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Effect of pre- and post-emergence (HPPD-Inhibitors) herbicides on weed dynamics and yield of *kharif* Maize (*Zea mays*)

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ABSTRACT

The research was conducted to determine the effect of new HPPD herbicides tembotrione, mesotrione, and topramezone on weed density, growth, and yield of maize. A field experiment was performed at the Agronomy farm of Lovely Professional University, Phagwara, Punjab, India, during the *kharif* season of the year 2022, in Randomized Complete Block Design (RCBD) with three replications and eight treatments of weed management including T1: Atrazine @1kg ha^{-1} PE, T2: Pyroxasulfone @127g ha^{-1} PE, T3: Pyroxasulfone @ 127g + Atrazine @ 1kg ha^{-1} PE (tank mixture), T4: Tembotrione @ 120g + Atrazine @ 1kg ha^{-1} + MSO Adjuvant at 20 DAS (Tank mixture), T5: Topramezone @ 25g + Atrazine @ 1kg ha^{-1} + MSO Adjuvant at 20 DAS (Tank mixture), T6: Mesotrione 2.27% w/w+ atrazine 22.7% w/w SC @ 3.5L ha^{-1} at 20 DAS (Ready to use), T7: Control (Weedy check) and T8: Weed free. However, the application of PoE herbicide T5 reduced the weed density significantly compared to T3 but was statistically at par with T6 and T4. There was a significant effect of herbicides on reducing weed dry matter, T5 gave superior results compared to T3 and was statistically at par with T4 and T6. Among the PoE herbicide T5 was significantly higher compared to T3 and statistically at par with T4. Effect on yield and yield component, the number of grains per cob was significantly higher in T8 compared to T7.

Key words : *Weed, Yield, Topramezone, Tembotrione, Mesotrione, Atrazine, Application*

Introduction

Maize is the most important cereal crop after wheat and rice. It has been termed as the "Queen of Cereals" because of its ability to cultivate throughout the year, high yielding potential, and its great scope in the industry. The production of maize in India has risen almost 16-fold from 1.73 million metric tonnes in 1950- 51 to 27.8 million metric tonnes in 2018-19 (Anonymous, 2021). The early stages of growth of maize are very sensitive to weed competition, though it is considered a robust growing plant in nature. For crop production, nutrients, water, sunlight, and space are essential resources, and weeds compete with crops for those resources, resulting in major losses in maize yield. Gantoli *et al*., (2013) noticed that infestation of weed flora decreased the yield of maize ranging from 38 to 65 percent. During the *kharif* season, wide- spaced crops suffer from heavy weed infestation.

Approximately 30-40 percent of applied nutrients are depleted by weeds. In agriculture, weeds are considered pests because they reduce productivity, reduce quality, and increase the cost of production. Because of increased labour costs and the non-availability of labour in the required quantity for hand

weeding, herbicides play a significant role as herbicide not only controls weed effectively and efficiently but also allows the cost of weed control to be reduced. Conventional methods of weed control are labour- intensive, expensive, and time-consuming, and they must be repeated frequently. As a result of pre- emergence and post-emergence herbicide application, herbicidal weed control will become more acceptable to farmers, without changing their existing agronomic practices, and will allow for the complete control of weeds. Application of atrazine and pendimethalin as PE are critical elements of today's weed management methods for maize, resulting in higher weed control efficiency, lower weed density, and lower dry weight. In the early stages of maize growth, atrazine @ 1.2 kg ha^{-1} and pendimethalin @ 1.0 kg ha^{-1} are effective at reducing weed emergence (Iqbal *et al*., (2020). Bollman *et al*., (2008) performed an experiment at three different places to determine the HPPD (inhibiting herbicides) viz. tembotrione, mesotrione, and topramezone as PoE. They concluded that the effectiveness of inhibiting herbicides was enhanced when they were mixed with atrazine. As a result, the current study was conducted to determine the effect of new HPPD (inhibiting) herbicides tembotrione, mesotrione, and topramezone on weed density, growth, and yield of maize.

Material and Methods

A field experiment was performed at the Agronomy farm of Lovely Professional University, Phagwara, Punjab, India, during the *kharif* season of the year 2022, to determine the effects of new generation's herbicides on weed density, weed dry weight, growth and yield of maize. The soil of the experimental field was clay loam soil having pH 8.4, EC 0.11 S/m, available N (221.5 kg ha^{-1}), available P (7.35 kg ha^{-1}) available K (136 kg ha^{-1}) and organic carbon 0.26%. The field experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications and eight treatments of weed management including T1: Atrazine @1kg ha^{-1} PE, T2: Pyroxasulfone @127g ha^{-1} PE, T3: Pyroxasulfone @ 127g + Atrazine @ 1kg ha^{-1} PE (tank mixture), T4: Tembotrione @ 120g + Atrazine @ 1kg ha^{-1} + MSO Adjuvant at 20 DAS (Tank mixture), T5: Topramezone @ 25g + Atrazine @ 1kg ha^{-1} + MSO adjuvant at 20 DAS (Tank mixture), T6: Mesotrione 2.27% w/w+ atrazine 22.7% w/w SC PoE @ 3.5 l h^{-1} at 20 DAS (Ready to use), T7: Control (Weedy check) and T8: Weed free. A 60 × 20 cm spacing was used for the maize variety 'ADV9293', with a recommended NPK fertilizer dose of 120:60:30 kg/ha. Herbicide was applied manually using a knapsack sprayer attached to a flood jet nozzle according to the treatments. After calibrating the sprayer, the amount of water used for PE application was 700 L ha^{-1} and 500 L ha^{-1} for PoE application. A quadrate of 30 x 30 cm was used to measure weed density weed and biomass of weeds at 30 days intervals until harvest at two randomly selected spots from the net plot area. According to the standard procedure, weed parameter and yield attributing characters were statistically analysed.

Results and Discussion

Weed Flora

During the investigation of the study, the major weed flora was composed of *Cyperus rotundus, Echinochloa colona, Dactyloctenium aegyptium, Digitaria sanguinalis, Eragrotis tenella, Leptochloa chinesis, Digera arvensis, Commelina banghalensis, Euphorbia hirta, Echinochloa esculenta, Elusine indicia, Ipomea purpurea* and *Cucumis melo*. Most of weed species associated with maize observed in this study were also recorded by Singh *et al*., (2015) and Khose *et al*., (2022) at New Delhi and Punjab respectively. However, it has been documented that the weed species vary from place to place, soil to soil, and season to season.

Effects on weeds Weed density (no m^{-2})

The weed density was significantly reduced in the weed-free treatment (T8) compared to the weedy treatment. However, the application PoE herbicide T5 (3.3) reduced the weed density significantly compared to T3 (6.4) but was statistically at par with T6 (4.2) and T4 (4.0) (Table 1). Lower the weed index better efficient is the treatment. Lowest weed count was recorded in weed free, due to all weeds were removed manually when they appeared during crop growth. Among chemicals spraying of topramezone along with atrazine produced minimum weed density because tank mixture of these chemicals increased the efficacy of herbicides resulted in lower weed density (Swetha *et al*., 2015) and it may be due to use of adjuvant in mixture with herbicides, enhances retention of herbicides on surface of leaf and helps in penetration through cuticle layer of leaves,

as a result of maximum control over weeds (Bunting *et al*., 2004).

Weed dry matter (g)

There was a significant effect of herbicides on reducing weed dry matter, T5 (6.0) gave superior results compared to T3(11.8) and was statistically at par with T4 (6.4) and T6 (7.0). However, the weed-free treatment (1) produced the lowest dry matter compared to the control (18.3) (Table 1). Similar results were recorded by Swetha *et al*., (2018), treatment of topramezone + atrazine (25.2+ 250) produced lower weed dry weight at harvest stage. This might be due to prolonged and high efficacy of applied new HPPD inhibiting herbicides which decreased growth of weeds and even resulted in rapid depletion of carbohydrate reserves of weeds that already germinated, bleaching of leaves, through respiration, decreased the leaf area and restriction of photosynthesis and it agrees with (Bollman *et al*., 2008) and (Roy *et al*., 2008). Moreover, using tank mixture of topramezone and tembotrione with atrazine and adjuvant results in a distinct reduction in total weed dry weight and this might be due to an increased foliar absorption of herbicides by the target weeds (Grossmann and Ehrhardt, 2007).

Weed control efficiency (%)

The weed control efficiency of maize was significantly influenced by weed management treatments, with all treatments resulting in higher weed control efficiency than weedy control (0) (Table 1). The highest weed control efficiency was observed in weed-free treatment T8 (100) as compared to control. Among the PoE treatments, T5 (88.6) recorded maximum WCE which was closely followed by T4 (87.6) and T6 (86.5) (Table 1). Higher WCE, better the herbicide in controlling the weed population. Maximum WCE was recorded in PoE treatments and compared to PE treatments. Similar observations were observed by Madhavi *et al*., (2014) with topramezone and Singh *et al*., (2012) with tembotrione. This might be due to fact that the application of these chemicals gives season-long control of weeds because of their persistency in soil and resulted in higher weed control efficiency. Additionally, application of topramezone at different doses, recorded maximum WCE, was not showing any signs of phytotoxicity, according to Gitsopoulos *et al*., (2010) and Soltani *et al.,* (2007).

Table 1. Effect of herbicide on weed.

Treatment	Weed density (no/m^2)	Weed dry matter (g)	Weed control efficiency(%)
T1	7.9 (61.0)	13.9 (192.0)	41.8
T2	6.9 (47.4)	12.4 (154.3)	49.4
T3	6.4 (40.6)	11.8 (137.7)	56.5
T4	4.0 (15.2)	6.4 (42.2)	87.6
T5	3.3 (10.6)	6.0 (38.5)	88.6
T6	4.2 (16.8)	7.0 (49.6)	86.5
T7	11.8 (138.4)	18.3 (333.3)	0.0
T8	1.0 (0)	1.0 (0)	100.0
S. Em ±	0.3	0.7	2.3
CD (0.05)	0.9	2.0	7.0

Effect on yield and yield component

The number of grains per cob was significantly higher in T8 (434.0) compared to T7 (320.3), due to less competition for crop in term of space, light and nutrition. Among the PoE herbicide, T5 (430.9) was significant compared to T3 (392.0) and statistically at par with T4 (427.5) followed by T6 (425.5). The higher seed index was observed in T5 (41.2) followed by T4 (40.8) and T6 (40.6). The grain yield was significantly higher in T5 (59.1) compared to other treatments but statistically at par with T4 (58.2) followed by T6 (57.3). Similarly, the higher stover yield was observed in T5 (90.4) which was at par with T4 (89.6) and T6 (88.6). The findings of yield and yield components were substantiating with the results of Veeresh *et al*., (2014), Shambhu Prasad and Rakesh Kumar, (2017) and Swetha *et al*., (2015). Among chemical application of topramezone along with atrazine, yield and yield components were closely followed by tembotrione and mesotrione. This might be due to these new generation herbicides provided effective control over the maximum weeds. Moreover, weed free treatment produced significantly higher grain yield, may be due to better growth and development of crop. Apart from this, significantly lower seed yield was recorded in control treatment, this may be due higher competition, weed density and weed dry matter. Similarly, infestation of weed reduced maize yield by 50 to 69% and 32 to 42%, according to Kumar *et al*., (2012) and Sarma and Gautam, (2010) respectively.

Conclusion

Spraying of Topramezone @ 25g + Atrazine @ 1kg ha^{-1} + MSO adjuvant was found to be most effective

Table 2. Effect on yield and yield components of *kharif* maize.

Treatments	Number of grains/ cob	Seed index (g)	Grain yield (q ha^{-1})	stover yield (q ha^{-1})
T1	369.3	33.0	47.0	75.8
T2	380.7	35.9	48.3	77.2
T3	392.0	36.6	50.8	79.5
T4	427.5	40.8	58.2	89.6
T5	430.9	41.2	59.1	90.4
T6	425.5	40.6	57.3	88.6
T7	320.3	29.2	39.2	65.1
T8	434.0	41.5	61.4	91.7
S. Em±	3.2	0.5	0.7	1.1
C.D (0.05)	9.7	1.5	2.2	3.4

in reducing weed density, dry weight, weed index and increased the yield and yield component followed by Tembotrione @ 120g + atrazine @ 1kg ha^{-1} + MSO adjuvant and Mesotrione 2.27% w/w+ atrazine 22.7% w/w SC @ 3.5L ha^{-1}. The results revealed that application on HPPD inhibiting PoE herbicides significantly superior to PE herbicides.

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