



## Research Article

# Understanding Farmer Perceptions of Herbicide Efficacy and Resistance in Khyber Pakhtunkhwa

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**Abstract** | A field survey was conducted in the wheat fields of four districts (Peshawar, Mardan, Charsadda and Swat) in Khyber Pakhtunkhwa, Pakistan, during 2018-19. A questionnaire was used to collect data from the farmers. Among the interviewed farmers, 40% were between the ages of 35 and 50 years, while 52% were having high school education. All respondents confirmed the use of herbicides, with 42% considering them the most effective strategy for weed control. Data analysis revealed that three aryloxyphenoxypropionate herbicides (clodinafop-propargyl, fenoxaprop-P-ethyl and diclofop-methyl) are employed to control various grass weeds, such as little seed canary grass (*Phalaris minor* L.) and wild oats (*Avena fatua* L.). In the studied areas, 41% of respondents reported that little seed canary grass persisted despite treatment with the herbicide clodinafop-propargyl. Our findings highlight the urgent need for continued research and development of more effective herbicide solutions to improve weed management and address the challenges faced by farmers in Khyber Pakhtunkhwa.

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## Introduction

Wheat (*Triticum aestivum* L.) is a major staple food in Pakistan. The Pakistani economy is based on agriculture, which contributes about 21% to the Gross Domestic Product (GDP) and provides livelihoods for about 45% of the total population (Kousar *et al.*, 2020).

Weeds can reduce crop output by 10–50% worldwide

if not managed effectively (Nakka *et al.*, 2019). In Pakistan, nearly 45 weed species significantly impact wheat production in various rain-fed and irrigated areas (Qureshi and Bhatti, 2001). Previous studies have reported 20–40% yield losses due to weeds, resulting in substantial economic losses (Ahmad *et al.*, 2003). Common troublesome weeds include *Lolium* spp., *Phalaris minor*, and *Avena fatua* (Nakka *et al.*, 2019). *P. minor* is particularly dominant in wheat crops across various regions of Pakistan (Siddiqui and

Bajwa, 2001; Siddiqui *et al.*, 2010).

*P. minor* Retz., also known as little seed canary grass, is a competitive and problematic weed in wheat crops due to its growth potential and competitive nature (Siddiqui and Bajwa, 2001; Chhokar *et al.*, 2008). This self-pollinated, cool-season grass weed is indigenous to the Mediterranean region (Hashim *et al.*, 2019). Herbicide application is a primary method for managing weeds, with around 150 chemical compounds targeting 25 different sites of action currently in use. However, the repeated application of these herbicides has led to many documented instances of herbicide resistance since the 1970s (Gherekhloo *et al.*, 2021). Herbicides that inhibit acetolactate synthase (ALS), acetyl-CoA carboxylase (ACCase), and Photosystem II (PS-II) are commonly used to control grass weeds in wheat (Gherekhloo *et al.*, 2016). However, repeated use has led to resistant biotypes in various grass weeds, with moderate resistance risk observed in *Phalaris* species (Moss *et al.*, 2019). Herbicide resistance has been documented in at least 23 cases, including multiple and cross-resistance, with mechanisms related to PS-II, ACCase, and ALS inhibitors observed in *P. minor*, *P. paradoxa*, and *P. brachystachys* (Heap, 2021). The emergence of herbicide-resistant *Phalaris* species poses a serious threat to crop yields and sustainable wheat production and may impact the biodiversity of associated weed communities (Gherekhloo *et al.*, 2011; Travlos, 2012). Effective management strategies are essential to address these risks. Herbicide resistance, defined as the evolved ability of a weed population to withstand herbicides that would normally be lethal (Heap and LeBaron, 2001), has been rising. *P. minor* resistance to ACCase and ALS herbicides has been documented in numerous countries, including Australia, India, Iran, Israel, Mexico, South Africa, and the United States (Heap, 2018). Multiple resistance has been confirmed in India and South Africa (Chhokar and Sharma, 2008).

The rise in herbicide resistance reflects an overreliance on herbicides. This issue affects both highly developed and low-resource farming systems, with resistance emerging in areas using single herbicides or modes of action extensively (Valverde *et al.*, 2000). To combat resistance, strategies to reduce selection pressure such as varying herbicide use and incorporating diverse control methods are essential (Mortensen *et al.*, 2000).

## Materials and Methods

A field survey based on visual observation and filling of prescribed questionnaire from different farmers, wheat growers, research associates, research officers and teachers was planned and conducted. A total of 30 respondents from each districts were interviewed using the prescribed questionnaire. Seeds of the major weed *P. minor* were collected from the respective locations and sites to investigate herbicide resistant weeds in wheat crop from the following four districts of Khyber Pakhtunkhwa during October-May (2018-19).

### Districts

- Peshawar
- Mardan
- Charsadda
- Swat

Chi-square test was applied for statistical analysis in Excel using the CHISQ test function.

### Chi-square test formula

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Where;  $\chi^2$  is the chi-square test statistic,  $\Sigma$  is the summation operator (it means take the sum of),  $O$  is the observed frequency,  $E$  is the expected frequency

## Results and Discussion

Khyber Pakhtunkhwa is one of the major provinces contributing to agriculture. Four different locations (Peshawar, Charsadda, Mardan and Swat) were selected for the survey, which are explained below:

### Age of the respondents

The ages of the respondents in the surveyed districts are presented in Table 1. Table 1 shows that 51 respondents were between 35 and 50 years old, 34 were over 50 years old, and 15 were under 35 years old. This survey indicates that in every district, younger individuals are engaged in agriculture. This suggests that if farmers receive the necessary training, they could potentially increase overall crop yields. Age is a significant factor that can influence the nation's agriculture. Guo *et al.* (2015) reported in a related study that age significantly impacts agricultural productivity. Statistical analysis further reveals that

there is no correlation between respondents' ages and their districts ([Table 1](#)).

**Table 1:** Age of the respondents for the survey on herbicide resistance.

| District  | 25- 35 years | 35-50 | Above 50 | Total |
|-----------|--------------|-------|----------|-------|
| Peshawar  | 4            | 18    | 8        | 30    |
| Charsadda | 3            | 20    | 7        | 30    |
| Mardan    | 5            | 15    | 10       | 30    |
| Swat      | 3            | 18    | 9        | 30    |
| Total     | 15           | 51    | 34       | 120   |

Chi-square = 2.04, *p*-value = 0.916

#### Education of the respondents

[Table 2](#) lists the educational backgrounds of the interviewees, indicating that the majority were well-educated. A significant proportion of respondents (64) held a high qualification level, while 29 had a high school certificate and 17 had primary education. Only 10% of the respondents were illiterate. [Table 2](#) presents data illustrating the respondents contributions based on their educational status. In Peshawar, research associates typically held an agricultural diploma and had adopted farming as their profession (17 respondents). In Mardan and Swat, there was little difference, with 16 and 19 respondents in this category, respectively. MSc graduates and other scientific officers were more prevalent in the districts of Swat and Mardan, while they were observed to be very limited in Peshawar.

**Table 2:** Education of the respondents for the survey on herbicide resistance.

| District  | Illiterate | Primary | High | Above high | Total |
|-----------|------------|---------|------|------------|-------|
| Peshawar  | 2          | 4       | 7    | 17         | 30    |
| Charsadda | 2          | 5       | 11   | 12         | 30    |
| Mardan    | 3          | 6       | 5    | 16         | 30    |
| Swat      | 3          | 2       | 6    | 19         | 30    |
| Total     | 10         | 17      | 29   | 64         | 120   |

Chi-square = 6.946, *p*-value = 0.643

The respondents educational backgrounds are important for delivering accurate and effective agricultural practices and information. Our findings further support [Uygun's \(2008\)](#) conclusion that there is a statistically significant positive correlation between the output of wheat per area and the number of educated farmers and graduates in the teaching profession.

#### Major crops/vegetable

[Table 3](#) provides information on the principal crops and vegetables grown in the surveyed districts. In Peshawar, the major crops are maize, sugarcane and wheat. Charsadda and Mardan also primarily grow maize, wheat and sugarcane. Swat is notable for its major crops, wheat and rice, as well as its main products, peaches and apples. There is a significant relationship between the major crops and the districts. Each district has a niche market, with notable differences between them. For instance, apples and peaches are lucrative crops in Swat but not in other regions.

**Table 3:** Major crops/vegetable grown in the survey on herbicide resistance.

| District  | Wheat | Rice | Sugar- cane | Peach/ Apple | Maize | Total |
|-----------|-------|------|-------------|--------------|-------|-------|
| Peshawar  | 30    | 0    | 30          | 0            | 30    | 30    |
| Charsadda | 30    | 0    | 30          | 0            | 30    | 30    |
| Mardan    | 30    | 0    | 30          | 0            | 30    | 30    |
| Swat      | 30    | 30   | 0           | 30           | 30    | 30    |
| Total     | 120   | 30   | 90          | 60           | 120   | 120   |

Chi-square = 1.788, *p*-value = 0.00

**Table 4:** Crop rotation with wheat for the survey on herbicide resistance.

| District  | Yes | No | Rotation crops   | Total |
|-----------|-----|----|------------------|-------|
| Peshawar  | 30  | 0  | Maize, Sugarcane | 30    |
| Charsadda | 30  | 0  | Maize, Sugarcane | 30    |
| Mardan    | 30  | 0  | Maize, Sugarcane | 30    |
| Swat      | 30  | 0  | Rice             | 30    |
| Total     | 120 | 0  |                  | 120   |

Chi-square = 18.020, *p*-value = 0.00

#### Crop rotation

The information in [Table 4](#) shows that while all respondents in Peshawar indicated they used crop rotation, farmers in Mardan, Swat and Charsadda reported rotating wheat with other crops. In Peshawar, about 10% of the farmers did not alternate their wheat crop with another legume crop. Many of the farmers and wheat growers surveyed have incorporated crop rotation with wheat. In Peshawar, Mardan and Charsadda, the rotation crops include maize and sugarcane. In Swat, where the climate is favorable for rice cultivation, farmers alternate between growing wheat and rice. The data clearly indicate that the majority of farmers and wheat growers in every district are practicing crop rotation with wheat. Crop rotation significantly reduces weed development and positively

impacts wheat grain production. It is also practiced for enhancing soil fertility. These findings are consistent with those of [Liebman and Dyck \(1993\)](#), who found that crop rotation and intercropping reduce biomass production and weed population density.

#### *Intercropping with wheat*

Data presented in [Table 5](#) provides information on the use of intercropping with wheat in four locations: Peshawar, Mardan, Charsadda and Swat. The results indicate that a large number of farmers have adopted intercropping with wheat, with a total of 79 participants. In Swat, 3 farmers were not practicing intercropping with wheat, while 14 were not doing it in Peshawar. However, a significant number of farmers have adopted intercropping on their land. [Table 5](#) shows that 27 farmers in Swat and 19 in Mardan have implemented intercropping with wheat, with similar results observed in Charsadda (17) and Peshawar (16). Various crops and fruits are intercropped with wheat, such as sugarcane in Peshawar, Charsadda and Mardan, and peach in Swat. A large area is devoted to wheat, but intercropping is also a common practice, with farmers choosing their crops based on demand. Intercropping is beneficial for increasing yield; according to [Song et al. \(2007\)](#), it improves crop yield and alters nitrogen and phosphorus availability. [Khan et al. \(2013\)](#) also reported that intercropping is economical and profitable for farmers, as it allows for the efficient use of limited resources.

**Table 5:** *Intercropping with wheat.*

| District  | Yes | No | If yes    | Total |
|-----------|-----|----|-----------|-------|
| Peshawar  | 16  | 14 | Sugarcane | 30    |
| Charsadda | 17  | 13 | Sugarcane | 30    |
| Mardan    | 19  | 11 | Sugarcane | 30    |
| Swat      | 27  | 03 | Peach     | 30    |
| Total     | 79  | 41 |           | 120   |

*Chi-square = 11.077, p-value = 0.011*

#### *Major constraints to wheat production*

[Table 6](#) presents various challenges related to wheat production. Majority of the respondents (52) identified weeds as the primary obstacle to wheat production, with other issues (34) such as diseases, natural disasters, etc., ranking second. There were 24 complaints about seed quality in the surveyed areas. Additionally, only 12 individuals expressed confidence in the use of agrochemicals. Analysis of data revealed that in Peshawar, 50% percent wheat

growers considered weeds a significant obstacle to wheat production. In Charsadda, however, this percentage differs, with 12 respondents considering weeds as a threat to wheat production. The same number of respondents (12) in Mardan also perceived weeds as a significant issue. Furthermore, the problem of high-quality seed availability for various crops and vegetables was reported by 10 respondents in Swat, with a similar issue reported by 7 respondents in Mardan. Four respondents each in Peshawar and Charsadda cited seed quality a concern. One possible explanation for this could be that Peshawar, as the provincial capital, has access to the national market, while Swat, being a district in the far north, has limited market access.

**Table 6:** *Major constraints to wheat production for the survey on herbicide resistance.*

| District  | Major constraints |               |               |        | Total |
|-----------|-------------------|---------------|---------------|--------|-------|
|           | Weeds             | Quality seeds | Agrochemicals | Others |       |
| Peshawar  | 15                | 4             | 3             | 8      | 30    |
| Charsadda | 12                | 4             | 4             | 10     | 30    |
| Mardan    | 12                | 7             | 3             | 8      | 30    |
| Swat      | 13                | 9             | 2             | 8      | 30    |
| Total     | 52                | 24            | 12            | 34     | 120   |

*Chi-square = 4.342, p-value = 0.887*

Another issue affecting wheat productivity is the availability and proper application of agrochemicals, which impacts all the areas studied. Three farmers in Peshawar reported struggling with the improper application of agrochemicals. Additional constraints present in all four locations included biotic stress and the high cost of inputs. The data showed that these constraints have significantly reduced wheat yield in these locations. Similar findings were reported by [Dhaka et al. \(2016\)](#), who identified biotic stress, lack of knowledge, high input costs, and weeds as major factors contributing to the yield gap in wheat crops. These results are also in agreement with [Khan et al. \(2013\)](#) who found that 22.8% of farmers in Peshawar reported weeds as a major problem in wheat production. There is no significant relationship between the regions and the constraints posed by weeds.

#### *Best weed management practices*

[Table 7](#) highlights information on effective strategies for managing weeds in Peshawar, Mardan, Charsadda

and Swat. The use of herbicides has shown the strongest positive response for controlling weeds in wheat. According to the data, the majority of respondents (79) across all districts believed that chemical control is the most effective management strategy for controlling weeds in wheat and many other crops. Crop rotation is the second most preferred method in all four districts, with the highest reported herbicide usage ratio. Crop rotation was also mentioned by 14 farmers and knowledgeable individuals from the examined areas, and 27 district respondents identified it as the best control strategy.

**Table 7:** *Best weed management practices in districts survey on herbicide resistance.*

| District  | Best weed management practices |               |              | Total |
|-----------|--------------------------------|---------------|--------------|-------|
|           | Herbicides                     | Crop rotation | Hand weeding |       |
| Peshawar  | 21                             | 8             | 1            | 30    |
| Charsadda | 22                             | 7             | 1            | 30    |
| Mardan    | 20                             | 5             | 5            | 30    |
| Swat      | 16                             | 7             | 7            | 30    |
| Total     | 79                             | 27            | 14           | 120   |

*Chi-square = 9.469, p-value = 0.149*

In Mardan and Swat, hand weeding is also considered an effective management technique; however, in Peshawar and Charsadda, this method is much less favored, with only one respondent in each area recommending it. Herbicide use was widespread in Swat, Mardan, Charsadda and Peshawar. This research demonstrates that various weed control techniques can effectively eradicate weeds while also increasing wheat yield.

Our findings align with those of [Lobell et al. \(2004\)](#), who showed that while key controls may vary from year to year, management adjustments can significantly enhance wheat yield. Similar observations were noted by [Amare \(2004\)](#), who provided descriptions of various weed management techniques.

#### *Reason for using herbicides*

The responses of interviewees regarding the reasons for using herbicides is summarized in [Table 8](#). The data reveals that the majority of people agreed that herbicides provided the best weed control (67 respondents), followed by the fast action of herbicides (49 respondents). The least response was recorded for herbicides being non-laborious (30 respondents). The results indicate that most people use herbicides

primarily for effective weed control and to increase wheat production.

Various benefits and reasons for applying herbicides on agricultural land in Peshawar, Mardan, Charsadda and Swat are also highlighted in [Table 8](#). The data indicates that in Peshawar, 16 farmers and wheat producers used herbicides to achieve optimal weed control; however, in Mardan and Charsadda, this number differed, with 13 farmers reporting herbicide use. Similarly, 8 respondents in Peshawar and Swat, slightly fewer than in Mardan, believed that herbicides acted quickly, while 12 and 11 respondents in Mardan and Charsadda, respectively, used herbicides because of their quick action. Herbicide use is also considered non-laborious, according to reports from ten individuals in Swat and six farmers in Peshawar and Mardan.

**Table 8:** *Reason for using Herbicides in field survey on herbicide resistance.*

| District  | Reason for using herbicides |             |               | Total |
|-----------|-----------------------------|-------------|---------------|-------|
|           | Best control                | Fast action | Non laborious |       |
| Peshawar  | 16                          | 8           | 6             | 30    |
| Charsadda | 13                          | 11          | 6             | 30    |
| Mardan    | 11                          | 12          | 8             | 30    |
| Swat      | 13                          | 8           | 10            | 30    |
| Total     | 67                          | 49          | 30            | 120   |

*Chi-square = 3.698, p-value = 0.718*

These findings align closely with the research of [Kamrozzaman et al. \(2015\)](#), which suggested that herbicides could be a good substitute for manual weed control methods in wheat fields, and [Arif et al. \(2004\)](#), who explored whether herbicide treatment had a significant impact on wheat grain yield.

#### *Major herbicides used in the districts*

Different herbicides are used in Khyber Pakhtunkhwa in varying proportions, as shown in [Table 9](#). The data indicates that Phenoxaden and Mesosulfuran-methyl (found in Axial and Atlantis) are used in the highest proportion (51 respondents), followed by Phenoxaprop-p-ethyl (found in Puma Super) with 31 respondents. The table further showed that Phenoxy herbicide (MCPA) and Hydroxy benzonitrile (Bromoxynil + MCPA) are also in use, with 17 and 16 respondents, respectively. Although Clodinafop-propargyl (Topik) is an older herbicide and its usage has declined due to poor field performance, it is still

in use (5 respondents).

In Peshawar, farmers used both Topik and Puma Super herbicides on their crops, according (Table 9). Many wheat farmers and producers in Peshawar and Charsadda reported using up to two herbicides, Topik and Puma Super, largely because these pesticides were readily available. Similarly, 14 respondents in Peshawar used the herbicides Axial and Atlantis, while 12 farmers in Mardan, Charsadda and Swat also used Axial and Atlantis. Additionally, 4 and 5 respondents in Peshawar reported spraying MCPA alongside Bromoxynil. The data further revealed that five respondents in Swat were using different herbicide combinations, including Bromoxynil and MCPA. Several combinations of herbicides were identified in both areas, used to control weeds with both grass and broad leaves.

Similar findings were reported by Hussain *et al.* (2013), who found that the herbicide Bromoxynil + MCPA, both alone and in combination with Clodinafop (Topik), is highly effective at increasing wheat production. According to Khan *et al.* (1999), Buctril Super herbicide is an effective option for managing the broadleaf weed spectrum in D.I. Khan.

Mahmood *et al.* (2013) also reported that Axial 100 EC at 825 ml/ha is highly effective in reducing the population of grassy weeds.

*Putative herbicide resistance in weeds and level of severity*  
Observation of the respondents on the putative resistant weeds to different herbicides is depicted in Table 10. The data shows that the highest response was recorded for *Phalaris minor* L. (49), followed by *Avena fatua* (31). Among the resistant weeds, *Rumex dentatus* was the next most common, with 23 respondents reporting it. *L. aphaca* ranked fourth, with 9 respondents, followed by *C. arvensis* with 8 respondents. The highest resistance to *P. minor* L. was recorded across all districts, followed by *A. fatua*, likely due to crop mimicry at early growth stages and higher infestation rates. The least observed resistance was recorded for *L. aphaca* and *C. arvensis* with variations across different areas.

According to the data in Table 10, nearly 13 respondents in Peshawar, Mardan, Charsadda and Swat rated *P. minor* as a resistant weed. Very few farmers in Peshawar (15.0%) and similarly few in Mardan, Swat and Charsadda considered *C. arvensis* to be a resistant weed. Likewise, equal numbers of

**Table 9:** Major herbicides used in the districts.

| District  | Surveyed for herbicide resistance    |                                          |                                                           |                                |                                             | Total |
|-----------|--------------------------------------|------------------------------------------|-----------------------------------------------------------|--------------------------------|---------------------------------------------|-------|
|           | Major Herbicides                     |                                          |                                                           |                                |                                             |       |
|           | Clodina-<br>fop-propargyl<br>(Topik) | Phenoxy-<br>prop-p-ethyl<br>(Puma Super) | Phenoxaden and Mesosulfu-<br>ran-methyl (Axial, Atlantis) | Phenoxy<br>herbicide<br>(MCPA) | Hydroxy benzonitrile<br>(Bromoxynil + MCPA) |       |
| Peshawar  | 1                                    | 6                                        | 14                                                        | 4                              | 5                                           | 30    |
| Charsadda | 2                                    | 8                                        | 13                                                        | 3                              | 4                                           | 30    |
| Mardan    | 1                                    | 7                                        | 12                                                        | 6                              | 4                                           | 30    |
| Swat      | 1                                    | 10                                       | 12                                                        | 4                              | 3                                           | 30    |
| Total     | 5                                    | 31                                       | 51                                                        | 17                             | 16                                          | 120   |

*Chi-square* = 3.562, *p-value* = 0.990

**Table 10:** Name of the resistant weeds in districts surveyed on herbicide resistance.

| District  | Name of resistant weeds |                    |                       |                             |                        | Total |
|-----------|-------------------------|--------------------|-----------------------|-----------------------------|------------------------|-------|
|           | <i>Phalaris minor</i>   | <i>Avena fatua</i> | <i>Rumex dentatus</i> | <i>Convolvulus arvensis</i> | <i>Lathyrus aphaca</i> |       |
| Peshawar  | 13                      | 8                  | 6                     | 2                           | 1                      | 30    |
| Charsadda | 14                      | 7                  | 5                     | 2                           | 2                      | 30    |
| Mardan    | 12                      | 9                  | 6                     | 2                           | 1                      | 30    |
| Swat      | 10                      | 7                  | 6                     | 3                           | 4                      | 30    |
| Total     | 49                      | 31                 | 23                    | 9                           | 8                      | 120   |

*Chi-square* = 4.53, *p-value* = 0.972

**Table 11:** Weeds in order of severity for the survey on herbicide resistance.

| District  | <i>Phalaris minor</i> | <i>Avena fatua</i> | <i>Rumex dentatus</i> | <i>Lathyrus aphaca</i> | <i>Convolvulus arvensis</i> | <i>Chinupodium morale</i><br>L | Total |
|-----------|-----------------------|--------------------|-----------------------|------------------------|-----------------------------|--------------------------------|-------|
| Peshawar  | 13                    | 8                  | 4                     | 1                      | 1                           | 2                              | 30    |
| Charsadda | 14                    | 7                  | 5                     | 1                      | 1                           | 1                              | 30    |
| Mardan    | 14                    | 8                  | 4                     | 1                      | 2                           | 1                              | 30    |
| Swat      | 9                     | 9                  | 4                     | 7                      | 1                           | 0                              | 30    |
| Total     | 50                    | 32                 | 17                    | 10                     | 5                           | 4                              | 120   |

*Chi-square* = 15.014, *p-value* = 0.972

farmers from each location identified *A. fatua* and *R. dentatus* as resistant weeds in their fields. Furthermore, *L. aphaca* was reported as a resistant weed, with four respondents from Swat and two from Charsadda indicating that wheat growers are struggling with this weed in their fields. The data also revealed that extensive populations of *P. minor* and *A. fatua* are classified as noxious resistant weeds in both areas. Our findings align with those of Pavlychenko and Harrington (2011), who reported that *P. minor* and *A. fatua* are significant wheat weeds and *A. fatua* and *Brassica arvensis* are among the most aggressive competitors in grain crops.

Observations from the respondents regarding the order of severity in terms of herbicide resistance were also recorded (Table 11). *P. minor* L. ranked first (50), followed by *A. fatua* (32). *R. dentatus* L. *aphaca* and *C. arvensis* are also considered very severe weeds of the wheat crop, with counts of 17, 10 and 5, respectively.

Based on their overall detrimental impact on the wheat crop in both locations, the various weeds were ranked differently (Table 11). According to the data, *P. minor* was considered the most severe weed, with 13 respondents in Peshawar and more than 14 in Charsadda and Mardan indicating its prevalence. Additionally, nine farmers in Swat and eight each in Peshawar and Charsadda reported *A. fatua* as the second most severe weed. Four farmers in Peshawar and more than four in Charsadda identified *R. dentatus* as the third most severe weed. In Swat, seven farmers reported issues with *L. aphaca*, while one farmer each in Peshawar and Mardan ranked it as the fourth most severe weed. The data also indicated that *C. arvensis* ranked fifth in severity, with reports from farmers in Peshawar and Mardan noting its impact on production. All of these findings are consistent with Marwat et al. (2013).

## Conclusions and Recommendations

In conclusion, the comprehensive survey conducted across the four districts of Khyber Pakhtunkhwa highlights the critical role of various demographic factors, such as age and education in shaping agricultural practices and outcomes. The findings reveal that younger and educated farmers are increasingly engaged in the region's agriculture, potentially leading to innovations in crop management and yield enhancement. The data also highlight the significance of crop rotation, intercropping and effective weed management strategies, including the use of herbicides, in maintaining wheat production. The challenges identified, particularly weed resistance, emphasize the need for continued research and the implementation of targeted interventions. By addressing these constraints and leveraging the knowledge of local farmers, the province of Khyber Pakhtunkhwa can improve its agricultural productivity, aligning with broader goals of sustainable development and food security. This study not only contributes to our understanding of agricultural dynamics in Khyber Pakhtunkhwa but also provides actionable insights for policymakers, researchers and farmers aiming to optimize wheat production in the face of evolving challenges.

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## Novelty Statement

This study contributes to understanding of agricultural dynamics in Khyber Pakhtunkhwa. It also provides actionable insights for policymakers, researchers and farmers aiming to optimize wheat production in the

face of evolving challenges.

## Author's Contribution

**Saima Hashim:** Conceptualization, supervision, funding acquisition and write-up.

**Shah Fahad:** Original writing, statistical analysis and editing.

## Conflict of interest

The authors have declared no conflict of interest.

## References

- Abbas, T., M.A. Nadeem, A. Tanveer, A. Matloob, N. Farooq, N.R. Burgos and B.S. Chahan. 2017. Confirmation of resistance in little seed canary grass (*Phalaris minor* Retz) to ACCase inhibitors in central Punjab-Pakistan and alternative herbicides for its management. Pak. J. Bot., 49(4): 1501-1507.
- Agarwal, P. and P. Khurana. 2017. Characterization of a novel zinc finger transcription factor (*TaZnF*) from wheat conferring heat stress tolerance in *Arabidopsis*. Cell Stress Chaperones, 23(2): 253-267. <https://doi.org/10.1007/s12192-017-0838-1>
- Ahmad, R., and A.S. Shaikh. 2003. Common weeds of wheat and their control. Pak. J. Water Res., 7(1): 73-76.
- Amare, T., 2004. Effect of weed management methods on weeds and wheat (*Triticum aestivum* L.) yield. Afr. J. Agric. Res., 9(24): 1914-1920.
- Arif, M., L. Awan and H.U. Khan. 2004. Weed management strategies in wheat (*Triticum aestivum* L.). Pak. J. Weed Sci. Res., 10(1-2): 11-16.
- Bano, S., M. Ashraf and N.A. Akram. 2014. Salt stress regulates enzymatic and non-enzymatic antioxidative defense system in the edible part of carrot (*Daucus carota* L.). J. Plant Int., 9(1): 324-329. <https://doi.org/10.1080/17429145.2013.832426>
- Chhokar, R.S., R.K. Sharma and R.P.S. Verma. 2008. Multiple herbicide resistance in little seed canary grass (*Phalaris minor*): A threat to wheat production in India. Weed Biol. Man., 8(2): 112-123. <https://doi.org/10.1111/j.1445-6664.2008.00283.x>
- Choudhary, D., P.K. Singh, N.K. Chopra and S.C. Rana. 2016. Effect of herbicide and herbicide mixture on weeds in wheat. Indian J. Agric. Res., 50(2): 107-112. <https://doi.org/10.18805/ijare.v50i2.9587>
- Coleman, R.K., G.S. Gill and G.J. Rebetzke. 2001. Identification of quantitative trait loci for traits conferring weed competitiveness in wheat (*Triticum aestivum* L.). Austral. J. Agric. Res., 52(12): 1235-1246. <https://doi.org/10.1071/AR01055>
- Coleman, R.K., G.S. Gill and G.J. Rebetzke. 2001. Identification of quantitative trait loci for traits conferring weed competitiveness in wheat (*Triticum aestivum* L.). Aust. J. Agric. Res., 52(12): 1235-1246. <https://doi.org/10.1071/AR01055>
- Collavo, A., S. Panozzo, G. Lucchesi, L. Scarabel and M. Sattin. 2011. Characterisation and management of *Phalaris paradoxa* resistant to ACCase-inhibitors. Crop Prot., 30(3): 293-299.
- Delye, C., 2005. Weed resistance to acetyl- coenzyme A carboxylase inhibitors: An update. Weed Sci., 53(5): 728-746. <https://doi.org/10.1614/WS-04-203R.1>
- Dhaka, B.L., R.K. Bairwa and N.L. Meena. 2016. Yield gap and constraints analysis in wheat production in Humid South Estem part of Rajasthan. Int. J. Agric. Sci., 8(12): 1160-1162.
- Duke, S.O., 2012. Why have no new herbicide modes of action appeared in recent years? Pest Man. Sci., 68: 505-512. <https://doi.org/10.1002/ps.2333>
- FAO, 2005. Food and agriculture organization of the United Nations. Crop prospects and food situation. March, 2005.
- FAO, 2013. Food and Agriculture Organization of the United Nations. International wheat production statistics. November, 2014.
- Gherekhloo, J., M.H.R. Mohassel, M.N. Mahalati, E. Zand, A. Ghanbari, M.D. Osuna and R. De Prado. 2011. Confirmed resistance to aryloxyphenoxypropionate herbicides in *Phalaris minor* populations in Iran. Weed Biol. Manage., 11: 29-37. <https://doi.org/10.1111/j.1445-6664.2011.00402.x>
- Gherekhloo, J., M. Oveisi and E. Zand, R. De Prado. 2016. A review of herbicide resistance in Iran. Weed Sci., 64: 551-561. <https://doi.org/10.1614/WS-D-15-00139.1>
- Guo, G., Q. Wen and J. Zhu. 2015. The impact

- of aging agricultural labor population on farmland output from the perspective of farmers preference. Mathematical problem in engineering: Article ID 730618. 1-7. <https://doi.org/10.1155/2015/730618>
- Haider, G., A. Bashir and M.S. Tabassam. 1997. Consumptive use of water by wheat under optimum management conditions. Ann. Prog. Rep. WMRPCSU. pp. 114.
- Hashim, S., A. Jan, S. Fahad, H.H. Ali, M.N. Mushtaq, K.B. Laghari and B.S. Chauhan. 2019. Weed management and herbicide resistant weeds: A case study from wheat growing areas of Pakistan. Pak. J. Bot., 51(5): 1761-1767.
- Heap, I. and H. LeBaron. 2001. Introduction and overview of resistance. In: Herbicide resistance and world grains. CRC Press. pp. 1-22.
- Heap, I., 2018. International survey of herbicide resistant weeds. Available online: <http://www.weedscience.org> (accessed on 15 September 2021).
- Hussain, Z., K.B. Marvat, F. Munsif, A. Samad and K. Ali. 2013. Evaluation of various herbicide and their combinations for weed control in wheat crop. Pak. J. Bot., 45(1): 55 -59.
- Kamrozzaman, M.M., M.A.H. Khan, S. Ahmed and A.F.M.R. Qudus. 2015. Effect of herbicide in controlling broad leaf and sedge of weeds in wheat (*Triticum aestivum* L.). The Agriculturists. 13(2): 54 -61.
- Khan, M.A., Z.I. Ahmad, G. Hassan and M.S. Baloch. 1999. Efficacy of different herbicide for controlling broad leaf weeds in wheat (*Triticum aestivum* L.). Pak. J. Biol. Sci., 2(3): 732 734.
- Khan, M.A., K.B. Marwat, Umm-e-Kulsoom, Z. Hussain, S. Hashim, A. Rab and K. Nawab. 2013. Weed control effects on the wheat-pea intercropping. Pak. J. Bot., 45(5): 1743-1748.
- Kousar, B., A. Bano and N. Khan. 2020. PGPR modulation of secondary metabolites in tomato infested with *Spodoptera litura*. Agronomy, 10(6):778. <https://doi.org/10.3390/agronomy10060778>
- Liebman, M. and E. Dyck. 1993. Crop rotation and intercropping strategies for weed management. J. Ecol. S. Am., 3(1): 92- 122.
- Lobell, D.B., J.I.O. Monasterio, G. Asner, R.L. Naylor and W.P. Falcon. 2004. Combining field survey, remote sensing and regression trees to understand yield variations in an irrigated wheat landscape. Agron. J. 97(1): 241-249.
- Mahmood, A., J. Iqbal, M.B. Chattha and G.S. Azhar. 2013. Evaluation of various herbicides for controlling grassy weeds in wheat crop. Mycopath, 11(1): 39- 44.
- Marwat, S.K., K. Usman, N. Khan, M.U. Khan, E.A. Khan, M.A. Khan and A.U. Rehman. 2013. Weeds of wheat crop and their control strategies in Dera Ismail Khan District, Khyber Pakhtunkhwa, Pakistan. Amer. J. Plant Sci., 4(1): 1- 11.
- Mortensis, Bastiaans and Sattin. 2000. The role of ecology in the development of weed management systems: an outlook. Weed Res., 40(1): 49-62.
- Moss, S., L. Ulber and I.N. Hoed. 2019. A herbicide resistance risk matrix. Crop Prot., 115: 13-19. <https://doi.org/10.1016/j.cropro.2018.09.005>
- Nakka, S., M. Jugulam, D. Peterson and M. Asif. 2019. Herbicide resistance: Development of wheat production systems and current status of resistant weeds in wheat cropping systems. Crop J., 7(6):750-760.
- Pavlychenko, T.K and J.B. Harrington. 2011. Competitive efficiency of weeds and cereal crops. Canad. J. Res. 10(1): 77- 94.
- Qureshi, R., G.R. Bhatti and G. Shabbir. 2011. Floristic inventory of Pir Mehr Ali Shah Arid Agriculture University research farm at Koont and its surrounding areas. Pak. J. Bot., 43(3): 1679-1684.
- Siddiqui, I. and R. Bajwa. 2001. Variation in weed composition in wheat fields of Lahore and Gujranwala divisions. Pak J. Biol. Sci., 4: 492- 504.
- Siddiqui-Jain, A., D. Drygin, N. Streiner, P. Chua, F. Pierre, S.E. O'Brien and K. Anderes. 2010. CX-4945, an orally bioavailable selective inhibitor of protein kinase CK2, inhibits prosurvival and angiogenic signaling and exhibits antitumor efficacy. Cancer Res., 70(24): 10288-10298.
- Song, Y.N., F.S. Zhang, P. Marschner, F.L. Fan, H.H. Gao, X.G. Bao, J.H. Sun and L. Li. 2007. Effect of intercropping on crop yield of wheat (*Triticum aestivum* L.). J. Biol. Fertil. Soils, 43(5):565-574.
- Travols, I.S., 2012. Evaluation of herbicide-resistance status on populations of little seed canary grass (*Phalaris minor* Retz.) from southern Greece and suggestions for their

- effective control. *J. Plant Prot. Res.*, 52: 308–313.  
<https://doi.org/10.2478/v10045-012-0050-3>
- Uygun, S. 2008. The impact of Jhon Dewey on the teacher education system in turkey. *Asia-Pacific J. Teacher Edu.*, 36(4): 291-306.
- Valverde, O., C. Ledent, F. Beslot, M. Parmentier and B.P. Roques. 2000. Reduction of stress-induced analgesia but not of exogenous opioid effects in mice lacking CB1 receptors. *Euro. J Neurosci.*, 12(2): 533-539.