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Integrated Weed Management in *Rabi* Sweet Corn (*Zea mays* L. var. *Saccharata*)

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Abstract

A field experiment was conducted during *rabi* 2010-11 at Junagadh (Gujarat, India) to find out most efficient and economical method of weed control in *rabi* sweet corn (*Zea mays* L. var. *saccharata* Sturt). The pre-emergence (PRE) herbicides viz., atrazine, pendimethalin and oxadiargyl were combined either with hand weeding (HW) and interculturing (IC) or with post-emergence (POST) herbicide 2, 4-D (SS) to evolve integrated weed management. The weed flora of the experimental site constituted *Digera arvensis*, *Cyperus rotundus, Brachiaria* spp., *Asphodelus tenuifolius, Indigofera glandulosa, Amaranthus viridis, Acanthospermum hispidum, Panicum colonum, Launaea nudicaulis, Euphorbia hirta, Chenopodium album, Portulaca oleracea, Dactyloctenium aegyptium* and *Celosia argentea*. The results revealed that physical methods viz., weed free, HW and IC twice at 15 and 30 days after sowing (DAS) as well as integrated methods viz., atrazine @ 0.5 kg a.i. /ha as PRE+HW and IC at 30 DAS and pendimethalin @ 0.9 kg a.i. /ha as PRE+HW and IC at 30 DAS significantly enhanced growth and yield attributes ultimately higher cob and fodder yields over unweeded check. The treatments viz., weed free, HW and IC twice at 15 and 30 DAS, atrazine @ 0.5 kg a.i. /ha as PRE+HW and IC at 30 DAS, and pendimethalin @ 0.9 kg a.i. /ha as PRE+HW and IC at 30 DAS also recorded the lower weed population at 30, 60 DAS and at harvest, dry weight of weed at harvest with lower weed index and higher weed control efficiency and herbicidal efficiency index. These treatments were found economical by recording higher net returns and B: C ratio compared to unweeded check.

Keywords: Sweet corn; *Zea mays* L. var. *saccharata* Sturt; Atrazine; Pendimethalin; Oxadiargyl, 2, 4-D.

Introduction

Maize is considered as the "Queen of Cereals". Being a C_4 plant, it is capable to utilize solar radiation more efficiently even at higher radiation intensity. In Indian agriculture, maize assumes a special significance on account of its utilization as food, feed and fodder besides several industrial uses. Sweet corn (*Zea mays* L. var. *saccharata* Sturt), also called Indian corn, sugar corn and pole corn, is a variety of maize with a high sugar content. Nature of weed problem in *rabi* maize is quite different from that of the rainy season maize. In the rainy season emergence of maize and weed start simultaneously and first 20-30 days are most critical looking to crop-weed competition. Contrarily in the winter maize, weed emerges most often after the first irrigation. However, wider row spacing and liberal use of irrigation and fertilizers lead to more growth of weeds [1]. Yield loss due to weed in maize varies from 28 to 93%, depending on the type of weed flora and intensity and duration of crop-weed competition [2]. Pre-emergence application of herbicides may lead to cost effective control of the weeds right from the start which otherwise may not be possible by manual weeding. The study was carried out to find economically effective method of weed control for realising higher productivity and profitability of *rabi* sweet corn.

Materials and Methods

The experiment was carried out at Instructional Farm, Department of Agronomy, Junagadh Agricultural University, Junagadh (Gujarat, India) during *rabi*-2010-11. The experimental soil was clayey in texture and low in available N and P, and moderate in available potash. Sweet corn variety 'Sugar-75' was used in the experiment. The temperature ranged from 9.7 to 20.6°C during *rabi* season. The crop was sown on 11th December with the seed rate of 15 kg/ha at spacing of 60 cm x 20 cm. Standard package of practices was followed throughout the cropping season. The crop was harvested on 27th March.

To evolve integrated weed management, pre-emergence (PRE) herbicides viz., atrazine, pendimethalin and oxadiargyl were combined either with hand weeding (HW) and interculturing (IC) or with post-emergence (POST) herbicide 2, 4-D (SS) to evolve integrated weed management. The experiment comprised nine treatments, namely, (1) Atrazine @ 0.5 kg a.i./ha as PRE+HW & IC at 30 days after sowing (DAS), (2) Pendimethalin @ 0.9 kg a.i./ha as PRE+HW & IC at 30 DAS, (3) Oxadiargyl @ 90 g a.i./ha as PRE+HW & IC at 30 DAS, (4) Atrazine @ 0.5 kg a.i./ha as PRE+2,4-D (SS) @ 0.5 kg a.i./ha as POST at 30 DAS, (5) Pendimethalin @ 0.9 kg a.i./ha as PRE+2,4-D (SS) @ 0.5 kg a.i./ha as POST at 30 DAS, (6) Oxadiargyl @ 90 g a.i./ha as PRE+2,4-D (SS) @ 0.5 kg a.i./ha as POST at 30 DAS, (7) HW & IC twice at 15 & 30 DAS, (8) weed free and (9) weedy check, were replicated thrice in randomized block design.

Pre-emergence herbicides were applied next day of sowing and post-emergence herbicide was sprayed at 30 DAS. The spraying was done using knapsack sprayer with flat fan nozzle keeping spray volume of 500 L/ha. Weeding was done by labours and interculturing was done by bullock drawn harrow in between two rows of the crop. In manual weed control treatments, weeds were uprooted and removed at 30 DAS as per treatment. In weed free plots, the weeds were removed manually after every seven days for ensuring complete weed free condition.

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Growth and yield attributes as well as cob and fodder yields were recorded at harvest of the crop. Number of weeds (monocots, dicots and sedge) was counted at 30, 60 DAS and harvest using 1 m x 1 m quadrat from each plot. At harvest time, after uprooting of weeds, the weeds were sun-dried completely till reached to constant weight and finally the dry weight was recorded for each treatment and expressed as kg/ha. Weed control efficiency (WCE), weed index (WI) and herbicide efficiency index (HEI) were calculated by the formulae suggested by Kondap and Upadhayay (1985), Gill and Kumar (1969) and Krishnamurthy et al., respectively [3-5].

$$WCE(\%) = \frac{DW_C - DW_T}{DW_C} \times 100$$

Where, DW_C and DW_T are dry matter accumulation of weeds in unweeded control and treated plot, respectively.

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

Where; Y_{WF} and Y_T are the yield from weed-free plot and yield from treated plot, respectively.

$$HEI = \frac{Y_T - Y_C}{Y_C} \times 100$$

Where, Y_t and Y_c are yield from treated and unweeded control plot, respectively.

The data were subjected to statistical analysis by adopting appropriate analysis of variance as described by Gomez and Gomez [6]. Wherever the F values were found significant at 5 per cent level of probability, the critical difference (C.D. at 5%) values were computed for making comparison among the treatment means. The data on weed count were subjected to square root transformation [6]. Gross returns (monetary income from cob and fodder yields), net returns (monetary income obtained after deducting cost of cultivation from gross returns) and B:C ratio (gross returns divided by cost of cultivation) were calculated using prevailing market price of inputs (including treatments), labour and produce for assessing the economic viability of treatments.

Results and Discussion

Weed flora

The weed flora in the experimental site constituted by monocot weeds viz., *Brachiaria* spp. (19.0%), *Asphodelus tenuifolius* Cav. (9.5%), *Indigofera glandulosa* L. (8.8%), *Panicum coloratum* L. (2.4%) and *Dactyloctenium aegyptium* (L.) Willd (1.3%) and dicot weeds viz., *Digera arvensis* Forsk (21.0%), *Amaranthus viridis* L. (6.0%), *Acanthospermum hispidum* DC. (3.7%), *Launaea nudicaulis* L. (2.3%), *Euphorbia hirta* L. (2.0%), *Chenopodium album* L. (1.6%), *Portulaca oleracea* L. (1.4%), and *Celosia argentea* L. (1.0%) and sedge weed *Cyperus rotundus* L. (20.0%).

Crop growth and yield

Growth and yield attributes as well as cob and fodder yield were significantly influenced by different weed control practices (Table 1). Results showed that significantly the highest cob length (22.95 cm), cob girth (16.25 cm), number of cobs per plant (1.40), number of kernels per cob (275.67), fresh weight of cob (136.06 g), highest dry weight of cob (41.97 g), cob yield (7674 kg/ha) and fodder yield (37659 kg/ha) were recorded under weed free. However, the weed free treatment remained statistically equivalent to HW & IC at 15 & 30 DAS atrazine @ 0.5 kg a.i./ha as PRE+HW and IC at 30 DAS and pendimethalin @ 0.9 kg a.i./ha as PRE+HW & IC at 30 DAS. The improved growth and yield attributes under these treatments might be due to periodical removal of weeds by hand weeding or pre-emergence herbicide supplemented with manual weeding and interculturing as evidenced by less number of weeds and dry weight of weeds (Table 2), which might have maintained high soil fertility status and moisture content by means of less removal

Treatments	Cob length (cm)	Cob girth (cm)	Cobs per plant	Kernels per cob	Fresh weight of cob (g)	Dry weight of cob (g)	Green cob yield (kg/ha)	Green fodder yield (kg/ha)
Atrazine+HW & IC	20.85	14.91	1.28	267.33	130.43	36.40	6271	34572
Pendimethalin+HW & IC	20.81	13.87	1.27	261.00	126.81	34.35	6292	33329
Oxadiargyl+HW & IC	20.71	13.40	1.25	243.03	120.60	28.95	5861	28097
Atrazine+2,4-D (SS)	20.62	13.98	1.26	252.03	126.48	35.28	5997	30333
Pendimethalin+2,4-D (SS)	20.69	13.78	1.25	246.04	126.00	33.53	5986	30309
Oxadiargyl+2,4-D (SS)	20.56	13.61	1.20	235.33	122.10	28.71	5799	27704
HW & IC twice	22.32	15.71	1.35	270.33	132.10	40.36	6642	35769
Weed free	22.95	16.25	1.40	275.67	136.06	41.97	7674	37659
Weedy check	17.47	12.75	1.15	225.33	117.83	25.19	5382	25590
C.D. (P=0.05)	2.79	2.10	0.14	31.66	10.71	7.41	1186	5702

Table 1: Effect of different treatments on growth and yield.

Treatments	Monocot weeds per m²			Dicot weeds per m²			Sedge weeds per m²			Dry weight of weed (kg/ha)
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	
Atrazine+HW & IC	2.24 (4.53)	1.83 (2.87)	1.42 (1.53)	1.74 (2.53)	1.42 (1.53)	1.37 (1.41)	2.52 (5.87)	1.83 (2.87)	1.79 (2.73)	322.92
Pendimethalin+HW & IC	2.29 (4.77)	1.89 (3.10)	1.50 (1.77)	1.80 (2.77)	1.60 (2.10)	1.57 (2.00)	2.62 (6.43)	2.05 (3.77)	2.00 (3.60)	431.60
Oxadiargyl+HW & IC	3.14 (9.54)	2.87 (7.87)	2.65 (6.64)	2.74 (7.20)	2.70 (6.87)	2.67 (6.79)	3.50 (11.9)	2.87 (7.87)	2.85 (7.75)	477.08
Atrazine+2,4-D (SS)	2.96 (8.46)	2.78 (7.46)	2.61 (6.46)	2.64 (6.79)	2.55 (6.46)	2.51 (6.28)	3.27 (10.3)	2.96 (8.26)	2.93 (8.13)	412.50
Pendimethalin+2,4-D (SS)	3.04 (8.92)	2.81 (7.58)	2.62 (6.58)	2.76 (7.25)	2.53 (6.25)	2.54 (6.23)	3.26 (10.3)	3.00 (8.52)	2.98 (8.38)	437.85
Oxadiargyl+2,4-D (SS)	3.81 (14.1)	3.64 (12.8)	3.44 (11.3)	3.53 (12.1)	3.36 (10.8)	3.35 (10.7)	4.05 (16.1)	3.89 (14.8)	3.85 (14.6)	525.00
HW & IC twice	2.20 (4.38)	1.58 (2.04)	1.38 (1.42)	1.95 (3.38)	1.34 (1.30)	1.24 (1.05)	1.96 (3.38)	1.73 (2.58)	1.70 (2.46)	183.33
Weed free	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.00
Weedy check	5.52 (30.1)	6.72 (44.8)	6.91 (47.5)	5.05 (25.1)	6.25 (38.8)	6.49 (41.8)	6.29 (39.1)	6.80 (45.8)	6.83 (46.3)	882.64
C.D. (P=0.05)	0.71	0.61	0.62	0.76	0.66	0.68	0.61	0.56	0.54	94.59

Table 2: Effect of different treatments on weed parameters.
Note: $\sqrt{x+0.5}$ transformation and figures in parenthesis are original values.

Treatment	WI	WCE	HEI	Gross returns (`/ha)	Cost of cultivation (`/ha)	Net returns (`/ha)	B:C
Atrazine+HW & IC	18.28	63.41	16.52	97281	34520	62761	2.82
Pendimethalin+HW & IC	18.01	51.10	16.91	96247	35370	60877	2.72
Oxadiargyl+HW & IC	23.63	45.95	8.90	86708	35170	51538	2.47
Atrazine+2,4-D (SS)	21.85	53.27	11.43	90299	33670	56629	2.68
Pendimethalin+2,4-D (SS)	22.00	50.39	11.22	90170	34370	55800	2.62
Oxadiargyl+2,4-D (SS)	24.43	40.52	7.75	85691	34170	51521	2.51
HW & IC twice	13.45	79.23	23.41	102193	35270	66923	2.90
Weed free	0.00	100.0	42.59	114396	36470	77926	3.14
Weedy check	29.87	0.00	0.00	79410	32870	46540	2.42

Table 3: Effect of different treatments on weed index, weed control efficiency, herbicidal efficiency index and economics

Market Price: Commodity`/kg			Herbicide	:	`/kg or L
Urea	:	5.87	Atrazine	:	350
DAP	:	19.50	Pendimethalin	:	400
Green cob	:	10.00	Oxadiargyl	:	1080
Green fodder	:	1.00	2,4-D (SS)	:	400

of plant nutrients and moisture by weeds. These findings are in close conformity with those reported by Sinha et al., Kolage et al., Mandal et al., Kamble et al. and Deshmukh et al. [7-11].

Weed parameters

The weed management treatments significantly influenced the weed population (Table 2). The weed free check recorded the lowest weed population. HW & IC at 15 & 30 DAS also recorded significantly lower weed population, which remained statistically at par with atrazine @ 0.5 kg a.i./ha as PRE+HW & IC at 30 DAS and pendimethalin @ 0.9 kg a.i./ha as PRE+HW & IC at 30 DAS. Except weed free, the lowest dry weight of weed was observed under HW & IC at 15 & 30 DAS, though it was found statistically at par with atrazine @ 0.5 kg a.i./ha as PRE+HW & IC at 30 DAS. A perusal of data presented in Table 2 indicated that besides weed free, HW & IC at 15 & 30 DAS contained minimum WI, while maximum WCE and HEI, closely followed by pendimethalin @ 0.9 kg a.i./ha as PRE+HW & IC at 40 DAS and atrazine @ 0.5 kg a.i./ha as PRE+HW & IC at 30 DAS. This might be attributed to the effective control of weeds under these treatments, which reflected in less number of weeds and ultimately lower weed biomass. In addition to this, dense crop canopy might have suppressed weed growth and ultimately less biomass. The weedy check recorded significantly the highest number and dry weight of weeds owing to uncontrolled condition favoured luxurious weed growth leading to increased density and dry matter of weeds (Table 3). These findings are in close conformity with those reported by Sinha et al., Kolage et al. and Verma et al. [8,12,13].

Economics

The investigated data revealed that maximum net returns of `77926/ha and B:C of 3.14 were realized with weed free treatment, followed by HW & IC at 15 & 30 DAS and atrazine @ 0.5 kg/ha as PRE+HW & IC at 30 DAS. The lowest net returns of ` 46540/ha was accrued under treatment weedy check with B: C value of 2.42. The higher benefit under these treatments might be due to higher production of cob as well as fodder leading to increased monetary returns with comparatively lower cost. These findings are in close vicinity with those reported by Malviya and Singh, Rao et al., and Sunitha et al. [14-16].

Conclusion

On the basis of the results obtained from present field study, it can be concluded that effective management of weeds with profitable green cob and fodder yield of sweet corn in *rabi* season can be obtained by keeping the crop weed free throughout crop period or adopting two hand weeding and interculturing at 15 and 30 DAS. However under paucity of labours, pre-emergence application of atrazine @ 0.5 kg a.i./ha+HW & IC at 30 DAS or pendimethalin @ 0.9 kg a.i. /ha as pre-emergence+HW & IC at 30 DAS would be the better option under south Saurashtra Agro-climatic conditions.

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