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Bio-Efficacy of Tembotrione 34.4% SC on Diverse Weed Flora and Productivity of *Kharif* Maize (*Zea mays* L.)

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ABSTRACT

An investigation was carried out at Varanasi during *kharif* season of 2017-18 to assess the influence of herbicide (tembotrione 100 g ai. ha^{-1} (PoE), tembotrione 110 g ai g ai. ha^{-1} (PoE), tembotrione (34.4% SC) 120g ai. ha^{-1}, tembotrione (34.4% SC) market sample 120g ai. ha^{-1}, topramezone 33.6g ai. ha^{-1}, weed free and weedy check) on weeds and yield of maize in randomized block design with three replication. Among herbicidal treatments, post emergence (PoE) application of tembotrione (34.4% SC) 120g ai. ha^{-1} recorded significantly lowest density and dry weight of grassy, broad leaf weeds and sedges; and it also recorded highest weed control efficiency and grain yield of maize over weedy check and it was statistically at par with tembotrione (34.4% SC) market sample 120g a ai. ha^{-1}, tembotrione (34.4% SC) 110 g ai. ha^{-1}, topramezone 33.6g ai. ha^{-1} and tembotrione (34.4% SC) 100 g ai. ha^{-1}, respectively. However, all the herbicidal treatments recorded significantly lower density and dry weight of weeds than weedy check. None of the herbicidal treatments was effective as weed free (hand weeding at 20 and 40 DAS) for the reduction of weed density and their dry weight, resulted significantly the highest grain yield of maize.

Highlights

- Post emergence (PoE) application of tembotrione (34.4% SC) 120g ai. ha^{-1} recorded lowest density and dry weight of weeds and recorded highest weed control efficiency and grain yield of maize as compared to other treatments.

Keywords: Broad leaf weeds, Grassy weeds, Sedges, Tembotrione, Maize yield, WCE

Maize (*Zea mays* L.), an important crop for food and nutritional security in India, is grown in diverse ecologies and seasons covering 9.25 m ha acreage with 25.2 mt production (IIMR Annual report 2016-17). Maize is a key source of food, globally it provides nearly 30% of the food calories to more than 4.5 billion peoples in 94 developing countries, and the demand of maize is expected to double worldwide by 2050 to meet this rising demand and thus higher maize production is need of the hour (Yadav *et al.* 2016). Major area of maize in India is during *kharif* season in which weed is one the most important yield limiting factor (Singh *et al*. 2015) because it grown at wider row spacing which results in greater infestation of weeds in the early stages (Kumar *et al*. 2017). Many factors that adversely affect the maize production. The losses caused by weeds have been estimated to be much higher than those caused by insects, pests and diseases together (Fakkar and Amin 2012). Weeds germinate even before its germination and flourish luxuriously taking advantage of its slow initial growth. Weed competition throughout the crop season reduces yield by 40-60%% depending upon time and intensity of weed infestation (Dixit *et al*. 2016). Amongst these production factors management of diverse weed flora (grasses, sedges and broad-leaved species) plays major role in increasing productivity of maize (Barla *et al*. 2016). So, there is need to ascertain the critical period of crop weed competition and evolve appropriate herbicides for controlling diverse weed flora for exploring the yield potential of this crop. Conventional cultural practices of weed management additional benefits of providing greater aeration, improving root growth enabling greater absorption of moisture and nutrients from deeper soil layers and moisture conservation cannot be ignored. The increasing demand of labour due to rapid industrialization and adoption of intensive and multiple cropping systems, sometimes the farmers fail to carry out the timely agricultural operations, if any. Thus, to combat this situation, exploring the possibility of a suitable broad spectrum and cost effective herbicide deserves more attention. In general, chemical weed management by using post-emergence herbicides can lead to the efficient and cost effective control of weeds during critical period of crop weed competition, which may not be possible in manual or mechanical weeding due to its high cost of cultivation (Triveni *et al*. 2017). In order to optimize weed control efficacy and increasing productivity, the use of new herbicide molecule as post-emergence has been advocated for season-long weed control. Hence, there is an immense need to find out the best chemical for effective weed management in maize and hence this study was undertaken to identify the best chemical weed management practices in *kharif* maize.

MATERIALS AND METHODS

Experimental site and soil

The field experiment was conducted during *kharif* season of 2017-18 at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (25° 18′- N latitude, 83° 03′- E longitude and altitude of 129 m above mean sea level). The soil of the experimental field was sandy clay loam in texture, with slightly alkaline in reaction (pH 7.8). It was moderately fertile, being low in available organic carbon (0.43 %), available nitrogen (206 kg ha^{-1}), and available phosphorus (19.2 kg ha^{-1}) and potassium (238 kg ha^{-1}). Average values for bulk density 1.42 g cm^{-1}, particle density 2.62 g cm^{-1}, filed capacity 19.57 per cent, permanent wilting point 4.31 per cent and EC were 0.19 dS m^{-1}.

Treatment details

Seven weed control treatments *viz*. tembotrione (34.4% SC) 100 g ai. ha^{-1} (PoE), tembotrione (34.4% SC) 110 g ai. ha^{-1} (PoE), tembotrione (34.4% SC) 120 g ai. ha^{-1} (PoE), market sample 120g ai. ha^{-1}, topramezone 33.6g ai. ha^{-1}, weed free (HW at 20 and 40 DAS) and weedy check. These were evaluated under randomized block design (RBD) with three replications. Maize variety ′K-99′ was sown under conventional flat bed methods at 60x20 cm row spacing by machine. All the herbicides were applied as post emergence with the help of foot sprayer fitted with flat fan nozzle. The spray volume was 500 litres water ha^{-1}. Half amount of nitrogen and full dose of phosphorus and potash were applied as basal at the time of sowing, ¼ part of nitrogen was top dressed at knee-high stage and remaining ¼ part of nitrogen was top dress at tassel initiation stage. The nitrogen, phosphorus and potassium were applied in the form of urea, single super phosphate and murate of potash, respectively. Standard agronomic practices were followed to raise the crop.

Data collection and analysis

Weeds was removed an area of 0.25m^2 from randomly selected 3 spots in each plot by throughing a quadrate of 0.5×0.5m at 30 and 60 days after sowing. The collected weeds ere first sun-dried and then kept in an electric oven at 60^o C till the weight become constant, and dry weight was expressed as g m^{-1}. As wide variation existed in data, number and dry weight of weeds were transformed through squire-root $\sqrt{(x+0.5)}$ methods before analysis of variance. Maize was harvested manually, but was threshed by power operated thresher and yield of crop was recorded. Weed control efficiency and weed index was worked out at 30 and 60 DAS and weed index at harvest of crop. The experimental data were analyzed statistically and interpreted.

RESULTS AND DISCUSSION

Relative composition of weed flora at 30 DAS

Weed flora of the experimental site have been classified into grasses, broad leaved weeds and sedges (Table 1). The critical analysis of data indicated that among the grasses, *Echinochloa colona* (15.5%) was the predominant weed. Others grasses was *Cynodon dactylon* (15.2), *Echinochloa crusgalli* (13.8%), *Dactyloctenium aegyptium* (7.1%), *Digitaria* *sanguinalis* (4.0%) and *Brachiaria ramose* (3.1%); among broad leaved weeds *Commelina benghalensis* (5.6%), *Digera arvensis* (3.4%), *Amaranthus viridis* (3.0%), *Trianthema portulacastrum* (2.9%) and *Phyllanthus niruri* (2.7%) were dominant flora. *Cyperus rotundus* (13.1%) and *Cyperus esculantus* (10.5%) was the only sedge were present during experimentation. The relative composition of weeds envisage that grassy weeds constituted major part of weed flora (58.7%) followed by sedges (23.6%) and broad leaf weeds (17.7%) respectively, irrespective of herbicidal treatments. Singh *et al*. (2015) and Barla *et al.* (2016) also observed similar association of these weed species with maize.

Table 1: Relative composition of weeds in control plot at 30 DAS

Weed type	Weed species	Density (m^{-2})	Weed infestation (%)
Grassy weeds	*Echinochloa colona*	92.6	15.3
	Cynodon dactylon	90.7	15.0
	Echinochloa crusgalli	82.4	13.6
	Dactyloctenium aegyptium	42.2	7.0
	Digitaria sanguinalis	24.1	4.0
	Brachiaria ramose	18.2	3.0
	Total	**350.2**	**57.8**
Broad leaf weeds	*Commelina benghalensis*	33.4	5.5
	Digera arvensis	20.2	3.3
	Amaranthus viridis	18.1	3.0
	Trianthema portulacastrum	17.4	2.9
	Phyllanthus niruri	16.2	2.7
	Cleome viscose	9.96	1.6
	Total	**115.3**	**19.0**
Sedges	*Cyperus rotundus*	78.1	12.9
	Cyperus esculentus	62.5	10.3
	Total	**140.6**	**23.2**
Grand total		**606.1**	**100.0**

Density of grassy weeds

Among herbicidal treatments, post emergence (PoE) application of tembotrione (34.4% SC) 120g ai. ha^{-1} significantly reduced the density and dry weight of grassy weeds over weedy check and it was statistically at par with tembotrione (34.4% SC) market sample 120g ai. ha^{-1}, tembotrione (34.4% SC) 110 g ai. ha^{-1}, topramezone 33.6g ai. ha^{-1} and tembotrione (34.4% SC) 100 g ai. ha^{-1}, respectively (Table 2). However, all the herbicidal treatments recorded significantly lower density of grassy weeds than weedy check at all the stages of observation. None of the herbicidal treatments effective as hand weeding for the reduction of grassy weed population and their dry weight. These results are corroborated with the findings of Kumar *et al*. (2017).

Density of broad leaf weeds

Among weed treatments control treatments, hand weeding at 20 and 40 DAS recorded significantly lowest density and dry weight of broad leaf weeds. Post emergence (PoE) application of tembotrione (34.4% SC) 120g a ai. ha^{-1} significantly reduced the density nad dry weight of broad leaf weeds over weedy check and it was statistically at par with tembotrione (34.4% SC) market sample 120g ai. ha^{-1}, tembotrione (34.4% SC) 110 g ai. ha^{-1}, topramezone 33.6g ai. ha^{-1} and tembotrione (34.4% SC) 100 g ai. ha^{-1}, respectively (Table 2). These results are in close conformity with those of Lakshmi and Luther (2017) reported the superiority of hand weeding over herbicidal treatments.

Density of sedges

Weed management practices were found to reduce the density and dry weight of sedges significantly than weedy check. Among herbicidal treatments, post emergence (PoE) application of tembotrione (34.4% SC) 120g ai. ha^{-1} significantly reduced the density and dry weight of sedges over weedy check and it was statistically at par with tembotrione (34.4% SC) market sample 120g ai. ha^{-1}, tembotrione (34.4% SC) 110 g ai. ha^{-1}, topramezone 33.6g ai. ha^{-1} and tembotrione (34.4% SC) 100 g ai. ha^{-1}, respectively (Table 2). Lower weed population of sedges was associated with alone application of tembotrione 120 g ai ha^{-1} (PoE) might be due to better control of sedges in this treatment. Removing the weeds whenever they appear under the weed free treatment resulted in complete elimination of weed competition as it resulted in zero weed dry weight and their density. The weed free treatments performed better than all the herbicidal treatments in reducing the biomass of weeds.

Table 2: Effect of tembotrione 34.4% SC on density of and dry weight of weeds (m^2) at different stages of crop growth

Treatment	Dose	Density of weeds (m^{-2})						Dry weight of weeds (g m^{-2})					
	a.i. (g ha^{-1})	Grassy weeds		Broad leaf weed		Sedges		Grassy weeds		Broad leaf weed		Sedges	
		At 30 DAS	At 60 DAS	At 30 DAS	At 60 DAS	At 30 DAS	At 60 DAS	At 30 DAS	At 60 DAS	At 30 DAS	At 60 DAS	At 30 DAS	At 60 DAS
Tembotrione 34.4% SC	100	10.8 (117.1)	9.3 (85.3)	6.8 (45.7)	5.7 (31.7)	7.3 (52.8)	6.2 (37.7)	5.1 (25.8)	6.6 (43.5)	3.2 (10.1)	4.1 (16.2)	3.5 (11.6)	4.4 (19.2)
Tembotrione 34.4% SC	110	10.4 (107.9)	8.9 (78.6)	6.3 (39.4)	5.3 (27.3)	6.9 (46.9)	5.8 (33.4)	4.9 (23.7)	6.4 (40.1)	3.0 (8.7)	3.8 (13.9)	3.3 (10.3)	4.2 (17.0)
Tembotrione 34.4% SC(X Dose)	120	9.5 (88.9)	8.1 (64.7)	5.5 (29.7)	4.6 (20.6)	5.7 (32.5)	4.9 (23.2)	4.5 (19.6)	5.8 (33.0)	2.7 (6.5)	3.3 (10.5)	2.8 (7.2)	3.5 (11.8)
Tembotrione 34.4% SC (Market sample)	120	10.8 (116.5)	9.2 (84.6)	7.4 (53.8)	6.1 (37.2)	7.8 (60.9)	6.6 (43.5)	5.1 (25.6)	6.6 (43.1)	3.5 (11.8)	4.4 (19.0)	3.7 (13.4)	4.8 (22.2)
Topramezone 336 g l^{-1} SC	33.6	11.0 (119.6)	9.4 (87.0)	7.6 (56.6)	6.3 (39.1)	8.0 (63.5)	6.8 (45.3)	5.2 (26.3)	6.7 (44.4)	3.6 (12.5)	4.5 (19.9)	3.8 (14.0)	4.9 (23.1)
Hand weeding at 20 and 40 DAS	—	0.7 (00.0)	0.7 (00.0)	0.7 (00.0)	0.7 (00.0)	0.7 (00.0)	0.7 (00.0)	0.7 (00.0)	0.7 (00.0)	0.7 (00.0)	0.7 (00.0)	0.7 (00.0)	0.7 (00.0)
Weedy check	—	19.0 (358.7)	16.2 (261.5)	10.6 (112.2)	9.1 (83.2)	11.9 (140.7)	10.0 (100.3)	9.1 (82.1)	11.7 (137.2)	5.3 (27.2)	6.8 (45.4)	5.6 (31.4)	7.4 (54.2)
CD (p=0.05)	—	1.7	1.4	2.3	1.8	3.7	1.8	0.8	1.1	0.91	1.2	1.1	1.4

Original values are given in parentheses, which were transformed to $\sqrt{x + 0.5}$.

Effects on weed control efficiency (%)

Among herbicidal treatments, post emergence (PoE) application of tembotrione (34.4% SC) 120g ai. ha^{-1} recorded highest weed control efficiency (WCE) followed by WCE tembotrione (34.4% SC) market sample 120g ai. ha^{-1}, tembotrione (34.4% SC) 110 g ai. ha^{-1}, topramezone 33.6g ai. ha^{-1} and tembotrione (34.4% SC) 100 g ai. ha^{-1} , respectively (Table 2). This could be attributed to the lower density as well as dry matter accumulation by weeds in these treatments (Table 3). Highest weed control efficiency indicate its relative performance of particular set of treatment Lakshmi and Luther (2017). However, weed free treatments proved superiority over herbicidal treatments. Highest WCE associated with weed free can be attributed to its effective control of all types of weeds. These findings established support from Malviya *et al*. (2012) and (Lakshmi and Luther, 2017). Lower weed control efficiency among the herbicides was associated with tembotrione 100 g ai ha^{-1} (PoE) and Topramezone 336 g l^{-1} SC. It might be due to higher weed intensity and dry matter accumulation of weeds in this treatment.

Grain yield of maize

Post emergence (PoE) application of tembotrione (34.4% SC) 120g ai. ha^{-1} recorded significantly the highest grain yield over weedy check and it was at par with tembotrione (34.4% SC) market sample 120g ai. ha^{-1}, tembotrione (34.4% SC) 110 g ai. ha^{-1} , topramezone 33.6g ai. ha^{-1} and tembotrione (34.4% SC) 100 g ai. ha^{-1} , respectively (Table 3). However, all the herbicidal treatments recorded significantly highest grain yield than weedy check. None of the herbicidal treatments was comparable to hand weeding recorded maximum grain yield. These results are corroborated with the research results of Mukhrjee and Rai (2016), Stanzen *et al*. (2017) and Kumar *et al*. (2017). The minimum grain yield was recorded in weedy check because of more weed growth and poor performance of yield attributing characters. Similar results were also reported by Shankar *et al*. (2015). Relative weed free situation under herbicidal treatments reduced the crop weed competition and thus lead to higher vegetative growth and yield attributes significantly affected the grain yield of maize (Barla *et al*. 2016).

Table 3: Effect of tembotrione 34.4% SC on weed control efficiency and grain yield of *Kharif* maize

Treatment	Weed control efficiency at 60 DAS (%)				Grain yield (t ha^{-1})
	a.i. (g ha^{-1})	Grassy weeds	Broad leaf weed	Sedges	
Tembotrione 34.4% SC	100	67.4	64.4	64.5	5.23
Tembotrione 34.4% SC	110	69.9	69.3	68.5	5.40
Tembotrione 34.4% SC (X Dose)	120	75.3	76.9	78.2	5.48
Tembotrione 34.4% SC (Market sample)	120	67.6	58.2	59.0	5.30
Topramezone 336 g l^{-1} SC	33.6	66.7	56.1	57.3	5.28
Hand weeding at 20 and 40 DAS	—	100.0	100.0	100.0	5.68
Weedy check	—	—	—	—	3.96
CD (p=0.05)	—	—	—	—	0.19

CONCLUSION

On the basis of present study it is recommended that application of tembotrione (34.4% SC, PoE) 120g a.i. ha^{-1} recorded lowest density and dry weight of weeds and recorded highest weed control efficiency and grain yield of maize during *Kharif* season in Eastern part of Uttar Pradesh.

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