04	11.22	12.90	11.09	6.78	6.31	8.23	8.14	7.41
	(97.7)	(100.3)	(125.4)	(166)	(122.4)	(44.0)	(37.8)	(65.8)	(64.3)	(52.9)
S_6	13.45	13.74	14.16	15.91	14.35	10.22	9.59	10.79	10.58	10.31
	(180.4)	(188.3)	(200.1)	(252.7)	(205.4)	(102.4)	(89.9)	(114.5)	(110)	(104.2)
Mean	**9.01**	**8.94**	**9.26**	**10.67**		**6.47**	**6.62**	**7.30**	**7.37**	
	(80.6)	**(79.4)**	**(85.3)**	**(113.3)**		**(39.8)**	**(41.9)**	**(51.3)**	**(52.3)**	
	M	**S**	**M x S**	**S x M**		**M**	**S**	**M x S**	**S x M**	
SEm (±)	**0.18**	**0.16**	**0.35**	**0.32**		**0.14**	**0.13**	**0.27**	**0.26**	
LSD (0.05)	**0.37**	**0.33**	**0.71**	**0.66**		**0.29**	**0.26**	**0.55**	**0.51**	

Figure in parenthesis are mean of original value; Data subjected to square root transformation

Table 2: Effect of time of sowing and weed management practices on total weed density, weed dry weight of *Bt* cotton hybrid at 40 DAS (2016-17)

Treatment	Total weed density (No. m^2)					Total weed dry weight (g m^2)				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
S_1	9.85	9.56	10.14	10.79	**10.09**	4.91	5.19	6.07	6.63	**5.74**
	(95.0)	(89.4)	(100.8)	(114.4)	**(99.9)**	(23.6)	(26.4)	(36.3)	(43.4)	**(32.4)**
S_2	6.53	6.69	5.80	6.16	**6.32**	5.03	5.94	6.14	4.76	**5.50**
	(40.6)	(42.8)	(31.6)	(36)	**(37.9)**	(24.8)	(34.8)	(37.2)	(22.2)	**(29.7)**
S_3	7.33	6.20	6.07	6.35	**6.51**	4.59	5.16	4.28	8.17	**5.76**
	(51.8)	(36.4)	(34.9)	(38.3)	**(40.4)**	(20.6)	(26.1)	(17.8)	(66.2)	**(32.7)**
S_4	10.84	10.87	11.45	11.6	**11.20**	5.98	6.24	5.69	6.10	**6.01**
	(115.4)	(116.2)	(129)	(132.6)	**(123.4)**	(35.3)	(38.4)	(31.9)	(36.7)	**(35.6)**
S_5	8.33	8.69	9.61	10.22	**9.24**	7.77	7.47	8.61	9.99	**8.51**
	(67.4)	(73.6)	(90.3)	(102.4)	**(83.4)**	(59.9)	(55.3)	(73.6)	(99.3)	**(72.0)**
S_6	15.65	16.20	16.99	17.46	**16.59**	9.62	9.80	10.47	11.14	**10.28**
	(242.9)	(260.5)	(286.7)	(302.8)	**(273.2)**	(92.1)	(95.6)	(109.2)	(123.7)	**(101.2)**
Mean	**10.18**	**10.19**	**10.60**	**11.08**		**6.57**	**6.83**	**7.18**	**8.11**	
	(101.7)	**(101.8)**	**(110.3)**	**(120.7)**		**(42.7)**	**(46.1)**	**(51.0)**	**(65.2)**	
	M	**S**	**M x S**	**S x M**		**M**	**S**	**M x S**	**S x M**	
SEm (±)	**0.18**	**0.16**	**0.35**	**0.28**		**0.15**	**0.14**	**0.29**	**0.24**	
LSD (0.05)	**0.43**	**0.33**	**0.74**	**0.58**		**0.36**	**0.28**	**0.62**	**0.49**	

Figure in parenthesis are mean of original value; Data subjected to square root transformation

Table 3: Effect of time of sowing and weed management practices on seed cotton yield (kg ha^{-1})

Treatment	2015-16					2016-17				
	M_1	M_2	M_3	M_4	Mean	M_1	M_2	M_3	M_4	Mean
S_1	1473	1448	1183	1091	**1299**	1509	1397	1139	1048	**1273**
S_2	1971	1723	1532	1335	**1640**	1607	1451	1302	1292	**1413**
S_3	1360	1229	1270	1184	**1261**	1403	1274	1132	1064	**1218**
S_4	1304	1192	1164	1107	**1194**	1435	1298	1160	1121	**1254**
S_5	1778	1531	1468	1291	**1517**	1650	1506	1443	1409	**1502**
S_6	836	810	784	765	**799**	802	819	774	752	**782**
Mean	**1454**	**1322**	**1234**	**1129**		**1401**	**1291**	**1158**	**1114**	
	M	**S**	**M x S**	**S x M**		**M**	**S**	**M x S**	**S x M**	
SEm(±)	**59**	**63**	**108**	**118**		**46**	**58**	**119**	**84**	
LSD (0.05)	**108**	**126**	**216**	**236**		**93**	**116**	**235**	**115**	

Time of sowing

M_1- 1st August
M_2- 15th August
M_3- 1st September
M_4- 15th September

Weed management methods

S_1- PE pendimethalin 38.7% CS 0.68 kg ha^{-1} fb HW 40 DAS
S_2- PE pendimethalin 38.7% CS 0.68 kg ha^{-1} fb PoE pyrithiobac sodium 5% EC 62.5 g/ha
S_3- PE pendimethalin 38.7% CS 0.68 kg ha^{-1} fb PoE quizolofob ethyl 5% EC 50 g/ha
S_4- PE pendimethalin 30% EC 1.0 kg ha^{-1} fb HW 40 DAS
S_5- Hand weeding on 20 and 40 DAS
S_6 -Weedy check

competition during critical initial to peak growth period of *Bt* cotton. Similar results were reported by Hiremath *et al*. (2013)

Influence of time of sowing and weed management on productivity of Bt cotton hybrid

Results indicated that, seed cotton yield was significantly higher when sowing was done on 1st August (1971 and 1607 kg ha^{-1}) and the lower seed cotton yield was observed at 15th September sowing during 2015 and 2016, respectively. Seed cotton yield of *Bt* cotton (Table 3) was reduced drastically when the sowing was delayed beyond August 15. It might be due to the reduction of cumulative GDDs under delayed sowing in all the phenological stages (Fig 2). Early sowing (1st August) recorded higher cumulative GDDS compared to delayed sowing September 15 Optimum heat unit system (GDDs) facilitated cotton through higher photosynthesis, which might have led to higher plant height, dry matter production, sympodial branches, bolls plant^{-1} and seed cotton yield as compared to late sown Bt cotton hybrid. Sen *et al*. (2016) who had earlier reported that optimum time of sowing of lentil promising for better seed yield. Buttar *et al*. (2010) also observed that under Punjab condition, higher seed cotton yield was obtained in early sown American cotton *(G. hirsutum*) as compared to late sown. Many squares in the late sowing cotton did not form bolls and sowing date differences in final square number and boll numbers were due to a combination of temperature and early boll retention as observed by Liu *et al*. (2013) and Burke (2002).

From results it could be presumed that, early sowing of (1st August) *Bt* cotton hybrid with higher GDDs decreased the weed interaction accompanied by integrated weed management of pre emergence pendimethalin 38.7% CS 0.68 kg ha^{-1} followed by post emergence pyrithiobac sodium 5% EC 62.5 g ha^{-1} and quizalofop ethyl 5% EC 50 g/ha recorded higher weed control efficiency and seed cotton yield.

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