



Research Article

Evaluating the Efficacy of Different Herbicides Combinations on Wheat Yield and Weed Density

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Abstract | Wheat is considered one of the basic food and economic crops in Pakistan. Wheat productivity is immensely affected by weed infestation, which causes a yield reduction of 20-40%. Keeping this under consideration, the present study was conducted to evaluate the efficacy of some commonly used herbicides against broadleaf and narrow leaf weeds in wheat fields, with particular focus regarding their impact on wheat yield and economic viability. This research was conducted at the Adaptive Research Farm, Sheikhupura, Pakistan, during the 2023-2024 cropping season. Seven treatments with control of weedy check were compared for their efficacy against weeds under study in a randomized complete block design. In this context, 6 different herbicide combinations were checked. Data were recorded for weed density before and after herbicide application, percentage germination, number of productive tillers, number of grains per spike, thousand grain weight, and overall grain yield for the key parameters. The ANOVA results indicated significant differences among treatments concerning the number of productive tillers, thousand-grain weight, and grain yield. In this regard, application of the Pyroxsulum was found to be the most effective since it significantly reduced weed density and showed weed control efficiency up to 73.77% and 83.50% for narrow and broad leaf weeds, respectively. It also demonstrated a maximum grain yield (5493.3 kg ha⁻¹), which was significantly higher compared to the control (T7), that recorded a minimum yield (4223.3 kg ha⁻¹). Given the findings of this study, Pyroxsulum can be used as a highly effective herbicide for improving wheat productivity and economic returns.

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Introduction

Wheat is a staple food in Pakistan, the world's fifth-largest country. As of 2024, it had about 251 million people, accounting for roughly 3% of the global population. Pakistan grows wheat on 9.78 million hectares, accounting for 1.8% of its GDP. Wheat farming takes up 220 million hectares worldwide, with developing countries accounting for around half of that. Increasing wheat crop yield is critical given the country's annual population growth rate. Only 30-35% of Pakistan's wheat potential output is generated in fields (Popal, 2024) despite repeated efforts to improve it, this yield has continuously decreased. The population growth rate surpasses the annual yield advances achieved through several measures (Marwat *et al.*, 2013). Weed infestation significantly restricts wheat productivity, resulting in a 20-40% reduction in potential yield at harvest (Ahmad and Shaikh, 2003). Weed control is also essential in increasing crop productivity to deal with Pakistan's annual population explosion. Severe weed infestation is one of the leading causes of low wheat output in the country. Weeds are hidden wheat adversaries that cause massive crop output losses ranging from Rs. 115 to 200 billion annually (Atta and Khaliq, 2002). Weeds in wheat fields are controlled in various ways, including cultural, chemical, and mechanical approaches (Tiwarei and Singh, 2024).

Currently, pesticide use is the most common weed control approach worldwide (Soufizadeh *et al.*, 2007; Mobeen *et al.*, 2015; Qamar *et al.*, 2015). The chemical strategy, particularly herbicide treatment, is seen to be the most effective way to control weeds, increasing crop output while minimizing weed interference (Santos, 2009). Weeds lower crop productivity while also affecting crop quality and increasing harvesting, threshing, and cleaning costs (Naruhn *et al.*, 2021). Chemical weed management has been shown to increase wheat yield and productivity (Kaur *et al.*, 2018). However, excessive and irresponsible use of herbicides may lead to agricultural damage, difficulties for human and animal health, water and soil contamination, and the growth of herbicide-resistant weeds (Farooq *et al.*, 2011).

According to the thumb rule, lower weed biomass and density means less competition between crop and weed plants. Furthermore, pesticides and tillage can reduce weed infestation by 50% to 80% (Chhokar and

Malik, 2002). So, there is a need to improve wheat crop productivity and quality. The optimum herbicide option determines the crop's profitable return, the suggested application dose, and the appropriate timing (Fayad *et al.*, 1998). Taking into account all of the criteria described above, the goal of this study was to determine the best chemical combination for weed management in order to increase wheat production.

Our local farmers have very little and a limited awareness of herbicide use. They need to be taught how to calculate and calibrate herbicide doses. They apply one herbicide and are never told about herbicide rotations or mixtures that help prevent weed resistance development. However, they did not assess the synergistic or antagonistic effects of the herbicide mixtures. Several herbicide combinations can provide reasonable control of broad and narrow-leaved weeds, resulting in a significant reduction in their density and increased yield attributes when compared to control (Chaudhry *et al.*, 2008; Bostrom and Fogelfors, 2002).

As a result, an experiment was conducted on various herbicides commonly used in wheat crops to evaluate their impact on weed control alone and in combination with the herbicides' efficacy and economics on wheat grain production.

Significance of the study

This study will be helpful to maintain optimum herbicide utilization, minimize resistance development and vegetation impact by evaluating the efficacy of several different combinations of broadleaf- or narrowleaf-specific weed specifically. Thus, elucidating the synergistic and antagonistic effects of these combinations will be more helpful in developing sustainable weed management strategies resulting in increased wheat productivity.

Materials and Methods

Experimental design and treatments

A field experiment was conducted at Adaptive Research Farm, Sheikhpura during the cropping season of 2023-2024 in Punjab province Pakistan. The climate is an arid of the semi-arid type, very hot in summer and cold-wet in winter as it belongs to near humid or sub-humid region having warm summers with rain. The study employed a randomized complete block design (RCBD) with three replications. Six

herbicide treatments were tested, each replicated three times (Table 1).

Table 1: Details of herbicides with chemical name applied against broad and narrow leaf weeds in wheat during crop seasons 2023–2024.

Treat-ments	Herbicide combination	Dose per hectare
T1	Mesosulfuran + Iodosulfuran	250 g
T2	Flurasulum + Mesosulfuran methyl + MCPA	1000 ml
T3	Tribenuran methyl + Metsulfuran methyl + Pinoxaden	35g+825ml
T4	Cyprofluran + Isoproturan	2000 ml
T5	Flurasulum + Mesosulfuran	375 ml
T6	Pyroxsulum	375 ml
T7	Weedy Check	-

Crop management

Prior to sowing, field soil samples 0–15 cm depth were taken and analyzed for physical and chemical characteristics of soil (Table 2). A famous wheat cultivar “Akbar-19” which is high yielding under normal conditions was planted with a spacing of 22 cm between rows at a seed rate of 112 kg/ha. Basal fertilization included Diammonium Phosphate (DAP) and Sulphate of potash (SOP) were applied at recommended dose at soil preparation and Urea applied in two splits.

Table 2: Physico-chemical characteristics of soil.

Parameters	Value
Textural class	Loam
Organic matter (%)	0.63
pH	8.2
Electrical conductivity (EC) (dS m ⁻¹)	0.37
Total nitrogen (%)	0.028
Available phosphorus (ppm)	16.1
Extractable potassium (ppm)	106
Saturation percentage (%)	32

Data collection

Germination percentage per square meter: Germination was recorded in each plot using a 1 m x 1 m quadrat after emergence of wheat plants at 15 days after sowing.

Weed density per square meter: Broadleaf and narrow-leaf weed densities were separately recorded in each plot by using 1 m x 1 m quadrat, placed

randomly in each plot before herbicide application and again 30 days after spray.

Productive tillers per square meter: Productive tillers within a square meter were counted from each plot at maturity.

Grain yield (Kg/ha): Grain yield was calculated from a square meter sample in each plot, and standardized to a per-hectare basis.

Number of grains per spike: Ten spikes per plot were randomly sampled, and grains per spike were counted to calculate averages.

1000-grain weight (g): Thousand-grain weight was determined by weighing 1000 grains from three plot samples with a precise balance.

Weed control efficiency (WCE): It was calculated using the following equation:

$$WCE (\%) = \frac{WD_c - WD_t}{WD_c} \times 100\%$$

WD_c = Weed density (number/m²) in control plot, WD_t = Weed density in treated plot.

Statistical analysis

Data analysis was performed using Statistix 8.1 software. An analysis of variance (ANOVA) evaluated significant differences among herbicide treatments, followed by Fisher’s Least Significant Difference (LSD) test at a 5% significance level to compare treatment means.

Results and Discussion

Germination count of wheat plants

Germination data remained non-significant in all plots under experiment.

Grains per spike

Herbicide applications had marginal non-significance effects on grains per spike $F = 2.72$ and $P = 0.0660$. T1 (Mesosulfuran + Iodosulfuran) and T6(Pyroxsulum) had the highest number of grains per spike, indicating that herbicide application does not adversely affect the productivity of spikes (Table 4).

Productive tillers

Herbicide treatments had significant impact on the productivity tillers. Higher mean tillers (386) per acre were recorded in T6 (Pyroxsulum) followed by T4 (365) and T1 (364) treated plots (Table 4).

Table 3: Effect of various herbicides on weed density before and after application of herbicides.

Treatments	Weed density before treatment (m ⁻²)		Weed density after treatment (m ⁻²)		Weed control efficiency (%)	
	BLW	NLW	BLW	NLW	BLW	NLW
Mesosulfuran + Iodosulfuran (T1)	23.33 A	53.66 C	6.00 DE	10.83 D	74.28	79.81
Flurasulum + Mesosulfuran methyl + MCPA (T2)	23.00 A	53.83 C	15.66 C	22.66 C	31.88	57.89
Tribenuran methyl + Metsulfuran methyl + Pinoxaden (T3)	22.00 A	59.50 B	20.33 B	32.00 B	7.57	46.21
Cyprofluran + Isoproturan (T4)	23.33 A	54.83 BC	8.66 D	10.83 D	62.85	80.24
Flurasulum + Mesosulfuran (T5)	19.00 A	59.66 B	15.66 C	24.50 C	17.54	58.93
Pyroxsulum (T6)	20.33 A	66.66 A	5.33 E	11.00 D	73.77	83.50
Weedy check (T7)	23.00 A	59.50 B	25.00 A	39.00 A	-8.69	34.45
LSD P ≤ 0.05	5.95	5.26	2.93	3.53		

Means having different letters vary significantly at 5 % probability level. BLW (Broad leaf weeds), NLW, Narrow leaf weeds.

Table 4: Effects of various herbicides on yield parameters and yield of wheat.

Treatments	Germination count (m ⁻²)	No. of fertile tillers (m ⁻²)	Grains spike ⁻¹	1000-grains weight (g)	Grain yield (kg ha ⁻¹)
Mesosulfuran + Iodosulfuran (T1)	210.17 B	364.50 B	42.33 A	41.65 AB	5015.3 B
Flurasulum + Mesosulfuran methyl + MCPA (T2)	213.00 AB	353.50 C	39.66 AB	40.50 BC	4719.0 C
Tribenuran methyl + Metsulfuran methyl + Pinoxaden (T3)	211.33 B	344.00 E	39.33 B	40.05 C	4344.7 E
Cyprofluran + Isoproturan (T4)	211.00 B	365.33 B	40.66 AB	42.66 A	4980.3 B
Flurasulum + Mesosulfuran (T5)	209.67 B	346.67 DE	39.66 AB	40.40 C	4599.2 D
Pyroxsulum (T6)	218.00 A	386.33 A	42.33 A	41.00 BC	5493.3 A
Weedy Check (T7)	209.83 B	350.17 CD	38.00 B	40.45 BC	4223.3 F
LSD P ≤ 0.05	6.4703	4.7572	2.99	1.24	103.91

Means having different letters vary significantly at 5 % probability level.

Thousand grain weight: The herbicide application significantly affected the thousand grain weight and T4 (Cyprofluran + Isoproturan) resulting in the heaviest thousand grains weight at 42.667 g followed by 41.6 and 41.0 g which were recorded from plots treated with T1 (Mesosulfuran + Iodosulfuran) and T6 (Pyroxsulum) (Table 4).

Grain yield: The highest yield of grain was observed for treatment T6 (Pyroxsulum) at 5493.3 kg/ha, and it surpassed all others while the lowest yield was witnessed under treatment T7 (Weedy Check) which remained 4223.3 kg/ha. The treatments T1 and T4 remained at rank 2nd and 3rd and gave 5015.3 and 4980.3 kg/ha grains yield, respectively (Table 4).

Weed density

Generally, the pre-spraying dense conditions of both broadleaf and narrow-leaf weeds were close in all the treatments. It then offered a rather fair comparison of the effectiveness of all herbicide treatments. Following the application, treatment T6

(Pyroxsulum) and T1 (Mesosulfuran + Iodosulfuran), did exceptionally well in controlling narrow leaf and broad leaf weeds with 74.02 and 81.65 percent weeds control efficiency such that the remaining weeds were minimal compared to other herbicide treatments. From the rest of herbicides. Cyprofluran + Isoproturan gave 62.85% and 80.24% weeds control efficiency for narrow and broad leaf weeds, respectively (Table 3).

Germination count of wheat plants

The quantity of wheat seedlings germinated did not differ significantly in all the experiments. It demonstrates uniformity in seed quality and planting conditions as well as environmental factors across the study. Non-significant variation means that the other variables rather than germination may have caused subsequent plant growth or yield.

Grains per spike

The effect of herbicide application on number of grains per spike was non-significant. These results are in

agreement with those of [Abbas et al. \(2018\)](#), who also found that herbicides have little effect on grains per spike. The consistency of the results obtained implies that herbicides can be safely used in the management of wheat crops without negatively affecting critical yield components such as grains per spike, thereby providing weed control while maintaining stable productivity.

Productive tillers

The study indicated that herbicide treatments significantly affected the number of productive tillers per acre. The reason why there was an increase in productive tillers is the reduced competition from weeds, giving the wheat plants easy access to the resources the plant needs, including light, water, and nutrients. This may have increased the scope for tiller development due to improved resource availability, hence promoting general growth of the plant. These results concur with those of [Li et al. \(2017\)](#) and [Ahmed et al. \(2019\)](#), who also documented that effective weed management through herbicide application greatly diminishes interspecific competition, which in turn improves tiller production.

1000-grain weight

Herbicide application had the highest influence on 1000-grain weight, a major yield determinant in wheat production. These result shows that herbicides, in addition to causing weed suppression, provide an environment conducive to the development of heavier grains. Additionally, reduced weed pressure can result in improved plant health and efficiency in nutrient uptake, which contribute to grain weight. [Sharma and Singh \(2021\)](#) have supported the view of this study by reporting that weed management helps in establishing nutrient-rich soil conditions for crop growth that encourages the production of heavier grains.

Grain yield

Application of herbicides significantly influenced grain yield of wheat. Weeds compete with wheat plants for essential resources such as nutrients, water, and light. In the untreated plots (T7), this competition likely led to resource depletion, stunting plant growth and reducing grain production. Conversely, the herbicide-treated plots experienced reduced weed pressure, enabling the wheat plants to utilize resources more efficiently, thereby achieving higher yields. These results are supported by previous studies

conducted by [Gupta et al. \(2020\)](#) and [Khan et al. \(2020\)](#), which showed that proper weed management has a high positive impact on crop yields. Their study suggests that the elimination of weeds improves resource availability and uptake, hence better plant development and higher grain yield.

Weed density

Maximum weed control efficiency was observed in T6 (Pyroxsulum) and T1 (Mesosulfuran + Iodosulfuran) treatments. The reduction in weed density after these treatments clearly indicates that herbicides play an important role in reducing competition for the crop from weeds. Since these herbicides controlled both broad-leaf and narrow-leaf weeds, they enhanced the availability of resources for wheat, which ultimately improved growth and yield. This result is consistent with the work of [Liu et al. \(2019\)](#) and [Smith et al. \(2018\)](#), which obtained similar results, pointing to the need for effective weed management in agricultural ecosystems. The outcome mainly shows the efficiency of Pyroxsulum and Mesosulfuran + Iodosulfuran, as these herbicides not only efficiently suppressed weeds but also created the best conditions for wheat growth by reducing competition for nutrients, water, and light.

Conclusions and Recommendations

Pyroxsulum, Mesosulfuran + Iodosulfuran and Cyprofluran + Isoproturan, in particular, have been dramatic in killing weeds and increasing wheat yields. Yet, sustainable approaches toward weed control have to be concerned not only with chemical control but also with consequent impact on the environment and decades-long agricultural continuity. Considering that wheat is still the main crop in Pakistan, healthy and sustainable weed management strategies are likely to play a core role in maintaining food security as well as improving the livelihood of farmers. Implication: Results of this study give actionable recommendations for farmers, agronomists and policy decision makers who seek to enhance wheat productivity through improved weed management practices.

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sary resources and field facilities to conduct this study.

Novelty Statement

This study is unique in its comprehensive evaluation of various herbicide combinations for their efficacy in managing both broadleaf and narrow-leaf weeds in wheat fields under the semi-arid conditions of Punjab, Pakistan. Unlike previous studies, it highlights the comparative performance of six herbicide treatments; including Pyroxsulum and Mesosulfuran + Iodosulfuran, in enhancing wheat productivity and achieving superior weed control efficiency

Author's Contribution

Muhammad Shahbaz: Design the research experiment.
Muhammad Bilal Chattha: Supervise the research, manuscript review and editing.
Hasnat Babar: Performed the research experiment.
Shahbaz Ahmad: Proof reading and editing of manuscript.
Humaira Kalsoom: Analysis of data.
Tayyaba Manzoor: Analysis of data.
Abdul Rauf: Analysis of data.
Ahmad Nawaz: Application of weedicides.
Muhammad Tariq Chaudhry: Funding of resources.
Ishtiaq Hassan: Overall supervision and management of experiments.

Conflict of interest

The authors have declared no conflict of interest.

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