**Efficacy of various herbicides for weed management in late sown wheat (*Triticum aestivum* L.)**

**Abstract**

The research work entitled “Efficacy of various herbicides for weed management in late sown wheat (*Triticum aestivum* L.)” was carried out during *rabi* season 2023-2024 at the research farm of Faculty of Agriculture, Mullana, Ambala, Haryana. Weeds are significant biotic constraints that contribute to substantial yield reductions by competing with crop plants for essential resources such as sunlight, water and nutrients. The purpose of this study is to evaluate the efficacy of various herbicides in controlling weeds in late sown wheat, where shorter growing periods and limited resources intensify weed crop competition. The study aims to identify the most effective treatment for weed suppression and yield improvement. During the experiment the prominent weed flora observed in wheat fields are *Phalaris minor* (Gulli danda), *Avena fatua* (Jangli jai), *Polypogon monspeliensis*, (Chotti ghass) *Chenopodium album* (Bathua)*, Cynodon dactylon* (Doob), *Rumex dentatus* (Jangli palak), *Melilotus alba* (Metha), *Cyperus rotundus* (Dilla) etc. The experiment was laid out in randomized block designs with three replications, encompassing nine treatments for weed management *viz.*, T1 - PRE pendimethalin 1500 ml ha-1, T2 - PRE pyroxasulfone 125 g ha-1, T3 - PoE 2,4-D (a.e.) 500 ml ha-1, T4 - PoE sulfosulfuron 25 g ha-1, T5 - PoE metribuzin 250 g ha-1, T6 - PoE clodinafop-propargyl 60 g ha-1, T7 - PRE pendimethalin 1500 ml ha-1 *fb* PoE metribuzin 250 g ha-1, T8 - two hand weeding and T9 - weedy check. The research findings revealed that the herbicidal application of pendimethalin 1500 ml ha-1 *fb* metribuzin 250 g ha-1 was the most effective treatment in reducing weed density 5.12 (25.18) **m-2** and 5.66 (31.03) **m-2** and weed dry matter 5.95 (34.37)g m-2 **and** 7.34 (52.94) **g m-2 at 60 and 90 DAS,** compared to the other treatments except two hand weeding. This treatment significantly enhanced **growth parameters recording maximum plant height** 63.07 **cm, 91.97 cm and 96.33 cm** anddry matter accumulation 393.27 g m-2, 773.70 g m-2, 1003.93 g m-2 at 60 DAS, 90 DAS and at harvest respectively. Moreover, it significantly improved **yield attributes including** 336.20 m-2 of effective tillers**,** spike length 8.28 cm, 46.95 grains spike-1, and test weight 39.63 g **and recorded the highest** grain yield of 50.66 t ha-1 and straw yield of 67.10 t ha-1. Conversely, the **weedy check treatment** resulted in the highest weed density and weed dry matter and **lowest yield attributes and yield.**

**Keywords:** Pre-emergence, post-emergrnce, wheat, weed control, yield attributes and yield.

**Introduction**

Wheat (*Triticum aestivum* L.) is one of the most important staple crops in the world and falls under *Poaceae* family. It provides a significant portion of calories and protein for the human population making it a key component of agricultural economies (Shiferaw *et al*., 2013). It is cultivated on approximately **220 million ha worldwide**, making it the second most widely grown cereal after maize (FAO, 2022). In countries like **India, China, the United States, and Russia**, wheat cultivation contributes significantly to gross domestic product (**GDP) and employment** in the agricultural sector (Singh *et al*., 2021). India is the second largest producer of wheat after China. In India wheat is the second most cultivated cereal crop after rice contributing significantly to national grain production, particularly in the northern states (Singh *et al*., 2020). During the year 2022-23, wheat cultivation spanned 34.15 million hectares, yielding a total of 112.74 million tonnes (Anonymous, 2023).

Weeds are among the important biotic factors affecting the wheat production. The economic losses caused by weeds are of great importance in agricultural production. Weeds possess direct impact on the productivity of wheat systems, including costs of labor, equipment, chemicals and other management inputs. Indirect impact by the weeds on the wheat production has also been observed by competing with the crops for resources, harboring crop pests, interfering with water management reducing the grain yield and quality and increasing the cost of processing (Lee and Thierfelder., 2017). Weeds can significantly reduce 33-50% grain yield if not managed properly through agronomic or chemical control measures (Gupta and Sharma, 2020). The critical period for weed competition is initial 30 to 60 days after sowing and after that it will not be economical to eradicate the weeds from the field (Korav et al., 2018). So, timely weeding is most important to minimize the yield losses and therefore under such circumstances the only effective tool left to control weeds through the use of chemicals [(Beiermann*et al*., 2022).](https://arccjournals.com/journal/agricultural-reviews/R-2645#beiermann_2022) Management of weeds through the use of chemicals has been found as effective as realized under manual eradication in various crops including over and above benefits in saving extra costs involved in use of labour on manual eradication of weeds. For controlling weeds in wheat number of pre-emergence and post-emergence herbicides has already found their place in cultivation package of wheat [(Kaur *et al*., 2015)](https://arccjournals.com/journal/agricultural-reviews/R-2645#kaur_2018). Herbicides are categorized into pre-emergence such as pendimethalin and pyroxasulfone and post-emergence such as clodinafop-propargyl, metribuzin and 2,4-D. Grassy and broad leaf weeds can be controlled by sulfosulfuron, metribuzin and pendimethalin, on the other hand clodinafop-propargyl and fenoxaprop can only control narrow weeds (Chhokar *et al*., 2007). Herbicide resistant weeds such as Phalaris minor have become a significant challenge in wheat fields, especially in regions where certain herbicides have been used repeatedly ( Raseed, *et al*., 2020). Recent research has also explored the combined use of herbicides to combat herbicide resistance in weeds, providing a more sustainable approach to weed control (Bhullar *et al*., 2017).Therefore the selection of appropriate herbicides and their combinations is essential for achieving maximum efficacy while minimizing environmental impact. The present study aims to evaluate the effectiveness of various herbicides for weeds management in late sown wheat (*Triticum aestivum* L.). The research findings will provide insights into the most suitable weed management practices for optimizing wheat yield and profitability.

**Material and Methods**

The field experiment was conducted at the research farm of Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, Haryana during the *rabi* season of 2023–2024 to effect of various herbicides for weeds management in late sown wheat (*Triticum aestivum* L.). The research farm is located at Maharishi Markandeshwar University, Mullana, Haryana at an altitude of 272 meters above mean sea level, with geographical coordinates of 30.27°N latitude and 77.047°E longitude. The soil type of the experimental site was sandy loam, with an initial pH of 7.70. The maximum temperatures ranged from 6**°C to 45.7°C** with the lowest recorded in **January** and the highest in June**.** The crop variety used for the experiment was DBW-222, which was sown on December 6, 2023 using the pora method at a seed rate of 125 kg ha-1. The experiment was laid out in a randomized block design with three replications. The study evaluated nine different weed management treatments to manage weeds, applied with a knapsack sprayer using a flat fan nozzle. The treatments included T1 - PRE pendimethalin 1500 ml ha-1, T2 - PRE pyroxasulfone 125 g ha-1, T3 - PoE 2,4-D (a.e.) 500 ml ha-1, T4 - PoE sulfosulfuron 25 g ha-1, T5 - PoE metribuzin 250 g ha-1, T6 - PoE clodinafop-propargyl 60 g ha-1, T7 - PRE pendimethalin 1500 ml ha-1 *fb* PoE metribuzin 250 g ha-1, T8 - two hand weeding at 30 and 60 DAS and T9 - weedy check. The pre-emergence herbicides was applied **24 hours after sowing**, while the post-emergence herbicides was sprayed **30 days after sowing (DAS).** The nutrient were applied at **150:60:40 kg ha-1 N:P:K** respectively, using urea, **DAP and MOP** to optimize wheat growth. Half of the nitrogen (50%) was applied as a **basal dose at sowing**, while the remaining 50% was split equally, with **25% applied at the crown root initiation stage** and **25% after the second irrigation** to support crop development. Plant height (cm) of wheat plant was recorded by selecting five random plant from each plot. The data on dry matter accumulation (g m-2), number of tillers m-2 and yield attributes such as spike length (cm), number of grains spike-1, test weight (g), grain yield (q ha-1) and straw yield (q ha-1) were recorded . Weed density and dry weight of weeds were recorded at 30, 60 and 90 days after sowing (DAS) using a quadrat. Weed dry weight was determined by removed weed plants from ground level. These samples were first sun dried and then dried in an oven at 65°C until a constant weight was achieved, and weighing them using a precision balance, recorded and expressed in g m-2. The effectiveness of various weed management treatments were evaluated by calculating w**eed control** efficiency **(WCE)** using the formula provided by (Mani *et al.,* 1973).

Weed dry weight in weedy check - Weed dry weight in treated plot

WCE(%) = x 100

Weed dry weight in weedy check

The statistical analysis of the collected data was performed using the online software OPSTAT developed by Sheoran (2010) accessible at <http://14.139.232.166/opsta>t or [http://opstat.pythonany where.com/](http://opstat.pythonanywhere.com/)

**Results and Discussion**

**Growth Parameters**

The growth parameters such as plant height and dry matter accumulation of the wheat crop were significantly influenced by the various treatments administered in Table 1 at various growth stages 60 DAS, 90 DAS and at harvest. Out of different methods, the treatment involving two hand weeding treatment (T8) exhibited superior results, measuring 65.10 cm, 93.70 cm and 98.17 cm and achieving dry matter accumulation 401.93 g m-2, 789.97 g m-2, 1030.63 g m-2 at 60 DAS, 90 DAS and at harvest respectively which is statistically at par with herbicide treatment p**endimethalin *fb* metribuzin (T7)** recorded the highest plant height at all stages, with 63.07 **cm, 91.97 cm and 96.33 cm,** alongsidedry matter accumulation 393.27 g m-2, 773.70 g m-2, 1003.93 g m-2 at 60 DAS, 90 DAS and at harvest respectively. By reducing weed pressure over a longer duration, crops have better access to light, nutrients and moisture, enhancing photosynthesis and biomass production (Singhand Yadav, 2020). On the other hand, the **weedy check (T9)** exhibited the shortest plant heights throughout the growth period, with 49.83 cm, 75.37 cm and 81.22 cm and coupled with the lowest dry matter accumulations of **313.40 g m-2, 636.27 g m-2, and 824.90 g m-2** at 60 DAS, 90 DAS and at harvest respectively, indicating the negative impact of weed competition on crop growth. Similar findings were corroborated in previous studies by Singh *et al*. (2019) and Sangwan *et al.* (2018).

**No of tillers**

The effect of different weed management treatments on the number of tillers m-2 at 60 and 90 DAS is also presented in Table 1. At 60 and 90 DAS, two hand weeding **(T8**) recorded the highest number of tillers 347.73 **m-2 and** 378.77 **m-2**, respectively. These values are statistically equivalent to chemical treatment p**endimethalin *fb* metribuzin** (**T7) which** recorded the highest number of tillers 338.2 **m-2 at 60 DAS and** further increased to 368.37 **m-2 at 90 DAS,** while the lowest count was yieldedin weedy check (**T9)** 265.03 **m-2 and**288.77m-2 at 60 and 90 DAS respectively, highlighting the adverse impact of weed competition. The similar findings were previously reported by researcher Keshav *et al.* (2024) and Meena *et al*. (2017).

**Yield attributes and yield**

Table 2 presents a comprehensive summary of how various weed control strategies have influenced critical yield and yield attributes, including the number of effective tillers (m-2) spike length (cm), number of grains spike-1, and test weight (g). The **highest number of effective tillers 345.30 m-2,** with a spike length of 8.50 cm, a grain count of 48.50 grains spike-1, and test weight 40.06 g was recorded intwo **hand weeding (T8) which was** statistically at par with **(T7)** p**endimethalin *fb* metribuzin (T7 )** which yielded 336.20 m-2 of effective tillers**,** spike length 8.28 cm, 46.95 grains spike-1, and test weight 39.63 g. The maximum grain yield of 50.66 t ha-1 and straw yield of 67.10 t ha-1 were also achieved through two hand weeding (T8). Among the chemical treatments **(T7)** p**endimethalin 1500 ml ha-1 *fb* metribuzin 250 g ha-1** produced statistically equivalent results, with a grain yield of 48.35 t ha-1 and straw yield of 64.51 t ha-1. This is due to the reduced competition from weeds facilitating the crop to make better use of soil nutrients and moisture, supporting stronger vegetative growth and better grain filling (Singh and Yadav, 2020). The weedy check **(T8)** showed the poorest performance, emphasizing the importance of proper weed management for higher yield and better grain quality. Earlier studies conducted by Meena *et al*. (2017), Shakya *et al.* (2017) and Dev *et al*. (2013) has also highlighted findings consistent with these results.

### ****Weed Density****

The effect of various pre-emergence and post-emergence herbicide treatments was presented on weed density is presented in Table 3. At all intervals, the most minimal weed density was recorded in the two hand weeding (T8), which achieved an impressive 0.0 m-2, establishing it as the most effective method. Among chemical treatments, p**yroxasulfone 125 g ha-1 (T2)** 4.90 (23.04) **m-2** were the most effective followed closely by p**endimethalin 1500 ml ha-1 *fb* metribuzin 250 g ha-1 (T7)** 5.21 (26.18) **m-2** and p**endimethalin 1500 ml ha-1 (T1)** 5.26 (26.66) **m-2**. These treatments significantly reduced the emergence of weeds compared to the **(T9)** weedy check 11.05 (121.02) **m-2**. A similar trend was observed at 60 and 90 DAS, where p**endimethalin 1500 ml ha-1 *fb* metribuzin 250 g ha-1 (T7)** recorded the lowest weed density 5.12 (25.18) **m-2** and 5.66 (31.03) **m-2** indicating the long lasting residual and knockdown effect of the combination (Kumar and Singh 2019). The weedy check **(T9)** exhibited the highest weed density at 11.05 (**121.02) m-2, 12.89 (165.28) m-2 and** 13.42 (179.17) **m-2 at 30, 60 and 90 DAS respectively**, emphasizing the need for effective weed management practices. Among chemical methods, p**endimethalin *fb* metribuzin** emerged as the most effective and consistent treatment for managing all weeds across the crop cycle. The results highlight the superiority of **sequential application of pendimethalin *fb* metribuzin** as effective weed control strategies. Similar outcomes were reported in prior studies couducted by Sharma *et al.*(2024).

**Weed dry weight**

At 30, 60 and 90 DAS significant discrepancies in weed dry weight were noted across the various treatments as illustrated in the accompanying Table 3. Treatment (T8) which entailed two hand weeding proved to be remarkably effective, demonstrating results comparable to the most efficacious treatments in weed management throughout the crop cycle, ultimately yielding a dry weight of 0 g m-2. Among the chemical treatments assessed at 30 DASp**yroxasulfone 125 g ha-1** **(T2)** recorded a mere 3.27 (9.67) g m-2, closely followed by p**endimethalin 1500 ml ha-1 *fb* metribuzin 250 g ha-1 (T7)** resulted in a modest total weed dry weight of 3.49 (11.17) g m-2 and p**endimethalin 1500 ml ha-1 (T1)** 3.49 (11.20) g m-2indicating robust early stage weed suppression in contrast to the 7.20 (50.83) g m-2 observed in the **(T9)** weedy check. At both 60 and 90 DAS p**endimethalin 1500 ml ha-1 *fb* metribuzin 250 g ha-1** **(T7)** outperform all other chemical treatments with the lowest dry weight of 5.95 (34.37)g m-2 **and** 7.34 (52.94) **g m-2** , whereas the  **weedy check**  **(T9)** had the highest at 15.05 (225.61)g m-2 **and** 17.51 (305.66)g m-2 **resepectively**. Collectively, the combination of p**endimethalin *fb* metribuzin ensure** long weed suppression by targeting both early and late emerging weeds, reducing the weed seed bank and crop competition throughout the critical growth stages (Chokkar *et al*., 2012). The findings appear to be congruent with existing literature of Sharma *et al.*(2024) and Shahbaz *et al*. (2023) .

**Weed control efficiency**

The study elucidated in significant variation in weed control efficiency among different herbicide treatments and manual weeding practices at 30, 60 and 90 DAS (Table 4). The pinnacle weed control efficiency was attained through two hand weeding demonstrating 100% efficiency across all temporal stages. Among chemical treatments p**yroxasulfone 125 g ha-1 (T2)**showed highest efficiency 80.98% at 30 DAS. Furthermore, the application of p**endimethalin 1500 ml ha-1 *fb* metribuzin 250 g ha-1 (T7)** displayed superior performance with weed control efficiency escalating from 78.02% at 30 DAS to 84.77% at 60 DAS subsequently sustaining at 82.68% at 90 DAS. This indicates a strong and sustained effect against weed infestation. Similar trends were noted in preceding research Kaur *et al*. (2015) and Meena *et al.* (2019).

**Table 1: Effect of various weed control treatments on growth parameters in late sown wheat crop at different stages.**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments details** | | **Plant height (cm)** | | | **Dry matter accumulation (g m-2)** | | | **Number of tilers (m-2)** | |
| **60 DAS** | **90 DAS** | **at harvest** | **60 DAS** | **90 DAS** | **at harvest** | **60 DAS** | **90 DAS** |
| T1 | Pendimethalin @ 1500 ml ha-1 (PRE) | 58.97 | 84.31 | 89.64 | 363.77 | 718.8 | 934.1 | 314.1 | 343.73 |
| T2 | Pyroxasulfone @ 125 g ha-1 (PRE) | 60.40 | 86.60 | 91.47 | 370.6 | 735.2 | 948.63 | 322.9 | 350.33 |
| T3 | 2,4-D (a.e.) @ 500 ml ha-1 (PoE) | 53.95 | 78.53 | 83.43 | 335.27 | 681.93 | 893.47 | 286.60 | 316.70 |
| T4 | Sulfosulfuron @ 25 g ha-1 (PoE) | 55.90 | 81.60 | 86.10 | 347.3 | 700.30 | 916.53 | 301.47 | 331.83 |
| T5 | Metribuzin 250 @ g ha-1 (PoE) | 57.87 | 83.27 | 88.93 | 354.63 | 708.63 | 928.93 | 307.63 | 338.97 |
| T6 | Clodinafop-propargyl @ 60 g ha-1 (PoE) | 54.80 | 80.30 | 85.00 | 341.13 | 690.80 | 905.60 | 294.73 | 325.33 |
| T7 | Pendimethalin (PRE) @ 1500 ml ha-1 *fb* metribuzin @ 250 g ha-1 (PoE) | 63.07 | 91.97 | 96.33 | 393.27 | 773.70 | 1003.93 | 338.20 | 368.37 |
| T8 | Two hand weeding (30 & 60 DAS) | 65.10 | 93.70 | 98.17 | 401.93 | 789.97 | 1030.63 | 347.73 | 378.77 |
| T9 | Weedy check | 49.83 | 75.37 | 81.22 | 313.40 | 636.27 | 824.90 | 265.03 | 288.77 |
| SEm ± | | 1.34 | 2.02 | 2.11 | 9.66 | 18.31 | 23.24 | 7.67 | 8.35 |
| CD (at 5 %) | | 4.05 | 6.11 | 6.39 | 29.21 | 55.37 | 70.28 | 23.19 | 25.25 |

**Table 2 : Effect of various weed control treatments on yield attributes and yield of late sown wheat crop.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments details** | | **Effective tillers (m-2)** | **Spike length (cm)** | **Numberof grains spike-1** | **Test weight (g)** | **Grain yield (q ha-1)** | **Straw yield (q ha-1)** |
| T1 | Pendimethalin @ 1500 ml ha-1 (PRE) | 313.07 | 7.70 | 43.93 | 38.31 | 45.60 | 61.12 |
| T2 | Pyroxasulfone @ 125 g ha-1 (PRE) | 319.07 | 7.93 | 45.05 | 38.69 | 46.62 | 62.33 |
| T3 | 2,4-D (a.e.) @ 500 ml ha-1 (PoE) | 286.60 | 7.05 | 40.27 | 37.0 | 39.01 | 54.75 |
| T4 | Sulfosulfuron @ 25 g ha-1 (PoE) | 300.47 | 7.37 | 41.67 | 37.65 | 42.03 | 57.57 |
| T5 | Metribuzin 250 @ g ha-1 (PoE) | 306.63 | 7.53 | 42.63 | 37.88 | 43.50 | 59.26 |
| T6 | Clodinafop-propargyl @ 60g ha-1 (PoE) | 294.93 | 7.17 | 41.03 | 37.25 | 40.65 | 56.49 |
| T7 | Pendimethalin (PRE) @ 1500 ml ha-1 *fb* metribuzin @ 250 g ha-1 (PoE) | 336.2 | 8.28 | 46.95 | 39.63 | 48.35 | 64.51 |
| T8 | Two hand weeding (30 & 60 DAS) | 345.3 | 8.50 | 48.50 | 40.06 | 50.66 | 67.10 |
| T9 | Weedy check | 264.53 | 6.50 | 36.77 | 36.13 | 32.56 | 47.05 |
| SEm ± | | 6.70 | 0.18 | 0.99 | 0.43 | 0.90 | 1.26 |
| CD (at 5 %) | | 20.25 | 0.55 | 3.01 | 1.29 | 2.71 | 3.81 |

**Table 3 : Effect of various weed control treatments on total weed density and total dry weight of weed in late sown wheat crop at different stages.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments details** | | **Total Weed density (m-2)** | | | **Total dry weight of weed (g m-2)** | | |
| **30 DAS** | **60 DAS** | **90 DAS** | **30 DAS** | **60 DAS** | **90 DAS** |
| T1 | Pendimethalin @ 1500 ml ha-1 (PRE) | 5.26 (26.66) | 7.40 (53.76) | 8.22 (66.65) | 3.49 (11.20) | 8.62 (73.38) | 10.71 (113.70) |
| T2 | Pyroxasulfone @ 125 g ha-1 (PRE) | 4.90 (23.04) | 6.50 (41.31) | 7.15 (50.15) | 3.27 (9.67) | 7.56 (56.18) | 9.29 (85.26) |
| T3 | 2,4-D (a.e.) @ 500 ml ha-1 (PoE) | 11.02 (120.37) | 8.84 (77.15) | 9.90 (97.08) | 7.18 (50.56) | 10.31 (105.31) | 12.91 (165.62) |
| T4 | Sulfosulfuron @ 25 g ha-1 (PoE) | 10.97 (119.43) | 7.89 (61.19) | 8.76 (75.72) | 7.15 (50.16) | 9.19 (83.52) | 11.41 (129.18) |
| T5 | Metribuzin 250 @ g ha-1 (PoE) | 10.96 (119.02) | 7.70 (58.27) | 8.46 (70.65) | 7.14 (49.99) | 8.97 (79.54) | 11.02 (120.53) |
| T6 | Clodinafop-propargyl @ 60 g ha-1 (PoE) | 11.00 (120.02) | 8.45 (70.41) | 9.37 (86.80) | 7.17 (50.41) | 9.85 (96.11) | 12.21 (148.08) |
| T7 | Pendimethalin (PRE) @ 1500 ml ha-1 *fb* metribuzin @ 250 g ha-1 (PoE) | 5.21 (26.18) | 5.12 (25.18) | 5.66  (31.03) | 3.49 (11.17) | 5.95 (34.37) | 7.34 (52.94) |
| T8 | Two hand weeding (30 & 60 DAS) | 1.00 (0) | 1.00 (0) | 1.00 (0) | 1.00 (0) | 1.00 (0) | 1.00 (0) |
| T9 | Weedy check | 11.05 (121.02) | 12.89 (165.28) | 13.42 (179.17) | 7.20 (50.83) | 15.05 (225.61) | 17.51 (305.66) |
| SEm ± | | 0.18 | 0.20 | 0.21 | 0.13 | 0.20 | 0.29 |
| CD (at 5 %) | | 0.54 | 0.59 | 0.64 | 0.39 | 0.59 | 0.87 |

**\***Values in parenthesis are subjected to square root transformation (√x+1) before analysis.

**Table 4 : Effect of various weed control treatments on weed control efficiency in sown wheat crop at different stages.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatments details** | | **Weed control efficiency (%)** | | |
| **30 DAS** | **60 DAS** | **90 DAS** |
| T1 | Pendimethalin @ 1500 ml ha-1 (PRE) | 77.97 | 67.47 | 62.8 |
| T2 | Pyroxasulfone @ 125 g ha-1 (PRE) | 80.98 | 75.1 | 72.11 |
| T3 | 2,4-D (a.e.) @ 500 ml ha-1 (PoE) | - | 53.32 | 45.82 |
| T4 | Sulfosulfuron @ 25 g ha-1 (PoE) | - | 62.98 | 57.74 |
| T5 | Metribuzin 250 @ g ha-1 (PoE) | - | 64.75 | 60.57 |
| T6 | Clodinafop-propargyl @ 60 g ha-1 (PoE) | - | 57.4 | 51.55 |
| T7 | Pendimethalin (PRE) @ 1500 ml ha-1 *fb* metribuzin @ 250 g ha-1 (PoE) | 78.02 | 84.77 | 82.68 |
| T8 | Two hand weeding (30 & 60 DAS) | 100 | 100 | 100 |
| T9 | Weedy check | 0 | 0 | 0 |

**Conclusion**

The results of this study revealed that two hand wedding was the most effective treatment for suppressing diverse weed flora and significantly enhancing growth parameters, yield attributes, and overall yield by minimizing crop weed competition in wheat. Additionally this performance was found statistically at par with herbicidal application of pre-emergence pendimethalin @ 1500 ml ha-1 *fb* post-emergence metribuzin @ 250 g ha-1. This effectiveness is attributed to the sequential application where the pre-emergence herbicide inhibits weed germination right from the beginning, while the post-emergence herbicide eradicates weeds that emerge after sowing, preventing them from establishing dominance. This integrated approach not only sustains crop growth but also ensures prolonged weed suppression leading to improved resource utilization and higher productivity.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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