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RESEARCH ARTICLE

Weed management strategies in Bt cotton under Humid Southern Plain Zone of Rajasthan

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SUMMARY

A field experiment was conducted during two consecutive years of *Kharif* 2012 and 2013 at Agricultural Research Station, Banswara to find out suitable weed management strategies for Bt cotton. The experiment was laid-out in Randomized Block Design with three replications having nine treatments. Results revealed that, the application of pendimethalin 30% EC @ 0.75 kg a.i. / ha PE *fb* quizalofop-P- ethyl 50 g a.i. / ha at 20-30 DAS + one hoeing gave significantly higher bolls plant^{-1} (36.30), boll weight (4.22 g), seed cotton yield (2275 kg ha^{-1}), net return (Rs.55581/- ha^{-1}) and B:C (2.70) over rest of treatments, but it was found at par with weed free check and application of pyrithiobac sodium @ 62.5 g a.i./ ha *fb* quizalofop-P- ethyl 50 g a.i./ha at 20-30 DAS + one hoeing bolls plant^{-1}(34.84), boll weight (4.19 g), seed cotton yield (2251 kg ha^{-1}), net return (Rs.54669/- ha^{-1}) and B:C (2.64). The maximum weed control efficiency (60.75%), lowest weed population (12.39 m^{-2}) and weed dry matter accumulation (14.63 g m^{-2}) at 60 DAS were observed under application of pendimethalin 30% EC @ 0.75 kg a.i. / ha PE *fb* quizalofop-P- ethyl 50 g a.i. / ha at 20-30 DAS + one hoeing over rest of treatments. However, it was found at par with weed free check and application of pyrithiobac sodium @ 62.5 g a.i./ ha *fb* quizalofop-P- ethyl 50 g a.i./ha at 20-30 DAS + one hoeing.

Key Words : Cotton, Pendimathlin, Pyrithiobac sodium, Weed control efficiency

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Cotton (*Gossypium* spp L.) is one of the predominant fibre crop and play a pivotal role in agriculture, industrial development, employment generation and economic development of India. It is also called as "king of fibres" and "white gold" due to higher economical value among all cash crop. In India, cotton is an important commercial crop supporting the livelihood of about 7.7 million farmers. Cotton occupies an area of 12.25 million ha of which 11.6 million ha (94 %) is genetically modified cotton (Bt cotton) (Choudhary and Gaur, 2015). Yield in cotton is dependent on the climatic conditions, rainfall pattern, weed competition and incidence of pests and diseases. Weeds are a potential problem in cotton cultivation and reduce yield by 50 to 85 per cent depending upon the nature and intensity (Jain

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et al., 1981).

Cotton is a long duration crop and typically takes about 140-160 days to complete its life cycle. Throughout the growth cycle it is exposed to weeds and the competition there in. Every crop has a critical period of weed control (CPWC) which refers to the minimum time period during which the crop must beweed free. In cotton, the CPWC is the first 15 to 60 days (Ayyadurai and Poonguzhalan, 2011). Weed control methods such as hand pulling or pulling by sickle are laborious, tedious drudgery causing and expensive process. The labour requirement for such operations may be 60 to 70 person days during peak season demand (Rawat *et al.*, 2012). Weed management is an important aspect regarding obtaining higher crop yield as weeds are silent, malignant and massive forces, which reduce yield drastically. Though manual weeding is considered as best method but it is time consuming and uneconomical to control weeds. Therefore, it has given importance to the development and warrants the use of herbicides to get timely as well as effective weed control. Maximum yield can be derived when there is at least 95 per cent weed control (Sharma, 2008). Weed management systems should prevent weed interference, be economical and sustainable, reduce weed seed bank in soil, prevent weed resistance and neither injure cotton nor reduce quantity of lint yield diminution. Weeds can reduce lint quality due to additional trash and staining of fibres leading to low grades and discounted prices. To be successful, weed management systems require advance planting and timely execution. Any delay in an application may reduce weed control, higher herbicide use rates and herbicide costs. Hence, the study was carried out to find out suitable herbicides either alone or in sequence or in combination with cultural practices for proper and timely control of weeds.

MATERIAL AND METHODS

An experiment was conducted during two consecutive years of *Kharif* 2012 and 2013 at Agricultural Research Station, Banswara on weed management strategies in Bt cotton under humid Southern Plain Zone of Rajasthan. The experiment was laid-out in Randomized Block Design with three replications having nine treatments *i.e.* (Pendimethalin 30% EC @ 0.75 kg a.i./ha PE + one hoeing, Trifluralin @ 1.2 kg a.i./ha PE + one hoeing, Quizalofop-P-ethyl 50 g a.i./ha 30 DAS + one hoeing, Pendimethalin 30% EC @ 0.75 kg a.i./ha PE *fb* Quizalofop-P-ethyl 50 g a.i./ha at 20-30 DAS + one hoeing, Pyrithiobac sodium @ 62.5 g a.i./ha at 20-30 DAS + one hoeing, Pyrithiobac sodium @ 62.5 g a.i./ha *fb* Quizalofop-P-ethyl 50 g a.i./ha at 20-30 DAS + one hoeing, Glyphosate @ 1.0 kg a.i./ha as direct spray at 45 DAS, weed free check and weedy check). The experimental field was well prepared by two ploughing followed by harrowing and cultivator and one planking for uniform levelling were performed for sowing of cotton.

The soils of experimental field were (black cotton soil) clay loam texture and alkaline in reaction (pH 7.9 and 7.8). The soil was medium in available nitrogen (246 and 255 kg/ha) and phosphorus (48.85 and 50.56 kg/ha) and high in available potassium (323 and 325 kg/ha) during the year 2012 and 2013, respectively. The crop was sown in first week of June by dibbling of 2-3 seeds per hills and full dose of phosphorus and potash were applied before sowing, while nitrogen dose was given in two splits *i.e.* first half at the time of thinning and remaining half at flowering stage. All production and protection measures were applied as per package of the zone IV b.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Growth:

It is evident from pooled data that (Table 1) the application of pendimethalin 30% EC @ 0.75 kg a.i./ha PE *fb* quizalofop-P-ethyl 50 g a.i./ha at 20-30 DAS + one hoeing, pyrithiobac Sodium @ 62.5 g a.i./ha *fb* quizalofop-P-ethyl 50 g a.i./ha at 20-30 DAS + one hoeing and weed free check were found at par with each other in terms of plant height (114.72, 113.45 and 116.23 cm), monopodial branches plant^{-1} (1.33, 1.32 and 1.34) and sympodial branches plant^{-1} (26.81, 26.02 and 26.99), respectively over rest of the treatments during both the years as well as in pooled analysis. These results were supported by the findings of Jain *et al*. (1981) and Rawat *et al*. (2012).

Yield attributes:

An examination of two years pooled data shows that (Table 2) the application of pendimethalin 30% EC @ 0.75 kg a.i./ha PE *fb* quizalofop-P-ethyl 50 g a.i./ha

at 20-30 DAS + one hoeing gave higher bolls plant^{-1} (36.30) and boll weight (4.22 g) over application of pendimethalin 30% EC @ 0.75 kg a.i./ha PE + one hoeing, trifluralin @ 1.2 kg a.i./ha PE + one hoeing, quizalofop-P-ethyl 50 g a.i./ha 30 DAS + one hoeing, pyrithiobac sodium @ 62.5 g a.i./ha at 20-30 DAS + one hoeing, glyphosate @ 1.0 kg a.i./ha as direct spray at 45 DAS and weedy check. However, it was found at par with application of pyrithiobac sodium @ 62.5 g a.i./ha *fb* quizalofop-P-ethyl 50 g a.i./ha at 20-30 DAS + one hoeing and weed free check, bolls plant^{-1} (34.84 and 37.09) and boll weight (4.19 and 4.30 g) in the pooled analysis. In these treatments increased seed cotton yield might be due to least weed competition throughout growing season under the influence of sequential use of PE and POE herbicides with one inter-culture operation with lesser cost of cultivation. The similar results were reported by Prabhu *et al*. (2012) and Hiremath *et al*. (2013).

Seed cotton yield:

Pooled data of two years show that (Table 2) the application of pendimethalin 30% EC @ 0.75 kg a.i./ha PE *fb* quizalofop-P-ethyl 50 g a.i./ha at 20-30 DAS + one hoeing was recorded significantly higher seed cotton yield (2275 kg/ha) over application of pendimethalin 30% EC @ 0.75 kg a.i./ha PE + one hoeing, trifluralin @ 1.2 kg a.i./ha PE + one hoeing, quizalofop-P-ethyl 50 g a.i./ ha 30 DAS + one hoeing, pyrithiobac sodium @ 62.5 g a.i./ha at 20-30 DAS + one hoeing, glyphosate @ 1.0 kg a.i./ha as direct spray at 45 DAS and weedy check. However, it was found at par with the application of pyrithiobac sodium @ 62.5 g a.i./ha *fb* quizalofap-P-ethyl 50 g a.i./ha at 20-30 DAS + one hoeing and weed free check seed cotton yield (2251 and 2336 kg/ha), respectively during both the years as well as in the pooled analysis. Rawat *et al.* (2012) reported in his findings that, the crop under weed free plots attained lush growth due to elimination of weeds from inter and intra row spaces besides better aeration due to manipulation of surface soil and thus more spaces, water, light and nutrients were available for the better growth and development, which resulted in to superior growth and yield and consequently the highest yield of crop. These results are in confirmation with those obtained by Jain *et al*. (1981); Ayyadurai and Poonguzhalan (2011); Rawat *et al.* (2012) and Choudhary and Gaur (2015).

Weed population:

An examination of data (Table 3) shows that untreated check (control) recorded significantly higher weeds (52.00 m^{-2}) over weed free check (6.65 m^{-2}) at 60 DAS. Application of pendimethalin 30% EC @ 0.75 kg a.i./ha PE *fb* quizalofop-P-ethyl 50 g a.i./ha at 20-30DAS + one hoeing and pyrithiobac sodium @ 62.5 g a.i./ ha *fb* quizalofop-P-ethyl 50 g a.i./ha at 20-30 DAS + one hoeing were recorded lowest weeds (12.39 and 14.27 m^{-2}) at 60 DAS as compared to application of pendimethalin 30% EC @ 0.75 kg a.i./ha PE + one hoeing, trifluralin @ 1.2 kg a.i./ha PE + one hoeing, quizalofop-P-ethyl 50 g a.i./ha 30 DAS + one hoeing, pyrithiobac sodium @ 62.5 g a.i./ha at 20-30 DAS + one hoeing and glyphosate @ 1.0 kg a.i./ha as direct spray at 45 DAS, respectively in the pooled analysis. Similar

Table 1 : Effect of weed management practices on growth parameters of Bt cotton

Treatments	Plant height (cm)			Monopodial branches plant^{-1}			Monopodial branches plant^{-1}		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
Pendimethalin 30% EC @ 0.75 kg a.i. / ha PE + one hoeing	109.23	108.91	109.07	1.24	1.22	1.23	22.79	22.46	22.63
Trifluralin @ 1.2 kg a.i. / ha PE + one hoeing	107.98	106.04	107.01	1.21	1.20	1.21	22.14	21.98	22.06
Quizalofop-P- ethyl 50 g a.i. / ha 30 DAS + one hoeing	106.12	105.82	105.97	1.20	1.19	1.20	21.95	21.25	21.60
Pendimethalin 30% EC @ 0.75 kg a.i. / ha PE *fb* quizalofop-P- ethyl 50 g a.i. / ha at 20-30 DAS + one hoeing	115.00	114.43	114.72	1.33	1.32	1.33	26.90	26.72	26.81
Pyrithiobac Sodium @ 62.5 g a.i./ ha at 20-30 DAS + one hoeing	105.79	105.04	105.42	1.18	1.17	1.18	21.83	21.79	21.81
Pyrithiobac Sodium @ 62.5 g a.i./ ha *fb* quizalofop-P- ethyl 50 g a.i./ha at 20-30 DAS + one hoeing	113.68	113.21	113.45	1.32	1.31	1.32	26.04	26.00	26.02
Glyphosate @ 1.0 kg a.i./ha as direct spray at 45 DAS	93.58	92.00	92.79	1.13	1.12	1.13	16.70	16.64	16.67
Weed free check	116.50	115.95	116.23	1.34	1.33	1.34	27.08	26.90	26.99
Weedy check	90.46	88.06	89.26	1.12	1.11	1.12	16.15	16.01	16.08
S.E. $\pm$	0.98	1.02	0.92	0.02	0.03	0.02	0.97	1.05	0.93
C.D. (P = 0.05)	2.95	3.05	2.79	0.07	0.08	0.07	3.02	3.14	2.80

results were reported by Khan and Khan (2003).

Weed dry matter:

It is evident from pooled data (Table 3) shows that the untreated check (control) recorded significantly higher weed dry matter (43.55 g m^{-2}) at 60 DAS over weed free check (9.03 g m^{-2}). Application of pendimethalin 30% EC @ 0.75 kg a.i./ha PE *fb* quizalofop-P-ethyl 50 g a.i./ha at 20-30 DAS + one hoeing and pyrithiobac sodium @ 62.5 g a.i./ ha *fb* quizalofop-P-ethyl 50 g a.i./ ha at 20-30 DAS + one hoeing recorded lowest weed dry matter (14.63 and 15.15g m^{-2}) at 60 DAS as compared to application of pendimethalin 30% EC @ 0.75 kg a.i./ha PE + one hoeing, trifluralin @ 1.2 kg a.i./ ha PE + one hoeing, quizalofop-P-ethyl 50 g a.i./ha 30 DAS + one hoeing, pyrithiobac sodium @ 62.5 g a.i./ha at 20-30 DAS + one hoeing and glyphosate @ 1.0 kg a.i./ha as direct spray at 45 DAS, respectively. Similar findings showed that the cotton yield was reduced by 50 to 80 per cent with unchecked weed growth in Bt cotton (Rajendra and Jain, 2004).

Weed control efficiency:

Two years pooled data (Table 3) show that the under weed free check was recorded significantly higher weed control efficiency (68.91 %) over weedy check, application of pendimethalin 30% EC @ 0.75 kg a.i./ha PE + one hoeing, trifluralin @ 1.2 kg a.i./ha PE + one hoeing, quizalofop-P-ethyl 50 g a.i./ha 30 DAS + one hoeing, pyrithiobac sodium @ 62.5 g a.i./ha at 20-30 DAS + one hoeing and glyphosate @ 1.0 kg a.i./ha as direct spray at 45 DAS, respectively at 60 DAS. The application of pendimethalin 30% EC @ 0.75 kg a.i./ha PE *fb* quizalofop-P-ethyl 50 g a.i./ha at 20-30 DAS + one hoeing

Table 2 : Effect of weed management practices on yield attributes and seed cotton yield of Bt cotton

Treatments	Bolls plant^{-1}			Boll weight (g)			Seed cotton yield (kg ha^{-1})		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
Pendimethalin 30% EC @ 0.75 kg a.i. / ha PE + one hoeing	29.26	29.09	29.18	3.92	3.85	3.89	1848	1740	1794
Trifluralin @ 1.2 kg a.i. / ha PE + one hoeing	27.05	26.87	26.96	3.81	3.76	3.79	1772	1667	1720
Quizalofop-P- ethyl 50 g a.i. / ha 30 DAS + one hoeing	26.60	25.80	26.20	3.75	3.71	3.73	1726	1602	1664
Pendimethalin 30% EC @ 0.75 kg a.i. / ha PE *fb* quizalofop-P-ethyl 50 g a.i. / ha at 20-30 DAS + one hoeing	36.47	36.13	36.30	4.24	4.19	4.22	2304	2245	2275
Pyrithiobac Sodium @ 62.5 g a.i./ ha at 20-30 DAS + one hoeing	25.94	25.46	25.70	3.72	3.64	3.68	1700	1570	1635
Pyrithiobac Sodium @ 62.5 g a.i./ ha *fb* quizalofop-P- ethyl 50 g a.i./ha at 20-30 DAS + one hoeing	35.00	34.67	34.84	4.20	4.18	4.19	2297	2204	2251
Glyphosate @ 1.0 kg a.i./ha as direct spray at 45 DAS	19.80	19.59	19.70	3.43	3.37	3.40	1452	1395	1424
Weed free check	37.12	37.05	37.09	4.30	4.29	4.30	2378	2294	2336
Weedy check	17.00	16.80	16.90	3.36	3.30	3.33	1240	1188	1214
S.E. $\pm$	1.15	1.20	1.08	0.06	0.07	0.06	108	114	102
C.D. (P = 0.05)	3.48	3.66	3.25	0.19	0.22	0.18	330	345	307

Table 3 : Effect of weed management practices on weed population (m^{-2}), weeds dry matter and WCE of Bt cotton

Treatments	Weed population (m^2)			Weed dry matter (g m^2)			WCE (%)		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
Pendimethalin 30% EC @ 0.75 kg a.i. / ha PE + one hoeing	18.30	19.11	18.71	17.29	17.78	17.54	53.76	54.65	54.21
Trifluralin @ 1.2 kg a.i. / ha PE + one hoeing	19.65	20.98	20.32	18.08	18.90	18.49	52.15	53.90	53.03
Quizalofop-P- ethyl 50 g a.i. / ha 30 DAS + one hoeing	20.00	21.05	20.53	18.97	19.05	19.01	51.93	53.00	52.47
Pendimethalin 30% EC @ 0.75 kg a.i. / ha PE *fb* quizalofop-P-ethyl 50 g a.i. / ha at 20-30 DAS + one hoeing	12.00	12.78	12.39	14.59	14.67	14.63	61.29	60.20	60.75
Pyrithiobac Sodium @ 62.5 g a.i./ ha at 20-30 DAS + one hoeing	21.00	21.94	21.47	19.02	19.56	19.29	51.20	52.65	51.93
Pyrithiobac Sodium @ 62.5 g a.i./ ha *fb* quizalofop-P- ethyl 50 g a.i./ha at 20-30 DAS + one hoeing	14.00	14.53	14.27	15.05	15.24	15.15	58.08	58.94	58.51
Glyphosate @ 1.0 kg a.i./ha as direct spray at 45 DAS	24.01	24.67	24.34	21.44	21.86	21.65	45.21	46.01	45.61
Weed free check	6.50	6.80	6.65	8.96	9.10	9.03	67.55	70.27	68.91
Weedy check	48.00	56.00	52.00	42.10	45.00	43.55	0.00	0.00	0.00
S.E. $\pm$	1.29	1.34	1.20	0.57	0.69	0.58	1.21	1.30	1.15
C.D. (P = 0.05)	3.92	4.00	3.63	1.71	2.04	1.75	3.65	3.94	3.47

Table 4 : Effect of weed management practices on economics of Bt cotton

Treatments	Net return (Rs./ha)			B:C		
	2012	2013	Pooled	2012	2013	Pooled
Pendimethalin 30% EC @ 0.75 kg a.i. / ha PE + one hoeing	41284	39460	40372	2.10	2.00	2.05
Trifluralin @ 1.2 kg a.i. / ha PE + one hoeing	38576	36778	37677	1.94	1.85	1.89
Quizalofop-P- ethyl 50 g a.i. / ha 30 DAS + one hoeing	37458	34968	36213	1.92	1.79	1.86
Pendimethalin 30% EC @ 0.75 kg a.i. / ha PE *fb* quizalofop-P- ethyl 50 g a.i. / ha at 20-30 DAS + one hoeing	55432	55730	55581	2.69	2.71	2.70
Pyrithiobac Sodium @ 62.5 g a.i./ ha at 20-30 DAS + one hoeing	36300	33580	34940	1.83	1.70	1.76
Pyrithiobac Sodium @ 62.5 g a.i./ ha *fb* quizalofop-P- ethyl 50 g a.i./ha at 20-30 DAS + one hoeing	55101	54236	54669	2.66	2.62	2.64
Glyphosate @ 1.0 kg a.i./ha as direct spray at 45 DAS	29416	28930	29173	1.59	1.56	1.58
Weed free check	58674	58196	58435	2.96	2.94	2.95
Weedy check	23420	22892	23156	1.34	1.31	1.32
S.E. $\pm$	3045	3210	2877	0.15	0.17	0.15
C.D. (P = 0.05)	9267	9580	8560	0.43	0.49	0.44

and pyrithiobac Sodium @ 62.5 g a.i./ha *fb* quizalofop-P-ethyl 50 g a.i./ha at 20-30 DAS + one hoeing were found at par with each other in terms of weed control efficiency (60.75 and 58.51 %) in the pooled analysis. The higher WCE is attributed lower dry weight of weeds (Deshpande *et al*., 2006).

Economics:

Pooled data of two years show that (Table 4) the application of pendimethalin 30% EC @ 0.75 kg a.i./ha PE *fb* quizalofop-P-ethyl 50 g a.i./ha at 20-30 DAS + one hoeing was recorded significantly higher net returns (Rs. 55581/- ha^{-1}) and B:C (2.70) in the pooled analysis, but it was found at par with application of pyrithiobac sodium @ 62.5 g a.i./ha *fb* quizalofop-P-ethyl 50 g a.i./ ha at 20-30 DAS + one hoeing (Rs.54669/- ha^{-1}) and B:C (2.64) and weed free check (Rs.58435/- ha^{-1}) and B:C (2.95) over application of pendimethalin 30% EC @ 0.75 kg a.i./ha PE + one hoeing, trifluralin @ 1.2 kg a.i./ha PE + one hoeing, quizalofop-P-ethyl 50 g a.i./ha 30 DAS + one hoeing, pyrithiobac sodium @ 62.5 g a.i./ ha at 20-30 DAS + one hoeing, glyphosate @ 1.0 kg a.i./ ha as direct spray at 45 DAS and weedy check during both the years as well as in the pooled analysis. Similar results were reported by Srinivasan and Venkatesan (2002) who obtained the highest seed cotton yield.

Conclusion:

It could be concluded that, the application of pendimethalin 30 per cent EC @ 0.75 kg a.i./ha PE *fb* quizalofop-P-ethyl 50 g a.i./ha at 20-30 DAS + one hoeing and pyrithiobac sodium @ 62.5 g a.i./ ha *fb* quizalofop-P- ethyl 50 g a.i./ha at 20-30 DAS + one hoeing gave higher seed cotton yield and monitory return.

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