RESEARCH ARTICLE

WEED DYNAMICS AND PRODUCTIVITY OF MAIZE (*ZEA MAYS* L.) UNDER PRE AND POST EMERGENCE APPLICATION OF HERBICIDE

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Abstract: A field experiment was carried out at Ambikapur, during the *kharif* season of 2017-18 to work out effect of new herbicide molecule along with combinations of already tested herbicides in sequential application for weed management in maize. The field experiment was laid out in randomized block design with 11 weed management practices (alone and in combinations of atrazine, pendimethalin, halosulfuron, tembotrione, 2, 4-D, hand weeding and mechanical weeding) and replicated thrice. Pendemathalin (1000 ml ha^{-1}) PE fb Atrazine (750 g ha^{-1}) + 2,4-D Amine 0.4 kg ha^{-1} at 25 DAS as PoE provided significant weed management during the critical period of crop-weed competition. The treatment also recorded the lowest total weed density and dry weight with higher weed control efficiency at 50^{th} day of crop growth and contributed highest yield attributes *viz.*, cob length, cob girth, number of kernel rows cob^{-1}, number of kernels row^{-1}, 100 seed weight and kernel yield (5.98 t ha^{-1}) which was found statistically at par with Atrazine 1.5 kgha PE fb Tembotrione 120 g ha PoE at 25 DAS (5.82 t ha^{-1}) and mechanical weeding 20 and 45 DAS(5.53 t ha^{-1}). Although hand weeding twice at 15 and 40 DAS is the most effective treatment as compare to herbicidal treatments. Highest net returns (Rs. 50297.65 ha^{-1}) and B: C ratio (1.57) was recorded under by Atrazine 1.5 kgha PE fb Tembotrione 120 g ha PoE at 25 DAS which was found statistically at par with pendimethalin (1000 ml ha^{-1}) PE fb Atrazine (750 gm ha^{-1}) + 2,4-D Amine 0.4 kg ha^{-1} at 25 DAS as PoE in terms of net return (Rs. 50064.04 ha^{-1}) and B: C ratio (1.47).

Keywords: Maize, Weed management, Sequential application of herbicide

INTRODUCTION

Maize (*Zea mays* L.) is an exciting and leading crop which contributes considerably to world agriculture and more essentially to world's food basket of approximately 2000 million metric tons. Maize crop is one of the world's vital food crops, >5% dietary energy is supplied through maize. The broader adaptability and higher yield potential of maize and its utility as food, feed and forage crop signifies the importance of maize. It is mostly cultivated in an area of about 150 m ha in 160 countries.

Among the food cereal crops maize is one of the most important crop that can be grown in diverse condition, ecologies and uses. In India, maize covers 9,200 thousands ha area with the productivity of 2.82 metric t ha^{-1} during 2018-19 (Ministry of Agriculture, India). Among the various components of crop production technology, weed management in maize needs due attention. As this crop is grown in wide row spacing and the crops are sown with onset of the monsoon, which delivers a promising atmosphere for weed growth. Sharma *et al.* (2000) reported that experiment on crop-weed competition and revealed that the reduction of (33-50 percent) in grain yield due to infestation of weed. The higher loss in crop yield due to weed competition and it is evaluated to occur during the first 3-6 weeks *i,e* before the crop canopy has established thick enough to smoother the weeds (Shad *et al.,*1993). Weeds being a very serious and undesirable factor in crop production and responsible for yield loss may be up to 52% (Walia *et al*., 2005). Atrazine is applied as a pre emergence herbicides, do not provide effective control of many non-grassy, grassy and weeds, particularly the sedges (*Cyperus rotundus*L.) in maize and effective only up to twenty days after sowing there by allowing the growth, which also causes considerable loss in crop yield besides adding weed seeds to the seed bank to the soil. Most weed seeds germinate in different flushes and pre-emergence herbicides with their relative short residual life may not control weeds long enough to optimize yields. *Ageratum conyzoides, Cyperusrotandus*and*Spilanthusakhmela* germinate with maize as first flush but *Commelinabenghalensis, Murdanianudifolia, Celosia argentia, leucusaspera, Elusineindica*, *Echinocloacrusgali* etc. come in second flush. The other way is to apply two herbicides sequentially with different selectivity, for control of weed flora of both pre-emergence and post-emergence.

MATERIALS AND METHODS

The field experiment was carried out during *Kharif* season of 2017-18 at the Research farm, RMD College of Agriculture & Research Station, Ambikapur situated at $23^0$18' N latitude and $83^0$15' E longitude and at altitude of 611 meter above mean sea level which represents the northern hills agro-climatic zone of Chhattisgarh. The soil of the experimental site was sandy loam in texture, acidic in reaction (pH 5.7), medium in organic carbon (0.56), available nitrogen (234 kg ha^{-1}), available

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phosphorus (8.4 kg ha^{-1}) and available potassium (268 kg ha^{-1}). The experiment was carried out in randomized block design (RBD) with 3 replications. The treatments contained of eleven weed management practices. The treatment comprised of weedy check, two hand weeding at 15 and 40 DAS, two mechanical weeding at 20 and 45 DAS, atrazine 1.0 kg *a.i.* ha^{-1} as pre-emergence, atrazine (750 g ha^{-1}) + pendemathalin (750 ml ha^{-1}) pre-emergence, atrazine (1.5 kg ha^{-1}) fb 2,4-D amine 0.4 kg ha^{-1} at 25 DAS as PoE, halosulfuron 90 g ha^{-1} at 25 DAS, atrazine 1.5 kg ha^{-1}pre-emergence halosulfuron 90 g ha^{-1} 25 DAS, pendemathalin (1000 ml ha^{-1}) pre-emergence fb atrazine (750 g ha^{-1}) + 2,4-D amine 0.4 kg ha^{-1} at 25 DAS as PoE , atrazine 1.5 kgha^{-1} pre-emergence fbtembotrione 120 g ha^{-1} PoE at 25 DAS. Sowingwas done manually in 2nd week of July 'Super 502' maize hybrid variety was used. The crop was fertilized with recommended dose of fertilizer (150:80:60 kg ha^{-1} N: P_2O_5: K_2O) were applied equally in all treatments through iffco (12:32:16), urea and MOP.One fourth nitrogen, full dose of P_2O_5 and K_2O were applied as basal at the time of sowing. Remaining nitrogen was top dressed in three equal splits at Knee high stage (30 DAS), tasseling stage (50 DAS) and seed setting (65 DAS) equally in all treatments. Maize hybrid was sown at spacing of 60 cm with plant to plant spacing 20 cm to maintain the plant population of 83,333 plants ha^{-1}using 25 kg seeds ha^{-1}. All the herbicides and their combinations were applied as per treatment using knapsack sprayer fitted with flat fan nozzle using in 500 liter water ha^{-1}. Pre-emergence application of herbicides and HW at 15 to control the first weed flushes whereas 2nd and 3rd flushes were controlled by HW at 40 DAS, two mechanical weeder at 20 and 45 DAS and post-emergence application of herbicides. Data on weed population were recorded at 20, 50 days after sowing and at harvest. The observations of weed density and their dry matter were taken randomly from 0.25 m^2quadrate from net plot area from each treatment. Same were harvested and then oven dried at 48 hours 70^0C. To calculate the cost of weed control, the cost of each treatment was determined and then compared with each other according to the prevailing market prices of grains. Data on weed density and dry weight was subjected to square root transformation before analysis.

RESULTS AND DISCUSSION

Weed density and dry weight

Weed management practices significantly affected the weed density and their dry weight. Density of grasses, broad leaved weed, sedge and total weeds were reduced substantially (Table 1) by pendemathalin (1000 ml ha^{-1}) pre-emergence fb atrazine (750 g ha^{-1}) + 2,4-D amine 0.4 kg ha^{-1} at 25 DAS as PoE followed by atrazine (750 g ha^{-1}) + 2,4-D amine 0.4 kg ha^{-1}at 25 DAS as post emergence (61.49 and 14.73 respectively) compare to all other treatments except atrazine 1.5 kg ha^{-1} aspre-emergence followed by tembotrione 120 g ha^{-1} as post emergence at 25 DAS (77.68 and 18.87, respectively) and mechanical weeding at 20 and 45 day after sowing (82.33 and 19.49 respectively) showed pariety. Similar results were reported by Singh *et al.* (2012).

Weed control efficiency

The weed control efficiency at 50 DAS was significantly influenced by weed management practices. Higher weed control efficiency among herbicidal treatment was noticed in Pendimethalin (1000 ml ha^{-1}) PE fb Atrazine (750 gm ha^{-1}) + 2,4-D Amine 0.4 kg ha^{-1}at 25 DAS as PoE (Table 1) which showed parity with Atrazine 1.5 kg ha^{-1} PE fb tembotrione 120 gm ha^{-1} PoE at 25 DAS followed by 2 mechanical weeding at 20 and 40 DAS. These treatments were statistically superior over other herbicidal treatments. Maximum weed control efficiency was noticed in two hand weeding at 15 and 40 DAS whereas minimum was noticed underweedy check at 50 DAS and at harvest as compared to other treatments. High weed control efficiency may be attributed due to their effective control of complex weed flora viz., grassy as well as broad leaved weeds and some extent to sedge weed. This finding established support from Sunitha, *et al.* (2015), Gul, *et al.* (2011) who observed more weed control efficiency.

Table 1. Weed density, dry weight and weed control efficiency as influenced by different weed management practices in maize.

Treatments		Weed density				Dry weight of total weeds (g/m^2)	Weed control efficiency (%)
		Grassy	Broad-leaf	Sedge	Total		
T1	Control (weedy check)	14.41 (207.47)	13.37 (178.33)	7.69 (58.67)	21.98 (483.05)	10.70 (113.90)	0.00
T2	Two hand weeding at 15 and 40 DAS.	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00))	100.00
T3	Two mechanical weeding (20 and 45 DAS)	5.86 (33.87)	5.77 (32.80)	3.07 (9.00)	9.10 (82.33)	2.12 (19.49)	82.89

T4	Atrazine 1.0 kg /ha PE	9.83 (96.13)	9.29 (85.87)	6.61 (43.33)	15.62 (243.53)	7.64 (57.86)	49.19
T5	Atrazine (750 g ha) + Pendemathalin (750 ml ha) PE	8.69 (75.07)	6.64 (43.60)	4.11 (16.47)	12.14 (147.00)	5.94 (34.79)	48.91
T6	Atrazine (1.5 kg ha) fb 2,4-D Amine 0.4 kg ha at 25 DAS as PoE	7.34 (103.80)	6.72 (53.67)	6.72 (44.67)	14.78 (217.88)	7.25 (52.13)	54.22
T7	Halosulfuron 90 gha at 25 DAS	11.22 125.60)	10.95 (119.47)	3.89 (14.67)	16.87 (284.24)	8.20 (66.77)	41.37
T8	Atrazine 1.5 kg ha PE fb Halosulfuron 90 gha 25 DAS	9.30 86.00)	8.10 (65.20)	3.18 (9.67)	13.28 (175.99)	6.47 (41.45)	63.60
T9	Tembotrione 120 g ha PoE at 25 DAS	11.11 (123.00)	4.96 (24.13)	6.76 (45.33)	14.41 (207.18)	7.11 (50.00)	56.10
T10	Pendemathalin (1000 ml ha) PE fb Atrazine (750 g /ha) + 2,4-D Amine 0.4 kg ha at 25 DAS as PoE	5.03 (24.93)	4.37 (18.67)	3.74 (13.53)	7.87 (61.49)	3.90 (14.73)	87.07
T11	Atrazine 1.5 kgha PE fb Tembotrione 120 g ha PoE at 25 DAS	5.39 (28.67)	4.54 (20.13)	4.92 (24.00)	8.82 (77.68)	4.38 (18.87)	83.42
Sem ±		0.22	0.19	0.20	0.24	0.20	3.58
CD (0.05)		0.64	0.55	0.59	0.69	0.60	10.57

Note: Data in parenthesis (original value) was subjected to √X + 0.5 transformations.

Yield attributes and yield

Yield attributes viz., cob length (cm), cob girth (cm), no. of kernel rows cob^{-1}, no. of kernels row^{-1} and 100 kernel weight were significantly affected due to various weed management practices (Table 2). Among herbicidal treatments, Pendimethalin (1000 ml ha^{-1}) PE fb Atrazine (750 gmha^{-1}) + 2,4-D Amine 0.4 kg ha^{-1}at 25 DAS as PoE had higher value of yield attributing features followed by Atrazine 1.5 kg*a.i*ha^{-1}PE fb tembotrione120 gm ha^{-1} PoE at 25 DAS were found at par with Atrazine (750 g ha^{-1}) + Pendimethalin (750 ml ha^{-1}) PE and Atrazine 1.5 kg ha^{-1} PE fb halosulfuron 90 g ha^{-1} 25 DAS but significantly superior over other herbicidal treatments. Weedy check had significantly lower value yield attributing features as compared to other weed management practices.

The kernel and stover yield were significantly influenced due to different weed management practices (Table 2). Herbicidal treatment of pendimethalin (1000 ml ha^{-1}) PE fb Atrazine (750 gm ha^{-1}) + 2,4-D Amine 0.4 kg ha^{-1}at 25 DAS as PoE recorded higher kernel as well as stover yield which was at par with Atrazine 1.5 kg ha^{-1}PE fb tembotrione120 gmha^{-1}PoE at 25 DAS along with 2 mechanical weeding 20 and 45 DAS had but significantly superior over other herbicidal treatments. 2 hand weeding at 15 and 40 DAS (T_2) recorded maximum kernel and stover yield found significantly at par with T_{10} and T_{11} but significantly superior over other treatments. Minimum kernel and stover yield were obtained under weedy check (T_1) significantly inferior over other treatments.

Yield attributes of maize were significantly influenced by adapting different weed management practices and higher value were noticed under treatments had lower weed density and their dry weight and as a result of minimum weed competition. The reduction in weed competition in maize by the application of herbicides not only favored the crop plants with more availability of space, light, moisture and nutrients but also minimized weed interference, facilitating vigorous growth of crop plants. These results are found to be in close conformity with Biswas *et al.* (2018).

Economics

Weed management practices had significant influence on net return and benefit: cost ratio. Maximum net returns and benefit: cost ratio were obtain under treatment Atrazine 1.5 kg ha^{-1}PE fb tembotrione120 gmha^{-1}PoE at 25 DAS (T_{11}) which was almost similar to pendimethalin 1000 mlha^{-1} as pre emergence fb atrazine750 g ha^{-1}+ 2,4-D amine 0.4 kg followed by 2 mechanical weeding at 20 and 45 DAS. However, the minimum net returns were obtained in T_1 (weedy check). Herbicidal treatments showed significant direct yield advantage over weedy check in maximizing net return as well as B:C ratio. All the herbicidal treatments provided more net return than that of weedy check. Out of herbicides, Atrazine 1.5 kgha^{-1}PE fb Tembotrione 120 gmha^{-1}PoE (T_{11}) gave the highest net return of Rs. 50297.65 followed by Pendemathalin (1000 mlha^{-1})

PE fb Atrazine (750 g ha^{-1}) + 2,4-D Amine 0.4 kg ha^{-1}as PoE (Rs. 50064.04) as compared to 2 hand weedings (Rs. 45501.35. The lowest net return (Rs. 11350.29) and B: C ratio (0.38) were noticed under weedy checkwhereasunder weed management practices, lower B:C ratio was noticed under T_7 (0.61) and T_8 (0.97) that was mainly due to higher cost of halosulfuron. It was also observed that all the herbicidal treatments were more beneficial as compared to weedy check. This was because of more net returns than the money spent in crop production under these treatments. These results are found to be in close conformity with Shivamurugan *et al.* (2017) and Biswas *et al*. (2018).

CONCLUSIONS

Among herbicidal treatment pendemathalin (1000 ml ha^{-1}) PE fb Atrazine (750 g ha^{-1}) + 2,4-D amine 0.4 kg ha^{-1} at 25 DAS as post emergence significantly resulted lower density of weed, dry weight, weed index, weed control efficiency and enhanced grain yield over rest of the other weed control treatments except atrazine 1.5 kg ha^{-1} aspre-emergence followed by tembotrione 120 g ha^{-1} at 25 DAS and two mechanical weeding at 20 and 45 DAS. Although hand weeding twice at 15 and 40 DAS is the most effective treatment as compare to herbicidal treatments.

Atrazine applied 1.5 kg ha^{-1} aspre-emergence followed by tembotrione 120 g ha^{-1} at 25 DAS although, recorded maximum net returns and B:C ratio (50297.65 and 1.57 respectively) followed by pendemathalin (1000 ml ha^{-1}) PE fb Atrazine (750 g ha^{-1}) + 2,4-D amine 0.4 kg ha^{-1} at 25 DAS as post emergence (50064.04 and 1.47 respectively).

Table 2. Yield attributes, yield and economics of maize as influenced by different weed management practices.

		Yield attributes							Economics	
	Treatments	Cob length (cm)	Cob girth (cm)	No. of kernel rows cob^{-1}	No. of kernels row^{-1}	100 kernels weight (g)	Kernel yield (t ha^{-1})	Stover yield (t ha^{-1})	Net returns (Rs.)	B:C ratio
T1	Control (weedy check)	14.47	13.00	10.87	24.73	27.50	2.86	4.06	11350.29	0.38
T2	Two hand weeding at 15 and 40 DAS.	19.87	15.97	15.27	35.20	33.57	6.15	9.69	45501.35	1.11
T3	Two mechanical weeding (20 and 45 DAS)	18.10	15.20	14.80	33.90	31.40	5.53	8.49	42766.69	1.21
T4	Atrazine 1.0 kg /ha PE	16.10	14.37	14.07	32.40	30.33	4.32	6.54	30325.39	0.97
T5	Atrazine (750 g ha) + Pendemathalin (750 ml ha) PE	17.83	15.03	14.70	33.57	31.43	5.35	8.37	44368.50	1.42
T6	Atrazine (1.5 kg ha) fb 2,4-D Amine 0.4 kg ha at 25 DAS as PoE	16.37	14.50	14.33	32.87	30.97	4.69	7.45	34328.15	1.06
T7	Halosulfuron 90 gha at 25 DAS	15.00	14.27	13.80	32.27	30.20	4.20	6.40	22588.55	0.61
T8	Atrazine 1.5 kg ha PE fb Halosulfuron 90 gha 25 DAS	17.07	14.87	14.50	33.50	31.23	5.33	8.29	37155.68	0.97
T9	Tembotrione 120 g ha PoE at 25 DAS	16.47	14.80	14.47	33.27	31.13	5.17	8.11	42749.01	1.39
T10	Pendemathalin (1000 ml ha) PE fb Atrazine (750 g /ha) + 2,4-D Amine 0.4 kg ha at 25 DAS as PoE	19.13	15.76	15.13	34.93	33.03	5.98	9.45	50064.04	1.47
T11	Atrazine 1.5 kgha PE fb Tembotrione 120 g ha PoE at 25 DAS	18.83	15.40	15.07	34.33	32.83	5.82	9.21	50297.65	1.57
Sem±		0.52	0.31	0.39	1.10	0.59	0.21	0.27	-	-
CD (0.05)		1.53	0.91	1.16	3.24	1.73	0.63	0.80		

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