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Efficacy of Atrazine based Post-Emergence Herbicide Mixtures on Weed Dynamics and Maize (*Zea mays* L.) Productivity in Sub-Humid Southern Plain of Rajasthan

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A B S T R A C T

A field experiment was conducted on clay loam soil during *kharif*, 2017 at Instructional Agronomy Farm, Rajasthan College of Agriculture, Udaipur to find out the effect of herbicides and their tank mix application on weed dynamics, growth and yield of maize. The post-emergence tank mix application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS reduced weed density, weed dry matter and improved weed control efficiency of monocot, dicot and total weed at 60 DAS. The maximum number of cob/plant (1.47), cob weight/plant (154.94 g) and weight of grain/cob (119.17 g), number of grain row/cob (15.33), number of grain/row (29.67), test weight (228.33 g) and shelling percentage (76.94%) were obtained by weed control through tank mix applicationn of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS. Similarly, application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS also resulted in significantly higher grain, stover and biological yield compared to rest of treatments. Likewise, it was also superior most with respect to all the yield attributes, yield and shelling% as compared to the other treatment.

Introduction

Maize (*Zea mays* L.) is the third most important cereal in the world; it is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. In India, maize occupies 9.25 million ha area with production and productivity of 23.67 million tonnes and 2.53 t /ha respectively. Maize is highly productive crop with diversified uses, mainly as food and feed for livestock. It is an important source of carbohydrate, protein, iron, vitamin B, and minerals. Over 85% of its production in India is consumed as various processed foods like starch, corn syrup, popcorn, corn oil, corn flakes, roasted ears, biscuits, instant upma, instant kesari bhat, ready to eat maize puffs, chapaties. Apart from genetic and climatic factors the productivity of maize is very much affected by management issues. Among various factors of maize cultivation during rainy season weeds are considered to be of prime importance responsible for the low yield. The competition stress of weeds on crop for nutrients, water, light and space is

responsible for poor yield of maize (Kumar *et al*., 2015). In Rajasthan, maize is grown mainly during rainy season and weather conditions of crop growing season are conducive to excessive weed infestation. The excessive occurrence of weeds limits the full expression of yield potential of this crop. Maize is infested by a wide range of weed flora; *Commelina benghalensis, Echinochloa colona, Trianthema portulacastrum, Cyperus rotundus and Digera arvensis* dominate during early stages of the crop growth whereas *Dactyloctenium aegyptium and Physalis minima* dominate toward the tasseling and maturity of the crop (Rao *et al*., 2009).

The most critical period for crop-weed competition is first six weeks after planting of crop which may reduce yield by 28-100% (Dass *et al*., 2012). During this period, weeding is essentially required physical and mechanical means are expensive and many times timely operations are not possible due to continuous rains in monsoon season (Chopra and Angiras, 2008). Thus, attention must be focused on weed control measures to maintain the competitive ability of the threatened crop by minimizing weed interference during the critical growth phase of the crop. Most of the available herbicides for maize are applied as pre-emergence and these not effectively control the weed flora emerged during critical period of crop-weed competition. Under the existing practice, application of single herbicide under diverse and mixed weed flora does not provide satisfactory weed control for the desired period. Moreover, continuous use of single herbicide is known to result in the evolution of herbicide-resistance in weed species and shift in weed flora (Thakur and Sharma, 1997, Malviya and Singh, 2007). Atrazine alone has been widely used as pre-emergence herbicides for controlling of the weeds in maize under monocultures (Barla *et al*., 2016).Considering these facts and paucity of research finding, the present study was planned with objective to evaluate the effect of atrazine based post-emergence herbicide mixtures and their time of application on weed dynamics, growth and yield of maize.

Materials and Methods

The experiment was carried out at research farm of Raasthan college of Agriculture, Udaipur (24°35’ N latitude and 73°42’ E longitude.an altitude of 582.5 meter above mean sea level).The soil of experimental had low in nitrogen, medium in phosphorus, high in potassium and slightly alkaline and calcarious in nature.

The soil of the experimental field was clay loam in texture. The experiment was laid out in randomized block design with 13 treatment combination tested were as follows weedy check, atrazine 0.5 kg/ha at 10 DAS, atrazine 0.5 kg/ha at 15 DAS, atrazine 0.5 kg/ha at 20 DAS, atrazine 0.5 kg/ha + halosulfuron 0.09 kg/ha at 10 DAS, atrazine 0.5 kg/ha + halosulfuron 0.09 kg/ha at 15 DAS, atrazine 0.5 kg/ha + halosulfuron 0.09 kg/ha at 20 DAS, atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 10 DAS, atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS, atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 20 DAS, atrazine 0.5 kg/ha + topramezone 0.118 kg/ha at 10 DAS, atrazine 0.5 kg/ha + topramezone 0.118 kg/ha at 15 DAS and atrazine 0.5 kg/ha + topramezone 0.118 kg/ha at 20 DAS. The result were analyzed taking consideration of wed parameters such as as weed density, weed dry matter, weed control efficiency and plant parameter such as plant population, plant dry matter, plant height, number of cob/plant, cob weight/plant (g) and weight of grain/cob (g), number of grain row/cob, number of grain/row, test weight (g) and shelling percentage, grain yield, stover yield and biological yield.

Weed control efficiency was calculated at 60 DAS using the following formula (Mani *et al*., 1968).

Grain samples were drawn from the produce after weighing the net yield of each plot.From these,1000 grain were counted and weighing to record test weight (g). Biological yield was calculated by summing up the weight of thoroughly, grain and stover and expressed in t/ha.

Results and Discussion

Weed studies

The data reflected that proportion of density of monocot to dicot weeds in weedy check plots at 60 DAS 1:0.36. Likewise the dry matter record in corresponding plots revealed that the monocot versus dicot weed proportion was 1:0.40 at 60 DAS. The magnitude of existence of monocot and dicot weeds indicated that the crop suffered stress from a mixed flora of weeds.

The results (Table 1) indicated that all herbicide treatments either alone or tank mix application caused marked reduction in weed density and dry matter of monocot, dicot and total weeds at 60 DAS.

However, the trend of effects of weed control treatments was not similar for monocot and dicot weeds. In respect of total weeds, post-emergence application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS significantly reduced the weed density and total weed dry matter at 60 DAS followed by post-emergence application of atrazine 0.5 kg/ha + topramezone 0.118 kg/ha at 15 DAS compared to other weed control treatments.

The results corroborate the findings of Stanzen *et al.,* (2016) and Rana *et al.,* (2017). Maximum weed control efficiency of total weeds at 60 DAS was observed with application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS (97.49%) followed by atrazine 0.5 kg/ha + topramezone 0.118 kg/ha at 20 DAS (96.91%).

Crop studies

Plant population of maize was not significantly affected by weed control treatments. It was clear from data in (Table 2). that combination of herbicide and herbicide alone have no significant influence on plant population at harvest.The post-emergence application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS recorded the highest plant height at 60 DAS which was higher to rest of the treatments.

The per cent increase in plant height due to this treatment was 24.44%, over weedy check. The maximum dry matter accumulation at 60 DAS was recorded under post-emergence application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS treatment with the corresponding per cent increase of 57.89% compared to weedy check. The maximum number of cob/plant (1.47), cob weight/plant (154.94 g), weight of grain/cob (119.17 g), number of grain row/cob (15.33), number of grain/row (29.67), test weight (228.33 g) and shelling percentage (76.94%) were obtained by weed control through atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS. The result also has been reported by Singh *et al.,* (2012), Rao *et al.,* (2009), Nazreen and Subramanyam (2017).

The per cent increse in seed yield due to post-emergence application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS and post-emergence application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS was 121.37 and 109.89 respectively, over weedy check.

Table.1 Effect of treatments on weed density (No./m^2), weed dry matter (g/m^2) and weed control efficiency (%) at 60 DAS in maize

Treatments	Weed density*			weed dry matter			weed control efficiency		
	60 DAS			60 DAS			60 DAS		
	Monocot weeds	Dicot weeds	Total weeds	Monocot weeds	Dicot weeds	Total weeds	Monocot weeds	Dicot weeds	Total weeds
Weedy check	12.65 (159.47)	7.58 (57.04)	14.73 (216.50)	104.93	42.46	147.40	0.00	0.00	0.00
Atrazine 0.5 kg ha^{-1} at 10 DAS	5.66 (31.54)	3.55 (12.12)	6.64 (43.66)	19.78	8.98	28.76	81.13	78.70	80.45
Atrazine 0.5 kg ha^{-1} at 15 DAS	5.97 (35.19)	3.67 (13.01)	6.98 (48.20)	22.24	9.63	31.87	78.80	77.30	78.38
Atrazine 0.5 kg ha^{-1} at 20 DAS	6.47 (41.41)	4.43 (19.12)	7.81 (60.53)	25.76	14.12	39.88	75.45	66.70	72.93
Atrazine 0.5 kg ha^{-1} + Halosulfuron 0.09 kg ha^{-1} at 10 DAS	5.15 (26.03)	3.05 (8.84)	5.95 (34.86)	16.28	6.60	22.88	84.48	84.40	84.47
Atrazine 0.5 kg ha^{-1} + Halosulfuron 0.09 kg ha^{-1} at 15 DAS	5.11 (25.64)	3.48 (11.59)	6.14 (37.23)	15.73	8.62	24.35	85.00	79.59	83.46
Atrazine 0.5 kg ha^{-1} + Halosulfuron 0.09 kg ha^{-1} at 20 DAS	6.25 (38.55)	3.85 (14.36)	7.31 (52.91)	24.60	10.67	35.27	76.52	74.72	76.03
Atrazine 0.5 kg ha^{-1} + Tembotrione 0.125 kg ha^{-1} at 10 DAS	2.62 (6.39)	2.35 (5.01)	3.45 (11.40)	4.00	3.71	7.71	96.19	91.26	94.78
Atrazine 0.5 kg ha^{-1} + Tembotrione 0.125 kg ha^{-1} at 15 DAS	1.96 (3.34)	1.57 (1.97)	2.41 (5.31)	2.24	1.46	3.71	97.86	96.55	97.49
Atrazine 0.5 kg ha^{-1} + Tembotrione 0.125 kg ha^{-1} at 20 DAS	2.31 (4.85)	1.82 (2.81)	2.85 (7.66)	3.18	2.09	5.27	96.97	95.10	96.43
Atrazine 0.5 kg ha^{-1} + Topramezone 0.025 kg ha^{-1} at 10 DAS	2.61 (6.30)	2.00 (3.53)	3.21 (9.83)	4.10	2.62	6.73	96.09	93.80	95.43
Atrazine 0.5 kg ha^{-1} + Topramezone 0.025 kg ha^{-1} at 15 DAS	2.10 (3.91)	1.71 (2.44)	2.62 (6.35)	2.74	1.81	4.54	97.39	95.72	96.91
Atrazine 0.5 kg ha^{-1} + Topramezone 0.025 kg ha^{-1} at 20 DAS	2.76 (7.10)	2.72 (6.88)	3.81 (13.98)	5.35	5.13	10.48	94.90	87.90	92.88
SEm ±	0.09	0.08	0.10	0.59	0.55	0.92	NA	NA	NA
LSD(P=0.05)	0.26	0.23	0.29	1.71	1.59	2.70			

(*$\sqrt{x+0.5}$ Transformed values and Data in parenthesis are original values); NA: Not analysed

Table.2 Effect of herbicides on different yield attributes of maize

Treatment	Number of row/cob	Number of grain/row	Number of cob/plant	Cob weight(g)/plant	Weight. of grain(g)/cob	Test weight (g)
Weedy check	12.00	22.00	1.07	117.77	68.00	210.00
Atrazine 0.5 kg ha^{-1} at 10 DAS	13.33	25.67	1.12	147.62	106.08	213.33
Atrazine 0.5 kg ha^{-1} at 15 DAS	12.67	26.67	1.13	144.75	109.58	214.00
Atrazine 0.5 kg ha^{-1} at 20 DAS	12.00	27.33	1.17	147.10	105.40	219.33
Atrazine 0.5 kg ha^{-1} + Halosulfuron 0.09 kg ha^{-1} at 10 DAS	12.67	25.33	1.20	135.27	88.40	212.33
Atrazine 0.5 kg ha^{-1} + Halosulfuron 0.09 kg ha^{-1} at 15 DAS	14.67	25.00	1.13	136.32	83.17	215.33
Atrazine 0.5 kg ha^{-1} + Halosulfuron 0.09 kg ha^{-1} at 20 DAS	12.67	24.33	1.13	143.70	83.33	213.00
Atrazine 0.5 kg ha^{-1} + Tembotrione 0.125 kg ha^{-1} at 10 DAS	13.33	27.67	1.27	151.74	114.23	219.33
Atrazine 0.5 kg ha^{-1} + Tembotrione 0.125 kg ha^{-1} at 15 DAS	15.33	29.67	1.47	154.94	119.17	228.33
Atrazine 0.5 kg ha^{-1} + Tembotrione 0.125 kg ha^{-1} at 20 DAS	14.67	27.67	1.37	152.33	105.55	224.33
Atrazine 0.5 kg ha^{-1} + Topramezone 0.025 kg ha^{-1} at 10 DAS	14.00	27.33	1.33	147.10	104.17	218.33
Atrazine 0.5 kg ha^{-1} + Topramezone 0.025 kg ha^{-1} at 15 DAS	14.67	28.67	1.40	152.85	113.53	226.67
Atrazine 0.5 kg ha^{-1} + Topramezone 0.025 kg ha^{-1} at 20 DAS	12.67	27.67	1.33	147.10	112.67	223.33
SEm ±	0.67	0.53	0.07	1.66	2.11	3.05
LSD (P=0.05)	1.95	1.55	0.22	4.86	6.17	8.91

Table.3 Effect of herbicides on plant population, plant height (cm), plant dry matter (g/plant), grain yield (t/ha), stover yield (t/ha), biological yield (t/ha) and shelling % in maize

Treatment	Plant population at harvest	Plant height at 60 DAS	Plant dry matter at 60 DAS	Grain yield	Stover yield	Biological yield	Shelling %
Weedy check	56581	130.80	32.13	2.37	4.01	6.38	57.72
Atrazine 0.5 kg ha^{-1} at 10 DAS	59636	133.93	36.67	3.82	5.62	9.44	71.90
Atrazine 0.5 kg ha^{-1} at 15 DAS	60508	145.00	37.22	3.29	5.27	8.56	75.71
Atrazine 0.5 kg ha^{-1} at 20 DAS	60726	145.33	34.73	3.58	4.89	8.46	71.68
Atrazine 0.5 kg ha^{-1} + Halosulfuron 0.09 kg ha^{-1} at 10 DAS	60290	139.07	29.53	3.23	4.72	7.94	65.35
Atrazine 0.5 kg ha^{-1} + Halosulfuron 0.09 kg ha^{-1} at 15 DAS	58109	134.00	28.63	3.19	5.07	8.27	61.02
Atrazine 0.5 kg ha^{-1} + Halosulfuron 0.09 kg ha^{-1} at 20 DAS	58327	140.67	29.00	3.59	5.38	8.97	58.01
Atrazine 0.5 kg ha^{-1} + Tembotrione 0.125 kg ha^{-1} at 10 DAS	61550	150.67	45.07	4.83	7.02	11.85	75.32
Atrazine 0.5 kg ha^{-1} + Tembotrione 0.125 kg ha^{-1} at 15 DAS	61550	168.00	50.73	5.24	7.03	12.27	76.94
Atrazine 0.5 kg ha^{-1} + Tembotrione 0.125 kg ha^{-1} at 20 DAS	61356	154.47	44.50	4.96	6.88	11.85	69.30
Atrazine 0.5 kg ha^{-1} + Topramezone 0.025 kg ha^{-1} at 10 DAS	60883	163.00	48.60	4.89	6.77	11.66	70.84
Atrazine 0.5 kg ha^{-1} + Topramezone 0.025 kg ha^{-1} at 15 DAS	58423	166.73	49.73	4.64	6.95	11.58	74.26
Atrazine 0.5 kg ha^{-1} + Topramezone 0.025 kg ha^{-1} at 20 DAS	57175	148.67	45.93	4.60	6.89	11.48	76.59
SEm ±	1473	4.49	2.74	232	250	344	1.59
LSD (P=0.05)	NS	13.12	8.01	679	729	1004	4.65

The highest strover yield obtained with post-emergence application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS (7.03 t/ha) which was closed to post-emergence application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 10 DAS (7.02 t/ha) with per cent increase of 75.30 and 75.05, respectively over weedy check (4.01 t/ha). Amongst treatments, post-emergence application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS and post-emergence application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 20 DAS, post-emergence application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 10 DAS gave better results being at par with each other. The per cent increase in biological yield due to these treatments was 92.42,85.81 and 85.81, respectively over weedy check. The post-emergence application of atrazine 0.5 kg/ha + tembotrione 0.125 kg/ha at 15 DAS was found statistically at par atrazine 0.5 kg/ha + topramezone 0.118 kg/ha at 15 DAS with respect to shelling percentage (%),test weight (g) and decreasing order of merit. The results corroborate the findings of Patel *et al.*, (2006), Walia *et al.*, (2007), Choudhary *et al.*, (2013) and Rana *et al.*, (2017).

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