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EFFECT OF DIFFERENT WEED CONTROL PRACTICES AND FERTILIZER LEVELS ON THE WEEDS AND GRAIN YIELD OF WHEAT

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Abstract

A field experiment was conducted to assess the effect of different weed control practices and fertilizer levels on weeds and grain yield of wheat in winter 2002-03 and 2003-04. The experiment comprised of four weed control practices of viz., weedy check, pre-emergence application of pendimethalin, post-emergence application of isoproturon + carfentrazone ethyl and manual weed control (two hoeings) and three fertilizer levels viz., 0+ 0, 75 + 50 and 150 + 100 kg N + P_2O_5 ha^{-1}. Manual hoeing resulted in minimum weed density and dry weight in both the years. The maximum grain yield (5816 and 5071 kg ha^{-1}) was recorded in manual hoeing in 2002-03 and 2003-04 respectively mainly due to more number of fertile tillers, number of grains per spike and 100-grain weight. Weed density 40 days after sowing and weed dry weight increased significantly with each increased fertilizer level. The maximum grain yield was recorded with 150 + 100 kg N + P_2O_5 ha^{-1}. Manual weed control and application of 150 + 100 kg N + P_2O_5 ha^{-1} was found to be the best combination for obtaining higher grain yield of wheat.

Introduction

Wheat is the most important cereal crop because it is the staple food of the people of Pakistan. It was cultivated over an area of 8.22 million hectares in 2004-05. The total production was 19.50 million tones with an average grain yield of 2375 kg ha^{-1}. The average yield is lower than potential yield (Anon., 2005). Among various factors responsible for low yield, weed infestation and nutrient management are of supreme importance. Nitrogen and phosphorus are essential for normal growth and development of plants. Application of phosphorus produces primordia for reproductive stage and enhances root development, thus enable wheat to tolerate drought during period of water shortage (Li *et al*., 2003). Nitrogen promotes vegetative growth and photosynthetic activity in wheat and increases the water use efficiency of wheat. But our soils are deficient in these nutrients and we have to apply these nutrients in the form of fertilizers. In Pakistan, nitrogen use efficiency is 40-50% and phosphorus use efficiency is 15-20% (Qureshi & Zia, 1998). Among various causes of low nutrient use efficiency, weed crop competition is of supreme importance. The weeds can deprive the crop about 47% nitrogen, 42% phosphorus and 50% potash of their nutrient uptake (Kumar & Singh, 1998). Cultural, mechanical and chemical methods are commonly used for controlling weeds. Chemical weed control is an important alternative. Herbicides have shown to be beneficial and very effective means of controlling weeds in wheat because they are quite effective and efficient (Azad *et al.*, 1997). Herbicide use reduced the N-uptake in wheat (Azad, 1997) and post-emergence application of isoproturon @ 0.94-1.41 kg ha^{-1} and metoxaron @ 1.40-2.10 kg ha^{-1} increased the nitrogen uptake in wheat by 38.0, 47.3, 51.1 and 58.1% over control. (Walia *et al*., 2000). In view of these contrasting reports the present study was conducted to assess the effect of different weed control practices and fertilizer levels on the weeds and grain yield of wheat.

Materials and Methods

A field experiment to assess the effect of four weed control practices and different fertilizer levels on weeds and grain yield of wheat was conducted at the Agronomic Research Area, University of Agriculture, Faisalabad, Pakistan. The experiment comprised four weed control practices viz., weedy check, pendimethalin @ 1031 g a.i. ha^{-1} (Pre-emergence), isoproturon + carfentrazone ethyl @ 750 g a.i. ha^{-1} (Post-emergence) and manual weed control (2 hoeings) and three fertilizer levels of 0 + 0, 75 + 50 and 150 + 100 kg N + P_2O_5 ha^{-1}. The experiment was laid down in a randomized complete block design with split plot arrangement keeping the fertilizer levels in main plots and weed control practices in sub-plot having a net sub plot size of 1.5 x 5.0 m and it was replicated thrice. The most commonly used wheat variety "Inqlab-91" was used as a test crop. The crop was sown manually in 25 cm apart rows with a single row hand drill using a seed rate of 125 kg ha^{-1} on 7th November 2002 and 14th November 2003, respectively. The nitrogen and phosphorus as per treatment were applied in the form of urea and diammonium phosphate (DAP), respectively. All the phosphorus and half of the nitrogen were side-drilled at sowing time and the remaining half of nitrogen was top dressed at tillering with first irrigation. Pendimethalin was sprayed just after sowing before crop emergence while isoproturon + carfentrazone ethyl were sprayed after the first irrigation using a T-jet nozzle fitted knapsack sprayer after calibrating the volume of water. In manual weed control, two hoeings 20 and 40 days after sowing were performed. Data on weed density, weed dry weight, yield components and grain yield of wheat were recorded following standard procedure. The data collected was analyzed statistically using Fisher's analysis of variance technique. The Least Significance Difference (LSD) test at 5% probability level was used to compare the treatments' means following Steel *et al*., (1997).

Results

Total weed density was significantly affected by different weed control practices (Table 1). In 2002-03 the maximum density (76.76 m^{-2}) was recorded in weedy check (W_1) against the minimum (6.00 m^{-2}) in manual hoeing (W_4) which resulted in 70.67% control over weed check. Fertilizer levels also significantly affected the total weed density. The maximum (29.25 m^{-2}) was recorded at 150 + 100 kg N and P_2O_5 ha^{-1} against the minimum (24.00 m^{-2}) in control where no fertilizer was applied in 2002-03. Similar trend was followed in second year. The interaction between weed control practices and fertilizer levels was also significant in both the years. In 2002-03 the maximum weed density (88.00 m^{-2}) was recorded in weedy check at 150 + 100 kg N and P_2O_5 ha^{-1} (W_1 x F_2) against the minimum (5.00 m^{-2}) in manual hoeing at 75 + 50 kg N and P_2O_5 ha^{-1} (W_4 x F_1). In 2003-04 the maximum density (99.00 m^{-2}) was recorded in weedy check at 150 + 100 kg N and P_2O_5 ha^{-1} (W_1 x F_2). The minimum weed density was recorded in manual hoeing at 150 + 100 kg N and P_2O_5 ha^{-1} (W_4 x F_2) but was statistically at par with manual hoeing at 75 + 50 kg N and P_2O_5 ha^{-1} (W_4 x F_1) and manual hoeing without fertilizer application (W_4 x F_0). At each fertilizer level weedy check (W_1) resulted in maximum weed density against the minimum in manual hoeing (W_4) however, both the herbicide treatments (W_2 and W_3) resulted in statistically similar weed density.

Table 1. Effect of different weed control practices and fertilizer levels on weed density (m^{-2}) 40 DAS and grain yield of wheat (kg ha^{-1}).

Treatments	Weed density 40 DAS				Grain yield (kg ha^{-1})			
	2002-03		2003-04		2002-03		2003-04	
		% decrease over weedy check		% decrease over weedy check		% decrease over weedy check		% decrease over weedy check
	Weed control practices							
W_1 = Weedy check	76.67 a		83.67a		4963 d		4485 c	
W_2 = Pendimethalin (Pre-Em.) @ 1031 ml a.i. ha^{-1}	11.0 b	85.65	10.67b	87.24	5372 c	8.22	4840 b	7.90
W_3 = isoproturon + carfentrazone ethyl (Post-Em) @ 750 g a.i. ha^{-1}	13.33 b	82.61	10.67b	87.24	5584 b	12.49	4976 a	10.94
W_4 = Manual hoeing (Two)	6.00 c	70.67	5.00 c	94.02	5816 a	17.18	5071 a	13.05
LSD = 0.05	3.209		2.307		90.16		99.04	
	Fertilizer levels (kg N and P_2O_5 ha^{-1})							
F_0=0 + 0	24.00 c		23.50 c		4220 c		3870 c	
F1 = 75 + 50	27.00 b		28.00 b		5305 b		4869 b	
F2 =150 +100	29.25 a		31.00 a		6776 a		5791 a	
LSD = 0.05	0.8867		2.913		94.46		89.61	
	Interaction							
W_1 x F_0	64.00 c		66.00 c		3865 k		3568	
W_2 x F_0	11.00 def		13.00 d		4065 j		3856	
W_3 x F_0	14.00 d		10.00 de		4365 i		3965	
W_4 x F_0	7.00 efg		5.00 f		4586 h		4089	
W_1 x F_1	78.00 b		86.00 b		4892 g		4566	
W_2 x F_1	12.00 de		10.00 de		5298 f		4866	
W_3 x F_1	13.00 d		11.00 de		5432 f		4978	
W_4 x F_1	5.00 h		5.00 f		5598 e		5065	
W_1 x F_2	88.00 a		99.00 a		6133 d		5322	
W_2 x F_2	10.00 defg		9.00 e		6752 c		5798	
W_3 x F_2	13.00 d		11.00 de		6954 b		5986	
W_4 x F_2	6.00 fg		5.00 f		7265 a		6059	
LSD = 0.05	*5.0558*		*3.995*		156.9		NS	

Any two means not sharing a letter in common different at 5% probability level
DAS = Days after sowing

The effect of different weed control practices on dry weight of weeds 40 days after sowing was significant (Table 2). All weed control practices produced significantly lower dry weight of weeds and minimum dry weight was recorded in manual hoeing (W_4). The effect of fertilizers on total weight was also significant in both the years. The maximum and minimum was recorded at 150 + 100 kg N and P_2O_5 ha^{-1} (F_2) and control without fertilizer application (F_0), respectively.

The interaction between weed control practices and fertilizer levels was significant for both the years. In 2002-03 the maximum dry weight (30.64 g m^{-2}) was recorded in weedy check at 150 + 100 kg N and P_2O_5 ha^{-1} (W_1 x F_2) whereas the minimum (0.85 gm^{-2}) was recorded in manual hoeing without fertilizer application (W_4 x F_0). The difference between pre-emergence application of pendimethalin (W_2) and post-emergence application of isoproturon + carfentrazone ethyl (W_3) produced statistically similar dry weight at 0 + 0 (F_0) and 75 + 50 kg N and P_2O_5 ha^{-1} (F_1), however, at 150 + 100 kg N and P_2O_5 ha^{-1} (F_2) post-emergence application of isoproturon + carfentrazone ethyl (W_3) resulted in higher dry weight than pre-emergence application of pendimethalin (W_2).

The effect of weed control practices on total weed density was significant in both the years (Table 3). In 2002-03 the weedy check (W_1) resulted in significantly maximum weed density at harvest. It was followed by post-emergence application of isoproturon + carfentrazone ethyl (W_2) which gave 66.94% control over weedy check and was statistically at par with pre-emergence application of pendimethalin (W_2). Manual hoeing resulted in significantly minimum weed density (82.42% control over weedy check) In 2003-04 the maximum density was recorded in weedy check (W_1) against the minimum in manual hoeing (W_4) which was statistically at par with both herbicidal treatments. The effect of different fertilizer levels on weed density at harvest was non-significant.

The effect of different weed control practices on total weed dry weight was significant in both the years (Table 2). Significantly maximum dry weight of weeds was recorded in weedy check (W_1) against the significantly minimum in manual hoeing (W_4). The effect of fertilizer levels on total weed dry weight was also significant in both the years. Weed dry weight increased significantly with each increased fertilizer level and the maximum dry weight was recorded with application of 150 + 100 kg N and P_2O_5 ha^{-1} (F_2). The interaction between weed control practices and fertilizer levels was significant in 2003-04 and was non-significant in 2002-03. The significantly maximum dry weight (287.64 gm^{-2}) was recorded in weedy check at 150 + 100 kg N and P_2O_5 ha^{-1} (W_1 x F_2) against the minimum (43.16 gm^{-2}) in manual hoeing with out fertilizer application (W_4 x F_0). The differences between herbicide application treatments (W_2 & W_3) were non-significant at all fertilizer levels. Weedy check resulted in significantly maximum dry weight than all other weed control treatments at all fertilizer levels.

The effect of different weed control practices on number of fertile tillers was non-significant in both the years (Table 3). Different fertilizer levels however, significantly affected the number of fertile tillers. The application of fertilizer resulted in significantly higher number of fertile tillers over control where no fertilizer was applied. The increase in fertilizer level from 75 + 50 kg N + P_2O_5 ha^{-1} to 150 + 100 kg N + P_2O_5 ha^{-1} could not reach to level of significance in both the years. The interaction between weed management practices and fertilizer levels was non-significant in both the years.

Table 2. Effect of different weed control practices and fertilizer levels on dry weight of weed (gm^{-2}) 40 DAS, dry weight of weeds at harvest and number of grains per spike.

Treatments	Dry weight of weeds 40DAS		Dry weight of weeds at harvest		Number of grains per spike	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
	Weed control practices					
W_1 = Weedy check	22.07 a	22.90 a	233.92 a	242.86 a	48.26 c	46.63 c
W_2 = Pendimethalin (Pre-Em.) @ 1031 ml a.i. ha^{-1}	3.00 b	3.17 b	86.76 b	71.03 b	49.87 b	48.33 b
W_3 = isoproturon + carfentrazone ethyl (Post-Em) @ 750 g a.i. ha^{-1}	3.60 b	3.38 b	92.59 b	72.21 b	49.71 b	48.62 b
W_4 = Manual hoeing (Two)	1.42 c	1.26 c	59.74 b	46.33 b	52.51 a	49.43 a
LSD = 0.05	0.9884	1.061	26.11	26.30	0.4283	0.4396
	Fertilizer levels (kg N and P_2O_5 ha^{-1})					
F_0 =0 + 0	4.89 c	5.13 c	103.42 b	94.58 c	45.50 c	44.48 c
F1 = 75 + 50	7.61 b	7.63 b	121.59 a	108.32 b	51.32 b	49.52 b
F2 =150 +100	10.07 a	10.26 a	129.76 a	121.42 a	53.44 a	50.76 a
LSD = 0.05	0.2090	1.403	14.99	12.39	0.3759	0.7721
	Interaction					
W_1 x F_0	13.48 c	14.67 c	197.58	214.47 b	41.77 i	40.70 f
W_2 x F_0	2.09 ef	2.60 def	71.74	52.67 cd	46.20 g	45.40 e
W_3 x F_0	3.16 de	2.50 defg	81.94	68.03 cd	45.33 h	45.20 e
W_4 x F_0	0.85 f	0.74 g	62.42	43.16 d	48.70 f	46.63 d
W_1 x F_1	22.10 b	22.29 b	232.56	226.47 b	49.90 e	48.63 c
W_2 x F_1	3.55 de	3.41 de	100.67	83.74 c	51.17 d	49.13 c
W_3 x F_1	3.59 de	3.62 de	98.42	77.58 cd	51.43 d	49.97 b
W_4 x F_1	1.22 f	1.22 fg	54.74	45.51 d	52.77 bc	50.37 b
W_1 x F_2	30.64 a	31.73 a	271.66	287.64 a	53.10 b	50.57 ab
W_2 x F_2	3.37 e	3.50 de	87.89	76.68 cd	52.23 c	50.47 b
W_3 x F_2	4.05 d	4.01 d	97.42	71.04 cd	52.37 bc	50.70 ab
W_4 x F_2	2.21 ef	1.81 efg	62.06	50.34 cd	56.07 a	51.30 a
LSD = 0.05	1.712	1.837	NS	34.47	0.7418	0.7614

Any two means not sharing a letter in common different at 5% probability level
DAS = Days after sowing

Table 3. Effect of different weed control practices and fertilizer levels on weed density (m^{-2}) at harvest, fertile tillers (m^{-2}) and 1000-grain weight (g).

Treatments	Weed density at harvest				No of Fertile tillers		1000-grain weight	
	2002-03		2003-04					
		% decrease over weedy check		% decrease over weedy check	2002-03	2003-04	2002-03	2003-04
	Weed control practices							
W_1 = Weedy check	221.78 a		231.67 a		400.33	400.33	40.56 d	41.60 c
W_2 = Pendimethalin (Pre-Em.) @ 1031 ml a.i. ha^{-1}	68.22 b	69.24	53.11 b	77.08	402.22	403.44	43.07 c	43.99 b
W_3 = isoproturon + carfentrazone ethyl (Post-Em) @ 750 g a.i. ha^{-1}	73.33 b	66.94	55.89 b	75.88	404.11	403.44	43.81 b	43.85 b
W_4 = Manual hoeing (Two)	39.00 c	82.42	32.22 b	86.09	405.56	403.89	45.17 a	45.89 a
LSD = 0.05	22.69		26.60		NS	NS	0.3745	0.6982
	Fertilizer levels (kg N and P_2O_5 ha^{-1})							
F_0 =0 + 0	97.50		87.50		394.3 b	397.00 b	37.05 c	38.08 c
F1 = 75 + 50	104.92		97.75		405.6 a	405.30 a	43.87 b	43.82 b
F2 =150 +100	99.33		94.42		409.3 a	406.00 a	48.54 a	49.59 a
LSD = 0.05	NS		NS		7.980	3.687	0.2845	2.214

Any two means not sharing a letter in common different at 5% probability level
DAS = Days after sowing

Effect of different weed control practices on number of grains per spike of wheat was significant in both the years (Table 2). All weed control practices produced significantly higher number of grains over weedy check (W_1) and maximum were produced by manual hoeing (W_4). Number of grains per spike of wheat were affected significantly by different fertilizer levels. The maximum number of grains per spike were recorded in 150 + 100 kg N and P_2O_5 ha^{-1} (F_2) against minimum in control where no fertilizer was applied (F_0). The interaction between weed control practices and fertilizer levels was also significant in both the years. In 2002-03 the maximum number of grains per spike (56.07) were recorded in manual hoeing at 150 + 100 kg N and P_2O_5 ha^{-1} (W_4 x F_2) against the minimum (41.77) in weedy check without fertilizer application (W_1 x F_0). Application of pendimethalin and isoproturon + carfentrazone ethyl as pre and post-emergence resulted in statistically similar number at 75 + 50 and 150 + 100 kg N and P_2O_5 ha^{-1} but in plots where no fertilizer was applied pre-emergence application (W_2) resulted in significantly higher number of grains per spike than isoproturon + carfentrazone ethyl (W_3). Similarly weedy check resulted in significantly lower number of grains in control (no fertilizer) and 75 + 50 kg N and P_2O_5 ha^{-1} (F_1). Whereas at 150 + 100 kg N and P_2O_5 ha^{-1} (F_2) weedy check (W_1) produced significantly higher number of grains than pre-emergence application of pendimethalin (W_2). Similar trend was recorded in 2003-04.

The effect of different weed control practices was significant in both the years (Table 3). In 2002-03 the significantly maximum grain weight (45.17 g) was recorded at manual hoeing (W_4) against the minimum (40.56 g) in weedy check (W_1). Similar trend was observed in second year. Different fertilizer levels also affected the 1000-grain weight significantly. Significantly minimum grain weight was recorded in plots where no fertilizer was applied. Application of fertilizer increased 1000-grain weight significantly with each increase in fertilizer level and 150 + 100 kg N+ P_2O_5 ha^{-1} resulted in maximum grain weight. The interaction between weed control practices and fertilizer levels was non-significant in both the years.

The effect of different weed control practices and fertilizer levels on grain yield of wheat was highly significant in both the years (Table 1). The interaction between weed control practices and fertilizer levels was significant in 2002-03and non-significant in 2003-04. In 2002-03 the maximum grain yield (7265 kg ha^{-1}) was obtained with manual hoeing at 150 + 100 kg N + P_2O_5 ha^{-1} (W_4 x F_2) whereas the minimum (3865 kg ha^{-1}) was obtained in weedy check with out fertilizer application (W_1 x F_0). At each fertilizer level all weed control practices produced higher grain yield than weedy check (W_1) and the maximum grain yield was obtained in manual hoeing (W_4). Post emergence application of isoproturon + carfentrazone ethyl produced higher grain yield than pre-emergence application of pendimethalin at all fertilizer levels except at 75 + 50 kg N + P_2O_5 ha^{-1} where, both these weed control practices resulted in statistically similar grain yield.

Discussion

Decrease in weed density with weed control practices can be attributed to mortality of weed with herbicides application and manual hoeing. The results are in line with Sharma & Chander (1996) and Anil & Bhan (1998) who had reported higher weed density in weedy check. Increase in fertilizer enhanced the availability of nutrients resulting in higher weed population. The results are in line with those of Das & Yaduraju

(1999) and Panwar *et al*., (2000) who reported significant increase in weed density with increased fertilizer levels. The results are, however, in contrast with those of Toth (1999) who reported decrease in weed density with increased fertilizer level. This contradiction in results can be attributed to difference in fertility status of soil.

Higher weed density and better plant growth had increased the total dry weight of weeds. Application of herbicide and manual hoeing not only reduced the density of weeds but also suppressed the weed growth resulting in lower dry weight. These findings support previous findings of Hooda & Agrawal (1991, 1995) and Das & Yaduraju (1999) who reported maximum dry weight in weedy check. Lower weed dry weight in plots where no fertilizer was applied can be attributed to low fertilizer nutrients. Increase in weed dry weight with increased fertilizer level might be due to more nutrient uptake, better growth and higher density and fresh weight. The results are in line with those of Azad & Singh (1997) and Das & Yaduraju (1999) who had also reported an increase in dry weight with fertilizer application.

A maximum weed density in weedy check can be attributed to unchecked growth, while application of herbicide or hoeing caused mortality of weed resulting in lower weed density at harvest. A maximum weed density in weedy check has also been reported by Hooda & Agrawal (1995) and Khan *et al*., (2004). Unavailability of nutrients in control and suppression by well developed wheat plants resulted in similar weed density. The results are different from those of Hooda & Agrawal (1995) who reported increase in weed density with fertilizer application.

Higher dry weight of *Chenopodium mural* in weedy check might be due to more density and unsuppressed growth of *C. mural.* The results are in line with those of Hooda & Agrawal (1991, 1995) who had also reported maximum dry weight of weeds in weedy check. Increase in the dry weight with fertilizer application can be attributed to more density of *C. mural* and better growth due to availability of nutrients. Azad & Singh (1997) and Akhtar *et al*., (2002) had also reported higher dry weight of weeds at higher fertilizer level.

Lower number of fertile tillers in weedy check treatment can be attributed to higher weed density which increased competition for nutrients and other resources. Higher number of fertile tillers could be due to less number of weeds and lower competition which led to favourable environmental conditions and greater availability of essential nutrients resulting in increased fertile tillers. The results are in line with those of Das & Yaduraju (1999) and Anwar *et al*., (2003) who reported higher number of fertile tillers with herbicide application and manual hoeing. Increase in number of fertile tillers with fertilizer application might have been due to better nutrition which resulted in better plant growth which resulted in more number of fertile tillers. The results are in accordance with those of RonGen *et al*., (1999). Chaudhry & Mehmood (1998) and Abid *et al*., (2002) who reported significant increase in number of fertile tillers with increased fertilizer application.

Lower number of grains per spike can be attributed to lower spike length in weedy check treatment. Similar results have also been reported by Das & Yaduraju (1999) and Pandey & Verma (2002). Increase in number of grains per spike can be attributed to availability of nutrients and greater spike length of wheat. The results are in line with those of RonGen *et al*., (1996) who reported significant increase in number of grains with increased fertilizer level.

The probable reason for higher grain weight in plots where weed control practice was carried out was due to lower weed density which reduced the competition between wheat plants and weeds for nutrients, light, moisture and space relating in maximized utilization of resources by crop plants. Pandey & Verma (2002) have also reported lower 1000-grain weight in weedy check. Availability of nutrients and better plant growth might be the reason for heavier grains in high fertilizer levels. Increase in 1000-grain weight with increased fertilizer application had also been reported by Singh *et al*., (1998) and Chaudhry & Mehmood (1996).

Lower grain yield in weedy check treatment was mainly due to the lower number of grains per spike, 1000-grain weight and fertile tillers. Significantly lower grain yield in weedy check over chemical and non-chemical weed control had also been reported by Das & Yaduraju (1999). More grain yield with higher fertilizer application was probably due to more nutrients up take by wheat which resulted in better growth and development of crop plants. Thus more number of grains per spike and 1000-garin weight was produced that contributed to higher grain yield. Significantly higher grain yield of wheat due to fertilizer application had also been reported by Singh *et al*., (1998), Akhtar *et al*., (2002) and Abid *et al*., (2002).

Based upon the present studies it can be concluded that manual hoeing gave best weed control (86.09%) and maximum grain yield (5816 kg ha^{-1}). Application of 150 + 100 kg N + P_2O_5 ha^{-1} resulted in significantly higher grain yield (6776 kg ha^{-1}).

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