



ISSN Print: 2618-060X  
 ISSN Online: 2618-0618  
 NAAS Rating (2026): 5.20  
 IJRA 2026; 9(9): 1119-1126  
[www.agronomyjournals.com](http://www.agronomyjournals.com)  
 Received: 01-07-2026  
 Accepted: 20-08-2026  
 Published: 26-09-2026

#### Anita Mahapatra

Senior Scientist (Agronomy),  
 AICRP on Sunflower, OUAT,  
 Bhubaneswar, Odisha, India

#### Jyoti Patra

PG Scholar, Department of  
 Agronomy, College of  
 Agriculture, OUAT,  
 Bhubaneswar, Odisha, India

#### Biswa Ranjan Nayak

Senior Scientist (Agronomy),  
 RRTTS, OUAT, Ranital,  
 Odisha, India

#### Adrija Bhandari

PG Scholar, Department of  
 Agronomy, College of  
 Agriculture, OUAT,  
 Bhubaneswar, Odisha, India

#### Susree Snigdha Das

Ph.D. Scholar, Department of  
 Agronomy, College of  
 Agriculture, OUAT,  
 Bhubaneswar, Odisha, India

#### Soumya Mohanty

Ph.D. Scholar, Department of  
 Agronomy, College of  
 Agriculture, OUAT,  
 Bhubaneswar, Odisha, India

#### Corresponding Author:

##### Anita Mahapatra

Senior Scientist  
 (Agronomy), AICRP on  
 Sunflower, OUAT,  
 Bhubaneswar, Odisha, India

## Optimizing weed management in summer sunflower (*Helianthus annuus* L.) in east and south eastern coastal plain zone of Odisha

Anita Mahapatra<sup>1</sup>, Jyoti Patra<sup>2</sup>, Biswa Ranjan Nayak<sup>3</sup>, Adrija Bhandari<sup>4</sup>, Susree Snigdha Das<sup>5</sup>, Soumya Mohanty<sup>6</sup>

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i9o.6657>

#### ABSTRACT

Weed infestation remains a primary constraint limiting the productivity and profitability of summer sunflower (*Helianthus annuus* L.). To identify an effective, labour-efficient, and economically viable weed-management strategy, a field experiment was conducted during the summer season of 2024–25 at the Instructional Farm, OUAT, Bhubaneswar. The trial was laid out in a randomized block design with eight weed-management treatments replicated thrice. The experimental field was infested with diverse weed flora comprising grasses (*Cynodon dactylon*, *Digitaria* spp.), broadleaf weeds (*Croton bonplandianum*, *Amaranthus viridis*), and sedges (*Cyperus rotundus*). Results revealed that weed density and dry matter were significantly suppressed under all weed-control practices compared to the weedy check. The weed-free treatment (three hand weedings at 15, 30, and 45 DAS) recorded the lowest total weed density (10.48 m<sup>-2</sup>), lowest weed dry weight (4.51 g m<sup>-2</sup>), and highest weed control efficiency (85.13%) at harvest, leading to the highest seed yield (1858 kg ha<sup>-1</sup>) and oil yield (697 kg ha<sup>-1</sup>). However, sequential application of pendimethalin 1 kg ha<sup>-1</sup> (pre-emergence) followed by quizalofop-*p*-ethyl 5% EC @ 50 g ha<sup>-1</sup> (post-emergence at 18 DAS) produced a seed yield of 1710 kg ha<sup>-1</sup> and an oil yield of 638 kg ha<sup>-1</sup>. Unchecked weed growth led to a 55.12% yield loss and a negative net return (₹589 ha<sup>-1</sup>). Although the weed-free check generated the highest net return (₹59,895 ha<sup>-1</sup>), its high labour cost resulted in a lower benefit–cost ratio of 1.79. Conversely, the sequential application of pendimethalin followed by quizalofop-*p*-ethyl recorded the highest benefit–cost ratio of 1.90 along with a competitive net return (₹58,916 ha<sup>-1</sup>). Consequently, this sequential chemical approach emerges as the most economically viable strategy for large-scale summer sunflower farming under east and southeastern coastal plain zone of Odisha.

**Keywords:** Weed management, Pendimethalin, Quizalofop-*p*-ethyl, Weed control efficiency

#### Introduction

Sunflower (*Helianthus annuus* L.) is an important oilseed crop cultivated widely for its high-quality edible oil and nutritional value. The crop is valued for its oil rich in unsaturated fatty acids, particularly linoleic and oleic acids, besides containing proteins, vitamins (E, B, folate and niacin), minerals and antioxidant compounds (Petaru *et al.*, 2021; Islam *et al.*, 2016) [1, 2]. In India, sunflower contributes significantly to the India's edible oil sector and offers considerable scope for enhancing domestic oilseed production (Ramesh *et al.*, 2021) [3]. Globally, sunflower occupies an important position among edible oilseed crops, while in India it is cultivated over 1.94 lakh hectares with an annual production of around 2.36 lakh tones with an average productivity of 1214 kg ha<sup>-1</sup> (Annual report, sunflower, 2025-26) [4] and predominantly grown in Karnataka, Andhra Pradesh, Maharashtra and Tamil Nadu, with increasing adoption in non-traditional sunflower-growing regions including Odisha. The crop also has considerable potential in Odisha because of its suitability for *rabi* and summer cultivation and its importance as a source of edible oil. Despite its adaptability and economic importance, sunflower productivity is considerably constrained by weed infestation (Adhikary *et al.*, 2024) [5]. Weed problem in sunflower is considered a serious problem because weeds not only compete for water, nutrients, light and space but also serve as alternate host for several insect pests and diseases which reduce crop growth and yield (Sumathi *et al.*, 2009; Pannacci *et al.*, 2007) [6]. Hence, managing weed population below the economic threshold level is the basic need to optimize the productivity (Hatti *et al.*, 2018) [7]. Manual weeding and intercultivation are effective methods of weed control widely practised in India; however, their adoption is increasingly constrained by labour shortages and rising labour costs. Herbicides offer timely and effective weed management, but sole dependence on herbicides may lead to herbicide resistance, weed flora shifts, and environmental concerns. Integrated Weed Management (IWM) has been recognized as an environmentally sound and economically viable strategy for maintaining weed populations below economic threshold levels while reducing dependence on any single weed control method (Swanton *et al.*, 2008) [8]. Several studies have demonstrated that integration of pre-plant, pre-emergence,

and post-emergence herbicides with mechanical weed control significantly improves weed suppression, crop growth, nutrient uptake, and yield in oilseed crops (Choudhary *et al.*, 2022) [9]. However, the effectiveness and economic viability of a particular weed-management programme are strongly influenced by the prevailing weed flora, environmental conditions, crop variety and production system. Hence, location-specific evaluation of alternative combinations of pre-emergence, post-emergence, manual and mechanical weed-control practices is necessary. This is particularly relevant for sunflower production under the agro-ecological conditions of Odisha, where information on effective and economically feasible integrated weed-management schedules for sunflower remains comparatively limited. The study was therefore undertaken to identify an effective and economically viable weed-management strategy capable of minimizing crop-weed competition, improving sunflower growth and productivity and increasing profitability under the summer growing conditions of Bhubaneswar.

## Materials and methods

A field experiment was carried out at Instructional Farm of Odisha University of Agriculture & Technology (OUAT), Bhubaneswar during summer season of 2024-25. The soil of the experimental field was sandy loam in texture, slightly acidic (pH 6.05), medium in organic carbon (0.58%), low in available nitrogen (172 kg ha<sup>-1</sup>), medium in available phosphorous (22.5 kg ha<sup>-1</sup>) and low in available potassium (92.00 kg ha<sup>-1</sup>). The experiment was laid out in randomized block design with eight treatments and three replications viz, T<sub>1</sub>- pendimethalin 1 kg ha<sup>-1</sup> as pre-emergence, T<sub>2</sub>- quizalofop-p-ethyl 5% EC @ 50g ha<sup>-1</sup> as PoE at 18 DAS, T<sub>3</sub>- pendimethalin 1 kg ha<sup>-1</sup> as pre-emergence *fb* one HW at 30 DAS, T<sub>4</sub>- quizalofop-p-ethyl 5% EC @ 50g ha<sup>-1</sup> as PoE at 18 DAS *fb* one HW at 30 DAS, T<sub>5</sub>- pendimethalin 1 kg ha<sup>-1</sup> as pre emergence *fb* quizalofop-p-ethyl

5%EC @ 50g ha<sup>-1</sup> as PoE at 18 DAS, T<sub>6</sub>- two intercultivations at 20 and 40 DAS, T<sub>7</sub>- weed free (three HW at 15, 30 and 45 DAS) and T<sub>8</sub>- unweeded control. The management practice is kept constant for all the treatments except the weed management. Throughout the cropping periods, different species of weeds that were observed in the experimental field were recorded at a regular interval. At 30 DAS, 60 DAS and at harvest, the number of weeds in a square meter of each plot was counted. These weeds were then categorized into grasses, sedges and broad-leaved weeds, and their respective densities as well as total density were recorded. Dry weight of weeds was recorded at 30 DAS, 60 DAS and at harvest. The weeds were uprooted from the destructive sampling area of one square meter and were oven dried at 70 °C for obtaining a constant weight and the dry weight of weeds was expressed in g m<sup>-2</sup>. Weed control efficiency was calculated by the help of formula given by Mani *et al.*, 1973 [10].

$$WCE(\%) = \frac{X - Y}{X} \times 100$$

Where, X: Weed dry matter production in weedy plot Y: Weed dry matter production in treated plot.

Weed index indicates the extent of reduction in yield due to crop weed competition which was worked out for different treatments by adopting the formula given by Gill and Kumar, 1969 [11].

$$\text{Weed index} = \frac{A - B}{A} \times 100$$

Where, A: Seed yield of the weed free treatment, B: Seed yield of the particular treatment for which the index is computed.

LAI is the ratio between leaf area to ground area and is calculated by the following formula:

$$LAI = \frac{\text{Total leaf area per plant(cm}^2\text{)}}{\text{Ground area(cm}^2\text{)}} \times 100$$

Total leaf area is calculated by multiplying the actual leaf area per plant with number of plants per m<sup>2</sup>.

Crop growth rate indicates the increase in dry weight of plant per unit area of land per unit change in time and expressed as g d<sup>-1</sup>m<sup>-2</sup> and is calculated by the formula:

$$CGR (g d^{-1}m^{-2}) = \frac{W_2 - W_1}{P(T_2 - T_1)}$$

Where, W<sub>1</sub> and W<sub>2</sub> are dry matter at times t<sub>1</sub> and t<sub>2</sub> respectively, and P is land area.

The oil content in seed for each treatment plot was estimated by using Nuclear Magnetic Resonance (NMR) spectrometer (Tiwari *et al.*, 1974) [12]. The oil yield (kg ha<sup>-1</sup>) was calculated based on seed yield (kg ha<sup>-1</sup>) and corresponding oil content (%).

## Results and discussion

### Weed flora

The most common weeds (grasses, sedges, and broadleaves) associated with the sunflower crop found in the experimental field are listed in Table1. The major narrow leaved weeds observed were *Cynodon dactylon*, *Digitaria ciliaris*, *Digitaria sanguinalis*, *Dactyloctenium aegyptium*, *Echinochloa colona*, among broadleaf weeds *Croton bonplandianum*, *Spilanthes acmella*, *Phyllanthus niruri*, *Physalis minima*, *Cleome viscosa*, *Amaranthus viridis*, *Oldenlandia corymbosa*, *Alternanthera sessilis*, *Heliotropium indicum* were found and *Cyperus rotundus* and *Cyperus esculentus* were among predominant sedges observed (Selvakumar *et al.*, 2018; Mahapatra *et al.*, 2025b; Tripathy *et al.*, 2026) [14, 13, 15].

### Weed density

Grass population was significantly influenced by weed management treatments. Lowest grass population was found in weed free treatment at 30 DAS (4.38 m<sup>-2</sup>), 60 DAS (5.33m<sup>-2</sup>) and at harvest (6.28m<sup>-2</sup>) and highest weed population was found in weedy check treatment (8.35m<sup>-2</sup>, 9.26m<sup>-2</sup>, 10.35m<sup>-2</sup> at 30, 60 DAS and at harvest respectively). The sedge population was lowest in weed free treatment (three hand weeding at 15, 30 and 45 DAS) at 30 DAS, 60 DAS and harvest (3.29m<sup>-2</sup>, 3.98m<sup>-2</sup>, 5.37m<sup>-2</sup> respectively) followed by pendimethalin 1 kg ha<sup>-1</sup> as pre-emergence *fb* one HW at 30 DAS (3.97 m<sup>-2</sup>, 4.70 m<sup>-2</sup>, 5.68 m<sup>-2</sup> respectively). Weed free treatment recorded lowest broad leaf weed population throughout the growth stages. At harvest the lowest broadleaf weeds were found in weed free treatment (6.52 m<sup>-2</sup>) followed by pendimethalin 1 kg ha<sup>-1</sup> as pre-emergence *fb* one HW at 30 DAS (7.37 m<sup>-2</sup>). Throughout the growth period of the crop, weedy check treatment has shown highest number of broad leaf populations (8.17m<sup>-2</sup>, 9.17m<sup>-2</sup> and 10.78m<sup>-2</sup> at 30, 60 DAS and at harvest respectively). The total weed population at 60 DAS was lowest in weed free (8.65m<sup>-2</sup>) followed by the treatment two intercultivations at 20 and 40 DAS (10.17m<sup>-2</sup>) which was found at par with pendimethalin 1 kg ha<sup>-1</sup> as pre-emergence *fb* one HW at 30 DAS (10.40m<sup>-2</sup>). At harvest stage, weed free treatment showed lowest number of total weed population (10.48/m<sup>2</sup>) followed by pendimethalin 1 kg ha<sup>-1</sup> as pre-emergence *fb* one HW at 30 DAS (11.38m<sup>-2</sup>). Throughout the crop growth stage, highest numbers of weeds were found in Weedy check. This can be attributed to efficiency of manual weeding in reducing weed populations (Meti *et al.*, 2016; Tripathy *et al.*, 2026) [15].

### Dry weight of weeds

Weed dry weight increased from initial growth stage to harvest stage and was significantly affected by different weed management practices. At 30 DAS, weed dry weight per square-meter was minimum in Weed free ( $2.78 \text{ g m}^{-2}$ ) followed by the treatment two interculturalations at 20 and 40 DAS ( $3.76 \text{ g m}^{-2}$ ). The highest weed dry weight was found in weedy check ( $8.70 \text{ g m}^{-2}$ ). At 60 DAS, lowest weed dry weight was found in Weed free ( $3.81 \text{ g m}^{-2}$ ) followed by pendimethalin  $1 \text{ kg ha}^{-1}$  as pre-emergence *fb* one HW at 30 DAS ( $4.60 \text{ g m}^{-2}$ ) which is at par with two interculturalations at 20 & 40 DAS ( $4.80 \text{ g m}^{-2}$ ), whereas highest weed dry weight was found in weedy check ( $10.50 \text{ g m}^{-2}$ ). At harvest, weed free treatment gave lowest weed dry weight ( $4.51 \text{ g m}^{-2}$ ) followed by pendimethalin  $1 \text{ kg ha}^{-1}$  as pre-emergence *fb* one HW at 30 DAS ( $5.27 \text{ g m}^{-2}$ ) which was at par with the treatment two interculturalations at 20 and 40 DAS ( $5.61 \text{ g m}^{-2}$ ) (Shylaja *et al.*, 2008; Mahapatra *et al.*, 2025a) [17, 16].

### Weed control efficiency (WCE) and weed index (WI)

The weed free treatment showed higher weed control efficiency throughout the growth stages as the weeds are controlled in a timely, effective manner. At 30 DAS, the next best WCE was found in the treatment two interculturalations at 20 and 40 DAS whereas at 60 DAS and at harvest pendimethalin  $1 \text{ kg ha}^{-1}$  as pre-emergence *fb* one HW at 30 DAS resulted in better WCE than two interculturalations at 20 and 40 DAS, which was closely followed by pendimethalin  $1 \text{ kg ha}^{-1}$  as pre-emergence *fb* quizalofop-p-ethyl  $5\% \text{ EC @ } 50 \text{ g ha}^{-1}$  as PoE at 18 DAS. This can be attributed to mechanical weeding at early stage which help in reducing initial weed load, but application of herbicide followed by one hand weeding or application of one pre-emergence herbicide followed by one post-emergence herbicide that help in preventing weeds which escape the pre-emergence herbicide or emerged later provide a long term weed control, thus improving WCE at later growth stages (Shylaja and Sundari, 2008; Nagmani *et al.*, 2011) [18, 17]. After weed free treatment, the lowest WI was observed in pendimethalin  $1 \text{ kg ha}^{-1}$  as PE *fb* one HW at 30 DAS (5.81 %) followed by two interculturalations at 20 & 40 DAS (6.79%) *fb* pendimethalin  $1 \text{ kg ha}^{-1}$  as pre-emergence *fb* quizalofop-p-ethyl  $5\% \text{ EC @ } 50 \text{ g ha}^{-1}$  as PoE at 18 DAS (7.98 %) (Selvakumar *et al.*, 2018, Mahapatra *et al.*, 2024a, Mahapatra *et al.*, 2025b) [14].

### Growth and yield

Growth parameters were significantly influenced by weed management treatments. The highest plant height (175 cm) at harvest, stem girth (8.1 cm), LAI (3.02) at 60 DAS, dry weight ( $111.0 \text{ g plant}^{-1}$ ) at harvest and CGR ( $17.92 \text{ g day}^{-1} \text{ m}^{-2}$ ) was observed with the weed free treatment and the lowest values for all the growth parameters were observed with weedy check. After weed free, the treatments, pendimethalin  $1 \text{ kg ha}^{-1}$  as pre-emergence *fb* one HW at 30 DAS, pendimethalin  $1 \text{ kg ha}^{-1}$  as pre-emergence *fb* quizalofop-p-ethyl  $5\% \text{ EC @ } 50 \text{ g ha}^{-1}$  as PoE at 18 DAS and two interculturalations at 20 and 40 DAS remained statistically at par with respect to plant height, stem girth, LAI, dry weight of plant and CGR. This can be attributed to timely weed management by interculturalations or both pre-emergence and post-emergence herbicides, which helps in hindering nutrient and moisture uptake by weeds, leading to robust growth of the crop whereas poor weed management, as reflected in the weedy check, resulted in stunted plant growth (Karkanis *et al.*, 2022; Mahapatra *et al.*, 2024b) [19, 20].

The highest seed yield was obtained with weed free ( $1858 \text{ kg ha}^{-1}$ ), which remained at par with pendimethalin  $1 \text{ kg ha}^{-1}$  as pre-emergence *fb* one HW at 30 DAS, pendimethalin  $1 \text{ kg ha}^{-1}$  as pre-emergence *fb* quizalofop-p-ethyl  $5\% \text{ EC @ } 50 \text{ g ha}^{-1}$  as PoE at 18 DAS and two interculturalations at 20 and 40 DAS. The lowest seed yield ( $834 \text{ kg/ha}$ ) was recorded in weedy check. The highest seed yield in the weed free treatment may be due to regular manual weeding that helped in removal of all weed flushes, minimizing competition throughout the crop's growth cycle. While weed free yields the best results, integrated weed management practices, especially those com-

bining pre-emergence herbicides with either manual or post-emergence interventions, are nearly as effective and more feasible for large scale operation (Nagamani *et al.*, 2011; Baskaran and Kavimani, 2014; Narender *et al.*, 2017) [18, 21, 22]. Stover yield varied from 2438 to  $3938 \text{ kg ha}^{-1}$  among the treatments. The highest stover yield ( $3938 \text{ kg ha}^{-1}$ ) was recorded with pendimethalin  $1 \text{ kg ha}^{-1}$  as pre-emergence followed by one hand weeding at 30 DAS, closely followed by weed-free with  $3934 \text{ kg ha}^{-1}$ . Two interculturalations at 20 and 40 DAS and pendimethalin  $1 \text{ kg ha}^{-1}$  as pre-emergence *fb* quizalofop-p-ethyl  $5\% \text{ EC @ } 50 \text{ g ha}^{-1}$  as PoE at 18 DAS recorded 3868 and  $3781 \text{ kg ha}^{-1}$ , respectively. The lowest stover yield ( $2438 \text{ kg ha}^{-1}$ ) was recorded under the weedy check. The greater stover production under effective weed control can be attributed to reduced weed competition, which allowed sunflower plants to utilize available nutrients, moisture, light and space more efficiently, resulting in greater vegetative growth and dry-matter accumulation (Sumathi *et al.*, 2010; Narender *et al.*, 2017) [23, 22]. Harvest index ranged from 25.3 to 32.2%. The highest harvest index (32.2%) was recorded in T<sub>7</sub> (weed-free), followed by T<sub>6</sub> (31.3%), T<sub>5</sub> (31.1%) and T<sub>3</sub> (30.8%). The lowest harvest index (25.3%) was observed under the weedy check. The relatively high harvest index under T<sub>5</sub>, T<sub>6</sub> and T<sub>3</sub> also indicates efficient translocation and partitioning of assimilates towards seed formation. In contrast, severe weed competition under weedy check restricted crop growth and reduced seed production, resulting in a lower harvest index (Meti *et al.*, 2017) [24]. Oil yield showed a clear response to weed management and ranged from 307 to  $697 \text{ kg ha}^{-1}$ . The maximum oil yield ( $697 \text{ kg ha}^{-1}$ ) was recorded under T<sub>7</sub> (weed-free), followed by T<sub>3</sub> ( $656 \text{ kg ha}^{-1}$ ), T<sub>6</sub> ( $646 \text{ kg ha}^{-1}$ ) and T<sub>5</sub> ( $638 \text{ kg ha}^{-1}$ ). The minimum oil yield ( $307 \text{ kg ha}^{-1}$ ) was recorded under the weedy check. The substantially higher oil yield under effective weed management was mainly associated with higher seed yield, as oil yield is directly influenced by seed production and oil content (Parmar *et al.*, 2014; Tadavi *et al.*, 2017; Mahapatra *et al.*, 2025b) [25, 26, 13].

### Economics

Weed-management practices considerably influenced the economics of sunflower cultivation. The cost of cultivation ranged from ₹61,304  $\text{ha}^{-1}$  under the weedy check (T<sub>8</sub>) to ₹75,384  $\text{ha}^{-1}$  under the weed-free treatment (T<sub>7</sub>). The highest gross return (₹1,35,279  $\text{ha}^{-1}$ ) was obtained with weed free(T<sub>7</sub>), followed by T<sub>3</sub> (₹1,27,424  $\text{ha}^{-1}$ ), T<sub>6</sub> (₹1,26,090  $\text{ha}^{-1}$ ) and T<sub>5</sub> (₹1,24,488  $\text{ha}^{-1}$ ). The highest net return of ₹59,895  $\text{ha}^{-1}$  was recorded under weed free(T<sub>7</sub>), closely followed by T<sub>5</sub> (₹58,916  $\text{ha}^{-1}$ ) and T<sub>3</sub> (₹57,520  $\text{ha}^{-1}$ ). However, the B:C was highest under T<sub>5</sub> (1.90), followed by T<sub>3</sub> (1.82) and T<sub>6</sub> (1.80), whereas, weed free (T<sub>7</sub>) recorded a B:C ratio of 1.79. The relatively lower B:C ratio under weed free(T<sub>7</sub>) despite its higher gross and net returns, was due to the greater cost involved in three hand weedings. In contrast, pendimethalin  $1 \text{ kg ha}^{-1}$  as pre-emergence *fb* quizalofop-p-ethyl  $5\% \text{ EC @ } 50 \text{ g ha}^{-1}$  as PoE at 18 DAS recorded higher B:C due to lower cost of cultivation, resulting in a higher B:C. The weedy check recorded a negative net return (–₹589  $\text{ha}^{-1}$ ) and a B:C ratio of only 0.99, indicating that uncontrolled weed competition substantially reduced the economic viability of sunflower cultivation (Parmar *et al.*, 2014 and Tadavi *et al.*, 2017, Mahapatra *et al.*, 2025a&b) [25].

### Conclusion

Weed management had a pronounced influence on growth, productivity and economic returns of sunflower. Weed-free (three hand weedings at 15, 30 and 45 DAS) sunflower resulted in lowest weed density, dry weight, highest weed control efficiency, plant height, leaf area index, stem girth, dry matter accumulation, crop growth rate, seed yield ( $1858 \text{ kg ha}^{-1}$ ), harvest index (32.2%), oil yield ( $697 \text{ kg ha}^{-1}$ ), gross return (₹1,35,279  $\text{ha}^{-1}$ ) and net return (₹59,895  $\text{ha}^{-1}$ ). However, the higher cost associated with repeated hand weeding resulted in a B:C of 1.79. Sequential application of pendimethalin  $1 \text{ kg ha}^{-1}$  as pre-emergence *fb* quizalofop-p-ethyl  $5\% \text{ EC @ } 50 \text{ g ha}^{-1}$  as PoE at 18 DAS resulted in high sunflower productivity with the high

est B:C (1.90), which can be adopted in case of large-scale sunflower farming.

**Table 1.** Weed flora composition of the experimental plot

| Sl.no. | Botanical name                  | Family         | Common name                    | Ontogeny  | Group     |
|--------|---------------------------------|----------------|--------------------------------|-----------|-----------|
| 1      | <i>Cynodon dactylon</i>         | Poaceae        | Bermuda grass                  | Perennial | Grass     |
| 2      | <i>Digitaria ciliaris</i>       | Poaceae        | Crab grass                     | Annual    | Grass     |
| 3      | <i>Digitaria sanguinalis</i>    | Poaceae        | Hairy crab grass               | Annual    | Grass     |
| 3      | <i>Dactyloctenium aegyptium</i> | Poaceae        | Crow foot grass                | Annual    | Grass     |
| 4      | <i>Echinochloa colona</i>       | Poaceae        | Jungle rice                    | Annual    | Grass     |
| 5      | <i>Croton bonplandianum</i>     | Euphorbiaceae  | Jungle tulsi                   | Annual    | Broadleaf |
| 6      | <i>Spilanthes acmella</i>       | Asteraceae     | Tooth ache plant               | Perennial | Broadleaf |
| 7      | <i>Phyllanthus niruri</i>       | Phyllanthaceae | Stone breaker                  | Annual    | Broadleaf |
| 8      | <i>Physalis minima</i>          | Solanaceae     | Ground cherry                  | Annual    | Broadleaf |
| 9      | <i>Cleome viscosa</i>           | Capparaceae    | Asian spider flower            | Annual    | Broadleaf |
| 10     | <i>Amaranthus viridis</i>       | Amaranthaceae  | Slender amaranth               | Annual    | Broadleaf |
| 11     | <i>Oldenlandia corymbosa</i>    | Rubiaceae      | Diamond flower                 | Annual    | Broadleaf |
| 12     | <i>Alternanthera sessilis</i>   | Amaranthaceae  | Dwarf copperleaf               | Perennial | Broadleaf |
| 13     | <i>Heliotropium indicum</i>     | Boraginaceae   | Indian heliotrope              | Annual    | Broadleaf |
| 14     | <i>Cyperus rotundus</i>         | Cyperaceae     | Purple nut sedge               | Perennial | Sedge     |
| 15     | <i>Cyperus esculentus</i>       | Cyperaceae     | Yellow nut sedge               | Perennial | Sedge     |
| 16     | <i>Cyperus difformis</i>        | Cyperaceae     | Small flower<br>Umbrella sedge | Perennial | Sedge     |

Original values are given in parentheses, which are transformed to  $\sqrt{(x+0.5)}$ , HW- Hand weeding

| Treatments.                                                                                                                                                | Grasses         |                   |                   | Sedges          |                 |                 | Broad leaf      |                 |                   | Total weed        |                   |                   |
|------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|-------------------|-------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-------------------|-------------------|-------------------|-------------------|
|                                                                                                                                                            | 30DAS           | 60DAS             | At harvest        | 30DAS           | 60DAS           | At Harvest      | 30DAS           | 60DAS           | At Harvest        | 30DAS             | 60DAS             | At harvest        |
| T <sub>1</sub> : Pendimethalin 1 kg ha <sup>-1</sup> as pre-emergence                                                                                      | 5.23<br>(26.97) | 6.67<br>(43.97)   | 8.36<br>(69.50)   | 4.80<br>(22.67) | 7.31<br>(53.17) | 8.09<br>(65.00) | 6.39<br>(40.30) | 8.09<br>(65.00) | 8.98<br>(80.33)   | 10.82<br>(116.67) | 13.49<br>(181.50) | 15.06<br>(226.33) |
| T <sub>2</sub> : Quizalofop- <i>p</i> -ethyl 5% EC @ 50g/ha <sup>-1</sup> as PoE at 18DAS                                                                  | 5.26<br>(27.27) | 6.77<br>(45.30)   | 9.03<br>(80.97)   | 4.81<br>(22.67) | 7.38<br>(54.0)  | 8.28<br>(68.00) | 6.52<br>(42.00) | 8.35<br>(69.33) | 9.70<br>(93.67)   | 10.82<br>(116.67) | 13.66<br>(186.33) | 15.58<br>(242.33) |
| T <sub>3</sub> : Pendimethalin 1 kg ha <sup>-1</sup> as pre-emergence <i>fb</i> one HW at 30 DAS                                                           | 4.50<br>(19.83) | 4.60<br>(20.87)   | 5.27<br>(27.53)   | 3.97<br>(15.33) | 4.70<br>(21.67) | 5.68<br>(31.83) | 6.36<br>(40.00) | 6.76<br>(45.33) | 7.37<br>(54.00)   | 10.33<br>(106.33) | 10.40<br>(107.67) | 11.38<br>(129.17) |
| T <sub>4</sub> : Quizalofop- <i>p</i> -ethyl 5% EC @ 50 g ha <sup>-1</sup> as PoE at 18 DAS <i>fb</i> one HW at 30DAS                                      | 4.64<br>(21.10) | 5.59<br>(30.97)   | 7.16<br>(51.10)   | 4.87<br>(23.33) | 6.95<br>(48.0)  | 7.73<br>(59.33) | 6.47<br>(41.30) | 7.53<br>(56.33) | 8.56<br>(73.00)   | 10.77<br>(115.67) | 12.73<br>(161.67) | 14.41<br>(207.33) |
| T <sub>5</sub> : Pendimethalin 1 kg ha <sup>-1</sup> as pre-emergence <i>fb</i> Quizalofop- <i>p</i> -ethyl 5% EC @ 50 g ha <sup>-1</sup> as PoE at 18 DAS | 4.08<br>(16.13) | 5.27<br>(27.27)   | 5.97<br>(35.20)   | 4.49<br>(19.67) | 6.24<br>(38.67) | 6.91<br>(47.33) | 5.20<br>(26.70) | 7.20<br>(51.33) | 8.11<br>(65.33)   | 9.37<br>(87.33)   | 11.88<br>(140.67) | 13.04<br>(169.67) |
| T <sub>6</sub> : Two intercultivations at 20 and 40 DAS)                                                                                                   | 3.76<br>(13.77) | 4.80<br>(22.57)   | 5.61<br>(31.00)   | 4.41<br>(19.00) | 5.23<br>(27.0)  | 6.31<br>(39.33) | 4.77<br>(22.30) | 6.44<br>(41.00) | 7.75<br>(59.67)   | 8.61<br>(73.67)   | 10.17<br>(103.00) | 12.32<br>(151.33) |
| T <sub>7</sub> : Weed free (three hand weedings at 15, 30 and 45 DAS)                                                                                      | 2.78<br>(7.23)  | 3.81<br>(14.00)   | 4.51<br>(19.83)   | 3.29<br>(10.33) | 3.98<br>(15.33) | 5.37<br>(28.33) | 3.57<br>(12.30) | 5.61<br>(31.00) | 6.52<br>(42.00)   | 6.46<br>(41.33)   | 8.65<br>(74.33)   | 10.48<br>(109.33) |
| T <sub>8</sub> : Weedy check                                                                                                                               | 8.70<br>(75.20) | 10.50<br>(110.00) | 11.57<br>(133.33) | 7.05<br>(49.33) | 8.72<br>(75.67) | 9.48<br>(96.33) | 8.17<br>(66.30) | 9.17<br>(83.67) | 10.78<br>(115.67) | 13.61<br>(185.00) | 15.65<br>(244.67) | 17.86<br>(318.67) |
| SEm(±)                                                                                                                                                     | 0.162           | 0.222             | 0.221             | 0.158           | 0.273           | 0.106           | 0.155           | 0.196           | 0.239             | 0.215             | 0.197             | 0.199             |
| CD( <i>p</i> = 0.05)                                                                                                                                       | 0.492           | 0.672             | 0.670             | 0.48            | 0.83            | 0.32            | 0.47            | 0.59            | 0.73              | 0.65              | 0.60              | 0.60              |

**Table 2.** Weed density at different growth stages of sunflower as influenced by weed management

| Treatments                                                                                                                                                 | Weed dry weight (g/m <sup>2</sup> ) |                |               | Weed control efficiency (%) |       |         | Weed Index (%) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|----------------|---------------|-----------------------------|-------|---------|----------------|
|                                                                                                                                                            | 30 DAS                              | 60 DAS         | Harvest       | 30DAS                       | 60DAS | Harvest |                |
| T <sub>1</sub> : Pendimethalin 1 kg ha <sup>-1</sup> as pre-emergence                                                                                      | 5.23 (26.97)                        | 6.67 (43.97)   | 8.36 (69.50)  | 64.14                       | 60.03 | 47.88   | 38.65          |
| T <sub>2</sub> : Quizalofop- <i>p</i> -ethyl 5% EC @ 50g/ha <sup>-1</sup> as PoE at 18DAS                                                                  | 5.26 (27.27)                        | 6.77 (45.30)   | 9.03 (80.97)  | 63.74                       | 58.82 | 39.28   | 45.13          |
| T <sub>3</sub> : Pendimethalin 1 kg ha <sup>-1</sup> as pre-emergence <i>fb</i> one HW at 30 DAS                                                           | 4.50 (19.83)                        | 4.60 (20.87)   | 5.27 (27.53)  | 73.63                       | 81.03 | 79.35   | 5.81           |
| T <sub>4</sub> : Quizalofop- <i>p</i> -ethyl 5% EC @ 50 g ha <sup>-1</sup> as PoE at 18 DAS <i>fb</i> one HW at 30DAS                                      | 4.64 (21.10)                        | 5.59 (30.97)   | 7.16 (51.10)  | 71.94                       | 71.85 | 61.68   | 31.71          |
| T <sub>5</sub> : Pendimethalin 1 kg ha <sup>-1</sup> as pre-emergence <i>fb</i> Quizalofop- <i>p</i> -ethyl 5% EC @ 50 g ha <sup>-1</sup> as PoE at 18 DAS | 4.08 (16.13)                        | 5.27 (27.27)   | 5.97 (35.20)  | 78.55                       | 75.21 | 73.60   | 7.98           |
| T <sub>6</sub> : Two intercultivations at 20 and 40 DAS)                                                                                                   | 3.76 (13.77)                        | 4.80 (22.57)   | 5.61 (31.00)  | 81.69                       | 79.48 | 76.75   | 6.79           |
| T <sub>7</sub> : Weed free (Three hand weeding at 15, 30 and 45 DAS)                                                                                       | 2.78 (7.23)                         | 3.81 (14.00)   | 4.51 (19.83)  | 90.38                       | 87.27 | 85.13   | -              |
| T <sub>8</sub> : Weedy check                                                                                                                               | 8.70 (75.20)                        | 10.50 (110.00) | 11.57(133.33) | -                           | -     | -       | 55.12          |
| SEm(±)                                                                                                                                                     | 0.162                               | 0.222          | 0.221         |                             |       |         |                |
| CD( <i>p</i> = 0.05)                                                                                                                                       | 0.492                               | 0.672          | 0.670         |                             |       |         |                |

**Table 3.** Effect of weed management on weed dry weight, WCE and weed index.

Original values are given in parentheses, which are transformed to  $\sqrt{(x+0.5)}$ , HW- Hand weeding

**Table 4.** Effect of weed management treatments on growth and yield of sunflower

| Treatments                                                                                                                                                 | Pl.ht at harvest (cm.) | LAI at 60 DAS | Stem girth (cm.) | Dry weight (g plant <sup>-1</sup> ) | CGR At 45-60 DAS (g day <sup>-1</sup> m <sup>-2</sup> ) | Seed yield (Kg ha <sup>-1</sup> ) | Stover yield (Kg ha <sup>-1</sup> ) | Harvest Index (%) | Oil yield (Kg ha <sup>-1</sup> ) |
|------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------|---------------|------------------|-------------------------------------|---------------------------------------------------------|-----------------------------------|-------------------------------------|-------------------|----------------------------------|
| T <sub>1</sub> : Pendimethalin 1 kg ha <sup>-1</sup> as pre-emergence                                                                                      | 131.0                  | 2.40          | 6.9              | 81.7                                | 11.06                                                   | 1140                              | 3133                                | 26.7              | 424                              |
| T <sub>2</sub> : Quizalofop- <i>p</i> -ethyl 5% EC @ 50 g ha <sup>-1</sup> as PoE at 18DAS                                                                 | 127.0                  | 2.15          | 6.2              | 67.6                                | 10.81                                                   | 1020                              | 2826                                | 26.5              | 378                              |
| T <sub>3</sub> : Pendimethalin 1 kg ha <sup>-1</sup> as pre-emergence <i>fb</i> one HW at 30 DAS                                                           | 160.0                  | 2.83          | 7.8              | 100.0                               | 16.12                                                   | 1750                              | 3938                                | 30.8              | 656                              |
| T <sub>4</sub> : Quizalofop- <i>p</i> -ethyl 5% EC @ 50 g ha <sup>-1</sup> as PoE at 18 DAS <i>fb</i> one HW at 30DAS                                      | 136.0                  | 2.51          | 7.1              | 75.3                                | 11.90                                                   | 1269                              | 3317                                | 27.8              | 473                              |
| T <sub>5</sub> : Pendimethalin 1 kg ha <sup>-1</sup> as pre-emergence <i>fb</i> Quizalofop- <i>p</i> -ethyl 5% EC @ 50 g ha <sup>-1</sup> as PoE at 18 DAS | 144.0                  | 2.69          | 7.5              | 89.7                                | 15.00                                                   | 1710                              | 3781                                | 31.1              | 638                              |

(continued on next page)

| Treatments                                                           | Pl.ht at harvest<br>(cm.) | LAI at 60 DAS | Stem girth<br>(cm.) | Dry weight<br>(g plant <sup>-1</sup> ) | CGR<br>At 45-60 DAS<br>(g day <sup>-1</sup> m <sup>-2</sup> ) | Seed yield<br>(Kg ha <sup>-1</sup> ) | Stover yield<br>(Kg ha <sup>-1</sup> ) | Harvest Index<br>(%) | Oil yield<br>(Kg ha <sup>-1</sup> ) |
|----------------------------------------------------------------------|---------------------------|---------------|---------------------|----------------------------------------|---------------------------------------------------------------|--------------------------------------|----------------------------------------|----------------------|-------------------------------------|
| T <sub>6</sub> : Two inter-cultivations at 20 and 40 DAS)            | 152.0                     | 2.75          | 7.6                 | 93.3                                   | 15.51                                                         | 1732                                 | 3868                                   | 31.3                 | 646                                 |
| T <sub>7</sub> : Weed free (Three hand weeding at 15, 30 and 45 DAS) | 175.0                     | 3.02          | 8.1                 | 111.0                                  | 17.92                                                         | 1858                                 | 3934                                   | 32.2                 | 697                                 |
| T <sub>8</sub> : Weedy check                                         | 91.0                      | 1.78          | 4.4                 | 53.0                                   | 8.65                                                          | 834                                  | 2438                                   | 25.3                 | 307                                 |
| SEm(±)                                                               | 5.9                       | 0.120         | 0.33                | 4.02                                   | 0.915                                                         | 75.8                                 | 211.1                                  | 1.50                 | 27.3                                |
| CD(p = 0.05)                                                         | 18.0                      | 0.37          | 1.0                 | 12.2                                   | 2.77                                                          | 230                                  | 640                                    | 4.3                  | 83                                  |

**Table 5.** Economics (₹ ha<sup>-1</sup>) of sunflower as influenced by different Integrated weed management

| Treatments                                                                                                                                                  | Cost of cultivation<br>(₹ ha <sup>-1</sup> ) | Gross Return<br>(₹ ha <sup>-1</sup> ) | Net Return<br>(₹ ha <sup>-1</sup> ) | B:C  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|---------------------------------------|-------------------------------------|------|
| T <sub>1</sub> : Pendimethalin 1 kg ha <sup>-1</sup> as pre-emergence                                                                                       | 63568                                        | 82992                                 | 19424                               | 1.31 |
| T <sub>2</sub> : Quizalofop- <i>p</i> -ethyl 5% EC @ 50 g ha <sup>-1</sup> as PoE at 18DAS                                                                  | 63308                                        | 74222                                 | 10914                               | 1.17 |
| T <sub>3</sub> : Pendimethalin 1 kg ha <sup>-1</sup> as pre-emergence <i>fb</i> one HW at 30 DAS                                                            | 69904                                        | 127424                                | 57520                               | 1.82 |
| T <sub>4</sub> : Quizalofop- <i>p</i> -ethyl 5% EC @ 50 g ha <sup>-1</sup> as PoE at 18 DAS <i>fb</i> one HW at 30DAS                                       | 69644                                        | 92376                                 | 22732                               | 1.33 |
| T <sub>5</sub> : Pendimethalin 1 kg ha <sup>-1</sup> as pre- emergence <i>fb</i> Quizalofop- <i>p</i> -ethyl 5% EC @ 50 g ha <sup>-1</sup> as PoE at 18 DAS | 65572                                        | 124488                                | 58916                               | 1.90 |
| T <sub>6</sub> : Two intercultivations at 20 and 40 DAS)                                                                                                    | 70104                                        | 126090                                | 55986                               | 1.80 |
| T <sub>7</sub> : Weed free (Three hand weeding at 15, 30 and 45 DAS)                                                                                        | 75384                                        | 135279                                | 59895                               | 1.79 |
| T <sub>8</sub> : Weedy check                                                                                                                                | 61304                                        | 60715                                 | -589                                | 0.99 |

## References

- Islam RT, Hossain MM, Majumder K, Tipu AH. *In vitro* phytochemical investigation of *Helianthus annuus* seeds. Bangladesh Pharmaceutical Journal. 2016;19(1):100-105.
- Petraru A, Ursachi F, Amariei S. Nutritional characteristics assessment of sunflower seeds, oil and cake. Perspective of using sunflower oilcakes as a functional ingredient. Plants. 2021;10(11):2487.
- Ramesh K, Mahapatra A, Roy A, Bhaskar S. Reviving horizontal area expansion of sunflower (*Helianthus annuus* L.) in rice fallow ecosystems: A relook. Journal of Oilseeds Research. 2021;38(2):121-131.
- ICAR-Indian Institute of Oilseeds Research. Annual Report, Sunflower, 2025-26. Rajendranagar, Hyderabad-500 030, Telangana; 2025.
- Adhikary P, Patra PS. Effect of integrated weed management on summer greengram under alluvial soil of West Bengal. Indian Journal of Weed Science. 2024;56(1):39-45.
- Sumathi V, Subramanyam D, Koteswara Rao DS, Reddy DS. Effect of planting pattern and weed management on nutrient uptake and economics of rabi sunflower and its associated weeds. Indian Journal of Weed Science. 2009;41(1and2):65-70.
- Hatti V, Ramachandrapa BK, Mudalagiriappa. Weed dynamics in conservation agricultural systems as influenced by conservation tillage and nutrient management practices under rainfed finger millet. Indian Journal of Weed Science. 2018;50(4):355-364.
- Swanton CJ, Mahoney KJ, Chandler K, Gulden RH. Integrated Weed Management: Knowledge-Based Weed Management Systems. Weed Science. 2008;56(1):168-172.
- Choudary VK, Dubey RP, Mishra JS. Weed management in oilseed crops: A review. Indian Journal of Weed Science. 2022;54(4):411-420.
- Mani VS, Malla ML, Gautam K, Bhagwandas C. Weed killing chemicals in potato cultivation. Indian Farming. 1973;22:17-18.
- Gill GS, Kumar V. Weed index- A new method for reporting weed control trials. Indian Journal of Agronomy. 1969;16:96-98.
- Tiwari PN, Gambhir PM, Rajan TS. Rapid and non-destructive determination of seed oil by pulsed nuclear magnetic resonance technique. Journal of American Oil Chemical Society. 1974;57:104-109.
- Mahapatra A, Gandotra P, Khatua R. Weed management in rice fallow sunflower under zero tillage in coastal Odisha. International Journal of advanced biochemistry research. 2025;9(11):44-47.
- Selvakumar T, Srinivasan K, Rajendran L. Performance of chemical weed management in irrigated sunflower. International Journal of Agricultural Sciences. 2018;10(20):7395-7397.
- Tripathy S, Lalawmpuia, Mohapatra A, Sethy AK, Dash AC, Prameela G, Sai SN, Pradhan DD, Mahapatra SS, Dash D, Anil. Dynamics of weed flora and integrated weed management for enhancing sunflower (*Helianthus annuus* L.) productivity. Plant Science Today. 2026;13(sp2):1-8.
- Mahapatra A, Bisoyi BB, Ramesh K. Integrated weed management in sunflower under modified spacing. Journal of oilseed research. 2025;42(2):176-180.
- Shylaja R, Sundari A. Weed management in sunflower (*Helianthus annuus* L.). Indian Journal of Weed Science. 2008;40(1 and 2):94-95.
- Nagamani C, Naidu SM, Subramanyam D. Weed dynamics and yield of sunflower as influenced by varied planting patterns and weed management practices. Indian Journal of Weed Science. 2011;43(1&2):101-104.

19. Karkanis A, Nakopoulos D, Palamioti C, Giannoulis KD, Palamiotis TI, goumenos G, Danalatos NG. Effects of post-emergence herbicides and period of Johnson grass (*Sorghum halepense* (L.) Pers.) control on growth and yield of sunflower crops. *Agronomy*. 2022;12(3):581.
20. Mahapatra A, Nikhita D, Mohanty S, Khatua R. Integrated weed management in sunflower. *International Journal of Research in Agronomy*. 2024;7(11):574-577.
21. Baskaran R, Kavimani R. Integrated weed management in maize-sunflower cropping system. *Indian Journal of Weed Science*. 2014;46(4):330-332.
22. Narender J, Padmaja J, Srinivas A, Sailaja V. Evaluation of efficacy of different herbicides for efficient weed control in sunflower (*Helianthus annuus* L.). *International Journal of Pure and Applied Bio science*. 2017;5(4):1576-1581.
23. Sumathi V, Subramanyam D, Rao DS, Reddy DS. Effect of planting pattern and weed management on weed flora and yield of rabi sunflower. *Indian Journal of Weed Science*. 2010;42(3&4):212-216.
24. Meti RN, Geetha KN, Shankar AG, Prathima AS, Prakash P. Weed management practices for improving productivity and nutrient uptake of sunflower (*Helianthus annuus* L.) in Alfisols. *Environment & Ecology*. 2017;35(4):2801-2805.
25. Parmar VT, Patel JG, Vasave JB. Efficacy of Different Herbicides in Sunflower under South Gujarat Condition. *Trends in Bio sciences*. 2014;7(14):1624-1629.
26. Tadavi AG, Chorey AB, Gaikwad GS, Sawadhkar SM. Integrated weed management in sunflower. *International Journal of current microbiology and applied sciences*. 2017;6(9):1080-1088.
27. Lehoczky E, Reisinger P, Komives T, Szalai T. Study on early competition between sunflower and weeds in field experiments. *Journal of plant Diseases and Protection*. 2006;20:935-940.
28. Mahapatra A, Mohanty L, Ramesh K, Bhol R. Response of sunflower-weed ecosystem to herbicide oxadiagryl and integrated weed management options. *Journal of oilseed research*. 2024;40:203-206.
29. Pannacci E, Tei F. Effects of mechanical and chemical methods on weed control, weed seed rain and crop yield in maize, sunflower and soyabean. *Crop Protection*. 2014;64:51-59.

**How to cite this article:** Mahapatra A, Patra J, Nayak BR, Bhandari A, Das SS, Mohanty S. Optimizing weed management in summer sunflower (*Helianthus annuus* L.) in east and south eastern coastal plain zone of Odisha. *International Journal of Research in Agronomy*. 2026;9(9):1119-1126. doi: <https://www.doi.org/10.33545/2618060X.2026.v9.i9o.6657>