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Effect of New Pre-and Post-Emergence Herbicide Molecules in Maize on a Sandy Loam Soil of Telangana in India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: To evaluate the efficacy of new pre and post-emergence herbicides on crop growth, yield attributes and yield in *kharif* maize.
Study Design: Randomized Block Design.
Place and Duration of Study: Agriculture Research Station, Karimnagar, during *kharif,* 2023.

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Methodology: The experiment involved ten different treatments arranged in a randomized block design, with three replications for each treatment. Treatments were T_1 -Atrazine 50% WP 0.5 kg a.i ha^{-1} as PE *fb* HW at 40 DAS, T_2 -Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* HW at 40 DAS, T_3 - Halosulfuron methyl 5% + atrazine 48% WG (RM) 0.05625 + 0.540 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS, T_4 - Topramezone 10 g l^{-1} + atrazine 300 g l^{-1} SC (RM) 0.775 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS, T_5 - Mesotrione 2.27% w/w + atrazine 22.7% w/w SC (RM) 0.875 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS, T_6 - Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* halosulfuron methyl 75% WG 0.0675 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS, T_7 - Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione 34.4% SC 0.12 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS, T_8 - Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* topramezone 336 g l^{-1} w/v SC 0.252 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS, T_9 - Weedy check, T_{10} - Weed free (HW at 20 and 40 DAS).

Results: It was notable that at 30, 60, 90 days after sowing (DAS) and harvest, the weed-free treatment (HW at 20 and 40 DAS) recorded the maximum weed control efficiency, plant population, plant height, leaf area, dry matter production, cob length, cob girth, number of kernel rows cob^{-1}, number of kernels cob^{-1}, grain yield, stover yield and harvest index at both initial and final stages. Among the herbicidal treatments, significantly higher weed control efficiency, plant height, leaf area, dry matter production, cob length, cob girth, number of kernel rows cob^{-1}, and number of kernels cob^{-1} were recorded by the application of pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS which was found on par with pyroxasulfone @0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS, mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS, topramezone + atrazine (RM) 0.775 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS and pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* halosulfuron methyl @ 0.0675 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS. However, significantly lower plant height, leaf area, dry matter production, cob length, cob girth, number of kernel rows cob^{-1}, number of kernels cob^{-1}, grain yield and stover yield were observed under weedy check treatment. Application of pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (6875 and 7792 kg ha^{-1}) recorded the significantly maximum grain yield and stover yield which was on par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS (6406 and 7195 kg ha^{-1}), mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS (6250 and 6944 kg ha^{-1}), topramezone + atrazine (RM) 0.775 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS (6039 and 6583 kg ha^{-1}) and pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* halosulfuron methyl @ 0.0675 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS (5917 and 6806 kg ha^{-1}).

Conclusion: Based on the results of this investigation in maize, it can be concluded that among various weed control tactics, application of pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS, pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS and mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS proved to be the most effective herbicides in controlling weeds. This regimen showed superior performance in growth, yield attributes, and overall yield due to the high weed control efficiency of these herbicides.

Keywords: Pyroxasulfone; tembotrione; topramezone; mesotrione + atrazine (RM); halosulfuron methyl; plant height; yield.

1. INTRODUCTION

Maize (*Zea mays* L.) is the world's third leading cereal crop after wheat and rice. It is cultivated in tropical, subtropical, and temperate climates. It is known as the "Queen of Cereals". This title is attributed to maize due to its high yield, versatility, and nutritional value. Maize is a staple food in many parts of the world and is utilized in a wide range of products, including food, animal feed, and industrial raw materials. Its usage pattern is diverse, with 51% used as poultry feed, 20-25% consumed as human food, 10-12% used for cattle feed, and 1% reserved for seed. It has evolved into an industrial crop on a global scale, with 83% of its production worldwide and 76% of its production in India serving the feed, starch, and biofuel industries. It is crucial to increase maize acreage and productivity in the coming years to meet the rising demands for feed, food,

and industrial uses, especially considering the rapid growth of the livestock and poultry industries in India [1].

Maize accounts for 8% and 25% of the world's total area and production under cereal crops. In India, maize covers 10.74 M ha of area, with an average yield of 35.67 million tonnes and productivity of 3321 kg ha^{-1} (E&S Division, DA&FW 2023-24), while in Telangana it is grown in an area of 4.86 lakh hectares with a production of 26.68 lakh tonnes and productivity of 5490 kg ha^{-1} (DA&FW 2023-24).

The major maize-producing states in India include Karnataka (19.4 lakh ha), Madhya Pradesh (15.4 lakh ha) Maharashtra (13.05 lakh ha), Uttar Pradesh (8.91 lakh ha), Rajasthan (8.8 lakh ha), Bihar (7.28 lakh ha) Telangana (4.86 lakh ha) and Tamil Nadu (4.56 lakh ha) (DA&FW 2023-24).

In Telangana, during *kharif* 2023, maize was grown in an area of 4.86 lakh hectares with a production of 26.68 lakh tonnes and productivity of 5490 kg ha^{-1} (DA&FW 2023-24). The major maize-growing districts in Telangana include Kamareddy (30149 ha), Rangareddy (29022 ha), Vikarabad (26026 ha), Bhadradri (22252 ha), Mahboobabad (22030 ha), Jagitial (18869 ha), Nizamabad (15183 ha), Siddipet (15072 ha), Nagarkurnool (14906 ha) and Mahbubnagar (11678 ha) (Directorate of economics and statistics, 2022-23).

Some of the grassy and broad-leaf weeds observed in maize fields are *Cyperus rotundus* L., *Cynodon dactylon* L., *Commelina benghalensis* L., *Amaranthus retroflexus* L., *Dinebra arabica* L., *Tridax procumbens* L., *Euphorbia hirta* L., *Euphorbia geniculata* L., *Parthenium hysterophorus* L., *Digera arvensis* L., *Phyllanthus niruri* L., *Celosia Argentea* L and *Acalypha indica* L. These weeds are among the most problematic globally, infesting maize fields and consequently increasing production costs.

Traditionally, weed control in agriculture involved manual methods such as hoeing and the use of animal-drawn implements. However, the growing shortage of human labour and increasing wage costs have made hand-weeding less practical. Additionally, manual and mechanical weeding methods are costly and often impractical, especially during the monsoon season, when persistent rainfall results in muddy and challenging field conditions. Herbicides present the most viable alternative for weed control in such conditions. Their utilization has transformed farming practices in crops like rice, wheat, and maize in India, demonstrating remarkable effectiveness in managing the diverse weed flora associated with maize cultivation.

"Chemical weed management by using pre and post-emergence herbicides can lead to the efficient and cost-effective control of weeds during critical periods of crop weed competition, which may not be possible with manual or mechanical weeding due to high cost of cultivation" [2].

In India, farmers are mostly applying atrazine at 1.0 kg a.i ha^{-1} as a pre-emergence herbicide and 2,4-D at 1.0 kg a.i ha^{-1} as a post-emergence herbicide in maize. However, these herbicides are often ineffective against a wide range of weed species, and it is well-documented that the persistence of atrazine in the soil can lead to residual effects.

In the light of this challenging context in agriculture, new generation of pre- and post-emergence herbicides were developed for effective control of the weeds in maize crop. Hence, it is proposed to test the new pre and post-emergence herbicides in the present investigation. The new herbicides used in this study are Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1}, Topramezone 10 g l^{-1} + atrazine 300 g l^{-1} SC (RM) 0.775 kg a.i ha^{-1}, Mesotrione 2.27% w/w + atrazine 22.7% w/w SC (RM), Halosulfuron methyl 75% WG 0.0675 kg a.i ha^{-1}, Tembotrione 34.4% SC 0.12 kg a.i ha^{-1} and Topramezone 336 g l^{-1} w/v SC 0.252 kg a.i ha^{-1}.

2. METHODS AND MATERIALS

The field experiment was carried out at Agriculture Research Station (ARS), Karimnagar during *kharif* (2023). The experimental site is geographically situated in the Northern Zone of Agro climatic zone in Telangana. The soil texture of the experimental site is Sandy loam with neutral pH (6.6), E.C (0.35 ds m^{-1}), low in organic carbon (0.41 %), low in available N (267.5 kg ha^{-1}) and high in available Phosphorous (37.4 kg ha^{-1}) and available potassium (287.25 kg ha^{-1}).

The experiment was comprised of ten different treatments arranged in a randomized block design, with three replications for each. The treatments were T_1 -Atrazine 50% WP 0.5 kg a.i ha^{-1} as PE *fb* HW at 40 DAS, T_2 -Pyroxasulfone

85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* HW at 40 DAS, T_3 - Halosulfuron methyl 5% + atrazine 48% WG (RM) 0.05625 + 0.540 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS, T_4 - Topramezone 10 g l^{-1} + atrazine 300 g l^{-1} SC (RM) 0.775 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS, T_5 - Mesotrione 2.27% w/w + atrazine 22.7% w/w SC (RM) 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS, T_6 - Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* halosulfuron methyl 75% WG 0.0675 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS, T_7 - Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione 34.4% SC 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS, T_8 - Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* topramezone 336 g l^{-1} w/v SC 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS, T_9 - Weedy check, T_{10} - Weed free (HW at 20 and 40 DAS).

The observations were recorded on weed control efficiency at 30 DAS, initial and final plant population, plant height, leaf area, dry matter production, cob length, cob girth, number of kernel rows cob^{-1}, number of kernels cob^{-1}, grain yield, stover yield and harvest index in maize at 30, 60, 90 DAS and harvest. Weed control efficiency is calculated as the percentage reduction in weed dry matter yield in the treated plots compared to the untreated control 60 days after sowing (DAS) as under on equation 1:

$$\text{WCE} = \frac{\text{Dry weight of weeds inunweeded control (g m}^{-2}) - \text{Dry weight of weeds in treatment plot (g m}^{-2})}{\text{Dry weight of weeds in unweeded control (g m}^{-2})} \times 100$$

The seeds were sown with a spacing of 60×20 cm in between the lines. The recommended dose of fertilizers (RDFs) for all the treatments was 200:60:50 kg ha^{-1} of N, P_2O_5, and K_2O, using urea, di-ammonium phosphate (DAP), and murate of potash (MOP) respectively. A total of 828 mm of rainfall was recorded over 36 rainy days. The weekly mean maximum temperature during the crop growth period ranged from 28.9°C to 42.4°C with an average of 35.8°C. The weekly mean minimum temperature during the crop growth period ranged from 17.1°C to 31.6°C with an average of 25.0°C. The mean weekly sunshine ranged from 1.2 to 8.2 hours and the mean evaporation ranged from 0.9 to 4.3 mm. All recorded data from the study were subjected to statistical analysis using the analysis of variance technique for a randomized block design.

3. RESULTS AND DISCUSSION

3.1 Weed Control Efficiency

At 60 DAS, the highest weed control efficiency was observed in pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (92.44%) which was closely followed by hand weeding at 20 and 40 DAS, pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (90.57%) and mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (86.72%). The increased weed control efficiency observed in these treatments can be attributed to a reduced weed population and lower weed dry weight. Similar results were obtained by the findings of Hardwick et al. [3] Arslan et al. [4], Barua et al. [5], Chhokar et al. [6], Sundari et al. [7], Kaur et al. [8], Kakade et al. [9] and Lavanya et al. (2020). Among all the treatments, the T_9- weedy check provided the lowest weed control efficiency (0.00) (Fig. 1).

3.2 Crop Growth Parameters

3.2.1 Plant population

The salient findings on the initial and final plant stands under various weed management practices indicated that the initial or final plant stands were not significantly affected by weed management practices imposed (Fig. 2), demonstrating consistent emergence and stability throughout the crop growth period. This suggests a uniform plant population across all treatments. These results are similar with the findings of Hatti et al. [10], Jha et al. [11], Samant et al. [12], Mali et al. [13]) and Kumar et al. [14].

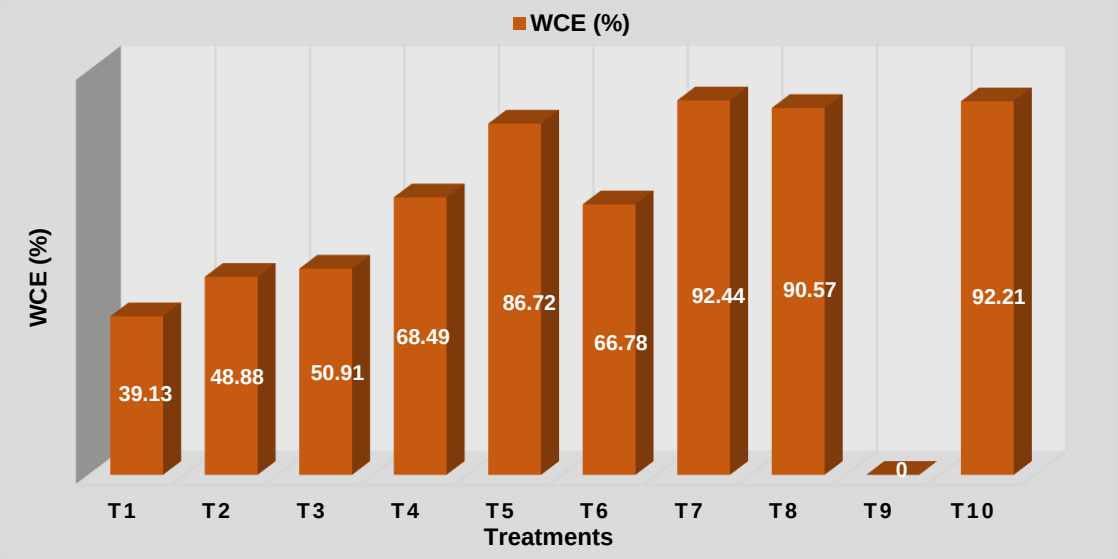

Fig. 1. Effect of different weed control treatments on weed control efficiency (%) in *kharif* maize at 60 DAS

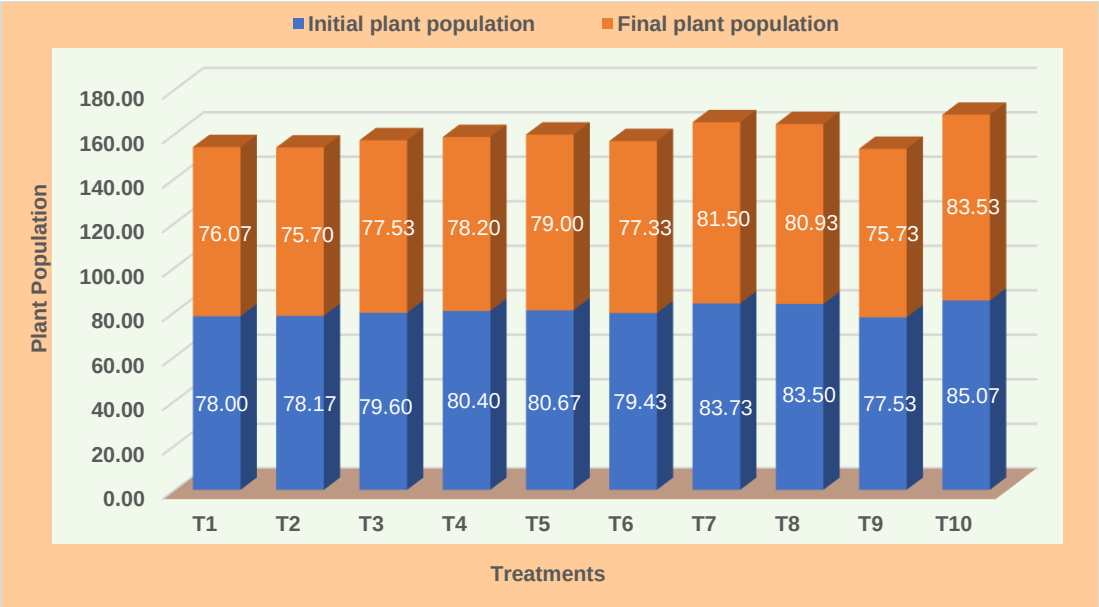

Fig. 2. Effect of different weed control on the initial and final plant population ('000 ha^{-1}) of *kharif* maize

3.2.2 Plant height (cm)

Weed control significantly influenced the plant height at all growth stages, except at 30 days after sowing (DAS) (Fig. 3). At this stage, weed control treatments had no effect on plant height, and the differences between treatments were statistically non-significant.

At 60 DAS, hand weeding at 20 and 40 DAS (142.6 cm) recorded a significantly higher plant height among all treatments. Among all herbicides, pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (141.8 cm) resulted in the maximum plant height which was statistically on par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (133.3 cm) and mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (127.3 cm). This could be attributed to the high

weed control efficiency and reduced crop-weed competition in these treatments. The lowest plant height was observed in the weedy check (90.6 cm) as weeds impeded plant growth by competing for soil moisture, nutrients, sunlight, and space during the growth period as noted by Kaur et al. [15], Khose et al. [16], Saimaheswari et al. [17], Sairam et a. [18], Sachan et al. (2024), and Bhagat et al. [19].

At 90 DAS, significantly higher plant height was recorded under weed-free treatment (Hand weeding at 20 and 40 DAS) (183.8 cm). Among all the herbicides, pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (182.3 cm) noticed the taller plants which were statistically on par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (178.7 cm) and mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (177.2 cm). However weedy check (118.2 cm) showed the lowest plant height.

Hand weeding twice at 20 and 40 DAS resulted in significantly higher plant heights at harvest (196.7 cm). Among the various herbicide treatments, pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (193 cm) noticed the higher plant height and it was found statistically on par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (187.6 cm) and mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (185.6 cm). This increase in plant height could be due to the suppression of weed growth, creating a weed-free environment that facilitated higher vegetative growth of the maize plants. However weedy check (138.0 cm) resulted in the lowest plant height. Similar results are also stated by Rao et al. [20], Rani et al. [21], Sachan et al. [22], Sundari et al. [19], Singh et al. [23] and Bhagat et al. [3], who stated that an increase in plant height could be due to the suppression of weed growth, creating a weed-free environment that facilitated higher vegetative growth of the maize plants.

3.2.3 Leaf area (cm^2 $plant^{-1}$)

The observations on leaf area obtained at 30, 60, and 90 DAS, and harvest due to various weed management practices are presented in Fig. 4. It was observed that hand weeding at 20 and 40 DAS (1335.7 cm^2 $plant^{-1}$) revealed a significantly higher leaf area over the rest of the treatments. Among various herbicides, pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (1298 cm^2 $plant^{-1}$) noticed the higher leaf area and remained on par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (1286.7 cm^2 $plant^{-1}$), mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (1236 cm^2 $plant^{-1}$). The minimum leaf area was found in the weedy check (997.3 cm^2 $plant^{-1}$).

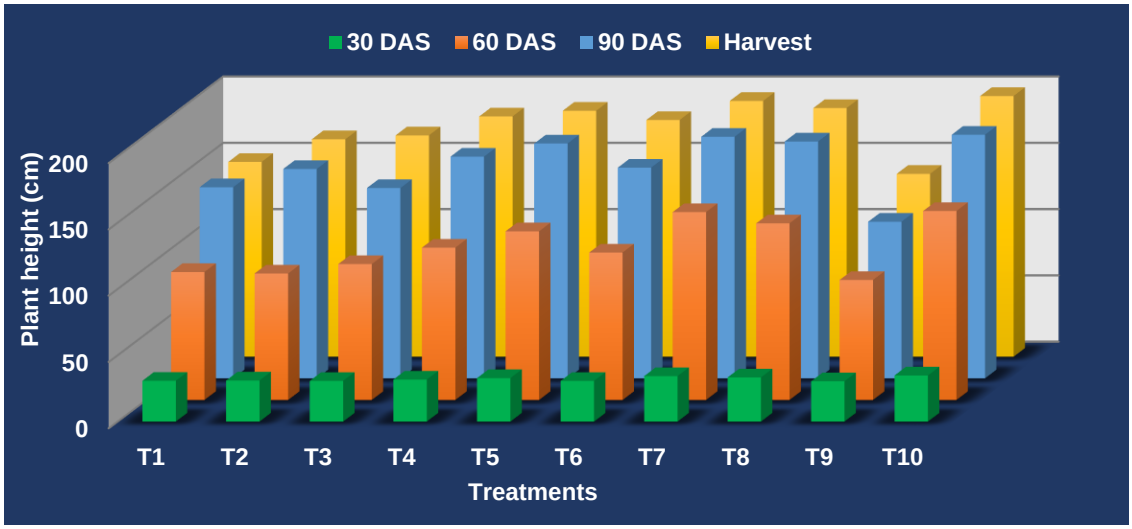

Fig. 3. Effect of different weed control treatments on plant height (cm) in *kharif* maize at 30, 60, 90 DAS and harvest

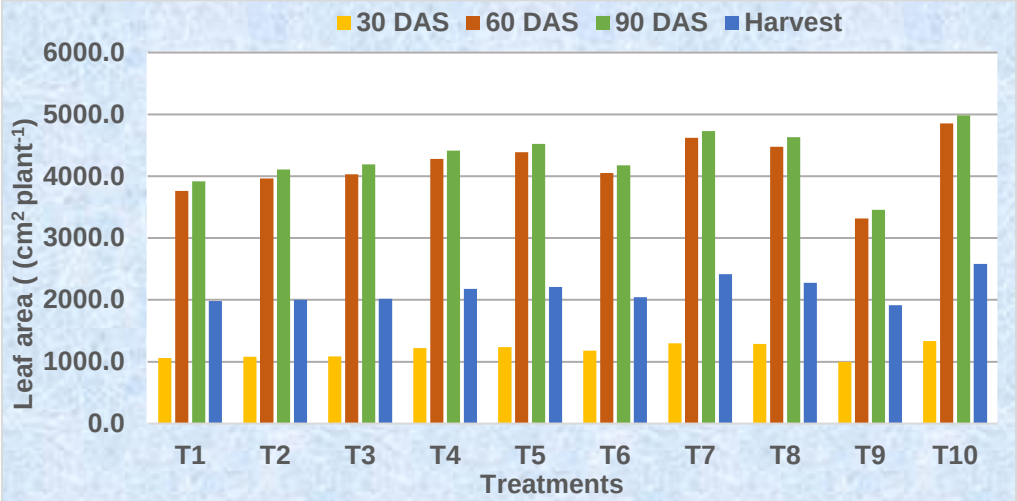

Fig. 4. Effect of different weed control treatments on leaf area in *kharif* maize at 30, 60, 90 DAS and harvest

Hand weeding at 20 and 40 DAS (4853.9 cm^2 $plant^{-1}$) recorded a significantly higher leaf area than the other treatments at 60 DAS. Among various herbicides, pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (4620 cm^2 $plant^{-1}$) resulted the higher leaf area and is on par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (4477.4 cm^2 $plant^{-1}$), mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (4386.3 cm^2 $plant^{-1}$).

Data at 90 DAS revealed that hand weeding at 20 and 40 DAS resulted in significantly more leaf area (4985 cm^2 $plant^{-1}$) than other treatments. Of the various herbicides, pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (4732.7 cm^2 $plant^{-1}$) observed the higher leaf area and it was on par to pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (4630.5 cm^2 $plant^{-1}$), mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (4523 cm^2 $plant^{-1}$). The weedy check had the lowest leaf area (3458.3 cm^2 $plant^{-1}$).

At harvest, hand weeding at 20 and 40 DAS (2584.3 cm^2 $plant^{-1}$) resulted in a significantly higher leaf area than all the other treatments. Among various herbicides, pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (2414.7 cm^2 $plant^{-1}$) recorded the higher leaf area which was on par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (2276.0 cm^2 $plant^{-1}$), mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (2209.3 cm^2 $plant^{-1}$), topramezone + atrazine (RM) 0.775 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (2178.4 cm^2 $plant^{-1}$). The lower leaf area was found in the weedy check (1914.0 cm^2 $plant^{-1}$). These results align with the findings of Rahman et al. [24], Yadav et al. [25], Raghuwanshi et al. [26], Ehsas et al. [27] and Negalur et al. (2020).

3.2.4 Dry matter production (kg ha^{-1})

The data on weed control efficiency (%) was obtained at 30, 60, and 90 DAS, and harvest. It was based on the total dry weight of weeds in the weedy check, and it differed significantly by various weed management strategies. The results are provided in Table 1.

The production of dry matter was a result of the efficient use of resources in an ideal crop-growing environment. The impact of weed management practices on the dry matter accumulation in maize at 30, 60, and 90 days after sowing (DAS) and at harvest is presented in Table 1.

At 30 days after sowing (DAS), the weed-free treatment (hand weeding at 20 and 40 DAS) (990 kg ha^{-1}) showed a notably higher dry matter production than other treatments. Amongst herbicides, pre-emergence application of pyroxasulfone @ 0.1275 kg a.i ha^{-1} *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS

fb HW at 40 DAS (959 kg ha^{-1}) resulted in a significantly greater dry matter production and was found at par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (938 kg ha^{-1}) and mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (914 kg ha^{-1}). The weedy check resulted in a significantly reduced dry matter production (779 kg ha^{-1}) compared to all other treatments.

At 60 DAS, weed-free treatment (6675 kg ha^{-1}) registered the highest dry matter production over the different weed control treatments. Pyroxasulfone @ 0.1275 kg a.i ha^{-1} *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (6584 kg ha^{-1}) recorded the significantly higher dry matter production among all herbicide treatments which was statistically at par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (6493 kg ha^{-1}) and mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS (6419 kg ha^{-1}). However, the weedy check (5591 kg ha^{-1}) treatment showed a markedly lower production of dry matter.

The highest dry matter production was observed in weed-free treatment (hand weeding at 20 and 40 DAS) (9089 kg ha^{-1}) at 90 DAS because of a weed-free environment and was superior over the rest of the treatments. Among herbicidal treatments, pyroxasulfone @ 0.1275 kg a.i ha^{-1} *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (8959 kg ha^{-1}) recorded the significantly higher dry matter production which was on par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (8788 kg ha^{-1}) and mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (8658 kg ha^{-1}). Whereas lower dry matter production was obtained in the weedy check treatment (7410 kg ha^{-1}) as the vegetative growth was hindered by the competing weeds.

At harvest, dry matter production was significantly higher in the weed-free treatment (hand weeding at 20 and 40 days after sowing) (8129 kg ha^{-1}). Amongst herbicides, pyroxasulfone @ 0.1275 kg a.i ha^{-1} *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (7902 kg ha^{-1}) noticed the significantly higher dry matter production which was on par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (7245 kg ha^{-1}) and mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (6944 kg ha^{-1}). Significantly lower dry matter accumulation was found in the weedy check (3096 kg ha^{-1}) over all other treatments. The notable increase in dry matter production was due to improved crop nutrition facilitated by decreased weed competition. This was reflected by significantly lower weed density, reduced weed dry weight, and increased weed control efficiency. These findings are in agreement with the outcomes Kour et al. [28], Kumar et al. [29], Supriya Gupta [30] and Kumar et al. [31], who who evaluated the effectiveness of new pre- and post-emergence herbicides in winter maize in Uttar Pradesh, concluded that both pre and post emergence herbicides (Pyroxasulfone 85% PE 159.4 g a.i ha^{-1} and tembotrione 34.4% SC PoE) were effective in suppressing weeds and promoting the development of winter maize.

3.2.5 Days to 50% tasseling and silking

Data on days to 50% tasseling and silking is presented in Table 2. and was notable that weed control have no significant effect on days to 50% tasseling and silking. The comparable times to achieve 50% tasseling and 50% silking across various treatments indicate that weed competition does not impact the flowering stages of maize. A similar observation was made by Odero et al. [32,33], Mastkar et al. [34] and Kumar et al. (2019), who concluded that various weed management practices did not have a significant impact on the number of days required for 50% tasseling.

3.3 Yield Attributes and Yield

3.3.1 Cob length (cm)

The weed-free treatment (hand weeding at 20 and 40 days after sowing) (17.87 cm) was observed with a significantly higher cob length relative to other weed management practices (Table 3). Among all herbicide treatments, pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (17.27 cm) resulted in the significantly higher cob length which remains on par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (16.6 cm) and mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (16.17 cm).

Table 1. Effect of different weed control treatments on plant dry matter production (kg ha^{-1}) in *kharif* maize at 30, 60, 90 DAS and harvest

S No	Treatments	30 DAS	60 DAS	90 DAS	Harvest
T_1	Atrazine 50% WP 0.5 kg a.i ha^{-1} as PE *fb* HW at 40 DAS	801	5670	7697	5686
T_2	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* HW at 40 DAS	846	5759	8021	6230
T_3	Halosulfuron methyl 5% + atrazine 48% WG (RM) 0.05625 + 0.540 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	850	5889	8430	6200
T_4	Topramezone 10 g l^{-1} + atrazine 300 g l^{-1} SC (RM) 0.775 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	882	6130	8546	6710
T_5	Mesotrione 2.27% w/w + atrazine 22.7% w/w SC (RM) 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	914	6419	8658	6944
T_6	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* halosulfuron methyl 75% WG 0.0675 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	852	5947	8238	6905
T_7	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione 34.4% SC 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	959	6584	8959	7902
T_8	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* topramezone 336 g l^{-1} w/v SC 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	938	6493	8788	7245
T_9	Weedy check	779	5591	7410	3096
T_{10}	Weed-free (HW at 20 and 40 DAS)	990	6675	9089	8129
	SEm (±)	25	198	249	646
	CD (0.05%)	74	416	524	1356

Table 2. Effect of different weed control treatments on days to 50 % tasseling and silking in *kharif* maize

S No	Treatments	Days to 50 % tasseling	Days to 50 % silking
T_1	Atrazine 50% WP 0.5 kg a.i ha^{-1} as PE *fb* HW at 40 DAS	62	64
T_2	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* HW at 40 DAS	60	65
T_3	Halosulfuron methyl 5% + atrazine 48% WG (RM) 0.05625 + 0.540 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	61	63
T_4	Topramezone 10 g l^{-1} + atrazine 300 g l^{-1} SC (RM) 0.775 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	61	64
T_5	Mesotrione 2.27% w/w + atrazine 22.7% w/w SC (RM) 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	60	63
T_6	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* halosulfuron methyl 75% WG 0.0675 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	61	63
T_7	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione 34.4% SC 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	60	62
T_8	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* topramezone 336 g l^{-1} w/v SC 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	60	63
T_9	Weedy check	63	65
T10	Weed-free (HW at 20 and 40 DAS)	59	61
	SEm (±)	1.51	1.59
	CD (0.05%)	NS	NS

3.3.2 Cob girth (mm)

The data on cob girth revealed no significant effect by various weed management practices on (Table 3). However, higher cob girth was obtained under weed-free (44.83 mm) followed by pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (43.14 mm). However, the lowest was recorded under the weedy check (36.20 mm).

3.3.3 Number of kernel rows cob^{-1}

The data pertaining to the effect of various weed management practices on the number of kernel rows per cob is shown in Table 3. The Distinct weed management tactics significantly influenced the number of kernel rows per cob in maize. The number of kernel rows per cob was significantly higher under the weed-free treatment (15.30). Among herbicide treatments, maximum number of kernel rows per cob observed in pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (14.67) and found on par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (14.43), mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (14.13), topramezone + atrazine (RM) 0.775 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (13.80) and pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* halosulfuron methyl @ 0.0675 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (13.77). A minimum number of kernel rows per cob was recorded in the weedy check (11.43).

3.3.4 Number of kernels cob^{-1}

Data regarding the number of kernels per cob in Table 3. revealed that weed-free treatment (578.17) recorded a significantly higher number of kernels per cob over other treatments. Pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (521.33) resulted maximum number of kernels per cob which was on par with the pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (481.27), and mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (457.17). All the other treatments are significantly superior to the weedy check (184.47). The findings of Harisha et al*.* [35] indicate similar results.

3.3.5 Grain yield (kg ha^{-1})

Grain yield represents the ultimate result of crop growth and the combined effect of growth and yield-contributing factors. A notable increase in maize grain yield was observed with the implementation of various weed management practices. The data on grain yield is presented in Table 4.

Hand weeding twice at 20 and 40 days after sowing had the maximum grain yield (7083 kg ha^{-1}) among all weed management practices. Due to improved aeration and increased access to space, water, light, and nutrients provided by the removal of weeds in between and within rows, the weed-free plots showed significant growth. The best conditions for growth and development resulted in improved yield qualities and, eventually, the highest yields. These results align with the findings of Sairam et al*.* [18]. Amongst the herbicide treatments, pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS (6875 kg ha^{-1}) recorded the significantly maximum grain yield which remains on par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS (6406 kg ha^{-1}) and mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS (6250 kg ha^{-1}). These results were consistent with the findings presented by Dey et al. [36], Mitra et al. [37], Shukla et al*.* [38], Choudhary et al. [39], Janak and Grichar [40], and Bhalse et al. [41].

The grain yield in the weedy check (2570 kg ha^{-1}) was significantly less compared to other treatments. The high levels of weed density and low weed control efficiency in the unweeded control caused a decrease in grain yield due to severe competition from weeds. These observations are consistent with findings from several studies that have recorded yield losses as a result of weed competition Yakadri et al. [42], Gupta et al. [30], Janak and Grichar [40], Nthebere et al. [43] and Bhalse et al*.* [41].

3.3.6 Stover yield (kg ha^{-1})

The stover yield of maize examined in the present investigation highlighted a significant influence by imposed weed management practices (Table 4).

Table 3. Effect of different weed control treatments on yield attributes in *kharif* maize

S No	Treatments	Cob length (cm)	Cob girth (mm)	No. of kernel rows cob^{-1}	Number of kernels cob^{-1}
T_1	Atrazine 50% WP 0.5 kg a.i ha^{-1} as PE *fb* HW at 40 DAS	13.10	38.28	12.47	315.27
T_2	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* HW at 40 DAS	14.37	39.49	13.07	374.80
T_3	Halosulfuron methyl 5% + atrazine 48% WG (RM) 0.05625 + 0.540 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	14.60	40.42	13.20	392.00
T_4	Topramezone 10 g l^{-1} + atrazine 300 g l^{-1} SC (RM) 0.775 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	15.93	41.72	13.80	432.53
T_5	Mesotrione 2.27% w/w + atrazine 22.7% w/w SC (RM) 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	16.17	41.97	14.13	457.17
T_6	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* halosulfuron methyl 75% WG 0.0675 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	15.00	41.35	13.77	422.50
T_7	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione 34.4% SC 0.12 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	17.27	43.14	14.67	521.33
T_8	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* topramezone 336 g l^{-1} w/v SC 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS	16.60	42.69	14.43	481.27
T_9	Weedy check	9.80	36.20	11.43	184.47
T_{10}	Weed-free (HW at 20 and 40 DAS)	17.87	44.83	15.30	578.17
	SEm (±)	0.60	1.65	0.50	24.67
	CD (0.05%)	1.78	NS	1.48	73.88

Table 4. Effect of different weed control treatments on grain yield (kg ha^{-1}), stover yield (kg ha^{-1}), and harvest index (%) in *kharif* maize

S No	Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest Index (%)
T_1	Atrazine 50% WP 0.5 kg a.i ha^{-1} as PE *fb* HW at 40 DAS	5013	5625	47.2
T_2	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* HW at 40 DAS	5363	5958	47.4
T_3	Halosulfuron methyl 5% + atrazine 48% WG (RM) 0.05625 + 0.540 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS	5401	6167	46.7
T_4	Topramezone 10 g l^{-1} + atrazine 300 g l^{-1} SC (RM) 0.775 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS	6039	6583	47.7
T_5	Mesotrione 2.27% w/w + atrazine 22.7% w/w SC (RM) 0.875 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS	6250	6944	47.4
T_6	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE fb halosulfuron methyl 75% WG 0.0675 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS	5917	6806	46.5
T_7	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE fb tembotrione 34.4% SC 0.12 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS	6875	7792	46.9
T_8	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE fb topramezone 336 g l^{-1} w/v SC 0.252 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS	6406	7195	47.1
T_9	Weedy check	2570	3069	45
T_{10}	Weed-free (HW at 20 and 40 DAS)	7083	8042	47
	SEm (±)	345	464	0.50
	CD (0.05%)	725	974	NS

The significantly highest maize stover yield was obtained under the weed-free plot (hand weeding at 20 and 40 DAS) (8042 kg ha^{-1}) compared to weed control practices. Among various herbicide treatments, pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* tembotrione @ 0.12 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS (7792 kg ha^{-1}) was significantly superior and resulted in the highest stover yield which was on par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS (7195 kg ha^{-1}) and mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS (6944 kg ha^{-1}). Comparable results were reported by Nazreen et al. [44], Nayak et al. [45], Bhalse et al. [41] and Shukla et al. [7], who concluded that maintaining a weed-free environment during the critical stages of crop growth enables higher nutrient uptake by the crop. The weedy check treatment noticed the lowest stover yield (3069 kg ha^{-1}).

3.3.7 Harvest index

The data presented in Table 4, illustrated that the various weed control practices had no significant effect on the harvest index. However, the highest harvest index was with the application of topramezone + atrazine (RM) 0.775 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS (47.7%) and the lowest harvest index in weedy check (45.6%). These findings align with the results of Sidhu et al. (2014), Mali et al. [13], and Acharya et al. [46], who noted that the high harvest index could be attributed to the more efficient translocation of photosynthates, as evidenced by the higher yields [47-49].

4. CONCLUSION

Based on the results of the present investigation to assess the impact of new pre- and post-emergence herbicide molecules in maize, it can be deduced that among distinct weed control tactics, pre-emergence application of pyroxasulfone @ 0.1275 kg a.i ha^{-1} *fb* post-emergence application of tembotrione @ 0.12 kg a.i ha^{-1} at 20 DAS *fb* HW at 40 DAS on par with pyroxasulfone @ 0.1275 kg a.i ha^{-1} as PE *fb* topramezone @ 0.252 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS and mesotrione + atrazine (RM) @ 0.875 kg a.i ha^{-1} as POE at 20 DAS *fb* HW at 40 DAS resulted in a significantly higher weed control efficiency, growth, yield attributes and yield in maize. These herbicides performed better in maize on the sandy loam soil of Telangana and showed superior performance in growth, yield attributes, and overall yield due to the high weed control efficiency.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Nalini N, Srinivas A, Ramprakash T, Rao VP. Growth, yield attributes and yield of Ajwain (*Trachyspermum ammi*) influenced by integrated Weed Management. Int. J. Pure App. Biosci. 2017;5(4):925-31.
2. Triveni, U., Rani, Y.S., Patro, T.S.S.K and Bharathalakshmi, M., 2017. Effect of different pre-and post-emergence herbicides on weed control, productivity and economics of maize. Indian Journal of Weed Science. *49*(3): 231-235.
3. Hardwick JM. Evaluation of pyroxasulfone in corn (*Zea mays* L.) and soybean (*Glycine max* L. Merr.) weed management programs. Louisiana State University and Agricultural and Mechanical College; 2013.
4. Arslan ZF, Williams MM, Becker R, Fritz VA, Peachey RE, Rabaey TL. Alternatives to atrazine for weed management in processing sweet corn. Weed Science. 2016;64(3):531-539.
5. Barua S, Lakra AK, Bhagat PK, Sinha AK. Weed dynamics and productivity of maize (*Zea Mays* L.) under pre and post emergence application of herbicide. Journal of Plant Development Sciences. 2019;11(7):409-413.
6. Chhokar RS, Sharma RK, Gill SC, Singh RK. Mesotrione and atrazine combination to control diverse weed flora in maize. Indian Journal of Weed Science. 2019; 51(2):145–150
7. Sundari A, Kalaisudarson S, Srinivasaperumal AP, Subashchandran S, Gowtham R. Response of irrigated maize to new herbicides. Plant Archives. 2019;2:2465-2468.
8. Kaur T, Bhullar MS, Kaur S. Tembotrione-a post-emergence herbicide for control of

diverse weed flora in maize (*Zea mays* L.) in north-west India; 2018.
9. Kakade SU, Deshmukh JP, Thakare SS, Solanke MS. Efficacy of pre-and post-emergence herbicides in maize. Indian Journal of Weed Science. 2020;52(2):143-146.
10. Hatti veeresh, Sanjay MT, Prasad TR, Murthy KK, Kumbar, Basavaraj, Shruthi MK. Effect of new herbicide molecules on yield, soil microbial biomass and their phytotoxicity on maize (*Zea mays* L.) under irrigated conditions. The Bioscan. 2014;9(3):1127-1130.
11. Jha P, Kumar V, Garcia J, Reichard N. Tank mixing pendimethalin with pyroxasulfone and chloroacetamide herbicides enhances in-season residual weed control in corn. Weed Technology. 2015;29(2):198-206.
12. Samant TK, Dhir BC, Mohanty B. Weed growth, yield components, productivity, economics and nutrient uptake of maize (*Zea mays* L.) as influenced by various herbicide applications under rainfed condition. Indian Journal of Weed Science. 2015;2(1):79-83.
13. Mali GR, Verma A, Malunjker BD, Bera M, Deekshith HN. Impact of different tank mix post-emergence herbicides with atrazine on weed control and productivity of maize (*Zea mays* L.). Journal of Pharmacognosy and Phytochemistry. 2020;9(6):1600-1603.
14. Kumar M, Chawla JS. Comparative study on weed control efficacy of different pre- and post-emergence herbicides in *Kharif* maize. Indian Journal of Weed Science. 2019;51(1): 32–35.
15. Kaur R, Raj R, Das TK, Singh R, Jaidka M, Shekhawat K. Managing weeds using sequential herbicides in maize for improving crop growth and productivity under irrigated conditions in north-western India; 2020.
16. Khose Pratap, Vani Bhumi Reddy, Menon Sandeep, Vyvahare Laxman, Thorhate, Pawan Yadav, Kiran, Gavekar Vidya. Impact of new generation herbicides on weed control efficiency and yield potential of spring maize in sandy loam soils of Punjab. Annals of Forest Research. 2022;65:592-601.
17. Saimaheswari K, Sagar GK, Chandrika V, Sudhakar P, Krishna TG. Effect of nitrogen and weed management practices in maize and their residual effect on succeeding groundnut. Indian Journal of Weed Science. 2022;54(1):36–4.
18. Sairam G, Jha AK, Verma B, Porwal M, Dubey A, Meshram RK. Effect of mesotrione 40% SC on weed growth, yield and economics of maize (*Zea mays* L.). International Journal of Environment and Climate Change. 2023;13(7):608-616.
19. Bhagat S, Kumar A, Puniya R. Effect of herbicides and their combinations on weeds, productivity and profitability of maize in rainfed sub-tropics of Jammu; 2019.
20. Rao CR, Prasad PVN, Venkateswarlu B. Assessment of different herbicides on yield and economics of kharif maize (*Zea mays* L.). International Journal of Agricultural Science and Research. 2016;6:409-414.
21. Rani BS, Chandrika V, Reddy GP, Sudhakar P, Sagar GK. Weed management with pre-and post-emergence herbicides in maize under maize-greengram cropping system. Indian Journal of Weed Science. 2021;53(4):405-410.
22. Sachan DS, Khan N, Maurya CL, Singh B. Influence of Different Herbicides on the Growth, Growth Attributes and Yield of Maize (*Zea mays* L.) under Central Plains Zone of Uttar Pradesh. Journal of Experimental Agriculture International. 2024;46(3):9-19.
23. Singh A, Chand M, Punia SS, Singh N, Rana SS. Efficacy of different herbicides on weed dynamics and productivity of kharif maize (*Zea mays*) and their residual effect on succeeding wheat crop (*Triticum aestivum*). The Indian Journal of Agricultural Sciences. 2019;90(5):895-899.
24. Rahman A, Trolove MR, James TK. Efficacy and crop selectivity of topramezone for post-emergence weed control in maize; 2013.
25. Yadav DB, Yadav A, Punia SS, Duhan A. Tembotrione for post-emergence control of complex weed flora in maize. Indian Journal of Weed Science. 2018;50(2):133–136.
26. Raghuwanshi M, Jha AK, Verma B, Yadav PS, Shrivastava A. Weed dynamics of fodder maize as influenced by different herbicides. International Journal of Environment and Climate Change. 2023;13(7):245-251.
27. Ehsas J, Desai LJ, Ahir NB, Joshi JR. Effect of integrated weed management on growth, yield, yield attributes and

weed parameters on summer maize (*Zea mays* L.) under South Gujarat condition; 2016.

28. Kour P, Kumar A, Sharma BC, Kour R, Kumar J, Sharma N. Effect of weed management on crop productivity of winter maize (*Zea mays*) + potato (*Solanum tuberosum*) intercropping system in Shiwalik foothills of Jammu and Kashmir. Indian Journal of Agronomy. 2014;59(1): 65-69.
29. Kumar S, Kaur R. Controlling phalaris minor with novel pyroxasulfone under conservation agriculture in the north-western indo-gangetic plains. The Indian Journal of Agricultural Sciences. 2024; 94(1):074-079.
30. Gupta S. The Bioefficacy of pre-and post-emergence herbicides in winter maize (*Zea Mays* L.). Tobacco Regulatory Science (TRS). 2021;2451-2462.
31. Kumar M, Kumar M, Singh D. Impact of sole and sequential application of herbicides on weeds, nutrients uptake and productivity of maize. Indian Journal of Weed Science. 2022;54(1):91–94.
32. Odero DC, Wright AL. Comparison of pyroxasulfone, s-metolachlor, and mesotrione for weed control in sweet corn on organic soils. Crop Management. 2013; 12(1):1-8.
33. Odero DC, Wright AL. Response of sweet corn to pyroxasulfone in high-organic-matter soils. Weed Technology. 2013; 27(2):341-346.
34. Mastkar A, Kushwaha HS, Kewat ML. Weed control efficiency, yield attributes and yield of maize (*Zea mays* L.) as influenced by weed management practices. Annals of Agricultural Research. 2022;43(3):267-271.
35. Harisha S, Seenappa C, Kalyanamurthy KN, Thimmegowda MN, Krishnamurthy N, Umashankar, Hanumanthappa DC. Effect of new generation mesotrione herbicide on growth and yield of maize (*Zea mays* L.); 2023.
36. Dey P, Pratap T, Singh VP, Singh R, Singh SP. Weed management options in spring sweet corn (*Zea mays* L. *saccharata)*. International Journal of Chemical Studies. 2018;6(5):647-650.
37. Mitra B, Bhattacharya PM, Ghosh A, Patra K, Chowdhury AK, Gathala MK. Herbicide options for effective weed management in zero-till maize. Indian Journal of Weed Science. 2018;50(2):137–141.
38. Shukla R, Bhatnagar A, Singh G, Singh DK, Rawat S, Kumar S. Effects of sequential and combined application of tank-mix herbicides on weed growth and productivity of maize (*Zea mays*). The Indian Journal of Agricultural Sciences. 2023;93(10):1153-1155.
39. Choudhary D, Chhokar RS, Gill SC, Samota SR, Kumar N, Yadav GL. Effect of tillage and herbicides on weeds and yield of maize (*Zea mays* L.). Journal of Cereal Research. 2022;14(2):204-210.
40. Janak TW, Grichar WJ. Weed control in corn (*Zea mays* L.) as influenced by preemergence herbicides. International Journal of Agronomy. 2016;(1):2607671.
41. Bhalse L, Jha AK, Verma B, Raghuwanshi, S, Porwal M, Sahu MP. Efficacy of pyroxasulfone and its combinations against weeds in wheat (*Triticum aestivum*). Indian Journal of Agronomy. 2023;68(4):443-446.
42. Yakadri M, Rani PL, Prakash TR, Madhavi M, Mahesh N. Weed management in zero till-maize. Indian Journal of Weed Science. 2015;47(3):240–245.
43. Nthebere K, Tata RP, Bhimireddy P, Gudapati J, Admala M, Latha PC. Cumulative impact of herbicides and tillage on the soil microbiome, fungal diversity and crop productivity under conservation agriculture; 2024.
44. Nazreen S, Subramanyam D. Sequential application of pre-and post-emergence herbicides to control mixed weed flora in maize. Indian Journal of Weed Science. 2017;49(3):293-294.
45. Nayak A, Khanda CM, Das S, Mohanty SK, Sahoo BB, Nayak BS. Enhancing hybrid maize (*Zea mays*) productivity, profitability, and energetics through tillage and weed-management practices in Eastern India. Indian Journal of Agronomy. 2022;67(2):152-157.
46. Acharya R, Karki TB, Adhikari B. Effect of various weed management practices on weed dynamics and crop yields under maize-wheat cropping system of western hills. Agronomy Journal of Nepal. 2022;153-161.
47. Aleem Ahmed MA, Susheela R. Weed management studies in *kharif* maize. Journal of Research, ANGRAU. 2012;40(3):121-123.
48. Amandeep Singh Sindhu, Jaswinder Singh, Sat Pal Saini, Vinay Kumar. Chemical control of hardy weeds in *kharif*

maize at farmers' fields in Punjab. Biennial Conference of Indian Society of Weed Science. 2014;304.

49. Gupta V, Verma A, Kumawat P, Bhimwal JP. Growth and yield of quality protein maize (*Zea mays* L.) as influenced by weed and nutrient management. Indian Journal of Pure and Applied Biosciences. 2021;9(1):344-353.

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