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G Prasanna Laxmi
PG Scholar, Department of
Agronomy, College of Agriculture,
PJTAU, Rajendranagar,
Hyderabad, Telangana, India

Dr. M Ramesh naik
Senior Scientist, Department of
Agronomy ICAR-NAARM,
Rajendranagar, Hyderabad,
Telangana, India

Dr. K Ramesh
Principal Scientist, Department of
Agronomy, ICAR-IIOR,
Rajendranagar, Hyderabad,
Telangana, India

Dr. G Kiran Reddy
Assistant Professor, Department of
Soil Science & Agricultural
Chemistry Agricultural College,
Huzurnagar, PJTAU, Telangana,
India

Corresponding Author:
G Prasanna Laxmi
PG Scholar, Department of
Agronomy, College of Agriculture,
PJTAU, Rajendranagar,
Hyderabad, Telangana, India

Effect of integrated weed management practices on weed control efficiency in *rabi* sunflower (*Helianthus annuus* L.)

G Prasanna Laxmi, M Ramesh Naik, K Ramesh and G Kiran Reddy

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Abstract

Weed infestation is a major constraint reducing sunflower productivity due to competition for nutrients, moisture, light and space. Integrated weed management combining herbicides with intercultivation may provide effective weed suppression and improve crop performance. An experiment was performed during *rabi* 2025-26 season to evaluate the effectiveness of integrated weed management approaches on weed control efficiency of sunflower (*Helianthus annuus* L.). The experiment was laid out in a Randomized Block Design (RBD) with three replications. Weed management practices significantly influenced weed control efficiency based on weed density and weed dry matter throughout the crop growth period. Hand weeding at 20 and 40 DAS (T_7) recorded the highest weed control efficiency based on weed density (94.16, 95.94 and 90.68%) and weed dry matter (93.78, 95.93 and 92.60%) at 30, 60 DAS and at harvest, respectively. During the crop growth period, pre-emergence application of pendimethalin 30% + imazethapyr 2% EC @ 240 g a.i. ha^{-1} fb intercultivation at 30 DAS (T_6) maintained weed control efficiency comparable with hand weeding at 20 and 40 DAS, recording (93.70, 95.64 and 89.71%) based on weed density and weed dry matter (92.07, 95.57 and 91.93%) based on at 30 DAS, 60 DAS and at harvest, respectively. The results indicated that pendimethalin 30% + imazethapyr 2% EC @ 240 g a.i. fb intercultivation at 30 DAS was the most effective integrated weed management practice for achieving higher weed control efficiency in sunflower.

Keywords: Sunflower, integrated weed management, Pendimethalin 30% + Imazethapyr 2% EC, Flurochloridone, weed control efficiency

1. Introduction

Sunflower (*Helianthus annuus* L.) is an important oilseed crop grown across the world for its high-quality edible oil (Mahapatra *et al.* 2023)^[4], rich nutritional value and diverse industrial uses (Goud *et al.*, 2022)^[3]. Its adaptability to different agro-climatic conditions and relatively short duration have made it a preferred crop in many countries. It is an important source of edible oil in India and is grown in states of Karnataka, Telangana, Andhra Pradesh, Maharashtra and Tamil Nadu both under rainfed and irrigated conditions. The crop is regarded as a component crop in several cropping systems due to a photo and thermoinsensitive nature, however the challenges from weeds continue to pose a threat for the sustainable production (Mahapatra *et al.*, 2026; Ramesh *et al.*, 2021)^[5, 10]. Uncontrolled weeds can cause significant nutrient depletion and loss of seed production (Renukaswamy *et al.*, 2012)^[14] besides other competition for other scarce resources (Selvakumar *et al.*, 2018)^[15]. Undoubtedly effective weed management, especially in time (Singh *et al.*, 2017)^[16] is the key for higher productivity since yield loss due to crop-weed competition is a function of crop species, growing environment, soil weed seed banks, etc. (Ramesh *et al.* 2022)^[13]. It has been demonstrated that the use of intercultivation in combination with the use of herbicides is an effective weed management method. In these systems, the intercultivation method is used to destroy weed species between rows, and herbicides are used in the row of the crop (Mishra *et al.*, 2023)^[8]. The integrated approach has also been shown to boost yields of seeds and stalks, with a positive impact on reducing weed competition and increasing overall sunflower productivity (Mani *et al.*, 2025)^[6]. Reduced water availability would alter the competitive balance between crops and some weed species (Ramesh *et al.* 2017a)^[11] particularly in the post-rainy season (*rabi*) crop. In this context, the present study was undertaken to evaluate

the effectiveness of integrated weed management practices on weed dynamics of *rabi* sunflower.

2. Materials and Methods

A field experiment was conducted during the *rabi* season of 2025–26 at the Narkhoda Research Farm of ICAR-Indian Institute of Oilseeds Research (ICAR-IIOR), Hyderabad, which is geographically located at 17.2° N latitude and 78.3° E longitude. The study was undertaken to evaluate the effect of integrated weed management practices on weed dynamics of *rabi* sunflower (*Helianthus annuus* L.). The experiment was laid out in a Randomized Block Design (RBD) with nine treatments and three replications. The gross plot size was 5.4 m × 3.9 m, while the net plot size was 3.6 m × 2.7 m. Sunflower hybrid Thilan-Tec SUNH-1 was sown at a spacing of 45 cm × 30 cm using a seed rate of 5 kg ha⁻¹. The treatments were T₁- Flurochloridone 18.3% w/w CS @ 250 g a.i. ha⁻¹, T₂- Flurochloridone 18.3% w/w CS @ 325 g a.i. ha⁻¹, T₃- Flurochloridone 18.3% w/w CS @ 400 g a.i. ha⁻¹, T₄- Pyroxasulfone 85% WG @ 100 g a.i. ha⁻¹, T₅- Pendimethalin 38.7% CS @ 675 g a.i. ha⁻¹, T₆- Pendimethalin 30%+ Imazethapyr 2% EC @ 240 g a.i. ha⁻¹, T₇- Hand weeding at 20 DAS and 40 DAS, T₈-Weed free check, T₉- Weedy check with thrice replications. Treatments T₁-T₇ were followed by intercultivation at 30 DAS. A blanket fertilizer dose of 75-90-30 kg ha⁻¹ of N, P₂O₅ and K₂O was followed. Weed density was recorded at 30 DAS, 60 DAS, and at harvest using the quadrat count method. A quadrat of 0.25 m × 0.25 m was placed randomly at four locations within each plot and both total and species-wise weed counts were recorded. The observations were converted and expressed as number of weeds m⁻². Weed dry matter was determined by collecting weeds from the net plot area. The collected samples were first sun-dried and subsequently oven-dried at 70°C for 48 hours until a constant weight was attained. The dry weight was then recorded treatment-wise and expressed as g m⁻². The weed count data were subjected to square-root transformation [$\sqrt{(x + 0.5)}$] to normalize the distribution before statistical analysis. Weed Control Efficiency (WCE) was calculated as the percentage reduction in weed dry matter under different weed management treatments compared with the weedy check. The WCE was computed using the formula suggested by Mani *et al.* (2015)^[7] as follows:
Dry weight of weeds in weedy check- Dry weight of weeds in

treated plot

$$WCE\ (\%) = \frac{\text{Dry weight of weeds in weedy check} - \text{Dry weight of weeds in treated plot}}{\text{Dry weight of weeds in weedy check}} \times 100$$

3. Results and Discussion

3.1 Weed control efficiency

3.3.1 Weed control efficiency (Weed density)

Weed control efficiency based on weed density was used to assess the effectiveness of integrated weed management practices in suppressing weeds (Table 1). Hand weeding at 20 and 40 DAS (T₇) recorded the highest weed control efficiency throughout the crop growth period, registering 94.16, 95.94 and 90.68% at 30 DAS, 60 DAS and at harvest, respectively, owing to the effective removal of weeds. Among the integrated herbicide treatments, pendimethalin 30% + imazethapyr 2% EC @ 240 g a.i. ha⁻¹ followed by intercultivation at 30 DAS (T₆) proved to be the most effective, recording weed control efficiency of 93.70, 95.64 and 89.71% at 30 DAS, 60 DAS and at harvest, respectively. This was followed by pyroxasulfone 85% WG @ 100 g a.i. ha⁻¹ followed by intercultivation at 30 DAS (T₄), which recorded weed control efficiency of (85.44, 89.89 and 82.62%) at the respective crop growth stages. Similar observations were made by Thambiyanan *et al.* (2024)^[17] and Ramesh *et al.* (2025)^[12].

3.1.2 Weed control efficiency (Weed dry matter)

The effectiveness of integrated weed management practices in suppressing weeds was evaluated using weed control efficiency based on weed dry matter, as presented in Table 1. Hand weeding at 20 and 40 DAS (T₇) recorded the highest weed control efficiency throughout the crop growth period, registering (93.78, 95.93 and 92.60%) at 30, 60 DAS and at harvest, respectively, owing to the effective removal of weeds. Among the integrated herbicide treatments, pendimethalin 30% + imazethapyr 2% EC @ 240 g a.i. ha⁻¹ *fb* intercultivation at 30 DAS (T₆) proved to be the most effective, recording weed control efficiency of (92.07, 95.57 and 91.93%) at 30 DAS, 60 DAS and at harvest, respectively. This was followed by pyroxasulfone 85% WG @ 100 g a.i. ha⁻¹ *fb* intercultivation at 30 DAS (T₄), which recorded weed control efficiency of (85.82, 91.61 and 84.73%) at the respective crop growth stages. This corroborates the findings of Rajesh *et al.*, (2024)^[9].

Table 1: Effect of integrated weed management practices on total weed density and weed dry matter Weed Control Efficiency (WCE) in *rabi* sunflower

S. No	Treatment	WCE- Weed density			WCE-Weed dry matter		
		30 DAS	60 DAS	At Harvest	30 DAS	60 DAS	At Harvest
T ₁	Flurochloridone 18.3% w/w CS @ 250 g a.i. ha ⁻¹ <i>fb</i> inter cultivation at 30 DAS	59.78	72.08	64.87	50.10	66.38	65.06
T ₂	Flurochloridone 18.3% w/w CS @ 325 g a.i. ha ⁻¹ <i>fb</i> inter cultivation at 30 DAS	67.44	75.91	68.86	55.41	71.86	70.26
T ₃	Flurochloridone 18.3% w/w CS @ 400 g a.i. ha ⁻¹ <i>fb</i> inter cultivation at 30 DAS	74.43	82.42	74.18	70.89	75.38	73.52
T ₄	Pyroxasulfone 85% WG @ 100 g a.i. ha ⁻¹ <i>fb</i> inter cultivation at 30 DAS	85.44	89.89	82.62	85.82	91.61	84.73
T ₅	Pendimethalin 38.7% CS @ 675 g a.i. ha ⁻¹ <i>fb</i> inter cultivation at 30 DAS	71.09	79.41	71.73	65.12	73.58	72.31
T ₆	Pendimethalin 30%+ Imazethapyr 2% EC @ 240 g a.i. ha ⁻¹ <i>fb</i> inter cultivation at 30 DAS	93.70	95.64	89.71	92.07	95.57	91.93
T ₇	Hand weeding at 20 DAS and 40 DAS	94.16	95.94	90.68	93.78	95.93	92.60
T ₈	Weed free check	-	-	-	-	-	-
T ₉	Weedy check	0.00	0.00	0.00	0.00	0.00	0.00

4. Conclusion

The results of the present investigation indicated that, among the integrated weed management practices evaluated, hand weeding at 20 and 40 DAS (T₇) was the most effective, recording the highest weed control efficiency based on both weed density and

weed dry matter throughout the crop growth period. Among the integrated herbicide-based treatments, pendimethalin 30% + imazethapyr 2% EC @ 240 g a.i. ha⁻¹ *fb* intercultivation at 30 DAS (T₆) proved to be the most effective, achieving superior weed suppression and higher weed control efficiency. The next

best performance was recorded with pyroxasulfone 85% WG @ 100 g a.i. ha⁻¹ fb intercultivation at 30 DAS (T₄), which also provided effective weed control in sunflower.

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