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Comparative efficacy of different herbicides on *Bt* cotton and their residual effect on succeeding crops

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ABSTRACT

The research work was conducted to study the comparative efficacy of different herbicides on *Bt* cotton and their residual effect on succeeding crops during **kharif** seasons of the years 2010, 2011 and 2012 at the farm of DWSR-Anand Centre, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat). Inter-culturing in conjunction with hand weeding carried out at 15, 30 and 45 DAS recorded minimum weed density with maximum weed control efficiency. The said treatment also recorded maximum seed cotton yield (3127 kg/ha) as well as additional profit over control (Rs. 46367/ha). The next best treatments in order : T_1–Pendimethalin @ 900 g/ha *fb* IC+HW at 30 and 60 DAS, T_2–Quizalofop-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS and T_5–Fenoxaprop-p-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS were found efficient and economical for weed management in *Bt* cotton. None of the herbicides applied at tested rates had adverse effect on succeeding wheat, chickpea and mustard crops.

Key words : Seed cotton, succeeding crops, weed density

INTRODUCTION

In India, manual and mechanical methods of weed control continue to be the major methods of weed control in any crop. These methods are cumbersome, though they are more effective in controlling weeds. The greatest competition usually occurs early in the growing season. Cotton yield is the product of interaction of several agronomic and environmental factors. Among the agronomic constraints of cotton production, weed infestations have historically been a major issue. Despite many advances in weed management technology, cotton growers still face significant challenges from weeds. In cotton, weeds cause several direct and/or indirect negative impacts viz., reducing fiber quality, reducing crop yield, increasing production costs and serving as hosts and habitats for insect-pests. Weeds can directly hinder cotton growth by competing for available resources and may be releasing allelopathic or growth-suppressing chemicals. Weeds are responsible for losses in cotton yield to the tune of 60% (Moolchand *et al.*, 2012). However, the degree of damage through competition of weeds is related to the types of weed flora, densities and duration of weed-cotton competition. Chemical weed control method is easy, time saving and effective in controlling weeds. Number of herbicides are recommended for each crop, in which most of selective and specific to the crop and persist in the soil for few months to a few years depending upon the chemical and concentration used. Hence, information regarding persistence and residual effect of herbicides in soil is essential to use them safely, effectively and for non-hazardous chemical weed control schedules. For that bioassay remains a major tool for qualitative and quantitative determination of herbicides residue in soil. Considering above facts, an attempt has been made to study the comparative efficacy of different herbicides on *Bt* cotton and their residual effect on succeeding crops.

MATERIALS AND METHODS

With a view to determine the comparative efficacy of different herbicides on *Bt* cotton and their residual effect on succeeding crops, the present investigation was conducted in **kharif** seasons of the years 2010 to 2012 at the farm of DWSR-Anand Centre, B. A. College

of Agriculture, Anand Agricultural University, Anand (Gujarat). The soil of experimental field was sandy loam in texture having low in available nitrogen, medium in available phosphorus and high in potassium with pH 8.15. The experiments was laid out in randomized complete block design with three replications. Twelve treatments comprised viz., pendimethalin 900 g/ha PE *fb* IC+HW at 30 and 60 DAS, quizalofop-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS, quizalofop-ethyl 100 g/ha POE, quizalofop-ethyl 100 g/ha POE *fb* IC+HW at 30 DAS, fenoxaprop-p-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS, fenoxaprop-p-ethyl 100 g/ha POE, fenoxaprop-p-ethyl 100 g/ha POE *fb* IC+HW at 30 DAS, IC+HW at 30 DAS *fb* glyphosate 1000 g/ha POE (protected spray) at 70 DAS, paraquat 500 g/ha POE (protected spray) *fb* IC+HW at 30 DAS, glyphosate 1000 g/ha POE (protected spray) *fb* IC+HW at 30 DAS, IC+HW at 15, 30 and 45 DAS and weedy check. The herbicides were applied using knapsack sprayer fitted with flat fan nozzle by mixing in 500 litre of water/ha as per treatments. The *Bt* cotton cv. VICH-5 BG-II was sown manually keeping the distance of 120 x 45 cm in all the three years of experimentation. After harvesting of the *Bt* cotton crop to know the residual effect of herbicides without disturbing the layout, each plot was manually prepared for sowing of succeeding crops. Four rows of each succeeding crop viz., chickpea, wheat and mustard were sown in each plot during **rabi** season at a recommended spacing of respective crop during all the three years of experimentation. The observations of succeeding crops viz., germination (No. of plants/m row length) at 10 DAS, while plant height (cm) and dry matter accumulation (g/ plant) of chickpea, wheat and mustard crops were recorded at 30 DAS and data were used for analysis.

RESULTS AND DISCUSSION

Effect on Weeds

Data presented in Table 1 indicate that the experimental field was infested with *Eragrostis major, Phyllanthus niruri, Eleusine indica, Digera arvensis, Echinochloa crusgalli, Dactyloctenium aegyptium* and *Boerhavia diffusa* and mean values of relative density of weeds recorded in weedy check on pooled basis were 48.4, 11.1, 9.7, 7.9, 6.9, 5.8 and 3.0%, respectively. Data on weed counts recorded at 25 and 50 DAS showed that significantly the lowest monocot, dicot and total weeds/m^2 were recorded in IC+HW carried out at 15, 30 and 45 DAS. Weed control efficiency (WCE) was recorded more than 72% in all the weed management treatments except treatment

Table 1. Weed flora and their relative density (%) in weedy check

S. No.	Monocot weeds/ Common name	Botanical name	Relative density (%)			
			2010	2011	2012	Mean
1.	Barnyard grass	*Echinochloa crusgalli* L.	7.0 (26)	8.3 (30)	5.5 (9)	6.9 (21.7)
2.	Goose grass	*Eleusine indica* (L.) Gaertn.	11.9 (44)	10.5 (38)	6.7 (11)	9.7 (31.0)
3.	Wild finger	*Dactyloctenium aegyptium* L.	5.9 (22)	6.6 (24)	4.9 (8)	5.8 (18.0)
4.	Love grass	*Eragrostis major* L.	56.3 (209)	56.4 (204)	32.5 (53)	48.4 (155.3)
	Other monocot weeds		4.3 (16)	2.8 (10)	7.4 (12)	4.8 (12.7)
	Dicot weeds/Common name					
1.	Pig weed	*Digera arvensis* Forst.	4.3 (16)	5.2 (19)	14.1 (23)	7.9 (19.3)
2.	Gripe weed	*Phyllanthus niruri* L.	6.2 (23)	7.5 (27)	19.6 (32)	11.1 (27.3)
3.	Creeping spiderling	*Boerhavia diffusa* L.	2.2 (8)	1.4 (5)	5.5 (9)	3.0 (7.3)
	Other dicot weeds		1.9 (7)	1.4 (5)	3.7 (6)	2.3 (6)

Figures in parentheses indicate original values.

Table 2. Number of monocot, dicot and total weeds as influenced by different weed management practices in *Bt* cotton (Pooled data)

S. No.	Treatments	Monocot weeds (No./m^2) at 25 DAS	Dicot weeds (No./m^2) at 25 DAS	Total weeds (No./m^2) at 25 DAS	Monocot weeds (No./m^2) at 50 DAS	Dicot weeds (No./m^2) at 50 DAS	Total weeds (No./m^2) at 50 DAS
1.	Pendimethalin 900 g/ha PE *fb* IC+HW at 30 and 60 DAS	5.2^{b} (26.8)	5.7^{c} (32.0)	7.7^{b} (58.8)	8.4^{a} (77.7)	3.1^{bc} (10.8)	9.1^{c} (87.4)
2.	Quizalofop-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS	5.5^{b} (29.4)	6.7^{abc} (43.8)	8.6^{b} (73.2)	7.4^{a} (58.4)	6.4^{a} (45.7)	9.9^{bc} (104.1)
3.	Quizalofop-ethyl 100 g/ha POE	5.8^{b} (32.7)	7.1^{ab} (49.9)	9.1^{b} (82.6)	10.7^{a} (131.8)	5.7^{a} (33.0)	11.4^{ab} (143.4)
4.	Quizalofop-ethyl 100 g/ha POE *fb* IC+HW at 30 DAS	5.4^{b} (29.4)	6.9^{ab} (46.8)	8.8^{b} (76.2)	7.9^{a} (62.7)	7.6^{a} (57.9)	10.9^{ab} (120.5)
5.	Fenoxaprop-p-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS	5.9^{b} (34.0)	6.4^{bc} (40.1)	8.7^{b} (74.1)	8.1^{a} (67.1)	6.1^{a} (38.6)	10.1^{abc} (105.7)
6.	Fenoxaprop-p-ethyl 100 g/ha POE	6.0^{b} (36.2)	6.5^{abc} (42.1)	8.9^{b} (78.3)	10.7^{a} (119.9)	5.3^{ab} (27.6)	10.6^{abc} (114.1)
7.	Fenoxaprop-p-ethyl 100 g/ha POE *fb* IC+HW at 30 DAS	5.6^{b} (31.4)	6.6^{abc} (42.6)	8.6^{b} (74.0)	7.6^{a} (60.1)	6.8^{a} (48.6)	10.2^{abc} (108.7)
8.	IC+HW at 30 DAS *fb* glyphosate 1000 g/ha POE (protected spray) at 70 DAS	14.4^{a} (220.4)	7.5^{ab} (56.1)	16.5^{a} (277.6)	7.8^{a} (65.8)	6.7^{a} (46.0)	10.4^{abc} (111.8)
9.	Paraquat 500 g/ha POE (protected spray) *fb* IC+HW at 30 DAS	6.9^{b} (46.6)	4.1^{d} (16.0)	7.9^{b} (62.6)	8.3^{a} (72.8)	5.5^{ab} (29.6)	10.0^{bc} (102.3)
10.	Glyphosate 1000 g/ha POE (protected spray) *fb* IC+HW at 30 DAS	6.7^{b} (44.12)	4.3^{d} (17.9)	7.8^{b} (61.1)	7.4^{a} (56.1)	5.4^{ab} (29.8)	9.2^{c} (86.8)
11.	IC+HW at 15, 30 and 45 DAS	1.0^{c} (0.0)	1.0^{c} (0.0)	1.0^{c} (0.0)	1.0^{b} (0.0)	1.0^{c} (0.0)	1.0^{d} (0.0)
12.	Weedy check	15.0^{a} (238.7)	7.6^{a} (57.7)	17.0^{a} (296.3)	10.2^{a} (109.8)	6.1^{a} (37.7)	11.9^{a} (147.4)
	S. Em±	1.19	0.36	0.83	1.01	0.48	0.95
	LSD (P=0.05)	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
	C. V. (%)	7.57	7.35	5.43	13.53	24.44	6.32
	Y x T S. Em±	0.30	0.25	0.29	0.62	0.77	0.95
	LSD (P=0.05)	0.86	0.70	0.82	1.76	NS	2.79

Original values in parentheses were transformed to √X+1. Sig. : Significant. NS : Not Significant.

Table 3. Yield and economics of *Bt* cotton as influenced by weed management practices

S. No.	Treatments	Seed cotton yield (kg/ha)	Stalk yield (kg/ha)	Total income (Rs./ha)	Additional income over control (Rs./ha)	Additional cost over control (Rs./ha)	Additional profit over control (Rs./ha)	ICBR	WCE at harvest (%)
1.	Pendimethalin 900 g/ha PE *fb* IC+HW at 30 and 60 DAS	3096	5350	129190	50472	5400	45072	1 : 8.35	83
2.	Quizalofop-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS	3014	5144	125704	46986	3700	43286	1 : 11.70	78
3.	Quizalofop-ethyl 100 g/ha POE	2345	4656	98456	19738	3200	16538	1 : 5.17	50
4.	Quizalofop-ethyl 100 g/ha POE *fb* IC+HW at 30 DAS	3063	5231	127751	49033	5000	44033	1 : 8.80	80
5.	Fenoxaprop-p-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS	2832	5112	118392	39674	3100	36574	1 : 11.80	72
6.	Fenoxaprop-p-ethyl 100 g/ha POE	2301	4566	96606	17888	2000	15888	1 : 7.94	48
7.	Fenoxaprop-p-ethyl 100 g/ha POE *fb* IC+HW at 30 DAS	2892	5105	120785	42067	3800	38267	1 : 10.07	74
8.	IC+HW at 30 DAS *fb* glyphosate 1000 g/ha POE (protected spray) at 70 DAS	2646	5044	110884	32166	3840	28326	1 : 7.38	68
9.	Paraquat 500 g/ha POE (protected spray) *fb* IC+HW at 30 DAS	2325	4953	97953	19235	3728	15507	1 : 4.16	55
10.	Glyphosate 1000 g/ha POE (protected spray) *fb* IC+HW at 30 DAS	2418	4997	101717	22999	3840	19159	1 : 4.98	64
11.	IC+HW at 15, 30 and 45 DAS	3127	5405	130485	51767	5400	46367	1 : 8.59	87
12.	Weedy check	1898	2798	78718	-	-	-	-	-

Table 4. Residual effect of herbicides applied in *Bt* cotton on succeeding **rabi** crops

S. No.	Treatments	Germination (No. of plants /m row legnth) at 10 DAS			Plant height (cm) at 30 DAS			Dry matter (g/plant) at 30 DAS		
		Chickpea	Wheat	Mustard	Chickpea	Wheat	Mustard	Chickpea	Wheat	Mustard
1.	Pendimethalin 900 g/ha PE *fb* IC+HW at 30 and 60 DAS	10.2	35.4	19.3	10.9	31.4	22.4	1.2	2.9	2.6
2.	Quizalofop-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS	10.1	35.7	19.3	11.1	31.7	22.4	1.3	2.7	2.6
3.	Quizalofop-ethyl 100 g/ha POE	10.0	35.8	19.4	10.8	31.5	22.3	1.2	2.3	2.5
4.	Quizalofop-ethyl 100 g/ha POE *fb* IC+HW at 30 DAS	10.0	35.7	19.3	10.8	31.8	22.3	1.3	2.9	2.7
5.	Fenoxaprop-p-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS	10.0	35.7	19.4	10.9	31.4	22.1	1.3	2.9	2.6
6.	Fenoxaprop-p-ethyl 100 g/ha POE	10.0	35.7	19.3	10.9	31.7	22.0	1.2	2.8	2.7
7.	Fenoxaprop-p-ethyl 100 g/ha POE *fb* IC+HW at 30 DAS	10.0	35.7	19.4	10.9	31.7	21.8	1.3	2.8	2.6
8.	IC+HW at 30 DAS *fb* glyphosate 1000 g/ha POE (protected spray) at 70 DAS	10.0	35.7	19.4	11.0	31.9	22.2	1.3	2.9	2.6
9.	Paraquat 500 g/ha POE (protected spray) *fb* IC+HW at 30 DAS	10.2	35.7	19.2	10.8	31.4	22.2	1.3	2.8	2.7
10.	Glyphosate 1000 g/ha POE (protected spray) *fb* IC+HW at 30 DAS	10.0	35.8	19.3	10.9	31.4	22.1	1.3	2.8	2.6
11.	IC+HW at 15, 30 and 45 DAS	10.1	35.0	19.2	10.9	31.6	22.2	1.2	2.8	2.6
12.	Weedy check	10.1	35.8	19.2	11.0	31.7	22.2	1.2	2.8	2.6
	S. Em±	0.10	0.26	0.16	0.31	0.17	0.22	0.02	0.07	0.06
	LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
	C. V. (%)	3.2	2.4	2.6	3.6	2.9	3.2	3.9	6.9	7.6
	Y x T S. Em±	0.19	0.50	0.29	0.23	0.31	0.41	0.03	0.11	0.11
	LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS : Not Significant.

IC+HW at 30 DAS *fb* glyphosate 1000 g/ha POE at 70 and 25 DAS. Further data indicated that treatments fenoxaprop-p-ethyl 100 g/ha POE and quizalofop-ethyl 100 g/ha POE were found poor in respect of control of monocot, dicot as well as total weeds at 50 DAS than that of other treatments. The lower weed count under said treatments may be attributed to the herbicidal and cultural practices followed in the respective treatments. Similar line of results was also reported by Nalayini *et al.* (2012). More than 85% WCE was recorded under all the weed management practices except treatments fenoxaprop-p-ethyl 100 g/ha POE and quizalofop-ethyl 100 g/ha POE, which recorded WCE of 52 and 55%, respectively, at 50 DAS. Unweeded check recorded the highest weed density and lower weed control efficiency in *Bt* cotton.

Effect on Crop

Seed cotton and stalk yield of *Bt* cotton were recorded and data are presented in Table 2. Seed cotton and stalk yield of *Bt* cotton were significantly higher in treatment IC+HW carried out at 15, 30 and 45 DAS than rest of the treatments barring treatment PE application of pendimethalin 900 g/ha PE *fb* IC+HW at 30 and 60 DAS, quizalofop-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS, quizalofop-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS, fenoxaprop-p-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS, fenoxaprop-p-ethyl 100 g/ha POE *fb* IC+HW at 30 DAS and IC+HW at 30 DAS *fb* glyphosate 1000 g/ha POE (protected spray at 70 DAS) except treatment with respect to stalk yield. Bhoi *et al.* (2010) reported the advantages of weed management methods recording significantly higher yield under weed free treatment. Further, higher yield under herbicidal treatments could be attributed to timely and effective control of weeds by applied herbicides coupled with cultural methods which resulted in better availability of soil moisture and nutrients which resulted in better nourishment of growth of the plants and thereby higher seed cotton yield. The results are in close conformity with the results of Gnanavel and Babu (2008).

Economics

The data on economic analysis of *Bt* cotton presented in Table 3 indicated that total income (Rs. 130485/ha), additional income over control (Rs.51757/ha) as well as maximum additional profit over control (Rs. 46367/ha) were recorded in treatment IC+HW carried out at 15, 30 and 45 DAS followed by PE application of pendimethalin 900 g/ha PE *fb* IC+HW at 30 and 60 DAS, quizalofop-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS, quizalofop-ethyl 50 g/ha POE *fb* IC+HW at 30 DAS and fenoxaprop-p-ethyl 100 g/ha POE *fb* IC+HW at 30 DAS. The ICBR values were found more than 1 : 8.35 in all the above weed management practices.

Bioassay Study

To know the residual effect of pre- and post-emergence application of herbicides in *Bt* cotton, succeeding crops viz., chickpea, wheat and mustard were sown and growth parameters viz., germination count (at 10 DAS), plant height as well as dry matter accumulation (at 30 DAS) were recorded. The results reported in Table 4 indicate that the differences due to different herbicidal treatments on growth parameters were found non-significant which indicated that there was no residual effect of pendimethalin, quizalofop-ethyl, fenoxaprop-p-ethyl, glyphosate and paraquat on succeeding crops.

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