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Effect of pre-emergence herbicides on weed management and economics of kharif sunflower (*Helianthus annuus* L.)

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ABSTRACT

A field experiment was conducted during kharif 2025 at the Experimental Farm, Agronomy Section, Oilseeds Research Station, Latur, Maharashtra, to evaluate the efficacy of pre-emergence herbicides for weed management and economics of kharif sunflower. The experiment comprised five pre-emergence herbicides followed by one hand weeding at 30 DAS, along with a weed-free treatment and a weedy check. The weed-free treatment recorded the highest seed yield (2042 kg ha⁻¹), along with the lowest total weed density (2.14 m⁻²), weed dry weight (1.55 g m⁻²) and highest weed control efficiency (95.72%) at harvest. Among the herbicidal treatments, pendimethalin 30% + imazethapyr 2% @ 480 g a.i. ha⁻¹ as PE fb one hand weeding at 30 DAS recorded the lowest total weed density (4.21 m⁻²), highest weed control efficiency (81.62%) and lowest weed index (3.88%), and its seed yield was statistically at par with metolachlor @ 1.0 kg a.i. ha⁻¹ and pyroxasulfone @ 127.5 g a.i. ha⁻¹, each applied as PE fb one hand weeding at 30 DAS. Although the weed-free treatment recorded the highest gross monetary return (₹157,663 ha⁻¹), its higher cost of cultivation reduced its economic advantage. The highest net monetary return (₹97,777 ha⁻¹) and benefit-cost ratio (2.91) were obtained with pendimethalin 30% + imazethapyr 2% @ 480 g a.i. ha⁻¹ followed by one hand weeding. Thus, pendimethalin 30% + imazethapyr 2% @ 480 g a.i. ha⁻¹ as PE fb one hand weeding at 30 DAS proved to be an effective and economical weed management option for kharif sunflower under the conditions of the present study.

Keywords: Kharif sunflower, Pre-emergence herbicides, Weed management, Weed density, Weed control efficiency, Economics

Introduction

Sunflower (*Helianthus annuus* L.), an important oilseed crop of the family Asteraceae, is valued worldwide for its edible oil, rich in linoleic and oleic acids. Weed competition is one of the major constraints limiting sunflower productivity, as weeds compete with the crop for nutrients, water, sunlight and space and consequently reduce seed yield (Wanjari *et al.*, 2000) [1]. The wider row spacing and slow initial growth of sunflower favour weed establishment and intensify crop-weed competition during the early growth period (Nagamani *et al.*, 2011) [2]. Maintaining the crop free from weeds during the critical period of crop-weed competition is therefore essential for realizing higher productivity, and different mechanical, chemical and cultural methods can be used for effective weed management in sunflower. However, non-availability of labour and increasing labour wages make timely manual weeding difficult and costly, creating a need for effective and economical chemical weed management options. Pre-emergence herbicides are useful for suppressing weeds during the initial period of crop growth; however, their efficacy and crop safety may vary with soil type, soil moisture and rainfall following application (Jursik *et al.*, 2015) [3]. Further, continuous use of herbicides with similar modes of action may lead to changes in weed flora and development of herbicide resistance (Powles *et al.*, 2010) [4]. Hence, evaluation of pre-emergence herbicides belonging to different chemical groups in combination with one hand weeding is important for achieving effective weed management during the critical period of crop-weed competition. Keeping in view these facts, the present investigation was undertaken to evaluate the performance of different pre-emergence herbicides along with one hand weeding for effective weed management and to work out the economics of different weed management treatments in kharif sunflower.

Materials and Methods

A field experiment was conducted during kharif 2025 at the Experimental Farm, Agronomy Section, Oilseeds Research Station, Latur, Maharashtra (18°05' to 18°75' N latitude, 76°25' to 77°25' E longitude; 540.63 m above mean sea level), in the semi-arid tropical Marathwada region. The soil was clayey in texture, medium deep, black in colour and well drained with a soil pH of 7.75 and 236.1 kg ha⁻¹ available nitrogen, 18.20 kg ha⁻¹ available phosphorus and 494.3 kg ha⁻¹ available potassium. The experiment was laid out in a randomized block design with seven treatments replicated thrice, comprising 21 plots, with a gross

plot size of 5.4 m × 4.5 m and a net plot size of 4.2 m × 3.9 m. The treatments comprised T₁: fluchloridone 18.3% CS @ 325 g a.i. ha⁻¹ as PE fb one hand weeding at 30 DAS

T₂: metolachlor @ 1.0 kg a.i. ha⁻¹ as PE fb one hand weeding at 30 DAS; T₃: pyroxasulfone @ 127.5 g a.i. ha⁻¹ as PE fb one hand weeding at 30 DAS T₄: oxyfluorfen @ 250 g a.i. ha⁻¹ as PE fb one hand weeding at 30 DAS T₅: pendimethalin 30% + imazethapyr 2% @ 480 g a.i. ha⁻¹ as PE fb one hand weeding at 30 DAS T₆: weed-free treatment maintained through three hand weedings at 15, 30 and 45 DAS and T₇: weedy check. The sunflower hybrid LSFH-171 was sown by dibbling on 21 July 2025 at a spacing of 60 cm × 30 cm with a seed rate of 5 kg ha⁻¹ and harvested on 27 October 2025. A fertilizer dose of 90:45:45 NPK kg ha⁻¹ was applied. All pre-emergence herbicides (T₁–T₅) were applied one day after sowing using a knapsack sprayer with 500 L ha⁻¹ water, followed by one hand weeding at 30 DAS. Weed density and weed dry weight at harvest were recorded using a 1.0 m² quadrat. The collected weeds were dried to constant weight and weed dry weight was expressed in g m⁻². Weed density and weed dry-weight data were subjected to square-root transformation ($\sqrt{x} + 0.5$) before statistical analysis. Weed control efficiency (WCE %) and weed index (WI, %) were calculated using standard formulae. Seed yield was recorded from the net plot and expressed in kg ha⁻¹. Economics of each treatment was worked out based on prevailing market prices to obtain gross monetary return (GMR), net monetary return (NMR) and B:C ratio. The experimental data were subjected to analysis of variance appropriate for randomized block design and treatment means were compared at the 5 per cent level of significance (Panse *et al.*, 1967) [5].

3. Results and Discussion

3.1 Weed flora

The experimental field was infested with dominant grasses, namely *Cynodon dactylon*, *Digitaria sanguinalis*, *Brachiaria eruciformis* and *Dinebra retroflexa*; dominant broad-leaved weeds included *Digera*

arvensis, *Parthenium hysterophorus*, *Trianthema portulacastrum*, *Euphorbia hirta*, *Phyllanthus niruri* and *Commelina benghalensis*; and *Cyperus rotundus* was the major sedge, remaining present at every growth stage because of its perennial, tuber-based propagation.

3.2 Effect on weed density, dry weight, WCE and weed index

Total weed density and weed dry weight increased progressively from 30 DAS to harvest in all the treatments, indicating the emergence of successive weed flushes during the crop season. The weed-free treatment (T₆) recorded significantly the lowest total weed density (2.14 No. m⁻²) and weed dry weight (1.55 g m⁻²), along with the highest weed control efficiency (95.72%) and a weed index of 0.00 per cent at harvest, owing to three timely hand weedings. Among the herbicidal treatments, pendimethalin 30% + imazethapyr 2% @ 480 g a.i. ha⁻¹ as PE fb one hand weeding at 30 DAS (T₅) recorded the lowest total weed density (4.21 No. m⁻²) and weed dry weight (3.07 g m⁻²), the highest weed control efficiency (81.62%) and the lowest weed index (3.88%). T₅ was statistically at par with metolachlor @ 1.0 kg a.i. ha⁻¹ as PE fb one hand weeding at 30 DAS (T₂) and pyroxasulfone @ 127.5 g a.i. ha⁻¹ as PE fb one hand weeding at 30 DAS (T₃). The weedy check (T₇) recorded significantly the highest weed density (11.68 No. m⁻²), weed dry weight (7.02 g m⁻²) and weed index (49.70%), reflecting greater weed interference throughout the crop season. The superior weed suppression under T₅ may be attributed to the combined activity of pendimethalin and imazethapyr, which provided effective control of a broad spectrum of weeds, followed by hand weeding at 30 DAS. Pendimethalin, a dinitroaniline herbicide, inhibits microtubule assembly and cell division in germinating weeds, whereas imazethapyr inhibits acetolactate synthase (ALS), thereby suppressing susceptible broad-leaved and sedge weeds. The present findings were in agreement with Mahapatra *et al.* (2024) [6] and Laxmi Prasanna *et al.* (2026) [7].

Table 1. Total weed density, weed dry weight, weed control efficiency (%) and weed index (%) at harvest as influenced by different treatments

Treatment	Total weed density (No./m ²)	Weed dry weight (g/m ²)	WCE (%)	Weed Index (%)
T ₁ - Fluchloridone 18.3% CS @ 325 g a.i. ha ⁻¹ as PE fb one HW at 30 DAS	6.32 (39.40)	4.85 (23.33)	52.04	21.27
T ₂ - Metolachlor @ 1.0 kg a.i. ha ⁻¹ as PE fb one HW at 30 DAS	4.72 (21.78)	3.49 (12.00)	76.08	8.62
T ₃ - Pyroxasulfone @ 127.5 g a.i. ha ⁻¹ as PE fb one HW at 30 DAS	4.94 (23.93)	3.64 (12.77)	73.53	11.15
T ₄ - Oxyfluorfen @ 250 g a.i. ha ⁻¹ as PE fb one HW at 30 DAS	6.71 (44.66)	5.15 (26.00)	45.83	28.44
T ₅ - Pendimethalin 30% + Imazethapyr 2% @ 480 g a.i. ha ⁻¹ as PE fb one HW at 30 DAS	4.21 (17.26)	3.07 (9.00)	81.62	3.88
T ₆ - Weed free treatment	2.14 (4.13)	1.55 (1.97)	95.72	0.00
T ₇ - Weedy check	11.68 (137.00)	7.02 (49.00)	0.00	49.70
S.Em. ±	0.307	0.246	—	—
C.D. at 5%	0.944	0.757	—	—
General Mean	5.82	4.11	60.69	17.58

Figures in parentheses are original values; data outside parentheses are square-root ($\sqrt{x} + 0.5$) transformed values.

3.3 Economics

The economic analysis revealed marked differences among the weed management treatments. The weed-free treatment (T₆) recorded the highest gross monetary return (₹1,57,663 ha⁻¹) owing to its higher seed yield; however, its higher cost of weed management reduced its economic advantage. Among the herbicidal treatments, pendimethalin 30% + imazethapyr 2% @ 480 g a.i. ha⁻¹ as PE fb one hand weeding

at 30 DAS (T₅) recorded the highest net monetary return (₹97,777 ha⁻¹) and B:C ratio (2.91). The higher economic returns under T₅ may be attributed to its higher seed yield resulting from effective weed suppression. The weedy check (T₇) recorded the lowest seed yield (1,010 kg ha⁻¹), net monetary return (₹38,759 ha⁻¹) and B:C ratio (1.99). Thus, pendimethalin 30% + imazethapyr 2% @ 480 g a.i. ha⁻¹ as PE fb one hand weeding at 30 DAS (T₅) proved to be the most remunerative treatment. Similar findings were reported by Laxmi Prasanna *et al.* (2026) [7], Suryavanshi *et al.* (2015) [8] and Pujeri *et al.* (2019) [9].

Table 2. Seed yield and economics (₹ ha⁻¹) of sunflower as influenced by different treatments

Treatment	Seed yield (kg/ha)	GMR (₹/ha)	NMR (₹/ha)	B:C ratio
T ₁ - Fluchloridone 18.3% CS @ 325 g a.i. ha ⁻¹ as PE fb one HW at 30 DAS	1581	122069	69464	2.32
T ₂ - Metolachlor @ 1.0 kg a.i. ha ⁻¹ as PE fb one HW at 30 DAS	1835	141680	91037	2.80
T ₃ - Pyroxasulfone @ 127.5 g a.i. ha ⁻¹ as PE fb one HW at 30 DAS	1784	137742	86394	2.68
T ₄ - Oxyfluorfen @ 250 g a.i. ha ⁻¹ as PE fb one HW at 30 DAS	1437	110950	59898	2.17
T ₅ - Pendimethalin 30% + Imazethapyr 2% @ 480 g a.i. ha ⁻¹ as PE fb one HW at 30 DAS	1930	149015	97777	2.91
T ₆ - Weed free treatment	2042	157663	95940	2.55
T ₇ - Weedy check	1010	77982	38759	1.99
S.Em. ±	84.29	6508	6508	—
C.D. at 5%	260	20053	20052	—
General Mean	1660	128158	77039	2.49

Conclusion

The weed-free treatment (three hand weeding at 15, 30 and 45 DAS) recorded the highest weed control efficiency, whereas pendimethalin 30% + imazethapyr 2% @ 480 g a.i. ha⁻¹ as PE fb one hand weeding at 30 DAS recorded the lowest weed density and weed dry weight among the herbicidal treatments, along with the highest net monetary return and B:C ratio. Hence, pendimethalin 30% + imazethapyr 2% @ 480 g a.i. ha⁻¹ as PE fb one hand weeding at 30 DAS can be regarded as an effective and economical weed management practice in *kharif* sunflower.

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