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## Integrated weed management strategies for enhancing productivity, nutrient uptake and economics of Indian mustard (*Brassica juncea* L.) under the Central Uttar Pradesh agro-climatic zone

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### Abstract

The current study, "Integrated Weed Management Strategies for Mustard (*Brassica juncea* L.) in the Central Uttar Pradesh Agro-Climatic Zone," was carried out at the Maharishi University of Information Technology (MUIT) Crop Research Farm in Lucknow, Uttar Pradesh, India, during the rabi season of 2025–2026. The experiment assessed how weed dynamics, crop growth, yield, nutrient absorption, quality, and mustard economics were affected by integrated weed control techniques. Weedy check, hand weeding, pre-emergence herbicides, herbicide combinations, mulching, interculture, and integrated weed control techniques were among the eight treatments that were examined. In comparison to the weedy check, the results showed that all weed control techniques considerably decreased weed density and weed dry weight. The treatments with the lowest weed infestation and the best weed control efficacy were Pendimethalin (PE) at the indicated dose and one hand weeding at 30 DAS ( $T_0$ ). Additionally, this treatment greatly enhanced oil output, nitrogen absorption, growth characteristics, yield attributes, and seed yield ( $27.3 \text{ q ha}^{-1}$ ). According to economic research,  $T_0$  had the highest benefit ratio (3.87) and net return ( $\text{₹}97,600 \text{ ha}^{-1}$ ). The study came to the conclusion that an efficient and financially feasible method for growing mustard in Central Uttar Pradesh is integrated weed control using pendimethalin and one-hand weeding.

**Keywords:** Mustard, *Brassica juncea* L., integrated weed management, weed control, pendimethalin

### Introduction

One of the most significant oilseed crops grown in India is Indian mustard (*Brassica juncea* L.), which is essential to the nation's edible oil industry. Mustard holds a significant position among the rabi oilseed crops because of its high oil content, wide range of adaptability, and relatively cheap input requirements. Mustard seed is a significant source of edible oil and nutritional security since it contains around 38–42% oil and 20–25% protein (Meena *et al.*, 2015) <sup>[10]</sup>. India is one of the world's leading producers of rapeseed-mustard, especially in the states of Rajasthan, Uttar Pradesh, Haryana, Madhya Pradesh, and Punjab, where the crop significantly boosts agricultural revenue and rural living.

Due to a number of biotic and abiotic factors, mustard productivity in India is still below the global average despite its economic significance. Among them, weed infestation is thought to be one of the main factors limiting agricultural output and quality. During the crucial phases of crop growth, weeds fiercely compete with mustard plants for nutrients, moisture, light, and space, which significantly lowers production. Depending on weed intensity, species composition, and length of crop-weed competition, unchecked weed infestation can result in yield losses of 20 to 50% (Rana and Chopra, 2013) <sup>[13]</sup>. Weeds also have a negative impact on crop development, seed quality, harvesting efficiency, and nutrient uptake.

Despite its effectiveness, manual weeding has grown more labor-intensive and unprofitable due to a lack of workers and rising wages. Applying herbicides is a quick and effective way to control weeds, however relying only on chemical herbicides can result in herbicide resistance, environmental problems, and changes in the composition of plant flora (Chauhan *et al.*, 2012) <sup>[1]</sup>. In order to effectively suppress weeds and increase crop yield, integrated weed management

(IWM), which combines cultural, mechanical, and chemical methods, has become a viable option.

Integrated weed management techniques increase crop yield and profitability by improving resource-use efficiency, nutrient availability, and weed control effectiveness (Kumar *et al.*, 2019)<sup>[6]</sup>. Pre-emergence herbicides like pendimethalin and oxadiargyl have been shown in recent research to efficiently control broad-spectrum weeds in mustard production under various agroclimatic conditions. When combined with manual weeding or intercultural operations, herbicide spraying has been shown to increase economic returns, growth parameters, nutrient absorption, and weed control efficiency when compared to individual weed control techniques.

Sustainable weed control strategies that reduce pesticide load while preserving increased productivity and profitability are the focus of recent developments in integrated weed management. In oilseed-based cropping systems, researchers have shown that integrated weed control enhances soil health, nutrient-use efficiency, and environmental sustainability in addition to lowering weed competition. Adopting integrated weed control techniques has become more crucial for attaining sustainable mustard production in light of shifting weather conditions and rising input prices.

However, little is known about how well integrated weed management techniques work in Central Uttar Pradesh's unique agroclimatic circumstances. In order to assess the impact of various integrated weed management strategies on weed dynamics, crop growth, yield attributes, productivity, nutrient uptake, quality parameters, and economics of mustard cultivation under the Central Uttar Pradesh Agro-Climatic Zone, the current study was conducted.

## Materials and Methods

At the Crop Research Farm, Maharishi University of Information Technology (MUIT), Lucknow, Uttar Pradesh, India, which is situated in the Central Uttar Pradesh Agro-Climatic Zone, a field experiment was carried out in the rabi season of 2025–2026. At an elevation of around 123 meters above mean sea level, the experimental location is located at roughly 26.84° N latitude and 80.95° E longitude. The area has a subtropical climate with chilly winters and moderate precipitation.

The experimental field's soil had a sandy loam texture, a slightly alkaline pH, medium phosphorus, low accessible nitrogen, and medium to high potassium. Prior to seeding, first soil samples were taken from the experimental location and examined using normal laboratory techniques.

Eight weed management treatments were used in three replications of the Randomized Block Design (RBD) experiment: T<sub>2</sub>–Weedy check, T<sub>2</sub>–Pendimethalin (PE), T<sub>2</sub>–Oxadiargyl (PE), T<sub>2</sub>–Pendimethalin (PE) followed by Quizalofop-p-ethyl (PoE), T<sub>2</sub>–Mulching, T<sub>2</sub>–Interculture with wheel hoe, and T<sub>2</sub>–Pendimethalin (PE) followed by one hand weeding at 30 DAS. A regionally appropriate cultivar of mustard was seeded at the prescribed spacing, and all treatments adhered to the same suggested agronomic techniques.

Pre-emergence herbicides were sprayed just after seeding, while post-emergence herbicides were sprayed using a backpack sprayer with a flat-fan nozzle at the suggested crop stage. Standard techniques were used to record observations on weed density, weed dry matter, weed management efficiency, growth parameters, yield characteristics, oil content, nutrient absorption (N, P, K, and S), seed and stover yield, and economics.

RBD-appropriate analysis of variance (ANOVA) was used to statistically assess the experimental data, and treatment means were compared at the 5% significant level.

## Results and Discussion

### Yield attributes

Several integrated weed control techniques had a considerable impact on mustard yield-attributing characteristics (Table 1). By reducing crop-weed competition at crucial phases of crop growth, effective weed management methods enhanced reproductive growth and yield components.

The treatments with the largest number of siliquae per plant (258.6), siliqua length (5.40 cm), number of seeds per siliqua (13.55), and test weight (5.48 g) were Pendimethalin (PE) at the prescribed dose and one hand weeding at 30 DAS (T<sub>8</sub>). Oxadiargyl (PE) + one hand weeding (T<sub>4</sub>) and Pendimethalin (PE) + Quizalofop-p-ethyl (PoE) (T<sub>4</sub>) closely followed this therapy.

The greater efficacy of integrated weed management treatments may be explained by the efficient suppression of weeds throughout the crop growth phase, which improves the crop's access to nutrients, moisture, sunshine, and growing space. Reduced weed competition improved yield qualities by increasing photosynthetic efficiency and assimilate transfer to reproductive structures.

On the other hand, because of intense weed competition that negatively impacted crop growth and reproductive development, the weedy check (T<sub>1</sub>) recorded the lowest values for all yield metrics. Numerous studies studying mustard under integrated weed control methods have similarly discovered similar results.

**Table 1:** Integrated Weed Management Practices on Yield Attributes of Mustard (*Brassica juncea* L.)

| Treatments                                                                          | Number of siliquae per plant | Length of siliquae (cm) | Seeds per siliqua | Test weight (g) |
|-------------------------------------------------------------------------------------|------------------------------|-------------------------|-------------------|-----------------|
| T <sub>1</sub> : Weedy check                                                        | 176.4                        | 4.12                    | 8.35              | 4.08            |
| T <sub>2</sub> : Two hand weedings (20 & 40 DAS)                                    | 187.8                        | 4.78                    | 9.55              | 4.32            |
| T <sub>3</sub> : Pendimethalin (PE) @ recommended dose                              | 197.2                        | 4.98                    | 10.4              | 4.52            |
| T <sub>4</sub> : Pendimethalin (PE) + Quizalofop-p-ethyl (PoE)                      | 204.6                        | 5.08                    | 11.1              | 4.88            |
| T <sub>5</sub> : Oxadiargyl (PE) + one hand weeding                                 | 218.3                        | 5.22                    | 12                | 5.08            |
| T <sub>6</sub> : Mulching (straw/residue @ 5 t ha <sup>-1</sup> )                   | 191.5                        | 4.9                     | 9.95              | 4.42            |
| T <sub>7</sub> : Interculture with wheel hoe at 25 DAS + one hand weeding           | 207.2                        | 5.03                    | 10.9              | 4.74            |
| T <sub>8</sub> : Pendimethalin (PE) @ recommended dose + one hand weeding at 30 DAS | 258.6                        | 5.4                     | 13.55             | 5.48            |
| SEM±                                                                                | 1.3                          | 0.036                   | 0.1               | 0.029           |
| CD (P≤0.05)                                                                         | 3.75                         | 0.108                   | 0.29              | 0.084           |

Mustard seed production, stover output, biological yield, and harvest index were all considerably impacted by integrated weed control techniques (Table 2). Higher biomass output and better

assimilate partitioning towards economic yield were the outcomes of effective weed management treatments that reduced crop-weed competition and increased crop growth.

The treatments with the highest seed production (27.3 q ha<sup>-1</sup>), stover yield (55.4 q ha<sup>-1</sup>), biological yield (82.7 q ha<sup>-1</sup>), and harvest index (33.05%) were Pendimethalin (PE) at the prescribed dose and one hand weeding at 30 DAS (T<sub>8</sub>). Oxadiargyl (PE) + one-hand weeding (T<sub>4</sub>) and Pendimethalin (PE) + Quizalofop-p-ethyl (PoE) (T<sub>4</sub>) came next. Effective weed suppression during the crucial crop growth stage, which results in improved use of nutrients, moisture, light, and space, may be the cause of the yield gain under integrated weed control treatments.

The effective transfer of photosynthates towards seed development was shown by the increased harvest index under integrated weed management methods. On the other hand, because of intense weed competition during the crop growth phase, the weedy check (T<sub>1</sub>) had the lowest seed output, stover yield, biological yield, and harvest index. Previous reports on mustard under integrated weed control techniques have shown similar results.

**Table 2:** Integrated Weed Management Practices on Seed Yield, Stover Yield, Biological Yield, and Harvest Index of Mustard (*Brassica juncea* L.)

| Treatments                                                                          | Seed Yield (q ha <sup>-1</sup> ) | Stover Yield (q ha <sup>-1</sup> ) | Biological Yield (q ha <sup>-1</sup> ) | Harvest Index (%) |
|-------------------------------------------------------------------------------------|----------------------------------|------------------------------------|----------------------------------------|-------------------|
| T <sub>1</sub> : Weedy check                                                        | 14.1                             | 38.2                               | 52.3                                   | 26.95             |
| T <sub>2</sub> : Two hand weedings (20 & 40 DAS)                                    | 17.8                             | 44.8                               | 62.6                                   | 28.45             |
| T <sub>3</sub> : Pendimethalin (PE) @ recommended dose                              | 19.5                             | 47.6                               | 67.1                                   | 29.05             |
| T <sub>4</sub> : Pendimethalin (PE) + Quizalofop-p-ethyl (PoE)                      | 21.9                             | 49.9                               | 71.8                                   | 30.55             |
| T <sub>5</sub> : Oxadiargyl (PE) + one hand weeding                                 | 23.9                             | 51.9                               | 75.8                                   | 31.55             |
| T <sub>6</sub> : Mulching (straw/residue @ 5 t ha <sup>-1</sup> )                   | 18.4                             | 45.7                               | 64.1                                   | 28.7              |
| T <sub>7</sub> : Interculture with wheel hoe at 25 DAS + one hand weeding           | 20.8                             | 48.7                               | 69.5                                   | 29.85             |
| T <sub>8</sub> : Pendimethalin (PE) @ recommended dose + one hand weeding at 30 DAS | 27.3                             | 55.4                               | 82.7                                   | 33.05             |
| SEM±                                                                                | 0.1                              | 0.15                               | 0.18                                   | 0.11              |
| CD (P≤0.05)                                                                         | 0.29                             | 0.43                               | 0.52                                   | 0.31              |

### Oil Content and Oil Yield

Oil output and nutritional content of mustard were significantly impacted by integrated weed control techniques, while differences in oil content were rather small between treatments (Table 3). Higher oil output was the outcome of improved crop growth and seed yield brought about by effective weed control measures.

The treatments with the greatest oil output (1040.5 kg ha<sup>-1</sup>) were Pendimethalin (PE) at the indicated dose, followed by one hand weeding at 30 DAS (T<sub>1</sub>), Oxadiargyl (PE) + one hand weeding (T<sub>5</sub>), and Pendimethalin (PE) + Quizalofop-p-ethyl (PoE) (T<sub>4</sub>). Improved crop growth, greater nutrient uptake, and increased seed output as a result of less weed competition might all contribute to the rise in oil yield under integrated weed control methods.

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The findings unequivocally showed that, in Central Uttar Pradesh, integrated weed control techniques increased mustard's oil output and nutritional status in addition to productivity.

**Table 3:** Integrated Weed Management Practices on Oil Content and Oil Yield of Mustard (*Brassica juncea* L.)

| Treatments                                                                          | Oil Content (%) | Oil Yield (kg ha <sup>-1</sup> ) | K Content (%) | S Content (%) |
|-------------------------------------------------------------------------------------|-----------------|----------------------------------|---------------|---------------|
| T <sub>1</sub> : Weedy check                                                        | 41              | 578.1                            | -             | -             |
| T <sub>2</sub> : Two hand weedings (20 & 40 DAS)                                    | 40.2            | 715.4                            | 1.1           | 0.43          |
| T <sub>3</sub> : Pendimethalin (PE) @ recommended dose                              | 39.6            | 770.8                            | 1.17          | 0.49          |
| T <sub>4</sub> : Pendimethalin (PE) + Quizalofop-p-ethyl (PoE)                      | 39              | 856.6                            | 1.3           | 0.53          |
| T <sub>5</sub> : Oxadiargyl (PE) + one hand weeding                                 | 38.7            | 920.4                            | 1.38          | 0.61          |
| T <sub>6</sub> : Mulching (straw/residue @ 5 t ha <sup>-1</sup> )                   | 39.2            | 742.6                            | 1.47          | 0.69          |
| T <sub>7</sub> : Interculture with wheel hoe at 25 DAS + one hand weeding           | 38.9            | 823.7                            | 1.27          | 0.51          |
| T <sub>8</sub> : Pendimethalin (PE) @ recommended dose + one hand weeding at 30 DAS | 38.3            | 1040.5                           | 1.36          | 0.59          |
| SEM±                                                                                | 0.019           | 3.2                              | 1.58          | 0.76          |
| CD (P≤0.05)                                                                         | 0.055           | 9.3                              | 0.009         | 0.002         |

### Nutrient Content

The amount of nitrogen (N), phosphorus (P), potassium (K), and sulfur (S) in mustard seed was greatly affected by integrated weed control techniques (Table 12). Effective weed management methods increased nutrient availability and decreased crop-weed competition, which boosted the seed's ability to absorb and accumulate nutrients.

With 2.22% N, 0.97% P, 1.58% K, and 0.76% S, Pendimethalin (PE) at the authorized dose and one hand weeding at 30 DAS (T<sub>2</sub>) had the highest nutritional content in the seed among the treatments. Oxadiargyl (PE) + one-hand weeding (T<sub>4</sub>) and

Pendimethalin (PE) + Quizalofop-p-ethyl (PoE) (T<sub>4</sub>) came next. One possible explanation for the higher nutrient content under integrated weed control treatments is the successful suppression of weeds, which improves nutrient absorption and translocation to the crop's reproductive sections.

On the other hand, because of intense weed competition for vital nutrients throughout the crop growth stage, the weedy check (T<sub>1</sub>) had the lowest nutrient content. The results showed that integrated weed control techniques improved the nutritional value of mustard seed in addition to increasing crop output.

**Table 4:** Integrated Weed Management Practices on Nutrient Content (N, P, K, and S) in Mustard Seed (*Brassica juncea* L.)

| Treatments                                                                          | N Content (%) | P Content (%) | K Content (%) | S Content (%) |
|-------------------------------------------------------------------------------------|---------------|---------------|---------------|---------------|
| T <sub>1</sub> : Weedy check                                                        | 1.72          | 0.59          | 1.1           | 0.43          |
| T <sub>2</sub> : Two hand weeding (20 & 40 DAS)                                     | 1.81          | 0.66          | 1.17          | 0.49          |
| T <sub>3</sub> : Pendimethalin (PE) @ recommended dose                              | 1.88          | 0.71          | 1.3           | 0.53          |
| T <sub>4</sub> : Pendimethalin (PE) + Quizalofop-p-ethyl (PoE)                      | 1.98          | 0.79          | 1.38          | 0.61          |
| T <sub>5</sub> : Oxadiargyl (PE) + one hand weeding                                 | 2.08          | 0.87          | 1.47          | 0.69          |
| T <sub>6</sub> : Mulching (straw/residue @ 5 t ha <sup>-1</sup> )                   | 1.84          | 0.73          | 1.27          | 0.51          |
| T <sub>7</sub> : Interculture with wheel hoe at 25 DAS + one hand weeding           | 1.95          | 0.82          | 1.36          | 0.59          |
| T <sub>8</sub> : Pendimethalin (PE) @ recommended dose + one hand weeding at 30 DAS | 2.22          | 0.97          | 1.58          | 0.76          |
| SEM±                                                                                | 0.015         | 0.006         | 0.009         | 0.002         |
| CD (P≤0.05)                                                                         | 0.043         | 0.017         | 0.025         | 0.005         |

### Recommendation

The best weed management strategy for increasing mustard seed yield, biological yield, and harvest index under the Central Uttar Pradesh Agro-Climatic Zone may be the application of Pendimethalin (PE) at the recommended dose followed by one hand weeding at 30 DAS, according to the experimental results. When compared to alternative weed control strategies, this integrated method produced the greatest seed production (27.3 q ha<sup>-1</sup>) and greatly increased total crop productivity.

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