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Effect of Tembotrione Herbicide on Weed Persistence, Crop Resistance and its Effects on Maize (*Zea mays* L.)

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ABSTRACT

A field experiment was conducted at School of Agricultural Sciences (SAS), Nagaland University, Medziphema campus, Nagaland, during the *kharif* season of 2023 and 2024 to study the effect of tembotrione herbicide on weed persistence, crop resistance and its effects on maize. The experiment was conducted in Randomized Block Design and comprised of ten treatments viz., T_1- Weedy check, T_2- Hand weeding at 20 & 40 DAS, T_3 – Tembotrione 100g ha^{-1} at 15 DAS, T_4- Tembotrione 125g ha^{-1} at 15 DAS, T_5 - Tembotrione 150g ha^{-1} at 15 DAS, T_6 – Tembotrione 100g ha^{-1} at 30 DAS, T_7 - Tembotrione 125g ha^{-1} at 30 DAS, T_8 - Tembotrione 125g ha^{-1} at 30 DAS, T_9 - Atrazine 750g ha^{-1} at 2 DAS and T_{10} – 2,4-D Na 800 g ha^{-1} at 20 DAS. Surfactant 20 (polyoxy-ethylene 20 sorbitan monolaurate) was used at the rate of 5ml/liter of water. Results of the experiment revealed that Tembotrione 150g ha^{-1} at 30 DAS resulted in the lowest weed persistence and highest crop resistance. The maximum decrease in weed population and weed dry matter was observed in the same treatment resulting in maximum weed control efficiency. The highest fresh weight of cobs and kernel yield cob^{-1} were observed in Tembotrione 150g ha^{-1} at 30 DAS resulting in highest yield of maize and also the benefit cost ratio. It can be concluded that application of Tembotrione 150g ha^{-1} at 30 DAS is recommended since it resulted in maximum control of weeds and highest crop resistance and the lowest weed persistence and ultimately resulted in maximum profit.

Keywords Crop resistance index, Hand weeding, Maize, Tembotrione, Weed persistence index.

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INTRODUCTION

Maize is one of the most important cereals crops in the world. The productivity of maize is hindered by the competing weeds as it is a *kharif* season crop. It is reported that weeds cause about 58% grain yield

losses in maize which accounts for more loss than other pest (Ihsan *et al.* 2015). Among the chemical methods, there are many herbicides available for controlling weeds. However, it is also cautioned that continuous use of one herbicide or use of herbicides with same mode of action for prolonged period causes development of herbicide resistance, environmental pollution and long residual effects in soil which make the crop production unprofitable. Therefore, rotation in the use of herbicides having different chemical classes and mode of action is a prerequisite in efficient management of chemical weed control. In this view, tembotrione herbicide which inhibits Hydroxy Phenyl Pyruvate Dioxygenase has different mode of action with the commonly used herbicides such as atrazine and 2,4-D might act as an alternative and therefore in order to find out the efficacy of this herbicide, the experiment has been conducted.

MATERIALS AND METHODS

The experiment was conducted during *kharif* season of 2023 and 2024 at School of Agricultural Science,Nagaland University, Medziphema Campus, Nagaland. The experiment was laid out in Randomized Block Design with three replications consisting of 10 treatments.

The soil of the experimental site was sandy loam with low in available N (186 kg/ha), medium in P_2O_5 (45.22 kg/ha) and high in K_2O (295.12 kg/ha). Maize variety RCM 76 was sown in the 1st week of July with seed rate of 20 kg ha^{-1} and was fertilized at N-P_2O_5-K_2O with 80-30-20 kg ha^{-1}. All the treatments were applied as per the dose and schedule. Surfactant 20 (polyoxy-ethylene 20 sorbitan monolaurate) was used at the rate of 5ml/liter of water. Herbicide treatments were applied as per treatment. The treatments include viz., T_1- Weedy check, T_2 - Hand weeding at 20 & 40 DAS, T_3- Tembotrione 100g ha^{-1} at 15 DAS, T_4 - Tembotrione 125g ha^{-1} at 15 DAS, T_5 - Tembotrione 150g ha^{-1} at 15 DAS, T_6 - Tembotrione 100g ha^{-1} at 30 DAS, T_7 - Tembotrione 125g ha^{-1} at 30 DAS, T_8 - Tembotrione 125g ha^{-1} at 30 DAS,T_9 - Atrazine 750g ha^{-1} at 2 DAS and T_{10} - 2,4-D Na 800 g ha^{-1} at 20 DAS. The various indices developed by Mishra and Misra (1997) have been used to identify the weed persistence and crop resistance index.

Weed persistence index (WPI): (Dry weight of weeds in treated plot/dry weight of weeds in control plot) × (weed count in the control plot / weed count in the treated plot).

Crop resistance index (CRI): (Dry matter production by crop in the treatment plot/dry matter production by crop in the control plot) × (dry weight of weed in control plot/dry weight of weeds in treatment plot).

RESULTS AND DISCUSSION

Major weed found in the experiment

The dominant broad leaf weeds found in the experiment are *Mimosa pudica, Commelina benghalensis, Amaranthus viridis, Sida cordifolia, Ageratum conzyoides, Bidens pilosa, Acmella oleracea, Chomolaena odorata.* Among the sedges *Cyperus rotundus, Kyllinga brevifolia* are dominant. *Eleusine indica, Cynadon dactylon, Seteria glauca, Oplismenus hirtellus, digitaria sanguinalis* are the dominant grasses found in the experimental field.

Weed density and weed dry matter

At 60 DAS, the lowest weed density (4.60 no. m^{-2}) was observed in treatment T_2 (Hand weeding at 20 and 40 DAS), which was significantly superior over rest of the treatments (Table 1). Among the herbicide treatment, T_8 (Tembotrione 150 g ha^{-1} at 30 DAS) recorded the lowest weed density which was at par with T_7 (Tembotrione 125 g ha^{-1} at 30 DAS) and which recorded 6.44 and 6.92 no. m^{-2} respectively. The same doe of tembotrione applied at different dates gave significant results. This may be due to more effective control of weeds for longer period of days comparatively. Patel *et al.* (2021), also reported that application of tembotrione significantly reduced weed flora and improved grain yield in maize and other cereal crops. The maximum weed density (16.87 no. m^{-2}) was recorded under T_1 (Weedy check).

The lowest weed dry matter (7.05 g m^{-2}) at 60 DAS is recorded under T_2 (Hand weeding at 20 and 40 DAS), which was found to be significantly superior to the rest. It was followed by T_8 (Tembotrione 150 g ha^{-1} at 30 DAS) and T_7 (Tembotrione 125 g ha^{-1} at 30

Table 1. Effect of treatments on weed density, weed dry matter, weed control efficiency, fresh weight of cob and weight of kernels per cob (pooled data).

Treatments	Weed density (no. m^{-2})	Weed dry matter (g m^{-2})	Weed control efficiency (%)	Fresh weight of cob (g)	Number of kernels per cob (g)
T_1- Weedy check	16.87 (284.17)	87.13	-	85.38	147.67
T_2 – Hand weeding at 20 & 40 DAS	4.60 (21.33)	7.05	89.03	163.89	427.50
T_3 – Tembotrione 100g ha^{-1} at 15 DAS	12.19 (148.50)	44.73	30.43	137.95	382.67
T_4 – Tembotrione 125g ha^{-1} at 15 DAS	11.44 (130.50)	40.15	37.55	140.28	392.00
T_5 – Tembotrione 150g ha^{-1} at 15 DAS	9.45 (89.17)	31.33	51.27	142.43	397.17
T_6 – Tembotrione 100g ha^{-1} at 30 DAS	7.59 (57.67)	26.43	58.88	150.67	400.17
T_7 – Tembotrione 125g ha^{-1} at 30 DAS	6.92 (48.17)	21.62	66.38	154.95	409.83
T_8 – Tembotrione 125g ha^{-1} at 30 DAS	6.44 (41.83)	17.73	72.41	159.08	420.33
T_9 – Atrazine 750g ha^{-1} at 2 DAS and	8.50 (72.67)	26.23	59.19	131.43	372.33
T_{10} – 2,4-D Na 800 g ha^{-1} at 20 DAS.	12.19 (148.50)	41.77	35.04	139.63	377.83
SEm ±	0.19	1.83	-	3.60	4.26
LSD (p=0.05)	0.53	5.22	-	10.26	12.13

Figures in the parenthesis are the original values which were subjected to square root transformation √X (actual weed count) + 0.5.

DAS) which recorded 17.73 and 21.62 g m^{-2} respectively (Table 1). The highest weed dry matter (87.13 g m^{-2}) was recorded in T_1 (Weedy check). Sharma *et al.* (2018) demonstrated that tembotrione 120 g ha^{-1} (PoE) significantly lowered weed dry weight and density and achieved high weed control efficiency. Rana *et al.* (2017) also found that application of Tembotrione 150 g ha^{-1}+Surfactant at 30 DAS effectively reduced the dry weight of *Echinochloa colona, Commelina benghalensis, Polygonum alataum, Ageratum conyzoides.*

Weed control efficiency

Table 1 also showed the weed control efficiency data where T_2 (Hand weeding at 20 and 40 DAS) recorded the maximum weed control efficiency (89.03%). Among the herbicide treatments, T_8 (Tembotrione 150 g ha^{-1} at 30 DAS) recorded 72.41% which the highest followed by T_7 (Tembotrione 125 g ha^{-1} + Surfactant at 30 DAS) with 66.38%. The lowest among herbicides was recorded in T_{10} (2, 4-D Na 800 g ha^{-1} + Surfactant at 20 DAS) (35.04 %). Application of tembotrione at 30 DAS was able to manage the weeds for a longer period of time which therefore has also resulted in higher weed control efficiency. These findings are consistent with the results reported by Kumar *et al.* (2017), who observed that Tembotrione at 150 g ha^{-1} applied at 20 DAS effectively reduced weed dry matter and resulted in the highest weed control efficiency (85.2 %) in maize. Similarly, Singh *et al.* (2020) also reported that application of tembotrione 120 g ha^{-1}as post emergence along with alachlor 2000g ha^{-1} as pre-emergence provided the highest weed control efficiency of 95.1%.

Fresh weight of cob

The maximum fresh weight (163.89 g) was recorded in T_2 (Hand weeding at 20 and 40 DAS), which was found to be at par with T_8 (Tembotrione 150 g ha^{-1} at 30 DAS) followed by T_7 (Tembotrione 125 g ha^{-1} at 30 DAS), recording 159.08 g and 154.95 g respectively. The effective broad- spectrum weeds control in

tembotrione at 30 DAS has resulted in better growth of crops which also resulted in higher cob weight.

These findings are in agreement with those of Singh *et al.* (2021), who reported significantly higher cob weight (162.4 g) in maize under two-hand weeding compared to 87.5 g in weedy check. They emphasized that hand weeding-maintained weed-free conditions during the early growth phases, resulting in better partitioning of assimilates toward cob formation.

Number of kernels cob^{-1}

The maximum number of kernels per cob (427.50) was recorded under T_2 (Hand weeding at 20 and 40 DAS) which was at par with T_8 (Tembotrione 150 g ha^{-1} at 30 DAS) followed by T_7 (Tembotrione 125 g ha^{-1} 30 DAS), which recorded 420.33 and 409.83 respectively (Table 1). The minimum number of kernels per cob (147.67) was recorded under T_1 (Weedy check). The significant increase in kernel number in all the treatments compared to weedy check might be due to weed control along with improved plant growth parameters. Chethan *et al.* (2023) also observed that twice hand weeding recorded highest number of kernels per cob in maize. Similarly, Kumar *et al.* (2019) reported that tembotrione at 150 g ha^{-1} significantly increased kernel number (419.0) compared to weedy plots.

Weed persistence index (WPI)

Weed persistence index as presented in the Table 2 showed that among the herbicide treatments, T_8 (Tembotrione 150 g ha^{-1} at 30 DAS) recorded the lowest WPI, indicating good control of weed after its application which is at par with T_9 (Atrazine 750 g ha^{-1} at 2 DAS) and T_7 (Tembotrione 125 g ha^{-1} 30 DAS), while the highest value is recorded in T_4 (Tembotrione 125g ha^{-1} at 15 DAS) which is at par with T_3, T_5, T_6 and T_{10} treatments suggesting comparatively lower ability to control weeds.

Crop resistance index (CRI)

The crop resistance index indicated better growth of crops due to weed management and it can be observed that hand weeding treatment recorded maximum crop resistance (25.56) as presented in Table 2. Among the herbicide treatments T_8 (Tembotrione 150 g ha^{-1} at 30 DAS) showed the highest CRI (8.52) which is at par with T_6 (Tembotrione 100 g ha^{-1} at 30 DAS) while T_3 (Tembotrione 100 g ha^{-1} at 15 DAS) recorded the lowest CRI. This indicates that T_8 resulted in better growth of crops due to higher weed management efficiency. Weedy check recorded the lowest value of CRI (1.0) which shows the maximum harmful effect on crop by the weeds.

Table 2. Effect of treatments on weed persistence index (WPI), crop resistance index (CRI), grain yield and B : C ratio (Pooled data).

Treatments	WPI	CRI	Grain yield (kg ha^{-1})	B : C ratio (mean)
T_1- Weedy check	1.00	1.00	1126.25	0.46
T_2 - Hand weeding at 20 & 40 DAS	0.29	25.56	3662.89	2.22
T_3 - Tembotrione 100g ha^{-1} at 15 DAS	0.66	2.79	2786.44	2.45
T_4 - Tembotrione 125g ha^{-1} at 15 DAS	0.68	3.20	2845.42	2.48
T_5 - Tembotrione 150g ha^{-1} at 15 DAS	0.64	4.44	2889.54	2.54
T_6 - Tembotrione 100g ha^{-1} at 30 DAS	0.67	4.91	2842.61	2.51
T_7 - Tembotrione 125g ha^{-1} at 30 DAS	0.60	6.26	2980.47	2.61
T_8 - Tembotrione 125g ha^{-1} at 30 DAS	0.53	8.52	3113.34	2.77
T_9 - Atrazine 750g ha^{-1} at 2 DAS and	0.59	5.51	2676.04	2.36
T_{10} - 2,4-D Na 800 g ha^{-1} at 20 DAS.	0.67	3.09	2586.28	2.26
SEm ±	0.03	1.11	36.54	-
LSD (p=0.05)	0.08	3.17	104.14	-

Grain yield

The maximum grain yield (3662.89 kg ha^{-1}) was recorded in T_2 (Hand weeding at 20 and 40 DAS), which was found to be significantly superior over all other treatments. It was then followed by T_8 (Tembotrione 150 g ha^{-1} + Surfactant at 30 DAS) recording 3113.34 kg ha^{-1} followed by T_7 (Tembotrione 125 g ha^{-1} 30 DAS), while the lowest grain yield (1126.25 kg ha^{-1}) was recorded under T_1 (Weedy check).

These results are consistent with the findings of Sandeep *et al.* (2018), who reported that application of tembotrione 150 g ha^{-1} significantly improved grain yield (3210 kg ha^{-1}) of maize compared to unweeded control (1050 kg ha^{-1}), due to better weed suppression and enhanced crop growth. Similarly, Singh *et al.*

(2023) observed that two hand weedings (at 20 and 40 DAS) produced the highest grain yield in maize.

B:SC ratio

The B:C ratio as presented in Table 2 shows that all the treatments could bring profitable returns in maize cultivation. It is apparent that weedy check results in substantial yield loss leading to uneconomical crop production. However, the highest B:C ratio was recorded when Tembotrione 150g ha^{-1} at 30 DAS has been used followed by Tembotrione 125g ha^{-1} at 30 DAS. Even though hand weeding recorded highest yield, it was not able to give higher B:C ratio than herbicides treatment since the operation was carried out twice and the higher labor charge has resulted to lower the B:C ratio.

CONCLUSION

Based on the findings of the experiment, it can be concluded that tembotrione application on maize could result in higher yield and profits to the maize growers. It is also found out that tembotrione @150 g ha^{-1} will result in higher efficacy and better economics when it is applied at 30 DAS of the crop compared to application at 15 DAS. This herbicide when rotated with other herbicides may help preventing weed resistance in future.

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