EVALUATION OF HERBICIDE MIXTURES FOR WEED CONTROL IN MAIZE (*Zea mays* L.) UNDER MIDDLE GUJARAT CONDITIONS

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ABSTRACT

A field experiment was carried out to evaluate the herbicide mixtures for weed control in maize (Zea mays L.) under middle Gujarat conditions at College Agronomy Farm, Gujarat Agricultural University, Anand during Kharif seasons of 2001-2002 and 2002-2003. The experiment was laid out in a randomized block design with four replications. The treatments comprised of viz., atrazine, alachlor and metolachlor each @ 1.0 kg a.i./ha, metribuzin @ 0.30 kg a.i./ha, pendimethalin @ 0.5 kg a.i./ha and their feasible mixtures were applied at half of the rate, weed free (2 hand weeding at 20 & 40 days after sowing) and weedy check. It was observed that maximum weed control efficiency (> 98 %) was achieved with pre-emergence application of atrazine @ 0.5 kg a.i./ha in combination with pendimethalin @ 0.25 kg a.i./ha and atrazine + alachlor each applied @ 0.5 kg a.i./ha and twice hand weeding carried out at 20 and 40 DAS. Similar trend was observed in grain yield.

Key words: *Herbicide mixtures, maize, hand weeding, weed control efficiency*

INTRODUCTION

Maize is one of the most important cereal crops in the world's agriculture economy both as food for human being and feed for animals. There are about 100 weed species in 66 genera and 24 plant families known to be problematic for maize in the country as they affect [1]Principal, N. M. College of Agriculture, NAU, Navsari, Gujarat, India on the growth and development of maize. Weeds are generally vigorous growers and their nutrient requirements are often greater than that of the crop plants. The magnitude of yield reduction due to infestation of grassy weeds, non-grassy weeds and sedges alone has been reported around 84.4, 31.7 and 21.5 per cent, respectively (Pandey *et al*. 1999). Chemical weed control is a better supplement to conventional methods and forms an integral part of the modern crop production. Most of the presently available herbicides provide only a narrow spectrum weed control. Many of them have activity only on annual species, while a few are only effective against perennials. Continuous usage of same herbicide or similar herbicides year after year over several years do certainly lead to elimination of sensitive weed species but leave out the tolerant weed species resulting in a gradual buildup of their population. Hence, use of two different chemicals with different mode of action enhanced the efficacy of weed control. Similarly, Thomson (1984) suggested combination of atrazine with pendimethalin for broad-spectrum weed control. Keeping in view the present investigation was carried out to study the effect of herbicide mixtures on weed growth and yield of maize.

MATERIALS AND METHODS

Field experiment was carried out for two consecutive rainy (*Kharif*) seasons of 2001-2002 and 2002-2003 at College Agronomy Farm, Anand Agricultural University, Anand.

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Geographically, Anand is situated at 22^0 - 35' N latitude, 72^0 - 55' E longitude at an altitude of about 45.1 meters above the mean sea level. The soil was sandy loam in texture having low in available nitrogen and medium in available phosphorus and high in potassium with pH 7.8. The experiment was laid out in randomized complete block design (RCBD) with four replications involving 16 treatments comprising atrazine, alachlor & metolachlor each @ 1.0 kg a.i./ha, metribuzin @ 0.30 kg a.i./ha, pendimethalin @ 0.50 kg a.i./ha and their feasible mixtures were applied at half of the rate in comparison with twice hand weedings carried out at 20 and 40 DAS and weedy check. Total 64 plots were laid out in the field with the plot size of 5.0 m x 3.6 m. The seeds of Gujarat Maize-4 were dibbled manually at 60 cm between and 20 cm within the line @ 25 kg seed/ha during the first week of July in both the years. All the herbicides were applied as pre-emergence using Knapsack sprayer fitted with flat fan nozzle by mixing in 500 L of water/ha as per treatment. After sowing of the seed immediately a light irrigation was given to the crop for uniform germination and next day the herbicide was spray as per the treatment. Full dose of phosphorus and half dose of the nitrogen through diammonium phosphate and urea were applied at the time of sowing and remaining quantity of nitrogen was applied at knee-high stage. The rainfall in two cropping seasons during 2001-02 and 2002-03 were 484 mm and 1110 mm, respectively. In general, weather conditions were favourable for plant growth and no severe pest and diseases noticed during both the years of experimentation. The package of recommended practices was adopted to maintain the crop. The observations of weed density and their dry matter were taken randomly from 1.0 m^2 quadrat from net plot area at 3 spots from each treatment and data were transformed to square root before their statistical analysis. Weed control efficiency (WCE) was calculated on the basis of formula suggested by Mani *et al*., (1973).

$$WCE = \frac{DWC-DWT}{DWC} \times 100$$

Where,

WCE = Weed Control Efficiency

DWC = Dry weight of weeds from control plot

DWT = Dry weight of weeds from treated plot

RESULTS AND DISCUSSION

The predominant weed flora of the experimental field was *Eleusine indica* (L.) Gartn., *Dactyloctinum aegyptium* (L.) P. Beauv., *Echinochloa crusgalli* P. Beauv., *Eragrostis major* Host., *Digitaria sanguinalis* (L.) Scop., as narrow leaved weeds and *Phyllanthus niruri* L., *Digera arvensis* Frosk., *Euphorbia hirta* L., *Boerhavia diffusa* L. as broad leaved weeds.

Table 01: Effect of various herbicidal treatments on weed density, weed dry matter and weed control efficiency (WCE)

Treatment	Dose (kg a.i./ha)	Weed density (No./m^2) at harvest			Weed dry matter (kg /ha) at harvest			WCE on Pooled basis (%)
		2001-02	2002-03	Pooled	2001-02	2002-03	Pooled	
T_1 : Atrazine	1.00	4.89^{efg} (23.00)	5.83^{def} (33.00)	5.36^{def} (28.00)	599.80^{cd}	667.41^{e}	633.6^{cd}	81
T_2 : Alachlor	1.00	6.74^{bcd} (44.50)	7.92^{bc} (61.75)	7.33^{bc} (53.13)	987.00^{b}	1097.50^{c}	1042.3^{b}	69
T_3 : Metolachlor	1.00	7.26^{b} (51.75)	8.48^{b} (71.00)	7.87^{b} (61.38)	1019.84^{b}	1213.30^{bc}	1116.6^{b}	66
T_4 : Metribuzin	0.30	6.84^{bc} (45.75)	8.06^{bc} (64.00)	7.45^{bc} (54.88)	1053.57^{b}	1284.60^{b}	1169.1^{b}	65
T_5 : Pendimethalin	0.50	6.10^{bcde} (36.25)	7.05^{cd} (48.75)	6.58^{cd} (42.50)	739.50^{c}	905.25^{d}	822.4^{c}	75
T_6 : Atrazine + Alachlor	0.50 + 0.50	2.64^{ij} (6.00)	3.67^{gh} (12.50)	3.15^{hi} (9.25)	55.56^{h}	74.41^{h}	65.0^{g}	98
T_7 : Atrazine + Pendimethalin	0.50 + 0.25	1.93^{j} (2.75)	2.64^{h} (6.00)	2.28^{i} (4.38)	28.77^{h}	40.50^{h}	34.6^{g}	99
T_8 : Atrazine + Metolachlor	0.50 + 0.50	2.87^{hij} (7.25)	3.63^{gh} (12.25)	3.25^{ghi} (9.75)	157.40^{gh}	238.80^{g}	198.1^{fg}	94
T_9 : Atrazine + Metribuzin	0.50 + 0.15	4.15^{fg} (16.25)	4.95^{ef} (23.50)	4.55^{ef} (19.88)	280.36^{fg}	347.25^{fg}	313.8^{f}	90
T_{10} : Metolachlor + Metribuzin	0.50 + 0.15	4.05^{gh} (15.50)	4.76^{fg} (21.75)	4.40^{efg} (18.63)	185.76^{fgh}	262.30^{fg}	224.0^{fg}	93
T_{11} : Metolachlor + Pendimethalin	0.50 + 0.25	3.70^{ghi} (12.75)	4.77^{fg} (21.75)	4.23^{fgh} (17.25)	255.90^{fg}	349.35^{fg}	302.6^{f}	91
T_{12} : Alachlor + Metolachlor	0.50 + 0.50	5.74^{cde} (32.00)	6.13^{de} (36.75)	5.94^{d} (34.38)	547.62^{d}	617.60^{e}	607.6^{d}	82
T_{13} : Alachlor + Pendimethalin	0.50 + 0.25	5.38^{ef} (28.00)	6.53^{d} (41.75)	5.96^{d} (34.88)	347.42^{ef}	413.89^{f}	380.7^{ef}	88.
T_{14} : Alachlor + Metribuzin	0.50 + 0.15	5.45^{de} (28.75)	6.59^{d} (42.50)	6.02^{d} (35.63)	503.97^{de}	600.55^{e}	552.3^{de}	83
T_{15} : Weed free (HW at 20 & 40 DAS)		4.95^{efg} (23.5)	6.10^{de} (36.25)	5.54^{de} (29.88)	48.50^{h}	64.98^{h}	56.7^{g}	98
T_{16} : Weedy check		12.93^{a} (166.25)	13.94^{a} (193.75)	13.43^{a} (179.88)	3065.48^{a}	3598.21^{a}	3331.8^{a}	--
S. Em. ±		0.13	0.13	0.12	54.59	49.78	62.06	--
C. D. (P=0.05)		Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	--
C.V. (%)		5.02	4.12	4.53	17.69	13.47	15.41	--

(Figures in parentheses indicate original values. Mean followed by common letter (s) in column are not significant by DNMRT at 5 % level of significance)

Effect on Weeds

Results presented in Table 01 clearly indicated that application of herbicide alone or as in mixtures reduced the density and dry matter of weeds significantly compared to unweeded check during the year 2001-2002, 2002-2003 and in pooled basis. Among different herbicidal treatments, significantly lower number of total weeds was noted in treatment of atrazine + pendimethalin but was at par with treatment atrazine in combination with alachlor and atrazine with metolachlor, whereas, significantly the highest numbers of total weeds were observed under weedy check treatment during 2001-2002, 2002-2003 and in pooled analysis, respectively. The minimum number of total weeds under application of atrazine + pendimethalin, atrazine + alachlor and atrazine + metolachlor might be due to longer persistence of these chemicals up to harvest. Treatments of metolachlor, metribuzin and alachlor applied as alone recorded significantly higher number of weeds as compared to all the herbicidal treatments but all were significantly superior to weedy check.

Dry weight of weeds was significantly altered due to different treatments during individual years as well as in pooled analysis (Table 01). Significantly lower dry weight of weeds (28.8 kg/ha) was achieved under treatment of atrazine + pendimethalin but was at par with weed free, atrazine + alachlor, atrazine + metolachlor and

metolachlor + metribuzin while, unweeded control recorded significantly the highest dry weight of weeds (3331.8 kg/ha) during 2001-2002. Application of herbicidal mixtures was found to be effective in reducing weed growth and infestation which resulted in poor dry weight of weeds. Among herbicides applied alone, atrazine and pendimethalin both being at par with each other showed their superiority over treatments metribuzin, metolachlor and alachlor. Gill *et al*. (1985) also observed lower dry weight of weeds under application of atrazine and pendimethalin as compared to weedy check in maize. Data on weed control efficiency (WCE) indicated that all the treatments in general gave more than 64 per cent weed control efficiency. The maximum weed control efficiency was observed under treatment of atrazine in combination with pendimethalin (99 %) followed by weed free treatment (98 %), atrazine + alachlor (98 %), atrazine + metolachlor (94 %), metolachlor + metribuzin (93 %) and metolachlor + pendimethalin (91 %). Higher weed control efficiency recorded under said treatments is as a result of better control of all types of weeds by herbicides and manual removal of weeds in weed free treatment. Shah and Koul (1990) and Thakur (1994) observed higher WCE under twice hand weeding carried out at 20 and 40 DAS in maize crop. More or less similar trend was also noticed for the year 2002-03 and in pooled analysis.

Table 02: Effect of various herbicidal treatments on yield attributes and yields of maize (Mean of 2 years)

Treatment	Dose (kg a.i./ha)	Cob length (cm)	Cob Girth (cm)	No. of grains/ cob	Test weight (g)	Grain yield (kg /ha)
T_1 : Atrazine	1.00	19.66^{b}	12.64^{b}	413.25^{cde}	19.4^{c}	3386^{bcd}
T_2 : Alachlor	1.00	19.50^{b}	12.53^{b}	406.50^{cdef}	19.3^{c}	3254de
T_3 : Metolachlor	1.00	18.95^{c}	12.25^{b}	378.13^{f}	18.5^{d}	3065^{e}
T_4 : Metribuzin	0.30	17.34^{d}	11.68^{c}	328.63^{g}	17.4^{e}	2439^{f}
T_5 : Pendimethalin	0.50	19.63^{b}	12.63^{b}	415.63^{bcde}	19.4^{c}	3314^{cd}
T_6 : Atrazine + Alachlor	0.50 + 0.50	20.49^{a}	13.43^{a}	435.25^{abc}	20.2^{ab}	3582^{ab}
T_7 : Atrazine + Pendimethalin	0.50 + 0.25	20.66^{a}	13.58^{a}	456.50^{a}	20.4^{a}	3652^{a}
T_8 : Atrazine + Metolachlor	0.50 + 0.50	20.50^{a}	13.33^{a}	428.75^{abc}	20.2^{ab}	3548^{ab}
T_9 : Atrazine + Metribuzin	0.50 + 0.15	20.25^{a}	13.19^{a}	424.88^{abcd}	19.7^{bc}	3489^{abc}
T_{10} : Metolachlor + Metribuzin	0.50 + 0.15	20.46^{a}	13.29^{a}	434.25^{abc}	20.1^{ab}	3494^{abc}
T_{11} : Metolachlor + Pendimethalin	0.50 + 0.25	20.44^{a}	13.33^{a}	427.75^{abc}	20.1^{ab}	3491^{abc}
T_{12} : Alachlor + Metolachlor	0.50 + 0.50	19.53^{b}	12.42^{b}	394.38^{def}	19.5^{c}	3271^{d}
T_{13} : Alachlor + Pendimethalin	0.50 + 0.25	20.45^{a}	13.33^{a}	439.00^{abc}	20.1^{ab}	3509^{abc}
T_{14} : Alachlor + Metribuzin	0.50 + 0.15	19.53^{b}	12.50^{b}	391.63^{ef}	19.5^{c}	3240de
T_{15} : Weed free (HW at 20 & 40 DAS)		20.68^{a}	13.66^{a}	448.13^{ab}	20.4^{a}	3658^{a}
T_{16} : Weedy check		14.64^{e}	10.49^{d}	243.50^{h}	13.6^{f}	1947^{g}
S. Em. ±		0.17	0.14	9.85	0.18	62.83
C. D. (P=0.05)		Sig.	Sig.	Sig.	Sig.	Sig.
C.V. (%)		4.37	3.76	6.83	2.65	10.85

(Mean followed by common letter (s) in column are not significant by DNMRT at 5 % level of significance)

Effect on Crop

All the weed control treatments proved significantly superior to unweeded control with respect to yield attributes and yield of maize. Increase in cob length, cob girth, no. of grains/cob and final yield of maize were observed due to different weed control treatments (Table 2). Hand weeding carried out at 20 and 40 DAS recorded maximum girth and length of cob followed by pre-emergence application of atrazine @ 0.50 kg a.i./ha in combination with pendimethalin @ 0.25 kg a.i./ha or atrazine + alachlor. Whereas, maximum number of grains/cob and test weight were recorded with pre-emergence application of atrazine @ 0.50 kg a.i./ha in combination with pendimethalin @ 0.25 kg a.i./ha followed by twice hand weeding carried out at 20 and 40 DAS. In general, twice hand weeding and pre-emergence application of atrazine @ 0.50 kg a.i./ha in combination with pendimethalin @ 0.25 kg a.i./ha were found to be superior and recorded higher grain yield (3658 and 3652 kg/ha, respectively) as compared to all the treatments of herbicide applied alone, alachlor + metolachlor, alachlor + metribuzin and weedy check. Higher grain yield under treatments of atrazine + pendimethalin, weed free, atrazine + alachlor, atrazine + metolachlor, alachlor + pendimethalin, metolachlor + metribuzin, metolachlor + pendimethalin and atrazine + metribuzin may be due to the fact that effective control of weeds and minimum dry weight of weeds lead to direct increase in uptake of nutrient and thereby proper growth and development of crop which resulted in higher girth and length of cob, number of grains/cob and test weight ultimately resulting into increased grain yield. To support this, Gill *et al*. (1977) and Durkic and Knezevic (1996) reported that combined application of atrazine and alachlor (T_6) recorded higher grain yield of maize, while Bially (1995) observed that application of atrazine in combination with pendimethalin or metolachlor (T_7 & T_8) resulted in significantly increase in the grain yield over other treatments.

CONCLUSION

Based on the findings emerged out from the present investigation, use of herbicide mixtures as pre-emergence application rather than a single herbicide is more effective in weed control in *Kharif* maize or if labourers are available easily then twice hand weeding done at 20 and 40 DAS was also found to be effective for weed control.

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