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Effect of herbicides on different weed species in wheat-chickpea intercropping system

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Abstract
In the 2020–2021 *Rabi* season, a field experiment was carried out at the Lovely Professional University's School of Agriculture in Phagwara, Punjab. The eight treatments in the field experiment were: Isoproturon 1000 g/ha (PoE), Pendimethalin 1000 ml/ha (PE), Pinoxaden 50 g/ha (PoE), Cladinofop-propargyl 60 g/ha (PoE), Hand weeding at 60 DAS, Metribuzin 250 g/ha (PE), Weedy Check, and Weed free check. The experiment was set up using a Randomized Block Design (RBD). A 2:1 intercropping ratio was used when sowing wheat and chickpeas, with a 30-cm row-to-row spacing. Several weed species, including *Phalaris minor, Chenopodium album, Rumex acetosella, Medicago denticulate, Melilotus indica, Anagallis arvensis, and Coronopus didymus,* were infested in the experimental field. The study findings indicate that pendimethalin 1000 ml/ha (PE) was the herbicide that most effectively reduced the amount of weeds (59.2 no. /m^2) and their dry matter (9.2 g/m^2). With the exception of *Medicago denticulate*, all the weeds were effectively controlled by it. With pendimethalin 1000 ml/ha (PE), the highest weed control efficiency and lowest weed index were also recorded.

Keywords: Herbicide, dry matter, weed control efficiency, weed density, weed index

Introduction

As the most significant cereal in the world, wheat (*Triticum aestivum* L.), and the third most important pulse crop in the world, chickpeas (*Cicer arietinum* L.), are both vital to the world's agricultural economy (FAO, 2003) [6]. The most common title for wheat is "king of cereals." The protein level of chickpeas is twenty-one percent, in contrast to eleven to twelve percent for wheat. From a yield and geographic perspective, wheat is the crop that is grown most commonly worldwide. Following rice in popularity in India is wheat. The most land is planted to wheat in U.P., although Punjab has the best productivity (45 q/ha). Because almost all of the land is irrigated and higher fertilizer doses and usage are required, Punjab has the highest wheat productivity. The largest producer of the wheat is European Union, which was followed by the other countries like China, India and USA. Around 667 million tonnes of wheat has been consumed in the world. Worldwide wheat consumption has been about 667 million tonnes. Since the population has been growing at an alarming rate over the past 15 years, wheat consumption has been rising steadily. In 2020, consumption of wheat surpassed 780 million tonnes (Anonymous, 2018) [1]. India is the world's leading producer of chickpeas, making about 70% of the total area and 65% of global production. According to Kumar *et al.*, 2014 [9], Madhya Pradesh is the Indian state with the largest acreage and output of chickpeas.

Due to their ability to compete with crops for light, space and nutrients, induce allelopathy, and increase overhead costs, weeds pose a serious threat to wheat production. According to Dangwal *et al.*, 2010 [5], weed affects wheat yields by 10 to 65 percent. The two most important variables that can impact wheat productivity are an ideal nitrogen dosage and timely weed control. Manual weeding is the most popular way to control weeds. But it's expensive and labor-intensive. Moreover, weeds growing within rows remain unchecked. Since labor is scarce and expensive, chemical weed control is the preferable method while mechanical or manual weeding is impractical (Chaudhari *et al.*, 2017) [3]. Because of its small stature and slow early development, chickpea is a poor weed competitor. Depending on the kind and intensity of weed flora and management practices, especially in the earlier growth stage, yield losses might range from 17 to 85% (Singh *et al.*, 2014) [11]. Weed control in chickpea is essential because crop-weed competition is higher at this stage of crop growth (Chouhan *et al.*, 2018) [4]. Growers of chickpeas have seen decreased income in recent years as a result of a severe weed infestation. Furthermore, input prices have increased more quickly than crop prices. The majority of Indian farmers use manual weeding, which is labor-intensive, time-consuming, and increases cultivation costs, in the lack of effective herbicides. You may eliminate early weed competition, lower yield losses, and save production expenses by using the appropriate herbicides. Herbicides are easy to use, economical, selective and with application time flexibility (Hoseiny and Jagannath, 2011) [7]. The current study was carried out to assess the efficacy of several herbicides for the control of various weed species in the wheat-chickpea intercropping system in light of these facts.

Materials and Methods

During the 2020–2021 *Rabi* season, a field experiment was carried out at the Lovely Professional University's School of Agriculture in Phagwara, Punjab. The pH of the sandy loam soil in the experimental field was 8.1. The soil had medium levels of accessible nitrogen (182.27 kg/ha), phosphorus (19.64 kg/ha), and potassium (184.56 kg/ha), with low levels of organic carbon (0.20%). Eight treatments—T_1-Pendimethalin 1000 ml/ha (PE), T_2-Isoproturon 1000 g/ha (PoE), T_3-Cladinofop-propargyl 60 g/ha (PoE), T_4-Pinoxaden 50 g/ha (PoE), T_5-Hand weeding at 60 DAS, T_6-Metribuzin 250 g/ha (PE), T_7-Weedy Check, and T_8-Weed free check were the eight treatments included in the RBD experiment layout. A 2:1 intercropping ratio was used when sowing the wheat variety Unnat-PBW-343 and the chickpea variation GNG-469, with a row-to-row spacing of 30 cm. Herbicides were applied at two to three DAS for pre-emergence and thirty to thirty-five DAS for post-emergence. Herbicides used for pre-emergence were sprayed using a backpack sprayer with a flat fan nozzle, and herbicides used for post-emergence were sprayed using a backpack sprayer with a flood jet nozzle. Several weed species, including *Phalaris minor, Chenopodium album, Rumex acetosella, Melilotus indica, Medicago denticulate, Anagallis arvensis, and Coronopus didymus,* were infesting the experimental field.

Three randomly selected locations were used to set up a 30 × 30 cm quadrate. Weed plants were first removed from the quadrate, cleaned in clean water, and then counted according to species. The weeds were then sun-dried and kept until they attained a consistent weight in an oven set at 65 °C. Weed data was transformed by using √(X+1) for statistical analysis. The corresponding formulas were used to compute the weed index (WI) and weed control efficiency (WCE).

$$\text{WCE (\%)} = \frac{\text{WCC} - \text{WCT}}{\text{WCC}} \times 100$$

Where,
WCC = Dry weight of weeds in the untreated control plot
WCT = Dry weight of weeds in treated plots

$$\text{Weed Index (\%)} = \frac{\text{X} - \text{Y}}{\text{X}} \times 100$$

Where,
X = Grain yield in the weed-free plot (kg ha^{-1})
Y =Grain yield in the treated plot (kg ha^{-1})

Results and Discussion

Effect on weeds density and dry matter: - The data displayed in Tables 1 and 2 demonstrated a significant decrease in species-specific weed density and dry matter, as well as total weed density and total dry matter compared to the weedy check. The weed free check and hand weeding at 60 DAS had the lowest measured weed density and dry matter. The most effective method for controlling the density and dry matter of *Phalaris minor* was pendimethalin 1000 ml/ha (PE), which was followed by cladinofop-propargyl 60 g/ha (PoE) and pinoxaden 50 g/ha (PoE). Pendimethalin 1000 ml/ha (PE) and isoproturon 1000 g/ha (PoE) were the most effective in reducing the density and dry matter of *Chenopodium album* and *Rumex acetosella*. The most effective method for controlling the density and dry matter of *Medicago denticulate* was metribuzin 250 g/ha (PE). The most effective treatments for reducing the density and dry matter of *Melilotus indica, Anagallis arvensis, and Coronopus didymus* were metribuzin 250 g/ha (PE) and pendimethalin 1000 ml/ha (PE). With the exception of *Medicago denticulate*, pendimethalin 1000 ml/ha (PE) proved efficient in controlling all weed species. Pendimethalin 1000 ml/ha (PE) had the lowest overall weed density (59.2 no./m^2) and dry matter (9.2 g/m^2) of all the herbicides, followed by isoproturon 1000 g/ha (PoE) (85.1 no./m^2) (10.4 g/m^2) respectively. However, the weedy check had the highest dry matter and overall weeds density. The findings published by Singh *et al.*, 2015 [12] and Kumar *et al.*, 2014 [9] were quite similar.

Weed control efficiency (%):- The data on weed control efficiency shown in Table 3 revealed that the wheat-chickpea intercropping system with weed-free and hand weeding had the highest weed control efficiency. Pendimethalin 1000 ml/ha (PE) had the highest weed control efficiency 86.9%; among the herbicide treatments while, isoproturon 1000 g/ha (PoE) came in second, at 85.5%. The weedy check has the lowest weed control efficiency. These results coincided with the conclusions stated by Kori *et al.*, 2021 [8] and Merga and Alemu (2019) [10].

Table 1: Effects of different herbicides on weeds density (no. m^{-2})

Treatments	*Phalaris minor*	*Chenopodium album*	*Rumex acetosella*	*Medicago denticulate*	*Melilotus indica*	*Anagallis arvensis*	*Coronopus didymus*	Total weed density
Pendimethalin 1000 ml/ha (PE)	0.0* (1.0)**	0.0 (1.0)	0.0 (1.0)	59.2 (7.8)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	59.2 (7.8)
Isoproturon 1000g/ha (PoE)	37.0 (6.1)	0.0 (1.0)	0.0 (1.0)	37.0 (6.2)	11.1 (3.5)	0.0 (1.0)	0.0 (1.0)	85.1 (9.2)
Cladinofop-propargyl 60 g/ha (PoE)	22.2 (4.7)	18.5 (4.4)	7.4 (2.7)	40.7 (6.4)	14.8 (3.9)	11.1 (3.5)	0.0 (1.0)	114.7 (10.7)
Pinoxaden 50 g/ha (PoE)	22.2 (4.8)	25.9 (4.4)	14.8 (3.9)	44.4 (6.7)	14.8 (3.9)	14.8 (3.9)	14.8 (3.9)	151.7 (12.3)
Hand weeding at 60 DAS	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)
Metribuzin 250 g/ha (PE)	44.4 (6.7)	11.1 (3.1)	3.7 (1.8)	29.6 (5.5)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	88.8 (9.4)
Weedy Check	62.9 (8.0)	37.0 (6.1)	22.2 (4.8)	55.5 (7.5)	40.7 (6.4)	44.4 (6.7)	25.9 (5.2)	288.6 (17.0)
Weed free check	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)
SE(m±)	0.3	0.8	0.4	0.3	0.2	0.2	0.2	0.4
CD (p = 0.05)	1.0	2.3	1.2	0.9	0.6	0.74	0.62	1.1

*Values given are the mean of original values, ** Data subjected to√(X+1) square root transformation

Table 1: Effects of different herbicides on dry matter of weeds (g m^{-2})

Treatments	*Phalaris minor*	*Chenopodium album*	*Rumex acetosella*	*Medicago denticulate*	*Melilotus indica*	*Anagallis arvensis*	*Coronopus didymus*	Total dry matter of weeds
Pendimethalin 1000 ml/ha (PE)	0.0* (1.0)**	0.0 (1.0)	0.0 (1.0)	9.2 (3.2)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	9.2 (3.2)
Isoproturon 1000g/ha (PoE)	7.0 (2.8)	0.0 (1.0)	0.0 (1.0)	6.8 (2.8)	0.7 (1.3)	0.0 (1.0)	0.0 (1.0)	10.4 (3.3)
Cladinofop-propargyl 60 g/ha (PoE)	4.5 (2.3)	6.2 (2.7)	2.6 (1.8)	6.8 (2.8)	1.7 (1.6)	0.6 (1.3)	0.0 (1.0)	22.4 (4.8)
Pinoxaden 50 g/ha (PoE)	4.7 (2.4)	7.9 (2.7)	3.2 (2.0)	9.1 (3.2)	1.9 (1.7)	0.2 (1.1)	0.9 (1.4)	27.9 (5.3)
Hand weeding at 60 DAS	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)
Metribuzin 250 g/ha (PE)	16.4 (4.1)	0.7 (1.3)	0.7 (1.3)	2.5 (1.9)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	24.6 (5.0)
Weedy Check	20.2 (4.6)	8.7 (3.1)	9.0 (3.2)	17.1 (4.3)	12.1 (3.6)	1.8 (1.7)	1.8 (1.7)	70.7 (8.5)
Weed free check	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)
SE(m±)	0.2	0.3	0.2	0.1	0.1	0.0	0.0	0.2
CD (p = 0.05)	0.46	1.00	0.54	0.33	0.20	0.12	0.0	0.71

*Values given are the mean of original values, ** Data subjected to$\sqrt{(X+1)}$ square root transformation

Weed index (%): The weed free check had the lowest weed index of wheat and chickpea, according to data on the weed index of wheat and chickpea shown in Table 3. The herbicide treatments with the lowest weed index in wheat and chickpea were pendimethalin 1000 ml/ha (PE) followed by isoproturon 1000g/ha (PoE). The weedy check had the significantly highest weed index for chickpea and wheat. These results concurred with the Bhoir *et al.*, 2016 [3] conclusion.

Table 3: Weed control efficiency (%) and weed index (%) of different herbicides

Treatments	Weed control efficiency (%)	Weed index (%)	
		Wheat	Chickpea
Pendimethalin 1000 ml/ha (PE)	86.9	10.7	13.8
Isoproturon 1000 g/ha (PoE)	85.5	19.3	37.6
Cladinofop-propargyl 60 g/ha (PoE)	68.3	20.7	44.8
Pinoxaden 50 g/ha (PoE)	60.6	25.1	53.0
Hand weeding at 60 DAS	100	14.6	16.5
Metribuzin 250 g/ha (PE)	65.2	28.4	55.9
Weedy Check	0	29.8	79.4
Weed free check	100	0	0

Conclusions

Based on the results of this experiment, it was determined that the various weed species had significantly dominated the experimental field. These various weed species included *Anagallis arvensis, Coronopus didymus, Medicago denticulate, Phalaris minor, Chenopodium album, Rumex acetosella*, and *Melilotus indica*. The study found that weed-free check and hand weeding had the lowest measured weed density and dry matter compared to weedy check. Pendimethalin 1000 ml/ha (PE) was the most effective method for controlling density and dry matter of Phalaris minor, *Chenopodium album, Rumex acetosella, Melilotus indica, Anagallis arvensis, and Coronopus didymus*, which was followed by the isoproturon 1000 g/ha (PoE). All weed species were efficiently controlled by pendimethalin at a rate of 1000 ml/ha (PE). But, it was unable to manage *Medicago denticulate*, though. The wheat-chickpea intercropping system with weed-free check followed by hand weeding had the highest weed control efficiency and lowest weed index. Among herbicidal treatments, Pendimethalin 1000 ml/ha (PE) had the lowest weed index (%) and the highest weed control efficiency (%). The weedy check had the highest dry matter and overall weeds density, which is consistent with previous findings.

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