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EFFECT OF NEW PRE AND POST EMERGENCE HERBICIDE MOLECULES IN *KHARIF* MAIZE

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ABSTRACT

The field experiment was conducted at Agriculture Research Station (ARS), Karimnagar, during kharif, 2023. This experiment was plotted in a randomized block design, with ten treatments with three replications. 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 experimental field soil was Sandy loam soils with a pH of 7.6 and EC of 0.23 dS m^{-1}. The experimental soil contains 0.28% organic carbon. The available nitrogen was low with 180 kg N ha^{-1} and the available phosphorus and potassium were high with 53 kg P_2O_5 ha^{-1} and 315 kg K_2O ha^{-1}, respectively. It was observed that various weed management practices significantly influenced the grain yield, stover yield and economic returns in maize. The weed-free treatment (hand weeding at 20 and 40 DAS) led to notably higher grain (7083 kg ha^{-1}) and stover yields (8042 kg ha^{-1}) over other treatments. Among herbicides, the application of pyroxasulfone at 0.1275 kg a.i ha^{-1} as a pre-emergence (PE) treatment *fb* tembotrione at 0.12 kg a.i ha^{-1} as a post-emergence (PoE) treatment at 20 DAS *fb* hand weeding at 40 DAS, resulted in the highest grain yield (6875 kg ha^{-1}) and stover yield (7792 kg ha^{-1}). This was statistically on par with the treatment of pyroxasulfone at 0.1275 kg a.i ha^{-1} as PE, followed by topramezone at 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* hand weeding at 40 DAS (6406 and 7195 kg ha^{-1} for grain and stover, respectively), as well as the mesotrione + atrazine (RM) combination at 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* hand weeding at 40 DAS (6250 and 6944 kg ha^{-1}). The higher benefit cost ratio was recorded in weed free treatment (2.49) and with the application of pyroxasulfone at 0.1275 kg a.i ha^{-1} as a pre-emergence (PE) *fb* tembotrione at 0.12 kg a.i ha^{-1} as a post-emergence (PoE) at 20 DAS *fb* hand weeding at 40 DAS (2.48). This was followed closely by pyroxasulfone at 0.1275 kg a.i ha^{-1} as PE, followed by topramezone at 0.252 kg a.i ha^{-1} as PoE at 20 DAS *fb* hand weeding at 40 DAS (2.28), as well as mesotrione + atrazine (RM) at 0.875 kg a.i ha^{-1} as PoE at 20 DAS with hand weeding at 40 DAS (2.27).
***Keywords*:** Pyroxasulfone, Tembotrione, Topramezone, Yield.

Introduction

Maize (*Zea mays* L.) ranks as the third most important cereal crop globally, following wheat and rice. It thrives across tropical, subtropical, and temperate regions and is often referred to as the "Queen of Cereals" due to its impressive yield potential, adaptability, and nutritional content. Maize serves as a staple food in various parts of the world and is widely utilized in food products, animal feed, and industrial materials. Its usage is diverse, with 51% allocated to poultry feed, 20-25% for human consumption, 10-12% for cattle feed, and 1% for seed. Over time, maize has become an industrial crop globally, with 83% of its total production worldwide, and 76% of India's production supporting the feed, starch, and biofuel sectors.

In India, maize is cultivated over an area of 10.74 million hectares, producing an average yield of 35.67 million tonnes with a productivity rate of 3321 kg per hectare (DA&FW 2023-24). The major maize growing 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 India, maize is predominantly grown during the kharif season, during which weeds pose the most significant challenge to yield potential. The first six weeks after planting are the most critical period for crop weed competition in maize. During this phase, the crop's slow initial growth, along with wider row spacing and favorable conditions for weed growth, can lead to a yield reduction of 28-100% (Sivamurugan *et al.*, 2017). Therefore, effective weed management is essential and can be achieved through both chemical and non chemical methods.

Chemical weed management through the use of pre and post emergence herbicides offers an efficient and cost-effective solution for controlling weeds during the critical crop weed competition period. This approach is often more economical compared to manual or mechanical weeding, which can significantly increase cultivation costs (Triveni *et al*., 2017). Farmers typically use atrazine at 1.0 kg a.i ha^{-1} as a pre-emergence herbicide, along with 2,4-D, tembotrione, and topramezone as post emergence herbicides in maize. However, these herbicides are often ineffective in controlling a broad spectrum of weed species, and the persistence of atrazine in the soil is well-known for causing residual effects.

In light of the new pre and post emergence herbicides formulated for effective weed management in maize crops, this study proposes to evaluate their effectiveness.

Materials and Methods

The field experiment was conducted at the Agricultural Research Station (ARS) in Karimnagar during the kharif season of 2023. The experimental site is located in the Northern Zone of the Agro-climatic zone of Telangana. The soil at the site is sandy loam with a slightly alkaline pH of 7.6, an electrical conductivity (E.C) of 0.23 dS m^{-1}, low organic carbon content (0.28%), low available nitrogen (180 kg ha^{-1}), and high levels of available P_2O_5(53 kg ha^{-1}) and K_2O (315 kg ha^{-1}).

Details of different treatments are as follows

The experiment involved ten treatments arranged in a randomized block design, with three replications. 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 seeds are sown at a spacing of 60×20 cm. The recommended fertilizer dosage 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.

Observations were recorded on grain and stover yield of maize, post-harvest soil analysis and economics.

Analysis of Soil Chemical Properties

Available Nitrogen (kg ha^{-1})

The available nitrogen content of the soil was evaluated using the alkaline potassium permanganate method as outlined by Subbaiah and Asija (1956) and reported in kg ha^{-1}.

Available Phosphorus (kg ha^{-1})

The available phosphorus content in soil was determined using Olsen's reagent with the help of a spectrophotometer as described by Olsen *et al*. (1954) and expressed in kilograms per hectare (kg ha^{-1}).

Available Potassium (kg ha^{-1})

By using a neutral normal ammonium acetate, available potassium content was extracted (Jackson, 1979). The extract's potassium content was measured using a flame photometer and expressed as kg ha^{-1}.

Economic Analysis of the Experiment

Cost of cultivation (ha^{-1})

The cultivation cost accounts for the total expenses incurred in cultivating one hectare of a crop. This computation was conducted based on current market prices for each treatment, considering inputs and the total labour engaged in the process.

Gross returns (ha^{-1})

Gross returns are determined by multiplying the seed yield (measured in kilograms per hectare) and stover yield (also in kilograms per hectare) by the prevailing selling prices.

Net returns (ha^{-1})

Net returns were calculated by deducting the cultivation costs from the gross returns. These findings were expressed as currency per hectare.

Net returns (ha^{-1}) = Gross returns (ha^{-1}) - Cost of cultivation (ha^{-1})

Benefit Cost ratio (B: C)

The benefit cost ratio (B: C) for each treatment was determined by dividing the gross returns by the corresponding cost of cultivation. This assessment was conducted by employing the formula introduced by Subbareddy and Raghuram in 1966.

$$\text{B : C ratio} = \frac{\text{Gross returns (ha}^{-1}\text{)}}{\text{Cost of cultivation (ha}^{-1}\text{)}}$$

Results and Discussions

Grain yield

A significant increase in maize grain yield was noted with the application of different weed management practices. The data related to grain yield can be found in Table 1.

Hand weeding twice at 20 and 40 days after sowing produced 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.* (2023). 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 Shukla *et al.* (2023), Janak and Grichar (2016) and Bhalse *et al.* (2023). The grain yield in the weedy check (2570 kg ha^{-1}) was significantly less compared to other treatments.

Stover yield (kg ha^{-1})

Various weed management treatments significantly affected the stover yield of maize, as shown in Table 1.

The highest stover yield in maize was recorded in a weed free plot (hand weeding at 20 and 40 DAS) (8042 kg ha^{-1}) over other treatments. 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 (6945 kg ha^{-1}). The weedy check recorded the significantly less stover yield (3069 kg ha^{-1}). This outcome might be due to maintaining a weed free environment throughout the critical stages of crop growth, which allows high uptake of nutrients by crop. Similar kind of results are confirmed by the findings of Bhalse *et al.* (2023) in wheat and Sundari *et al*. (2019), Kantwa *et al.* (2020), Mali *et al.* (2020) and Shukla *et al.* (2023). The weedy check treatment noticed the lowest stover yield (3069 kg ha^{-1}).

Post harvest soil analysis

Table 2. displays the available nutrient status of the soil following the maize harvest. The different weed management practices did not significantly impact the levels of available nitrogen, phosphorus, and potassium in the soil after the maize crop was harvested.

Table 1 : 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})
T_1	Atrazine 50% WP 0.5 kg a.i ha^{-1} as PE *fb* HW at 40 DAS	5013	5625
T_2	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* HW at 40 DAS	5363	5958
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
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	6582
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	6945
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
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
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
T_9	Weedy check	2570	3069
T_{10}	Weed free (HW at 20 and 40 DAS)	7083	8042
	SEm (±)	279	484
	CD (0.05%)	818	1118

Table 2 : Effect of different weed control treatments on soil available nutrients N, P and K (kg ha^{-1}) after harvest of *kharif* maize

S.No	Treatments	Nitrogen	Phosphorus	Potassium
T_1	Atrazine 50% WP 0.5 kg a.i ha^{-1} as PE *fb* HW at 40 DAS	251.7	33.8	286.3
T_2	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* HW at 40 DAS	256.0	34.2	293.8
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	253.4	34.3	291.3
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	253.8	34.8	301.1
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	254.9	35.1	303.2
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	253.7	34.4	295.6
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	256.1	35.3	304.6
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	255.5	35.2	302.5
T_9	Weedy check	249.9	33.7	278.5
T_{10}	Weed free (HW at 20 and 40 DAS)	256.5	36.0	305.7
	SEm (±)	6.6	1.0	8.5
	CD (0.05%)	NS	NS	NS

Economics

The details of cost of cultivation (ha^{-1}), gross returns (ha^{-1}), net returns (ha^{-1}) and benefit cost ratio, as affected by different weed control treatments, are presented in Table 3 (Fig. 1).

Weed free treatment (hand weeding at 20 and 40 DAS) recorded the higher cost of cultivation (62686 ha^{-1}) due to increased labour costs for hand weeding and this was followed by 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 (61811 ha^{-1}), 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 (61638 ha^{-1}) and 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 (61061 ha^{-1}).

The significantly higher gross returns (156083 ha^{-1}) were recorded in weed free treatment (hand weeding at 20 and 40 DAS) which remains on par with 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 (151479 ha^{-1}), 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 (141080 ha^{-1}), mesotrione + atrazine (RM) 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (137569 ha^{-1}), topramezone + atrazine (RM) 0.775 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (132806 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 (130464 ha^{-1}). These are significantly superior to those of other treatments, attributed to effective weed control, which led to increased grain yield, thereby increasing the gross returns. The lowest gross returns were observed with the weedy check treatment (56782 ha^{-1}).

Weed free treatment (hand weeding at 20 and 40 DAS) reported the significantly higher net returns (93397 ha^{-1}) and was on par with 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 (90418 ha^{-1}), 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 (79269 ha^{-1}), mesotrione + atrazine (RM) 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (77011 ha^{-1}), topramezone + atrazine (RM) 0.775 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (73620 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 (68826 ha^{-1}). However, a weedy check reported the lowest net returns (12846 ha^{-1}).

Significantly higher B: C ratio was reported in weed free treatment (hand weeding at 20 and 40 DAS) (2.49) and 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 (2.48) followed by 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 (2.28), mesotrione + atrazine (RM) 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (2.27), topramezone + atrazine (RM) 0.775 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS (2.24) 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 (2.12). Weedy check recorded a significantly lower B: C ratio (1.29). Although the hand weeding at 20 and 40 DAS achieved the highest gross returns, the increased labour wages led to a higher cost of cultivation. These results align with the findings of Kurre *et al.* (2017), Kumar *et al.* (2022) and Kantwa *et al.* (2023).

Table 3 : Economics on different weed control treatments in *kharif* maize

S. No.	Treatments	Cost of Cultivation (ha^{-1})	Gross returns (ha^{-1})	Net returns (ha^{-1})	B: C ratio
T_1	Atrazine 50% WP 0.5 kg a.i ha^{-1} as PE *fb* HW at 40 DAS	55861	110390	54529	1.98
T_2	Pyroxasulfone 85% w/w WG 0.1275 kg a.i ha^{-1} as PE *fb* HW at 40 DAS	57936	118045	60109	2.04
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	57686	119047	61361	2.06
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	59186	132806	73620	2.24
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	60558	137569	77011	2.27
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	61638	130464	68826	2.12
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	61061	151479	90418	2.48
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	61811	141080	79269	2.28
T_9	Weedy check	43936	56782	12846	1.29
T_{10}	Weed free (HW at 20 and 40 DAS)	62686	156083	93397	2.49
	SEm (±)		8922	8922	
	CD (0.05%)		26715	26715	

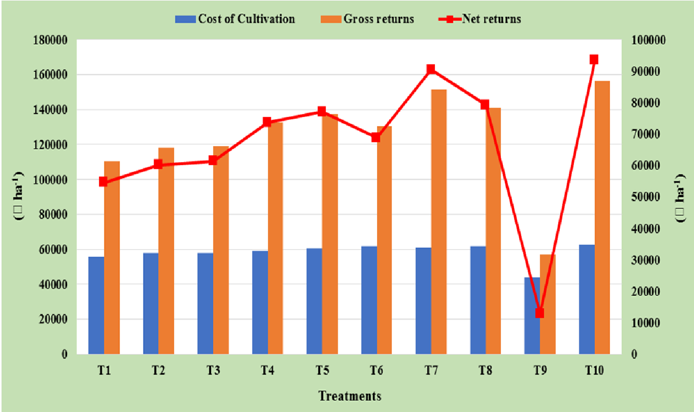

Fig. 1 : Economics on different weed control treatments in *kharif* maize

Conclusion

The yield of maize was significantly higher with 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. The availability of nitrogen, phosphorus and potassium in soil remained relatively unchanged after the harvest of maize, regardless of the weed management practices applied.

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, 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 were economical for weed management in maize with higher benefit cost ratio.

So the study concluded that application of pyroxasulfone 0.1275 kg a.i ha^{-1} *fb* post emergence (PoE) application of tembotrione 0.12 kg a.i ha^{-1} at 20 DAS *fb* HW at 40 DAS or 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 or mesotrione + atrazine (RM) 0.875 kg a.i ha^{-1} as PoE at 20 DAS *fb* HW at 40 DAS in *kharif* maize resulted in efficient and cost effective weed control, leading to higher yield and monetary returns.

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