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RESEARCH PAPER

Evaluation of post emergence tank mixture herbicides for efficient weed management in maize (*Zea mays* L.)

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Abstract: A field experiment was conducted under rainfed conditions during *kharif* 2020 at Agricultural College Farm, University of Agricultural Sciences, Dharwad, to study the effect of different doses of herbicides and to evaluate their efficacy as tank-mixtures for weed control in maize. The trial consisted 12 treatments laid out in RCBD with three replications. The results indicated that tank mixture application of Ametryn @ 0.75 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i ha^{-1} resulted in higher weed control efficiency, lower weed dry weight, lowest weed density with higher seed yield and higher net returns. The results revealed that one time application of tank mix post emergence herbicides of Ametryn @ 0.5 kg a. i. ha^{-1} in combination with topramezone @ 56.25 g a. i. ha^{-1} 25 days after sowing was found optimum for better weed management in maize resulting in to higher grian yield and net returns as compared to the present recommended practice.

Key words: Ametryn, Herbicides, Maize, Weed flora

Introduction

Maize (*Zea mays* L.) is one of the most important food crops in India and is increasingly gaining an important position in crop husbandry because of its higher yield potential and short growth duration. It is one of the most versatile crops grown throughout the tropical as well as temperate regions of the world and has multiple uses. In the world, it is grown on an area of 182 million hectares with an annual production of 987 million tones with a productivity of 5423 kg ha^{-1} (Anon., 2019). India is the fourth-largest producer of maize. The versatile nature of the crop allows it to grow across wide range of agro-ecological regions of the country. In India, it is cultivated on an area of 9.47 million ha with a production of 28.72 million tonnes and productivity of 3032 kg ha^{-1}. In Karnataka, it is cultivated on an area of 1.29 million ha with a production of 3.55 million tonnes and average productivity is about 2755 kg ha^{-1} (Anon., 2019).

Some of the major weed species observed in the trial were; Among the grassy weeds, *Brachiaria eruciformis*, *Cynodon dactylon* and *Dinebra retroflexa* were predominant during the crop period. The important broad leaved weeds observed were *Amaranthus viridis*, *Alternanthera sessilis*, *Corchorus trilocularis*, *Cyanotis cucullata*, *Commelina benghalensis*, *Digera arvensis*, *Euphorbia hirta*, *Euphorbia geniculata*, *Mollugo pentaphylla*, *Parthenium hysterophorus*, *Phyllanthus maderaspatensis*, *Phyllanthus fraternus*, *Portulaca oleracea* and *Trichodesma zeylanicum* and *Cyperus rotundus* among the sedges.

In the present-day context, application of herbicides involves multidisciplinary approach in safeguarding the plant, soil and environment; for which soil microorganisms are important links in soil-plant-herbicide-fauna-man relationships (Patel *et al.,* 2019). Maize gets infested with variety of weeds in rainy season and subjected to heavy weed competition, which often inflicts huge losses ranging from 28 to 100 per cent (Patel *et al*., 2006). Use of alternative tactics like tank mixing of herbicides to manage weeds is gaining popularity now-a-days and this also may include the use of newly released herbicides with new modes of action. Keeping all these aspects in view, an attempt was made to find out effective and economical herbicides and their combination for weed management in maize.

Material and methods

A field experiment was conducted at the Main Agricultural Research Station, Dharwad during *Kharif* 2020 to study the efficacy of post emergence tank mixture herbicides for weed management and their impact on productivity of maize. The soil was clay loam in texture having medium available nitrogen, phosphorus and potassium with pH 7.4. The experiment was laid out in randomized complete block design with three replications involving 12 treatments. Treatments consisted of post emergence application of Atrazine @ 1.0 kg a.i. ha^{-1} (T_1), Tank mix combination of Ametryn @ 0.75 kg a.i. ha^{-1} + 2,4-D @ 0.75 kg a.i. ha^{-1} (T_2), Ametryn @ 0.75 kg a.i. ha^{-1} + Tembotrione @ 75 g a.i. ha^{-1} (T_3), Ametryn @ 0.75 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i ha^{-1} (T_4), Ametryn @ 0.5 kg a.i. ha^{-1} + 2,4-D @ 0.75 kg a.i. ha^{-1} (T_5), Ametryn @ 0.5 kg a.i. ha^{-1} + Tembotrione @ 75 g a.i. ha^{-1} (T_6), Ametryn @ 0.5 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i. ha^{-1} (T_7), Recommended package of ractices (Atrazine @ 1.25 kg a.i. ha^{-1} *fb* one inter cultivation) (T_8), Atrazine @ 1.0 kg a.i (PE) *fb* Tembotrione @ 100 g a.i. ha^{-1} + Atrazine @ 250 g a.i. ha^{-1} (T_9), Atrazine @ 1.0 kg a.i (PE) *fb* Topramezone @ 75 g a.i. ha^{-1} + Atrazine @ 250 g a.i. ha^{-1} (T_{10}), Weedy check (T_{11}) and Weed free check (hand weeding) (T_{12}). The seeds NK-6240 were dibbled manually at spacing 60 x 20 cm at a seed rate of 25 kg seeds per ha. The herbicides were applied as post-emergence at 25 day after sowing using Knapsack sprayer fitted with flat fan nozzle by mixing 500 litres of water per ha. Entire dose of potassium, phosphorus and half dose of the nitrogen through diammonium phosphate, muriate of potash and urea were applied at the time of sowing and remaining quantity of

nitrogen was applied at knee-height stage. The recommended package of practices was adopted to maintain the crop.

Results and discussion

Effect post emergence tank mixture herbicides on weed parameters and weed control efficiency

Among the weed control treatments at 40 and 60 DAS significantly lower dry weight of weeds were recorded with Ametryn @ 0.75 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i ha^{-1} and Ametryn @ 0.75 kg a.i. ha^{-1} + Tembotrione @ 75 g a.i. ha^{-1} (4.22 and 4.50 g 0.5 m^{-2}, respictively), which were on par with Ametryn @ 0.5 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i. ha^{-1} (4.97 g 0.5 m^{-2}) (Table 1) It was mainly due to the lowest population of broad leaved weeds, sedges and grassy weeds. The results were in conformity with findings of Patel *et al.* (2006). During the entire crop growth higher weed dry weight of weeds were recorded in weedy check. However, on the other hand the lowest dry weight of weeds was recorded in weed free check. This could be attributed to control of weeds by hand weeding at regular intervals, which resulted in reduced dry matter production by weeds. At 40 and 60 DAS, among chemical weed control treatments application of Ametryn @ 0.75 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i ha^{-1} (T_4) resulted in higher weed control efficiency (78.14 %) compared to other weed control treatments, except T_3 *i.e* Ametryn @ 0.75 kg a.i. ha^{-1} + Tembotrione @ 75 g a.i. ha^{-1} (73.92 %). However, treatment T_7 *i.e* Ametryn @ 0.5 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i. ha^{-1} (73.58 %) also recorded higher weed control efficiency and found in next order compared to other weed control treatments. But among the weed control treatments lower weed control efficiency was recorded with application of Atrazine @ 1.0 kg a.i. ha^{-1} applied as PoE at 25 DAS (60.72 %), this might be due to higher weed population in these treatments. At 60 DAS, The total dry matter production was recorded with weed free check which were closely followed by Ametryn @ 0.75 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i ha^{-1} (T_4) and RPP (Recommended package of practices-Atrazine @ 1.25 kg a.i. ha^{-1} *fb* by one inter cultivation) (T_8). But at 90 DAS, The dry matter production was higher with treatment RPP (Recommended package of practices) Atrazine @ 1.25 kg a.i. ha^{-1} *fb* by one inter cultivation) (T_8) compared to other weed control treatments except T_4, T_3 and T_7. This was the result of luxuriant crop growth, as indicated by higher plant height, leaf area, leaf area index and which ensured higher dry matter

Table 1. Effect of post emergence tank mixture herbicides application on weed parameters and weed control efficiency

Treatment	40 DAS			60 DAS			Weed index (%)
	Weed density* (No. 0.5 m^{-2})	Dry weight (g 0.5 m^{-2})	WCE (%)	Weed density (No. 0.5 m^{-2})	Dry weight (g 0.5 m^{-2})	WCE (%)	
T_1 - Atrazine @ 1.0 kg a.i. ha^{-1} applied as PoE at 25 DAS	3.31(10.43)	2.52 (5.85)	58.37	4.29 (17.91)	2.88 (7.77)	60.72	18.77
T_2 - Ametryn @ 0.75 kg a.i. ha^{-1} + 2,4-D @ 0.75kg a.i. ha^{-1} as PoE at 25 DAS	2.91 (7.95)	2.34 (5.00)	64.40	3.10 (9.09)	2.56 (6.03)	69.50	8.13
T_3 - Ametryn @ 0.75 kg a.i. ha^{-1} + Tembotrione @ 75 g a.i. ha^{-1} as PoE at 25 DAS	2.79 (7.28)	2.24 (4.50)	67.89	3.03 (8.66)	2.38 (5.16)	73.92	7.18
T_4 - Ametryn @ 0.75 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i ha^{-1} at 25 DAS	2.73 (6.92)	2.17 (4.22)	69.91	2.93 (8.11)	2.19 (4.32)	78.14	3.17
T_5 - Ametryn @ 0.5 kg a.i. ha^{-1} + 2,4-D @ 0.75kg a.i. ha^{-1} as PoE at 25 DAS	2.96 (8.26)	2.48 (5.64)	59.82	3.22 (9.90)	2.64 (6.49)	67.84	11.95
T_6 - Ametryn @ 0.5 kg a.i. ha^{-1} + Tembotrione @ 75 g a.i. ha^{-1} as PoE at 25 DAS	2.90 (7.93)	2.40 (5.26)	62.60	3.11 (9.20)	2.52 (5.87)	70.29	9.53
T_7 - Ametryn @ 0.5 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i. ha^{-1} at 25 DAS	2.82 (7.44)	2.34 (4.97)	64.58	3.03 (8.68)	2.39 (5.23)	73.58	7.29
T_8 - RPP (Recommended Package of Practices) Atrazine @ 1.25 kg a.i. ha^{-1} followed by one inter cultivation)	2.85 (7.62)	2.38 (5.15)	63.29	3.00 (8.50)	2.55 (6.02)	69.55	4.10
T_9 - Atrazine @ 1.0 kg a.i (PE) fb Tembotrione @ 100 g a.i. ha^{-1} + Atrazine @ 250 g a.i. ha^{-1}	2.96 (8.26)	2.46 (5.54)	60.52	3.08 (8.97)	2.61 (6.29)	68.14	7.14
T_{10} -Atrazine @ 1.0 kg a.i (PE) fb Topramezone @ 75 g a.i. ha^{-1} + Atrazine @ 250 g a.i. ha^{-1}	3.05 (8.77)	2.51 (5.80)	59.62	3.14 (9.34)	2.67 (6.65)	66.40	11.84
T_{11} - Weedy check	4.87 (23.25)	3.81 (14.05)	-	5.98 (35.28)	4.50 (19.79)	-	37.40
T_{12} - Weed free check (Hand weeding)	0.71 (0.00)	0.71 (0.00)	100.00	0.71 (0.00)	0.71 (0.00)	100.0	0.00
S.Em. ±	0.07	0.13	1.30	0.09	0.17	1.64	0.66
C.D. (P=0.05)	0.23	0.38	3.81	0.29	0.49	4.82	1.94

HW: Hand weeding DAS: Days after sowing RPP: Recommended package of practice PoE: Post - emergent herbicide

*Transformed values: √x + 0.5-, figures in the parenthesis indicate original values.

production of might be due to lesser crop weed competation as reflected in higher weed control efficiency. Among the weed control treatments application of Ametryn @ 0.5 kg a.i. ha^{-1} + 2,4-D @ 0.75kg a.i. ha^{-1} and Ametryn @ 0.5 kg a.i. ha^{-1} + Tembotrione @ 75 g a.i. ha^{-1} has recorded lower dry matter accumulation (Table 2). These results were in confirmity with the findings of Swetha *et al.* (2018) and Kakade *et al.* (2020).

Effect post emergence tank mixture herbicides on grain yield and yield parameters of maize

Among the weed control treatments application of Ametryn @ 0.75 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i ha^{-1} has recorded higher grain yield (7926 kg ha^{-1}) as compared to other treatments, except, T_{12}, T_7, T_8, T_9 and T_3. Grain yield of maize was significantly lower in weedy check (T_{11}) (3897 kg ha^{-1}) as compared to rest of the treatments (Table 2). The higher grain yield in these treatments could be attributed to improved yield components such as higher number of grains cob^{-1}, higher grain weight cob^{-1} and 100 grain weight. The improvement in yield components was inturn due to improved growth attributes such higher total dry matter production and leaf area index. Thus, the improvement in growth and yield components was as a consequence of lower crop- weed competition, which shifted the balance in favour of crop in the utilization of nutrients, moisture, light and space. The results were in conformity with the findings of Walia *et al.* (2007), Swetha *et al.* (2018) and Kakade *et al.* (2020).

Among the weed control treatments treatment atrazine @ 1.0 kg a.i. ha^{-1} applied as PoE at 25 DAS (T_1), Ametryn @ 0.5 kg a.i. ha^{-1} + 2,4-D @ 0.75kg a.i. ha^{-1} (T_5) and ametryn @ 0.75 kg a.i. ha^{-1} + 2,4-D @ 0.75kg a.i. ha^{-1} (T_2) recorded lower yield (Table 2). This might be due to phytotoxicity effect of the crop during crop growth period these results are in conformity with finding of Shantveerayya, *et al.*, (2012).

Economics of application of post emergence tank mixture herbicides in maize

The data is presented in Table 2. Among the weed control treatments, tank mixture application of Ametryn @ 0.75 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i ha^{-1} (T_4) recorded higher net returns (₹ 80859 ha^{-1}) as compared to other weed control treatments except Ametryn @ 0.5 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i. ha^{-1} (T_7: ₹ 78407 ha^{-1}), Weed free check (T_{12} : ₹ 78480. ha^{-1}) and RPP *i.e* .Atrazine @ 1.25 kg a.i. ha^{-1} followed by one inter cultivation) (T_8 : ₹ 75625 ha^{-1}). This was due to higher gross returns recorded in these treatments as a consequence of higher economic yield of maize. These results were in conformity with the findings of Patel, *et al.*, (2006). Weedy check recorded lower net income.The benefit: cost ratio was higher with treatments T_4, T_7 and T_3 (3.13, 3.07 and 3.01 respectively) compared to other weed control treatments (Table 2). This was mainly due to higher economic yield, net returns and lower cost of cultivation. Though there were higher yield and gross income in tank mixture application of Ametryn @ 0.75 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i ha^{-1} ., the B: C ratio was low due to higher cost of cultivation. This result were in conformity with the findings of Walia *et al.* (2007) and Swetha *et al.* (2018).

Table 2. Effect of post emergence tank mixture herbicides application on grain yield, yield parameters and economics of maize

Treatment	Total dry matter production (g $plant^{-1}$)		Grain yield (kg ha^{-1})	Gross return (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B : C ratio
	60 DAS	90 DAS				
T_1 - Atrazine @ 1.0 kg a.i. ha^{-1} applied as PoE at 25 DAS	91.23	179.00	5535	83025	52135	2.69
T_2 - Ametryn @ 0.75 kg a.i. ha^{-1} + 2,4-D @ 0.75 kg a.i. ha^{-1} as PoE at 25 DAS	94.70	200.67	6345	95175	62413	2.91
T_3 - Ametryn @ 0.75 kg a.i. ha^{-1} + Tembotrione @ 75 g a.i. ha^{-1} as PoE at 25 DAS	96.40	215.33	6758	102675	68612	3.01
T_4 - Ametryn @ 0.75 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i ha^{-1} at 25 DAS	98.27	220.67	7926	118890	80859	3.13
T_5 - Ametryn @ 0.5 kg a.i. ha^{-1} + 2,4-D @ 0.75 kg a.i. ha^{-1} as PoE at 25 DAS	86.50	182.00	6195	92925	60543	2.87
T_6 - Ametryn @ 0.5 kg a.i. ha^{-1} + Tembotrione @ 75 g a.i. ha^{-1} as PoE at 25 DAS	90.30	207.00	6612	99180	65307	2.93
T_7 - Ametryn @ 0.5 kg a.i. ha^{-1} + Topramezone @ 56.25 g a.i. ha^{-1} at 25 DAS	93.00	212.33	7750	116450	78407	3.07
T_8 - RPP (Recommended Package of Practices) Atrazine @ 1.25 kg a.i. ha^{-1} followed by one inter cultivation)	97.13	222.33	7581	113715	75625	2.99
T_9 - Atrazine @ 1.0 kg a.i (PE) fb Tembotrione @ 100 g a.i. ha^{-1} + Atrazine @ 250 g a.i. ha^{-1}	96.67	209.00	6855	101100	67040	2.97
T_{10} - Atrazine @ 1.0 kg a.i (PE) fb Topramezone @ 75 g a.i. ha^{-1} + Atrazine @ 250 g a.i. ha^{-1}	94.23	197.00	6628	98670	59353	2.51
T_{11} - Weedy check	50.43	169.33	3897	58455	29685	2.03
T_{12} - Weed free check (Hand weeding)	99.67	226.33	8012	120180	78480	2.88
S.Em. ±	1.31	2.75	85	1210	1026	0.04
C.D. (P=0.05)	3.84	8.08	260	3814	3148	0.14

HW: Hand weeding DAS: Days after sowing RPP: Recommended package of practice PoE: Post - emergent herbicide

Conclusion

Based on the the results of the study it was concluded that one time application of tank mix post emergence herbicides of Ametryn @ 0.5 kg a. i. ha^{-1} in combination with topramezone @ 56.25 g a. i. ha^{-1}, 25 days after sowing was found optimum and cost effective for better weed management in maize leading to higher maize grain yield and net returns as compared to the present recommended practice.

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