

Efficiency of some herbicides and manual weeding for weed control in irrigated Bt cotton

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ABSTRACT

To evaluate the efficacy of some pre and post-emergence herbicides for weed control in Bt cotton (var. Beejdhhan 2), a field experiment was conducted during rainy seasons of 2014-15, 2015-16 and 2016-17 at Junagadh (Gujarat, India). The dominant weed flora in cotton field were *Digera arvensis*, *Eluopus villosus*, *Cyperus rotundus*, *Cynodon dactylon*, *Echinochloa crusgalli*, *Chenopodium album*, *Convolvulus arvensis*, *Trianthema monogyna*, *Amaranthus spinosus*, *Commelina benghalensis* and *Asphodelus tenuifolius*. The results revealed that treatments viz., hand weeding (HW) and interculturing (IC) at 30, 60 and 90 DAS, pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb HW and IC at 30 and 60 DAS, and pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb quizalofop 40 g ha⁻¹ as post-emergence at 45 DAS were found superior to the unweeded check in enhancing growth and yield attributes viz., plant height, number of monopodial and sympodial branches plant⁻¹, number of bolls plant⁻¹, single boll weight and seed cotton weight plant⁻¹ and ultimately increased seed cotton and stalk yields. These treatments also recorded lower dry weight of weeds and weed index along with higher weed control efficiency, net return and B:C ratio as compared to unweeded check.

Key words: Cotton, Glyphosate, Imazethapyr, Oxadiargyl, Pendimethalin, Quizalofop.

INTRODUCTION

Cotton is the most remunerative and important cash crop of India, particularly in Gujarat. After the development of high yielding, pest and diseases resistance Bt hybrids and availability of irrigation water due to adoption of different water harvesting techniques, area under cotton in the Saurashtra region of Gujarat is increasing day by day. Among the various factors responsible for deplorably low yield of irrigated cotton, severe weed infestation is important particularly in India. Initial slow growth, wide row spacing, high dose of chemical fertilizers combined with prostrate nature of its growth permit early and severe crop-weed competition resulting in loss of yield to the tune of 45 to 85% (Das, 2008). At present, manual weeding has become costly due to scarcity of labourers and hence it has become extremely difficult to keep the crop weed free. Effective and economical weed control in irrigated cotton is possible through integrating pre- and post-emergence herbicides along with hand weeding and interculturing (Shelke *et al.*, 2013; Patel *et al.*, 2014). Effectiveness of newly developed post-emergence herbicides viz., quizalofop, oxadiargyl, imazethapyr and glyphosate needs to be tested for irrigated cotton and hence, an experiment was undertaken to evaluate the efficacy of some pre and post-emergence herbicides for weed control in irrigated Bt cotton.

MATERIALS AND METHODS

A field experiment was conducted at Weed Control Research Farm, Department of Agronomy, Junagadh Agricultural University, Junagadh (Gujarat, India) during rainy seasons of 2014-15, 2015-16, 2016-17. The soil of the experimental plot was clayey in texture and slightly alkaline in reaction (pH 7.8 and EC 0.32 dS m⁻¹), low in available nitrogen (219 kg ha⁻¹), available phosphorus (22.7 kg ha⁻¹) and medium in available potash (243 kg ha⁻¹). The experiment comprising of 10 treatments viz., T₁: Pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb hand weeding (HW) and interculturing (IC) at 30 and 60 DAS, T₂: Oxadiargyl 90 g ha⁻¹ as pre-emergence fb HW and IC at 30 and 60 DAS, T₃: Pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb Pendimethalin 0.9 kg ha⁻¹ as herbigation at 45 DAS, T₄: Pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb Quizalofop 40 g ha⁻¹ as post-emergence at 45 DAS, T₅: Pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb Imazethapyr @ 75 g ha⁻¹ as post-emergence at 45 DAS, T₆: Pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb Oxadiargyl 90 g ha⁻¹ as post-emergence at 45 DAS, T₇: Pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb Glyphosate 0.96 kg ha⁻¹ as post-emergence directed spray at 75 DAS, T₈: HW and IC at 30, 60 and 90 DAS, T₉: Weed free, and T₁₀: Unweeded check, were laid out in randomized block design with three replications. The Bt cotton hybrid 'Beejdhhan 2' was sown at 120 cm x 45 cm spacing using

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seed rate of 1 kg ha⁻¹. FYM 15 t ha⁻¹ was incorporated in soil at the time of preparatory tillage. The crop was fertilized with 160-0-120 kg N-P₂O₅-K₂O ha⁻¹, of which 120 kg K₂O ha⁻¹ as muriate of potash and 40 kg N ha⁻¹ as ammonium sulphate were applied as basal, while 40 kg N ha⁻¹ as urea was top-dressed each at 30, 60 and 90 DAS. The pre-emergence herbicides were applied to soil on the next day of sowing. The knapsack sprayer fitted with flat fan nozzle was employed for spraying pre- and post-emergence herbicides using spray volume of 500 L ha⁻¹. Weed dry weight of weeds was recorded at harvest. Weed index (WI) and weed control efficiency (WCE) were worked out using following formulae suggested by Gill and Kumar (1969) and Kondap and Upadhyay (1985).

$$WI = \frac{Y_{WF} - Y_T}{Y_{WF}} \times 100$$

Where; YWF and YT are the yield from weed-free plot and yield from treated plot, respectively.

$$WCE (\%) = \frac{D_{WC} - D_{WT}}{D_{WC}} \times 100$$

Where, DW_C = Dry matter accumulation of weeds in unweeded control, DW_T = Dry matter accumulation of weeds in treated plot.

RESULTS AND DISCUSSION

Weed flora: The major weed flora observed in the cotton field were *Digera arvensis*, *Eluopus villosus*, *Cyperus rotundus*, *Cynodon dactylon*, *Echinochloa crusgalli*, *Chenopodium album*, *Convolvulus arvensis*, *Trianthema monogyna*, *Amaranthus spinosus*, *Commelina benghalensis* and *Asphodelus tenuifolius*.

Growth and yield attributes: An appraisal of data presented in Table-1 showed that growth and yield attributes of cotton were significantly influenced by different weed management practices. Significantly the highest plant height, number of monopodial and sympodial branches plant⁻¹, number of bolls plant⁻¹, single boll weight and seed cotton weight plant⁻¹ were recorded under the weed free check (T₉), however it

remained at par with HW at 30, 60 and 90 DAS (T₈), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb HW at 30 & 60 DAS (T₁) and pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb quizalofop 40 g ha⁻¹ at 45 DAS (T₄) in respect of number of monopodial and sympodial branches plant⁻¹, number of bolls plant⁻¹ and seed cotton weight plant⁻¹, and with HW at 30, 60 and 90 DAS (T₈), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb HW at 30 and 60 DAS (T₁) in case of plant height and single boll weight. Whereas, significantly the lowest values of these growth and yield attributes were registered under the weedy check (T₁₀). Periodical removal of weeds (T₈) or herbicide application supplemented with hand weeding and interculturing (T₁ and T₂) suppressed weeds, which in turn provided better weed free environment to the crop during critical period for growth and development. Singh and Kokate (2010) and Patel *et al.* (2014) also reported similar results.

Cotton yields: The data furnished in Table-2 showed that different weed management treatments significantly influenced the seed cotton yield during individual years and in pooled results. The weed free check (T₉) out yielded by producing significantly the highest seed cotton yield of 20.52, 19.74, 21.68 and 20.65 q ha⁻¹ during 2014-15, 2015-16, 2016-17 and in pooled results, respectively, however it remained statistically at par with HW at 30, 60 and 90 DAS (T₈), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb HW at 30 and 60 DAS (T₁), and pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb quizalofop 40 g ha⁻¹ at 45 DAS (T₄) during 2014-15, 2016-17 and pooled results, and with HW at 30, 60 and 90 DAS (T₈), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb HW at 30 and 60 DAS (T₁), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb quizalofop 40 kg ha⁻¹ at 45 DAS (T₄), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb herbigation of pendimethalin 0.9 kg ha⁻¹ as lay-by application (T₃) and pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb directed spray of glyphosate 0.96 kg ha⁻¹ at 75 DAS (T₇) in 2015-16. The yield increment with treatments T₉, T₈, T₁ and T₄ over the unweeded control (T₁₀) was to the tune of 268,

Table 1: Effect of weed management treatments on growth and yield attributes of cotton (Pooled over three years)

Treatment	Plant height (cm)	Number of monopodial branches plant ⁻¹	Number of sympodial branches plant ⁻¹	Number of bolls plant ⁻¹	Single boll weight (g)	Seed cotton weight plant ⁻¹ (g)
T ₁ : Pen+HW	112.2	1.58	14.35	32.00	4.94	102.8
T ₂ : Oxa+HW	90.1	1.40	13.08	23.70	3.64	74.9
T ₃ : Pen+Pen	103.2	1.50	13.75	31.20	4.70	96.4
T ₄ : Pen+Qui	105.5	1.56	14.24	31.32	4.80	100.9
T ₅ : Pen+Ima	101.9	1.41	13.40	27.00	4.76	85.4
T ₆ : Pen+Oxa	99.7	1.48	13.36	30.60	4.07	77.8
T ₇ : Pen+Gly	100.2	1.49	13.12	26.50	3.95	94.9
T ₈ : HW	116.7	1.61	14.53	33.50	5.08	105.6
T ₉ : WF	119.3	1.67	15.21	33.90	5.14	110.4
T ₁₀ : UWC	84.8	1.13	10.41	18.10	3.57	62.4
LSD (P=0.05)	13.0	0.12	1.01	2.60	0.32	12.9

Table 2: Effect of weed management treatments on cotton yield.

Treatment	Seed cotton yield (q ha ⁻¹)				Stalk yield (q ha ⁻¹)			
	2014	2015	2016	Pooled	2014	2015	2016	Pooled
T ₁ : Pen+HW	20.12	19.00	20.92	20.01	37.39	36.22	35.35	36.32
T ₂ : Oxa+HW	10.89	9.07	7.85	9.27	27.03	25.97	19.08	24.02
T ₃ : Pen+Pen	14.38	17.07	15.75	15.73	31.37	33.24	31.49	32.03
T ₄ : Pen+Qui	19.89	18.63	20.40	19.64	36.81	35.65	34.51	35.66
T ₅ : Pen+Ima	13.70	14.37	8.62	12.23	30.60	32.33	21.43	28.12
T ₆ : Pen+Oxa	12.03	9.69	7.46	9.73	30.39	23.20	18.07	23.88
T ₇ : Pen+Gly	12.71	16.54	9.26	12.84	31.09	32.60	20.61	28.10
T ₈ : HW	20.33	19.27	21.13	20.24	37.66	36.79	35.32	36.59
T ₉ : WF	20.52	19.74	21.68	20.65	39.99	36.81	36.85	37.88
T ₁₀ : UWC	5.61	4.58	6.64	5.61	15.91	13.03	17.57	15.50
LSD (P=0.05)	2.99	4.20	2.96	1.89	8.16	8.27	5.70	4.12

Table 3: Effect of weed management treatments on weed parameters and economic returns.

Treatment	Weed dry weight (kg ha ⁻¹)				WI (%)	WCE (%)	Net return (₹ ha ⁻¹)	B:C
	2014	2015	2016	Pooled				
T ₁ : Pen+HW	328	203	322	284	3.06	83.43	60,146	2.47
T ₂ : Oxa+HW	1150	1534	1211	1298	55.11	24.32	5,916	1.14
T ₃ : Pen+Pen	683	280	556	506	23.80	70.49	39,083	1.97
T ₄ : Pen+Qui	488	260	393	380	4.87	77.82	58,734	2.46
T ₅ : Pen+Ima	861	289	926	692	40.77	59.65	21,197	1.52
T ₆ : Pen+Oxa	938	1394	1330	1220	52.89	28.86	8,501	1.21
T ₇ : Pen+Gly	810	849	864	841	37.83	50.98	24,918	1.62
T ₈ : HW	209	188	264	220	1.96	87.16	57,992	2.31
T ₉ : WF	78	68	62	69	0.00	95.97	57,644	2.24
T ₁₀ : UWC	1446	1818	1883	1715	72.82	0.00	-9,091	0.76
LSD (P=0.05)	299	420	296	189				

Pen=Pendimethalin, HW=Hand weeding, Oxa=Oxadiargyl, Qui=Quizalofop, Ima=Imazethapyr, Gly=Glyphosate, WF=Weed free, UWC=Unweeded check

Market price (₹ kg⁻¹): Pendimethalin: 400, Imazethapyr: 1750, Oxadiargyl: 930, Glyphosate: 270, Quizalofop: 1280, Seed cotton: 50, Cotton stalk: 0.5

261, 257 and 250%, respectively. Significantly the lowest seed cotton yield (5.61, 4.58, 6.64 and 5.61 q ha⁻¹) was observed under the unweeded control (T₁₀) during all the three years and in pooled results.

The data furnished in Table-2 revealed that different weed management treatments significantly influenced the stalk yield of cotton during all the years and in pooled results. The weed free check (T₉) recorded significantly the highest stalk yield of 39.99, 36.81, 36.85 and 37.88 kg ha⁻¹ during 2014-15, 2015-16, 2016-17 and in pooled results, respectively, however it remained statistically at par with HW at 30, 60 and 90 DAS (T₈), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb HW at 30 and 60 DAS (T₁), and pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb quizalofop 40 g ha⁻¹ at 45 DAS (T₄) during 2014-15 and pooled results, with HW at 30, 60 and 90 DAS (T₈), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb HW at 30 and 60 DAS (T₁), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb quizalofop 40 g ha⁻¹ at 45 DAS (T₄), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb herbigation of pendimethalin 0.9 kg ha⁻¹ as lay-by application (T₃), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb imazethapyr 75 g ha⁻¹ at 45 DAS (T₅) and

pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb directed spray of glyphosate 0.96 kg ha⁻¹ at 75 DAS (T₇) in 2015-16, and with HW at 30, 60 and 90 DAS (T₈), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb HW at 30 and 60 DAS (T₁), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb quizalofop 40 g ha⁻¹ at 45 DAS (T₄) and pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb herbigation of pendimethalin 0.9 kg ha⁻¹ as lay-by application (T₃) in 2016-17. The increase in stalk yield with treatments T₉, T₈, T₁ and T₄ over the unweeded control (T₁₀) was to the extent of 144, 136, 134 and 130%, respectively. The unweeded control (T₁₀) registered significantly the lowest stalk yield (15.91, 13.03, 17.57 and 15.50 kg ha⁻¹) during all the three years and in pooled results. Effective control of weeds by manual weeding and/or herbicides under the above superior treatments might have reduce crop-weed competition for moisture, nutrients and sunlight and ultimately enhanced photosynthetic and metabolic activities in the crop, which reflected in improved growth and development of the crop and finally increased seed cotton and stalk yields. Similar results were also reported by Nadanassababady *et al.* (2002) and Yadav *et al.* (2006).

Weed parameters: The data (Table-3) indicated that different weed management treatments exerted significant effect on dry weight of weeds during 2014-15, 2015-16, 2016-17 and in pooled results. All the weed management treatments including weed free treatment significantly reduced dry weight of weeds over the unweeded check (T_{10}). During all the individual years and in pooled results, the weed free treatment (T_9) recorded significantly the lowest weed dry weight (78, 68, 62 and 69 kg ha⁻¹), which was statistically comparable to HW at 30, 60 and 90 DAS (T_8) in 2014-15 and 2016-17 and to HW at 30, 60 and 90 DAS (T_8), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb HW at 30 and 60 DAS (T_1), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb quizalofop 40 g ha⁻¹ at 45 DAS (T_4), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb herbigation of pendimethalin 0.9 kg ha⁻¹ as lay-by application (T_3) and pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb imazethapyr 75 g ha⁻¹ at 45 DAS (T_5) in 2015-16. Whereas, the unweeded check (T_{10}) recorded the highest dry weight of weeds (1446, 1818, 1883 and 1715 kg ha⁻¹).

Mean data of weed index (WI) and weed control efficiency (WCE) were given in Table-3. The results showed that treatments viz., HW at 30, 60 and 90 DAS (T_8), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb HW at 30 and 60 DAS (T_1) and pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb quizalofop 40 g ha⁻¹ at 45 DAS (T_4) recorded lower WI of 1.96, 3.06 and 4.87%. Similarly, the weed free check (T_9) recorded the highest WCE of 95.97%, followed by treatments viz., HW at 30, 60 and 90 DAS (T_8), pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb HW at 30 and 60 DAS (T_1) and pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb quizalofop 40 kg ha⁻¹ at 45 DAS (T_4) by recording WCE of 87.16, 83.43 and 77.82%, respectively. Weed suppression during initial stage by hand weeding and/or pre-emergence pendimethalin supplemented with manual

weeding or post-emergence quizalofop in the later stage provided effective control of weeds as evident from lower dry weight of weeds and excellent weed indices under the above treatments. The superiority of pendimethalin (Singh and Kokate, 2010; Patel *et al.*, 2014; Singh and Rathore, 2015) and quizalofop (Shelke *et al.*, 2013) was reported earlier.

Economic returns: Economics was worked out by using current market prices of produce and inputs used (Table-3). Application of pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb HW at 30 and 60 DAS (T_1) recorded maximum net returns of Rs.60,146 ha⁻¹, closely followed by pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb quizalofop 40 g ha⁻¹ at 45 DAS (T_4) and HW at 30, 60 and 90 DAS (T_8) which gave net returns of Rs.58,734 and 57,992 ha⁻¹, respectively.

The maximum B:C ratio of 2.47 was accrued with pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb HW at 30 and 60 DAS (T_1), closely followed by pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb quizalofop 40 g ha⁻¹ at 45 DAS (T_4) and HW at 30, 60 and 90 DAS (T_8) by recording B:C ratio of 2.46 and 2.31, respectively. Higher yield and comparatively less cost with these treatments gave higher returns over the unweeded check. Similar results were reported by Sankaranarayanan *et al.* (2002) and Madhu *et al.* (2014).

CONCLUSION

Economical and efficient control of weeds along with higher yield of Bt cotton could be achieved by pre-emergent application of pendimethalin 0.9 kg ha⁻¹ fb HW and IC at 30 and 60 DAS or sequential application of pendimethalin 0.9 kg ha⁻¹ as pre-emergence fb quizalofop 40 g ha⁻¹ as post-emergence at 45 DAS or HW at 30, 60 and 90 DAS on clayey soils of south Saurashtra agro-climatic zone of Gujarat.

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