Indian Journal of Weed Science **50**(3): 305–308, 2018

Print ISSN 0253-8040 Online ISSN 0974-8164

Tank mix application of tembotrione and atrazine to reduce weed growth and increase productivity of maize

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Article information

DOI: 10.5958/0974-8164.2018.00066.7

Type of article: Research note

Received : 7 April 2018
Revised : 27 July 2018
Accepted : 2 August 2018

Key words

Atrazine

Kharif maize

Stefes mero surfactant

Tembotrione

Yield

ABSTRACT

The experiment was carried out during *Kharif* (wet) season of 2014 at Agricultural Farm of Palli Siksha Bhavana, Visva-Bharati, Sriniketan, West Bengal to find the effect of tank mix application of tembotrione and atrazine on weed growth and productivity of *Kharif* maize. Nine treatments comprising of herbicide tembotrione as early post-emergence at 80, 100, 120 g/ha alone and in combination with atrazine at 500 g/ha, sole application of atrazine at 1000 g/ha and weeding twice at 25 and 40 DAS and unweeded control were assigned in a randomized block design in three replication. Results revealed that the experimental field was infested with all categories of weeds including grassy, broad-leaved and sedges. Among them the most predominant weeds were *Ludwigia parviflora*, *Cynodon doctylon*, *Cyperus rotundus* and *Fimbristylis miliacea*. Overall weed infestation caused about 48% reduction in yield of maize. Combined application of tembotrione with atrazine was significantly superior to its sole application in all the doses tested. Tembotrione at 100 g/ha + stefes mero surfactant at 733 g/ha + atrazine 500 g/ha considerably reduced the weed infestation- registering lower weed density, dry weight, weed index, higher weed control efficiency and increase in values of growth and yield attributes and yield of maize, which were comparable with tembotrione at 80 g/ha + stefes mero surfactant at 733 g/ha + atrazine 500 g/ha and tembotrione at 120 g/ha + stefes mero surfactant at 733 g/ha + atrazine 500 g/ha. Thus, early post-emergence application of tembotrione at 80-100 g/ha + stefes mero surfactant at 733 g/ha + atrazine 500 g/ha appeared to be the most promising weed management practice for higher weed control efficiency, yield, gross and net return of *Kharif* (wet) season maize in lateritic soil of West Bengal.

Maize is one of the most important cereal crops in the world agricultural both as food and feed. There is no cereal on the earth which has so immense potentiality; hence, it is called as 'Queen of cereals'. It is grown in almost all the states of India. It occupies an area of about 600 million/ha, which accounts for about 23% of the total area in the continent. It is next to rice, wheat and sorghum with regard to area and production in India. The crop is predominantly grown in *Kharif* (wet) season in India. The major yield reducing factors for maize cultivation in India are weeds (Pandey *et al*. 2001). Frequent rainfall, high temperature and higher relative humidity in *Kharif* season encourage germination, growth and heavy infestation of weeds in maize. Maize crop is infested with all categories of weeds including grassy, broad-leaved and sedges. The crop was infested with a wide range of weed flora, *viz*. *Cynodon dactylon, Echinochloa colona,* among the grasses*; Cyperus iria, Fimbristylis miliacea* among the sedges; and *Ludwigia parviflora, Commelina nudiflora, Cyanotis axillaris, Phyllanthus niruri, Melochia corchorifolia* among the broad-leaved weeds as major weeds out of which *Echinochloa colona, Cyperus rotundus, Commenlina benghalensis* and *Trianthema portulacastrum* dominated during early stages.

Weeds emerge along with the germination of maize seeds and grow rapidly in the early stage of crop growth, causing severe crop weed competition. In case, the weeds are not brought under control at right time, there is 50-60% reduction in yield (Chidda Singh 2009). However, the most critical period for crop weed competition is first six weeks after planting of crop because initial slow growth and

wider row spacing of maize, coupled with congenial weather conditions allow the weed growth which may reduce yield by 28-100% (Dass *et al*. 2012). Inadequate weed management especially during the first six weeks after sowing may cause maize yield losses ranging from 50 to 90% (Chikoye *et al.* 2004). Yield reduction in maize results from high competition between the crop and weed for water, light, nutrients especially when the competing weeds are of the same family with maize (Oerke and Dehne 2004). In maize generally, pre-emergence application of atrazine, pendimethalin, alachlor and post-emergence application of 2,4-D are being used. Applications of triazine group herbicides have been found effective to reduce the weed intensity in maize. Out of which, mix application of herbicides is coming out as very essential tool to tackle the problem of complex weeds in many crops including maize. Tembotrione is a new selective post-emergence herbicide that has been recently introduced for use in maize mixing with recommended herbicide atrazine. But it is essential to study the efficacy of the herbicide in different doses against different weed species in maize either alone or in combination with atrazine.

A field experiment was conducted during *Kharif* season of 2014 at Agriculture Farm, Institute of Agriculture, Visva-Bharati, Sriniketan, West Bengal. The farm is situated at 23°39' N latitude and 87°42' E longitude with an average altitude of 58.9 m above mean sea level under sub-humid, semiarid region of West Bengal. The soil was sandy loam in texture, slightly acidic in reaction (pH 6.8), low in organic C (0.46%) and available N (149.6 kg/ha), high in available P (28.42 kg/ha) and medium in available K (129.5 kg/ha). The experiment comprising of nine treatments was laid out in a randomized block design with three replications. The treatments under experimentation were tembotrione at 80 g/ha + stefes mero surfactant 733 g/ha, tembotrione at 80 g/ha + stefes mero surfactant 733 g/ha + atrazine 500 g/ha, tembotrione at 100 g/ha + stefes mero surfactant, tembotrione at 100 g/ha + stefes mero surfactant 733 g/ha + atrazine 500 g/ha, tembotrione at 120 g/ha + stefes mero surfactant , tembotrione at 120 g/ha + stefes mero surfactant 733 g/ha + atrazine 500 g/ha, atrazine 1000 g/ha, hand weeding 25 and 40 DAS , unweeded control. The treatments was applied with the help of knapsack sprayer after the sowing of seed. The powder or liquid formulation was diluted in the water according to the different doses and 1.2 L of spray solution per plot was applied for each treatment. The maize variety '*Kaveri Super 2020'*, was fertilized with 120 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha. All other recommended agronomic practices and plant protection measures were adopted to raise the crop. Data on weed population dynamics, dry weed biomass along with plant growth and yield attributes were recorded during the growth period. Weed control efficiency (%) was computed using the dry weed biomass of weeds.

Weed flora

The experimental field was infested with three categories of weeds under six families. The total number of weeds species was 9 out of which *Cynodon dactylon, Echinochloa colona,* among the grasses*; Cyperus iria, Fimbristylis miliacea* among the sedges; and *Ludwigia parviflora, Commelina nudiflora, Cyanotis axillaris, Phyllanthus niruri, Melochia corchorifolia* among the broadleaved weeds were present as major weeds (**Table 1**). Similar type of weed flora was reported by Ahmed and Susheela (2012), Haji *et al.* (2012), Dangwal and Singh (2013).

Effects on weed

The highest density and dry weed biomass of the entire weed species was recorded in unweeded control at both 45 DAS and 60 DAS. Among the herbicidal treatments application of tembotrione at 120 g/ha + stefes mero surfactant at 733 g/ha + atrazine 500 g/ha registered the lowest number and dry weight of *Cynodon dactylon*. No *Melochia corchorifolia* and *Phyllanthus niruri* was registered in treatments with the application of tembotrione at 80 g/ha + stefes mero surfactant at 733 g/ha + atrazine at 500 g/ha, tembotrione at 100 g/ha + stefes mero at 733 g/ha + atrazine at 500 g/ha, tembotrione at 120 g/ ha + stefes mero at 733 g/ha, tembotrione at 120 g/ha + stefes mero surfactant at 733 g/ha + atrazine 500 g/ haand atrazine 1000 g/ha (**Table 1**). Similar trend was observed in case of dry weight of *Melochia corchorifolia* and *Phyllanthus niruri*at 45 DAS and 60 DAS (**Table 2**).

All the three doses of tembotrione (80, 100, 120 g/ha) with surfactant and combination of atrazine 500 g/ha effectively controlled *Ludwigia parviflora, Cynotis axillaris* and *Commolina nudiflora*. Similar trend was observed in case of dry weight of *Ludwigia parviflora, Cynotis axillaris and Commolina nudiflora* at 45 DAS and 60 DAS. No *Cyperus rotundus* was registered in treatments with the application of tembotrione at 80 g/ha + stefes mero surfactant at 733 g/ha + atrazine at 500 g/ha, tembotrione at 100 g/ha + stefes mero at 733 g/ha + atrazine at 500 g/ha, tembotrione at 120 g/ha + stefes mero at 733 g/ha, tembotrione at 120 g/ha + stefes mero surfactant at 733 g/ha + atrazine 500 g/ha and

atrazine 1000 g/ha. Similar trend was observed in case of dry weight of *Cyperus rotundus*. The lowest count and biomass of *Fimbristylis miliacea*was registered under treatment tembotrione at 120 g/ha + stefes mero surfactant at 733 g/ha + atrazine 500 g/ha at 45 DAS and 60 DAS. All the herbicidal treatments are effectively controlled the count and dry weight of other weeds (*Echinocloa colona*) at both 45 DAS and 60 DAS. Among the herbicidal treatments, the lowest number and dry weight of total weeds was registerd in the higher doses of tembotrione at 120 g/ha + stefes mero surfactant at 733 g/ha + atrazine 500 g/ha at 45 DAS and 60 DAS.

Effects on crop

Weed infestation caused about 48% yield reduction in *Kharif* maize. The average girth of cob of maize varied significantly among the treatments. The highest average girth of cob was recorded in the tembotrione at 120 g/ha + stefes mero surfactant at 733 g/ha + atrazine 500 g/ha, which was statistically at par with tembotrione at 80 g/ha + stefes mero at 733 g/ha + atrazine 500 g/ha, tembotrione at 100 g/ha + stefes mero at 733 g/ha + atrazine 500 g/ha, hand weeding at 25 and 40 DAS. The highest number of kernals/cob was recorded in hand weeding at 25 and 40 DAS, which was statistically at par with tembotrione at 80 g/ha + stefes mero surfactant at 733 g/ha + atrazine 500 g/ha, tembotrione at 100 g/ha + stefes mero at 733 g/ha + atrazine 500 g/ha, tembotrione at 120 g/ha + stefes mero at 733 g/ha + atrazine 500 g/ha (**Table 3**). The highest number of kernel rows/cob was recorded in hand weeding at 25 and 40 DAS, which was statistically at par with tembotrione at 80 g/ha + stefes mero surfactant at 733 g/ha + atrazine 500 g/ha, tembotrione at 100 g/ha + stefes mero at 733 g/ha + atrazine 500 g/ha, tembotrione at 120 g/ha + stefes mero at 733 g/ha,

Table 1. Effect of treatments on weed density of different weeds (no./m^2) at 60 DAS of maize

Treatment	*C. dactylon*	*M. corchorifolia*	*P. niruri*	*L. parviflora*	*C. axillaris*	*C. nudiflora*	*C. rotundus*	*F. mileaceae*	Other weeds	Total
Tembotrione at 80 g/ha + stefes mero at 733 g/ha at 17 DAS	6.77 (45.33)	3.03 (8.66)	2.61 (6.33)	82.67	36.33	24.00	3.58 (12.33)	36.67	2.48 (5.66)	258.00
Tembotrione at 80 g/ha + stefes mero at 733 g/ha + atrazine at 500 g/ha at 17 DAS	3.58 (12.33)	0.71 (0)	0.71 (0)	15.33	12.00	7.67	0.71 (0)	16.33	0.71 (0)	63.67
Tembotrione at 100 g/ha + stefes mero at 733 g/haat 17 DAS	5.46 (29.33)	2.97 (8.33)	2.42 (5.33)	80.33	32.00	21.67	1.47 (1.66)	31.67	0.71 (0)	210.33
Tembotrione at 100 g/ha + stefes mero at 733 g/ha + atrazine at 500 g/ha at 17 DAS	3.39 (11)	0.71 (0)	0.71 (0)	14.33	10.67	6.00	0.71 (0)	14.67	0.71 (0)	56.67
Tembotrione at 120 g/ha + stefes mero at 733 g/ha at 17 DAS	5.12 (25.66)	0.71 (0)	1.68 (2.33)	72.67	31.33	21.67	0.71 (0)	23.33	1.47 (1.66)	178.67
Tembotrione at 120 g/ha + stefes mero at 733 g/ha + atrazine at 500 g/ha at 17 DAS	2.80 (7.33)	0.71 (0)	0.71 (0)	5.00	4.67	5.33	0.71 (0)	6.67	0.71 (0)	29.00
Atrazine at 1000 g/ha at 17 DAS	4.67 (21.33)	0.71 (0)	0.71 (0)	20.00	12.00	10.00	0.71 (0)	14.67	0.71 (0)	78.00
Two hand weeding at 25 and 40 DAS	3.67 (13)	1.58 (2)	1.35 (1.33)	16.67	6.00	5.33	4.30 (18)	12.67	0.71 (0)	75.00
Unweeded control	8.07 (64.66)	3.67 (13)	4.38 (18.66)	90.33	56.67	33.33	5.93 (34.66)	63.67	4.26 (17.66)	392.67
LSD (p=0.05)	4.11	0.35	0.30	11.13	4.62	3.49	0.54	4.57	0.28	18.2

Figures in parentheses are the original values. The data was transformed to $\sqrt{x+0.5}$ before analysis

Table 2. Effect of treatments on dry weight of different weeds (g/m^2) at 60 DAS of maize

Treatment	*C. dactylon*	*M. corchorifolia*	*P. niruri*	*L. parviflora*	*C. axillaris*	*C. nudiflora*	*C. rotundus*	*F. mileaceae*	Other weeds	Total
Tembotrione at 80 g/ha + stefes mero at 733 g/ha at 17 DAS	9.51	1.32 (1.24)	59.22	11.29	0.78 (0.10)	3.59	2.76 (7.14)	7.23	2.00 (3.53)	102.85
Tembotrione at 80 g/ha + stefes mero at 733 g/ha + atrazine at 500 g/ha at 17 DAS	2.40	0.71 (0)	12.11	3.25	0.71 (0)	1.17	0.71 (0)	3.01	0.71 (0)	21.94
Tembotrione at 100 g/ha + stefes mero at 733 g/haat 17 DAS	6.89	1.29 (1.16)	58.56	11.73	0.80 (0.14)	2.67	1.16 (0.88)	6.46	0.71 (0)	88.49
Tembotrione at 100 g/ha + stefes mero at 733 g/ha + atrazine at 500 g/ha at 17 DAS	1.87	0.71 (0)	10.31	2.72	0.71 (0)	0.81	0.71 (0)	2.71	0.71 (0)	18.41
Tembotrione at 120 g/ha + stefes mero at 733 g/ha at 17 DAS	6.29	0.71 (0)	46.04	8.77	0.75 (0.05)	2.58	0.71 (0)	5.48	1.25 (1.08)	70.31
Tembotrione at 120 g/ha + stefes mero at 733 g/ha + atrazine at 500 g/ha at 17 DAS	1.77	0.71 (0)	5.75	1.39	0.71 (0)	0.76	0.71 (0)	1.67	0.71 (0)	11.34
Atrazine at 1000 g/ha at 17 DAS	3.86	0.71 (0)	14.52	3.08	0.71 (0)	1.56	0.71 (0)	3.16	0.71 (0)	26.18
Two hand weeding at 25 and 40 DAS	3.18	0.86 (0.24)	12.13	1.62	0.72 (0.02)	0.86	2.20 (4.36)	3.28	0.71 (0)	25.69
Unweeded control	26.70	1.94 (3.31)	87.27	17.74	1.45 (1.65)	6.04	6.13 (37.0)	16.29	3.07 (8.95)	202.94
LSD (p=0.05)	4.11	0.16	5.86	1.52	0.15	0.37	0.26	0.33	0.15	12.03

Figures in parentheses are the original values. The data was transformed to $\sqrt{x+0.5}$ before analysis

Table 3. Effect of treatments on yield components, economics and weed control efficiency of maize cultivation

Treatment	Avg. girth of cob (cm)	No. of kernels per cob	No. of kernel rows per cob	500 kernel wt. (g)	Grain yield (t/ha)	Weed control efficiency (%) 60 DAS
Tembotrione at 80 g/ha + stefes mero at 733 g/ha at 17 DAS	10.27	290.9	10.67	70.83	3.45	49.4
Tembotrione at 80 g/ha + stefes mero at 733 g/ha + atrazine at 500 g/ha at 17 DAS	14.38	376.7	13.00	80.61	4.10	89.2
Tembotrione at 100 g/ha + stefes mero at 733 g/haat 17 DAS	11.41	303.1	11.33	72.5	3.77	56.6
Tembotrione at 100 g/ha + stefes mero at 733 g/ha + atrazine at 500 g/ha at 17 DAS	14.96	380.1	13.33	81.14	4.57	90.9
Tembotrione at 120 g/ha + stefes mero at 733 g/ha at 17 DAS	12.08	314.7	12.00	77.88	3.80	65.4
Tembotrione at 120 g/ha + stefes mero at 733 g/ha + atrazine at 500 g/ha at 17 DAS	15.04	368.4	12.33	79.52	4.31	94.4
Atrazine at 1000 g/ha at 17 DAS	12.15	307.7	11.67	74.06	3.80	87.1
Two hand weeding at 25 and 40 DAS	15.04	383.9	13.67	81.01	4.52	87.3
Unweeded control.	9.69	257.3	9.33	65.21	2.37	0.0
LSD (p=0.05)	2.25	48.56	1.76	18.28	0.48	-

tembotrione at 120 g/ha + stefes mero at 733 g/ha +atrazine 500 g/ha. Test weight of maize varies significantly tembotrione at 100 g/ha + stefes mero surfactant at 733 g/ha + atrazine500 g/ha recorded the highest test weight, which was statistically at par with tembotrione at 80 g/ha + stefes mero surfactant at 733 g/ha + atrazine 500 g/ha, tembotrione at 100 g/ ha + stefes mero surfactant at 733 g/ha, tembotrione at 120 g/ha + stefes mero surfactant at 733 g/ha, tembotrione at 120 g/ha + stefes mero surfactant at 733 g/ha + atrazine 500 g/ha, atrazine 1000 g/ha, hand weeding 25 and 40 DAS. The treatment tembotrione at 100 g/ha + stefes mero surfactant at 733 g/ha + atrazine 500 g/ha recorded the highest grain yield (4.57 t/ha), which was at par with tembotrione at 80 g/ha + stefes mero at 733 g/ha + atrazine 500 g/ha, tembotrione at 120 g/ha + stefes mero at 733 g/ha + atrazine 500 g/ha and hand weeding at 25 and 40 DAS. This result corroborates with the findings of Singh *et al.* (2012), Idziak and Woznica (2014), Sharma *et al.* (2000), Reddy *et al.* (2000), Deshmukh *et al.* (2009). Higher weed control efficiency in these treatments facilitated better availability of space, light and nutrients resulting in higher values of growth attributes, more number of grains ultimately higher yield. Among the herbicidal treatments, the combined application of tembotrione and atrazine registered the highest weed control efficiency (94.4%) at 60 DAS but was very close to that of tembotrione at 100 g/ha + stefes mero at 733 g/ha + atrazine at 500 g/ha, tembotrione at 80 g/ha + stefes mero surfactant at 733 g/ha + atrazine at 500 g/ha. Similar type of results was obtained by Singh *et al.* (2012), Woznica and Idziak (2014).

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