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Enhanced the kharif maize production through application of pre and post emergence herbicides

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ABSTRACT

Maize crop is dominating industrial crop in Maharashtra however; the weed control remains challenging in maize. The combination study of pre and post emergence herbicide is meager. A field experiment entitled “Effect of Pre and Post Emergence Application of Herbicides in Kharif Maize (*Zea mays* L.)” was carried out during kharif-2025 at AICRP on Maize, ZARS, Kolhapur with an objective of weed dynamics study, effect of pre-emergence and post-emergence herbicides and economics of various weed treatments. The field experiment was designed Randomized Block Design with twelve treatments and three replications. The highest yield attributes, viz; length of cob (19.57 cm), diameter of cob (17.18 cm), weight of cobs plant⁻¹ (171.92 g), weight of 100 seed (29.48 g), grain yield (74.73 q ha⁻¹), stover yield (90.94 q ha⁻¹), weed control efficiency (85.16 per cent) and higher net monetary returns (₹115346 ha⁻¹) was recorded in treatment of weed free. Among the herbicidal treatments, application of pre and post emergence herbicides, the weed free treatment was on par with application of atrazine @ 500 g a.i. ha⁻¹ (PE) fb topramezone @ 25 g a.i. ha⁻¹ (PoE) at 25 DAS and application of pyroxasulfone @ 127 g a.i. ha⁻¹ (PE) fb topramezone @ 25 g a.i. ha⁻¹ (PoE) at 25 DAS. Therefore, application of atrazine @ 500 g a.i. ha⁻¹ (PE) fb topramezone @ 25 g a.i. ha⁻¹ (PoE) at 25 DAS and also application of pyroxasulfone @ 127 g a.i. ha⁻¹ (PE) fb topramezone @ 25 g a.i. ha⁻¹ (PoE) at 25 DAS can be recommended for achieving higher yield attributes, yield, weed control efficiency, lower weed index, higher net monetary returns with highest B: C Ratio of kharif maize.

Keywords: Yield, Yield attributes, Weed-control efficiency, Weed index, Maize, Herbicides

Introduction

Maize (*Zea mays* L.) is widely recognized for its high yield potential and is often referred to as the “Queen of Cereals” and the “Miracle Crop.” Maize is cultivated over 139 million ha of area and around 600 million tonnes of maize is produced. Crop occupies the third position next to rice and wheat in area and production (Murdia *et al.*, 2016) [1]. In India, maize is predominantly cultivated during the kharif season but the productivity was less than other maize growing countries of world. The various factors affect directly on the productivity. Effective protection of maize from weeds, pests, and diseases is crucial to prevent significant yield losses and to maintain crop quality. Among these factors, weed management is particularly critical, especially during the early stages of growth. Yield reductions due to weed infestation can range from 28% to 93%, depending on the type, intensity, and duration of weed competition. The manual weeding is highly labour-intensive, time-consuming, expensive and is often not carried out at the most critical stages of crop-weed competition. In addition, the increasing scarcity of labour has made it difficult and uneconomical. As a result, farmers are increasingly adopting herbicides, as they provide timely and efficient weed control while significantly reducing the overall cost of weed management under different conditions (Oerke, 2005). Chemical weed control is widely regarded as an effective, practical, and economical alternative or supplement to manual weeding. Compared to hand weeding, it is more flexible, requires less labour, and is generally more cost-efficient (Sutton *et al.*, 2002) [2]. However, excessive or improper use of herbicides can lead to serious issues like development of weed resistance, contamination of ground water and environmental pollution. The indiscriminate or excessive use of herbicides may lead to resistant weed populations, ground-water contamination, and environmental degradation, all of which raise serious concerns for human health (Abdin *et al.*, 2000) [3]. Achieving effective weed control and maximizing crop productivity depends on the careful selection of herbicides based on the dominant weed flora, timely application according to crop growth stages, recommended dosages and application techniques (Mani *et al.*, 1968) [4].

The adoption of modern weed management practices can enhance maize yield by as much as 30% (Kumar *et al.*, 2017) [5]. These can be achieved by application of pre and post-emergence herbicides. Considering these factors, the present study was undertaken to evaluate the effective pre and post emergence herbicides in maize and its economics to enhance the crop performance.

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Materials and methods

Experimental Site & Location: The field experiment was carried out during *Kharif-2025* at AICRP on Maize Research Farm, Zonal Agricultural Research Station (ZARS), Shenda Park, Kolhapur. The Kolhapur comes under the Sub-montane Zone of Maharashtra and situated at an elevation of 548 m above the mean sea level. The experimental site was located at latitude of 16.67°N and a longitude of 74.24°E. During the experimental period, the total rainfall received was 961.9 mm in 72 rainy days. The highest rainy days was observed from 25 to 27th meteorological week. The average relative humidity was 93.7 per cent in morning and 82.6 per cent in evening. The minimum temperature varied from 20.3°C to 22.7°C and maximum temperature was in the range of 25.5°C to 29.8°C. The high rainfall received during 24th and 33rd meteorological weeks. The highest evaporation was recorded 2.8 mm day⁻¹ and lowest being 0.9 mm day⁻¹ on 29th and 30th meteorological weeks respectively. Over the entire pleasant climate was observed during crop period that benefitted to the maize crop in entire life cycle.

Experimental Soil: The soil of the experimental site was sandy clay loam in texture with neutral reaction (pH 7.0), moderate electrical conductivity of 0.15 dSm⁻¹, low available nitrogen (194.37 kg ha⁻¹), medium available phosphorus (21.77 kg ha⁻¹), medium available potassium (277.83 kg ha⁻¹) and low organic carbon (0.47 %).

Experimental Details: The uniform application of pre and post emergence herbicides was undertaken by using knapsack sprayer and as per the schedule. The maize hybrid '*Phule Maharshi*' (QMH-1025) developed by AICRP on maize, Kolhapur affiliated to Mahatma Phule Krishi Vidyapeeth, Rahuri (M.S) was sown by dibbling at spacing of 60 x 20 cm within 4.8 m x 3.6 m and 3.6 m x 3.4 m as gross and net plot sizes respectively. The features of *Phule maharshi* is tabulated in table 1. The inorganic fertilizers were applied as recommended dose (120:60:40 NPK kg ha⁻¹) and nitrogen was divided in three equal splits in which first split of nitrogenous fertilizer and full dose of phosphatic and potassic fertilizers were applied at the time of sowing as basal dose. The second half of nitrogenous fertilizer i.e. urea was applied at 30 DAS and third at 45 DAS. The inorganic fertilizers were applied by using urea (46% N), single super phosphate (SSP 16% P₂O₅) and muriate of potash (MOP 60% K₂O) as the sources of nitrogen, phosphorus and potassium respectively. All recommended agronomic practices of maize cultivation were carried out. The experiment was designed in randomized block design with twelve treatments that replicated thrice. The following treatments were included in this experiment.

T₁ : Weedy check

- T₂ : Weed free check
 T₃ : Application atrazine @ 500 g a.i.ha⁻¹ (PE) *fb* hand weeding at 25 DAS
 T₄ : Application of pyroxasulfone @ 127 g a.i.ha⁻¹ (PE) *fb* hand weeding at 25 DAS
 T₅ : Application of atrazine @ 500 g a.i. ha⁻¹ (PE) *fb* halosulfuron methyl @ 67 g a.i. ha⁻¹ (PoE) at 25 DAS
 T₆ : Application of atrazine @ 500 g a.i. ha⁻¹ (PE) *fb* tembotrione @ 120 g a.i. ha⁻¹ (PoE) at 25 DAS

T₁ : Weedy check

- T₇ : Application of atrazine @ 500 g a.i. ha⁻¹ (PE) *fb* topramezone @ 25 g a.i. ha⁻¹ (PoE) at 25 DAS
 T₈ : Application of atrazine @ 500 g a.i. ha⁻¹ (PE) *fb* mesotrion + atrazine (Ready mix) @ 300 g a.i. ha⁻¹ at 25 DAS
 T₉ : Application of pyroxasulfone @ 127 g a.i. ha⁻¹ (PE) *fb* halosulfuron methyl @ 67 g a.i. ha⁻¹ (PoE) at 25 DAS
 T₁₀ : Application of pyroxasulfone @ 127 g a.i. ha⁻¹ (PE) *fb* tembotrion @ 120 g a.i. ha⁻¹ (PoE) at 25 DAS
 T₁₁ : Application of pyroxasulfone @ 127 g a.i. ha⁻¹ (PE) *fb* topramezone @ 25 g a.i. ha⁻¹ (PoE) at 25 DAS
 T₁₂ : Application of pyroxasulfone @ 127 g a.i. ha⁻¹ (PE) *fb* mesotrion + atrazine (Ready mix) @ 300 g a.i. ha⁻¹ at 25 DAS

fb = followed by, (PE) = Pre-emergence, (PoE) = Post-emergence, DAS = Days after sowing

Table 1. Features of *Phule Maharshi*' (QMH-1025) hybrid

Sr. No.	Particulars	Features	
1	Maturity period (days)	Medium to Mid-late maturity (90-100)	
2	Parents	QMI-1403 x QMI-1401	
3	Area of adaption	Across the state of Maharashtra	
4	Special characters	• It is high yielding, orange yellow, semi-flint type • Multiple disease resistance including Maydis leaf blight • <i>Fusarium</i> stalk rot and Banded leaf and sheath blight • semi spreading in growth, • medium bold size (25-30 g 100 seeds⁻¹)	
5	Yield attributes	Grain	Straw
6	<i>Kharif</i>	75-80 q ha ⁻¹	12-14 tonnes/ha
7	<i>Rabbi</i>	85-90 q ha ⁻¹	13-15 tonnes/ha
8	Year of release	2017	

Source : Borle *et al.*, (2018)

Observations Recorded:

Yield Attributes and Yield (q ha⁻¹): Data about yield attributes, viz. Length of cob (cm), Diameter of cob (cm), Weight of cobs plant⁻¹ (g), Weight of 100 seed (g), Grain yield (q ha⁻¹), Stover yield (q ha⁻¹) were recorded at harvest. A quadrat of size 1 m x 1 m (1 m²) was placed in each net plot and the weeds within the frame were counted and recorded.

Weed Dynamics: The weed population count of grasses, broad leaves and sedges were recorded at harvest. Individual weed count summed up to obtain total weed count. For stat analysis this count was taken by converting weed count in square root formation. Weed control efficiency was calculated by formula suggested by (Kondap *et al.*, 1985) [6].

$$\text{Weed control efficiency (\%)} = \frac{WDM_c - WDM_t}{WDM_c} \times 100$$

Where, WDM_c = Weed dry matter in control plot, WDM_t = Weed dry weight in the treated plot. Weed index was computed as procedure

given by Gill *et al.* (1969) [7] using the following formula.

$$\text{Weed index (\%)} = \frac{X - Y}{X} \times 100$$

Where, X = yield from weed-free plot, Y = yield from the treated plot.

Economics: Net monetary returns are calculated by using following formula-

$$\text{Net monetary returns (NMR)} = \text{Gross monetary returns (GMR)} - \text{Cost of cultivation (COC)}.$$

Benefit: Cost Ratio it is calculated by using the following formula given by Rangaswamy *et al.* (2013) [8].

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

Results and discussion

The field experiment to find out the effective pre and post emergence herbicides was undertaken during *kharif*-2025 and results are given below.

Yield Attributing Characters: The data pertaining in Table 2 revealed that all evaluated yield-attributing characters exhibited significant variation among the treatments. The weed free treatment (T₂) was showing the highest cob length (19.57 cm), diameter of cob was (14.37 cm), weight per plant (171.92 g), weight of grains per cob (124.32 g) and 100-grain weight of seeds (29.48 g). However, it was on par with treatment T₇: the application of atrazine @ 500 g a.i. ha⁻¹ (PE) *fb* topamezone @ 25 g a.i. ha⁻¹ (PoE) at 25 DAS) and T₁₁: application of pyroxasulfone @ 127 g a.i. ha⁻¹ (PE) *fb* topamezone @ 25 g a.i. ha⁻¹ (PoE) at 25 DAS. The minimum yield attributing characters were observed in weedy check treatment (T₁) due to the poor vegetative growth and suppressed plant growth attributes, triggered by severe and continuous weed competition throughout the crop growing season (Swetha *et al.*, 2016) [9] and efficiently reducing

competition of weed, nutrients, water and sunlight for the crop (Singh *et al.*, 2021 and Koushal *et al.*, 2024) [10].

Yield (q ha⁻¹): It was observed from Table 2 that the weed-free check treatment secured the highest grain and stover yield (74.73 and 90.94 q ha⁻¹, respectively). This result that did not much differ significantly from treatment T₇ (72.62 and 87.61 q ha⁻¹ respectively) and T₁₁ (70.76 q ha⁻¹ and 85.60 q ha⁻¹ respectively). This performance is explained by a minimal weed presence, excellent weed control efficiency and a low weed index which promoted superior vegetative growth and upgraded all major yield components, driving the final grain production to its maximum potential (Bada *et al.*, 2022 and Shukla *et al.*, 2024) [11].

Weed Dynamics: The weed intensity, weed control efficiency and weed index was observed during experimental period and obtained results are enumerated and given in Table 3. Overall, the lowest weed intensity of grassy and broad leaves was recorded at harvest in T₂ treatment (2.91 and 4.55 respectively) and on par with T₇ (3.08 and 5.15 respectively) and T₁₁ (3.20 and 5.19 respectively). Similarly, trend was observed in sedges types of weeds.

Table 2. Yield attributes and yield of maize as affected by various treatments

Treatment	Length of cob (cm)	Diameter of cob (cm)	Weight of cobs plant ⁻¹ (g)	Weight of grain cob ⁻¹ (g)	Weight of 100 seed (g)	Grain yield (q ha ⁻¹)	Stover yield (q ha ⁻¹)
T ₁	9.58	10.15	110.08	66.89	35.20	35.20	46.95
T ₂	19.57	17.18	171.92	124.32	74.73	74.73	90.94
T ₃	16.50	14.82	152.73	106.33	64.31	64.31	83.66
T ₄	16.33	14.70	152.44	105.67	63.83	63.83	80.45
T ₅	15.07	13.67	147.00	104.67	60.61	60.61	76.60
T ₆	12.00	13.26	144.41	102.33	58.73	58.73	74.94
T ₇	18.60	16.98	169.00	122.26	72.62	72.62	87.61
T ₈	15.99	14.59	151.22	105.33	62.34	62.34	77.83
T ₉	13.17	13.40	146.27	104.33	59.65	59.65	75.44
T ₁₀	11.17	13.02	142.66	101.33	58.26	58.26	72.28
T ₁₁	17.97	16.53	167.27	121.10	70.76	70.76	85.60
T ₁₂	15.87	14.11	150.53	104.84	61.64	61.64	78.86
S.Em±	0.61	0.51	4.89	4.77	0.91	2.14	2.46
C.D. (P = 0.05)	1.80	1.48	14.34	13.99	2.67	6.28	7.22
General mean	15.15	14.37	150.46	105.78	25.08	61.89	77.60

Significant variations in the weed control efficiency (WCE) of mixed weed flora (grasses, broadleaves and sedges) are clearly evident from the data delineated in Table 3. The weed free check established complete dominance across the entire vegetative and reproductive phases, yielding 85.06% weed control efficiency at harvest. The treatment T₇ (81.11%) and T₁₁ (79.48%) at harvest which was found to be at par in nature with weed free check treatment.

Regarding weed intensity, treatment T₂ maintained superiority over weedy check i.e. 51.57% due to unmitigated weed interference.

Among the herbicidal application, the lowest weed index was documented in T₇ (1.33%) and T₁₁ (4.29%). This might be due to the dual-layered strategy effectively checked weed regeneration and multiplication, keeping the weed count significantly low until the crop reached maturity (Rasool *et al.*, 2020 and Albrecht *et al.*, 2025) [12]. The pre-emergence herbicides (atrazine and pyroxasulfone) effectively suppressed early weed flushes, while the subsequent post-emergence application of topamezone at 25 DAS successfully eradicated late-emerging weeds.

Table 3. Weed dynamics of Maize at harvest as affected by various treatments

Treatment	Total weed intensity (No.m ⁻²)			Weed Control Efficiency (%)	Weed Index (%)
	Grassy	Broad leaves weeds	Sedge		
T ₁	33.88(5.87)	147.43(12.18)	11.19(3.48)	0.00	51.57
T ₂	7.50(2.91)	19.73(4.55)	1.45(1.56)	85.06	0.00
T ₃	10.02(3.32)	36.20(6.04)	2.77(1.93)	74.87	12.94
T ₄	10.30(3.36)	39.27(6.34)	3.02(2.00)	72.60	13.74
T ₅	13.28(3.78)	56.87(7.60)	3.77(2.18)	61.45	18.04
T ₆	14.20(3.90)	72.23(8.56)	5.62(2.57)	52.07	20.54
T ₇	8.55(3.08)	25.51(5.15)	2.20(1.77)	81.11	1.33
T ₈	11.18(3.49)	47.55(6.97)	3.17(2.04)	67.72	15.64
T ₉	13.82(3.85)	62.27(7.95)	4.83(2.41)	57.78	18.89
T ₁₀	16.64(4.08)	82.87(9.16)	6.58(2.75)	45.47	24.23
T ₁₁	9.22(3.20)	29.56(5.49)	2.23(1.80)	79.48	4.29
T ₁₂	12.47(3.67)	49.48(7.05)	4.18(2.27)	66.09	16.64
S.Em±	0.15	0.17	0.10	2.10	0.99
C.D. (P = 0.05)	0.45	0.72	0.28	6.15	2.90
General mean	3.71	7.25	2.23	61.97	16.49

* Fig in parenthesis () are square root transformed values

Economics: The data of economic analysis with respect to gross monetary return, cost of cultivation, net monetary return and benefit cost ratio of various weed is presented in Table 4.

The highest cost of cultivation (₹ 86733 ha⁻¹) recorded in treatment T₂ due to requirement more labour and high wages for manual weeding followed by T₃ (₹ 76233 ha⁻¹). This is because of combined use of manual weeding, mechanical methods, and additional inputs. Increased labour, equipment, and management complexity raise expenses, though these costs are offset by improved weed control and higher yields. Similar results reported by Lodh *et al.*, (2021) [13] and

Roy *et al.*, (2023) [14]. The maximum gross and net returns were achieved in treatment T₇ (₹ 196184 ha⁻¹ and ₹ 133635 ha⁻¹, respectively) with highest B:C ratio (3.15) followed by T₁₁ (₹ 191232 ha⁻¹ and ₹ 126032 ha⁻¹, respectively) with B:C ratio (2.95). It might be due to its effective weed control, which significantly improves maize grain yield and crop productivity by minimizing weed competition weed management enhances nutrient, water, and light availability for maize plants, leading to better growth and higher yields. Similar conclusions were made by Begum *et al.*, (2025) and Sanodiya *et al.* (2025) [15].

Table 4. Economics of maize as affected by various treatments

Treatments	Cost of Cultivation (₹ ha ⁻¹)	Gross Monetary Return (₹ ha ⁻¹)	Net Monetary Return (₹ ha ⁻¹)	B:C ratio
T ₁	56911	96218	39307	1.75
T ₂	86733	202079	115346	2.33
T ₃	76233	175251	99018	2.30
T ₄	76215	173297	97082	2.27
T ₅	65758	164606	98848	2.50
T ₆	68583	159679	91096	2.33
T ₇	62550	196184	133635	3.15
T ₈	68358	169063	100705	2.47
T ₉	65738	162012	96274	2.46
T ₁₀	68570	157886	89316	2.30
T ₁₁	65200	191232	126032	2.95
T ₁₂	68342	167642	99300	2.45
S.Em±	-	5142	5142	0.12
C.D. (P = 0.05)	-	15082	15082	0.36
General mean	69099	167929	98830	2.44

Conclusion

The application of atrazine @ 500 g a.i. ha⁻¹ (PE) *fb* topamezone @ 25 g a.i. ha⁻¹ (PoE) at 25 DAS and also application of pyroxasulfone @ 127 g a.i. ha⁻¹ (PE) *fb* topamezone @ 25 g a.i. ha⁻¹ (PoE) at 25 DAS achieving higher yield attributes, yield, weed dynamics and economics of *kharif* maize. Therefore, application of atrazine @ 500 g a.i. ha⁻¹ (PE) *fb* topamezone @ 25 g a.i. ha⁻¹ (PoE) at 25 DAS and

also application of pyroxasulfone @ 127 g a.i. ha⁻¹ (PE) *fb* topamezone @ 25 g a.i. ha⁻¹ (PoE) at 25 DAS can be recommended for achieving higher yield, weed dynamics and economics.

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