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EFFECT OF WEED MANAGEMENT AT VARIOUS GROWTH STAGES ON THE YIELD AND YIELD COMPONENTS OF WHEAT (*TRITICUM AESTIVUM* L.)

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ABSTRACT

Field study was conducted to evaluate the effect of weed management at various growth stages on the yield and yield components of wheat, at Malkandher Research Farm, NWFP Agricultural University Peshawar, Pakistan, during 1998-99. Total number of productive and unproductive tillers were non-significantly affected by weed management methods and stages of growth, while their interaction had significant effect on these parameters. Highest spike length (12.35 cm), number of grains spike^{-1} (53.37) and spikelets spike^{-1} (19.20) were recorded when weeds were controlled at 2-5 leaf to boot stage of wheat crop. Spike length was significantly increased at 2-5 leaf stage of weed control. Thousand grains weight (g), harvest index and grain yield (t ha^{-1}) were also significantly increased by all stages of weed management. Highest harvest index (33.75 %) and grain yield (3.28 t ha^{-1}) were recorded when weeds were controlled at 2-5 leaf stage.

Key words: Wheat, weed management, growth stages, yield, yield components

INTRODUCTION

Being a major source of nourishment, wheat ranks first as a staple food item in Pakistani diet. It is a major source of carbohydrates and contains an important substance "glutin" which increases its utility for baking products. Despite extensive research and continuous efforts by agricultural scientists over the last few decades, per unit area production is not upto the potential yield, to bridge the gap between the actual and potential yield. One of the main reasons for low production is weed infestation of the wheat crop, thus resulting in failure to get maximum advantage of resources. Several reports address the importance of weed control and method of weed control at different stages of wheat crop and weeds. Methods of weed management significantly affected the total number of tillers, 1000 grain weight and harvest index (Tanji and Regehr, 1989, Singh et al., 1989, Fang and Wang,1990). Grain yield could be significantly affected by growth stages of wheat (Sharma et al. 1991). Application of herbicides 30 days after sowing was most effective in decreasing dry matter of weeds and increasing grain yield, while effectiveness of herbicides decreased with a delay in their application (Prasad, 1985). Isoproturon and manual weeding were superior to metoxuron for weed control (Thakur and Singh, 1989) and Malik et al. (1993). Jarwar et al. (1999) observed that chemical weed control method was also effective along with cultural methods of weed control. However, an integration of chemical, cultural and hand weeding (mechanical) control methods was more effective in controlling weeds than their isolated applications (Rao, 1983). While, Sabir (1990) found that hand weeding treatments gave maximum increase in the yield of wheat, whereas skip row sowing gave the lowest yield. Balyan et al. (1992) reported that herbicide application at 30 DAS gave highest grain yield in wheat. Similarly, Khan et al. (2002) reported that herbicidal application at 45 DAS gave greater grain yield of wheat. Weeds were efficiently controlled at the 2 leaves stage of the wheat crop as compared to 6 leaves stage (Agenbag and Crous, 1999).

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In order to study the effect of weed control on the yield of wheat at different stages of wheat, the present experiment was carried out to investigate the best method of weed control at different stages of wheat.

MATERIALS AND METHODS

An experiment was laid out to study the effect of different weed management methods on the yield and yield components of wheat at Malkandher Agricultural Research Farm, NWFP Agricultural University Peshawar, Pakistan during 1998-99. The experiment was laid out in Randomized Complete Block (RCB) design, replicated four times with a plot size of 4 x 4 m^2. Recommended dose of nitrogen and phosphorus was applied in the form of urea and diammonium phosphate. The following weed management practices at different growth stages were adopted.

A. Weed management practices

1. Mowing 2. Hoeing 3. Interculture 4. Chemical (Tribunil @2.5 L ha^{-1}) 5. Weedy check

B. Growth stages of wheat

1. 2-4 leaf stage 2. 4 leaf to boot stage
3 Boot to flowering stage 4. Soft dough grain to maturing stage

During the course of studies, the data were recorded on Weed count $unit^{-1}$ area (15x15 cm^2), number of tillers m^{-2}, number of productive tillers m^{-2}, number of unproductive tillers m^{-2}, spike length (cm), number of spikelets $spike^{-1}$, number of grains $spike^{-1}$, spike weight (g), thousand grain weight (g), harvest index (%) and grain yield (t ha^{-1}).

The data collected were analyzed by subjecting to the ANOVA technique and subsequently the significant means were separated by the Least Significant Differences (LSD) test (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Weeds count $unit^{-1}$ area (15x15 cm^2)

Data in Table 1 indicated that weeds density $unit^{-1}$ area at 2-5 leaf stages was in the range of 13-15 weeds. After the application of weed control methods, 85% reduction in the number of weeds was achieved with Tribunil at the rate of 2.5 liter ha^{-1}, followed by mowing with 78% weeds control. While interculturing and hoeing controlled 73 and 67 % of weeds when compared with control plots. At 4 leaf to boot stage, maximum reduction in weeds (78 %) was achieved with hoeing followed by mowing. Interculture and chemical control had 54 and 43 % reduction in weeds population, respectively. At boot to flowering stage, hoeing reduced weed population by 82 % while mowing 70 %. In contrast, in weedy check plots, there was an increase (25 %) in weed growth. This may be due to the reason that grown up plants could not be easily checked with chemical treatment while their up rooting by hoeing was most effective. At soft dough grain to maturity stage control plots were infested with 40 % more weeds and recorded 58, 57, 36 and 30 % reduction in number of weeds $unit^{-1}$ area by mowing, hoeing, interculture and chemical methods, respectively. The possible reason for this reduction in weed population due to mowing and hoeing could be that plants were totally up rooted. Similar results were reported by Hashim et al, (2002). They reported that maximum weeds density was recorded in weedy check plots.

Number of tillers m^{-2}

Data concerning number of tillers m^{-2} is shown in Table 2. Statistical analysis of the data revealed that the effect of growth stages and methods of weed management had non-significant effect on number of tillers m^{-2}, while their interaction was significant. However it can be inferred from the data shown in table 2 that highest number (398) of tillers m^{-2} were produced in the interaction of interculture x S1 (soft dough grain to maturity). While the lowest (349) tillers m^{-2} were recorded at soft dough grain to maturity stage in the control plots. Similar results were also reported by Tangi and Regehr (1988) who reported that grain and straw yield increased by an average of 100 and 28

%, respectively in early herbicidal treated plots and 44 & 10 %, respectively in late herbicidal treated plots as compared to unweeded control plots.

Table 1. Weed count unit area^{-1} (15x15 cm^2) as affected by weed management methods at various growth stages of wheat.

Treatments	Stage 1			Stage 2			Stage 3			Stage 4		
	Bef.	Aft.	% (+/-)	Bef.	Aft.	% (+/-)	Bef.	Aft.	% (+/-)	Bef.	Aft.	%(+/-)
Mowing	14	3.0	-78	16	5.0	-68	20	6.0	-70	15	6.3	-58
Hoeing	13	4.2	-67	17	3.6	-78	19	4.0	-78	14	6.0	-57
Interculture	15	4.0	-73	16	7.3	-54	21	9.5	-54	13	8.3	-36
Tribunil	14	2.0	-85	17	6.2	-43	20	9.0	-52	14	9.7	-30
Weedy check	15	20.0	+33	18	24.0	+33	21	27.0	+28	20	24.5	+22

Bef. = Before Aft. = After % (+/-) = % increase(+)/% decrease (-)

Stage 1 = 2-5 leaf stages Stage 2 = 4 leaf to boot stage
Stage 3 = Boot to flowering stage Stage 4 = Soft dough grain to maturity stage

Table 2. Number of tillers m^{-2} as affected by weed management methods at various growth stages of wheat.

Method of weed management	Stages of growth of wheat				Mean
	Stage 1	Stage 2	Stage 3	Stage4	
Weedy check	350.00 ef	351.00 ef	355.00 ef	349.00 f	351.30
Mowing	384.30 ab	384.80 abc	371.30 bcd	381.30 abc	379.60
Hoeing	377.80 abc	365.80 cde	360.80 def	385.50 ab	372.50
Interculture	379.30 abc	379.00 abc	380.00 abc	389.00 a	381.80
Tribunil	384.00 ab	380.50 abc	377.80 abc	351.30 ef	373.40
Mean	375.10	371.60	369.00	371.30	

LSD value at 5 % for S x M = 61.14

Number of productive tillers m^{-2}

It is clear from Table 3 that different growth stages and methods of weed management had non-significant while their interaction had significant effect on number of productive tillers plant^{-1}. Maximum number (384.39) of productive tillers m^{-2} were recorded in the interaction of Interculture x 2 leaf stage (S1) while minimum (333.00) of productive tillers m^{-2} were recorded in interaction of weedy check x S1 (soft dough grain to maturing stage). The logic behind significant interaction could be the various control techniques that affected weed population and their growth was checked thereby diverting nutrients and moisture channel towards the development of wheat (culm), fully utilizing solar radiation and converting assimilates into various food components for vigorous growth of wheat. These observations are supported by Singh et al. (1988).

Number of unproductive tillers m^{-2}

Statistical analysis of the data showed that various growth stages and weed management had non significant, while their interaction had significant effect on number of unproductive tillers m^{-2} (Table 4). Highest number (16.00) of unproductive tillers m^{-2} were recorded in the interaction of control plots x S4 (soft dough grain to maturity stage) while the lowest (4.75) unproductive tillers m^{-2} were observed in the interaction of interculture and soft dough grain to maturity stage (S4).

Table 3. Number of productive tillers m^{-2} as affected by weed management methods at various growth stages of wheat.

Method of weed management	Stages of wheat growth				Mean
	Stage 1	Stage 2	Stage 3	Stage 4	
Weedy check	338.00 de	338.00 de	340.00 de	333.00 e	337.30
Mowing	377.80 ab	374.80 ab	362.30 bc	374.80 ab	372.40
Hoeing	372.00 ab	359.00 bc	353.00 cd	380.30 a	366.10
Interculture	371.50 abc	370.80 abc	336.80 de	384.30 a	365.80
Tribunil	378.00 a	374.00 ab	367.30 abc	337.30 de	364 10
Mean	367 5	363.30	351.90	361.90	

LSD value at 5 % for S x M = 18.89

Man followed by different letters are significantly different each other at ($P \leq 0.05$)

Table 4. Number of non-productive tillers m^{-2} as affected by weed management methods at various growth stages of wheat.

Method of weed management	Stages of growth of wheat				Mean
	Stage 1	Stage 2	Stage 3	Stage 4	
Weedy check	12.00 bcd	13.00 ABC	15.00 AB	16.00 A	14.00
Mowing	6.50 ef	6.50 EF	9.00 DE	6.50 EF	7.12
Hoeing	5.75 ef	6.50 EF	7.75 EF	5.50 EF	6 37
Interculture	7.75 ef	8.25 DEF	9.25 CDE	4.75 F	7.50
Tribunil	6 00 ef	6.50 EF	7.50 EF	14.00 AB	8.50
Mean	7.60	8.15	9.70	9.35	

LSD value at 5 % for S x M = 3.757

Spike length (cm)

Statistical analysis of the data showed that different growth stages had significantly affected spike length (Table 5). It can be seen from the data presented in Table 5 that maximum spike length (12.35 cm) was recorded at 4 leaf to boot stage (S2), while the other stages were at par with each other. This increase in spike length at 4 leaf stage to boot stage and weeds controlled fully at this stage supported wheat crop to utilize nutrients, moisture, space and solar energy resulted in increased spike length. Weed control techniques with spike length in the range of 10.30 to 10.52 cm, were recorded in mowing, hoeing and interculturing plots, respectively. When interaction was taken into account, control methods x stages of wheat growth were significant. It is clear from the data that longer spikes of 11.53 cm were recorded in the interaction of soft dough grain to maturity (S4) x mowing. The lowest spike length of 9.00 cm was noted in the interaction of S4 (soft dough grain to maturity) x control plot. Similar results were reported by Fang and Wang (1990). They reported that weeds affected the yield of wheat mainly through reducing spike length.

Number of spikelets $spike^{-1}$

Analysis of the data revealed that all stages of wheat growth had significantly affected spikelets $spike^{-1}$. It can be inferred from Table 6 that highest number of spikelets $spike^{-1}$ were recorded when weeds were controlled at soft dough grain to maturity stage (S4), while the other stages of wheat growth were almost at par with each other. The possible reason may be that weeds were controlled and the food materials were spared for the growth and development of wheat crop, which resulted in increased number of spiklets $spike^{-1}$. Similar results were also reported by Fang and Wang (1990), who investigated that weeds affected the yield of wheat mainly by spikelets number and seed setting.

Table 5. Spike length (cm) as affected by weed management methods at various growth stages of wheat.

Method of weed management	Stages of growth of wheat				Mean
	Stage 1	Stage 2	Stage 3	Stage 4	
Weedy check	9.98 c-h	9.15 gh	9.16 gh	9.00 h	9.32
Mowing	9.72 d-h	9.98 c-h	9.99 c-h	11.53 a	10.30
Hoeing	10.49 b-e	9.84 c-g	9.64 e-h	10.55 a-e	10.13
Interculture	10.72 a-e	10.16 b-g	10.14 b-g	11.09 ab	10.52
Tribunill	10.81 abc	10.28 b-f	9.80 c-h	9.32 fgh	9.80
Mean	10.34 b	12.35 a	9.74 B	10.29 b	

LSD value at 5 % for S x M = 1.016
LSD value at 5 % for Stages = 0.9088

Table 6. Number of spikelets spike^{-1} as affected by weed management methods at various growth stages of wheat.

Method of weed management	Stages of growth of whea*				Mean
	Stage 1	Stage 2	Stage 3	Stage 4	
Weedy check	19.00	18.00	18.00	18.00	18.25
Mowing	20.00	18.75	18.50	20.75	19.50
Hoeing	22.75	19.75	19.25	21.25	20.12
Interculture	19.25	19.25	18.75	21.50	19.68
Tribunill	20.25	20.25	18.75	18.25	19.37
Mean	19.75 a	19.20 a	18.65 a	20.00 a	

LSD value at 5 % for Stages =1.675
Mean followed by different letters are significantly different each other at P ≤ 0.05

Number of grains spike^{-1}

Data regarding number of grains spike^{-1} are presented in Table 7. Statistical analysis of the data showed that growth stages had significantly affected grains spike^{-1}. The highest (55.94) grains spike^{-1} were recorded at soft dough grain to maturity stage (S4) when compared with the other growth stages. Weed control methods were non significant while the interaction between growth stages and weed control methods were significant. It can be inferred from the data that maximum (62.59) grains spike^{-1} were recorded in the interaction of S4 (soft dough grains to maturity stage) x mowing. The minimum (43.51) grains spike^{-1} were recorded in the interaction of 4 leaf to boot stage (S2) x control plot. Similar results were reported by Khan et al, (2002). They reported that weed control did not affect the number of grains spike^{-1}.

Table 7. Grains spike^{-1} as affected by weed management methods at various growth stages of wheat.

Method of weed management	Stages of growth of wheat				Mean
	Stage 1	Stage 2	Stage 3	Stage 4	
Weedy check	50.16 g-j	43.51 k	48.00 ijk	47.24 jk	48.47
Mowing	54.26 f-h	54.25 c-h	52.98 e-j	62.59 a	56.02
Hoeing	55.91 b-g	53.87 d-i	51.97 f-j	59.88 abc	55.40
Interculture	59.35 a-d	56.83 a-f	54.59 c-g	61.51 ab	58.07
Tribunil	58.12 a-e	55.19 c-g	55.28 c-g	48.48 H-K	54.25
Mean	55.56 a	53.37 a	52.56 a	55.94 a	

LSD value at 5 % for S x M = 5.880
LSD value at 5 % for Stages =5.260

Spike weight (g)

Table 8 presents data regarding ear (spike) weight. Analysis of the data showed that all stages of wheat growth had significantly affected spike weight of wheat plant. Weed control methods and their interaction with different growth stages were non significant. However mean value of the data revealed that heavier spikes (3.10 g) were recorded when weeds were controlled at 2-5 leaf stages and lighter spikes (2.47 g) were noted when weeds were controlled at boot to flowering stage. This

clear that weeds during their early growth periods were fully checked or suppressed to some extant and thus available resources were utilized by wheat crop without any competition which resulted in increased ear weight when compared to other stages of growth.

Table 8. Ear weight (g) as affected by weed management methods at various growth stages of wheat.

Method of weed management	Stages of growth of wheat				Mean
	Stage 1	Stage 2	Stage 3	Stage 4	
Weedy check	2.97	2.55	2.31	2.11	2.48
Mowing	3.15	2.95	2.10	3.23	2.85
Hoeing	3.08	2.72	2.44	3.20	2.86
Interculture	3.13	3.14	2.50	3.10	2.99
Tribunil	3.18	3.08	3.02	2.48	2.94
Mean	3.10 A	2.88 AB	2.47 B	2.84 AB	

LSD value at 5 % for Stages =0.5755

1000-grains weight (g)

Data regarding 1000 grains weight revealed that different weed control methods had significantly affected 1000 grains weight (Table 9). Maximum (51.88 and 51.83 g) 1000 grains weight was observed in mowing and hoeing plots, respectively, while lowest (37.31 g) 1000 grains weight was recorded in control plots. In case of mowing plots, leaves of the weeds were cut, while in hoeing roots were damaged (up rooted) and thus the available nutrients were utilized by the crop plant (wheat). These observations helped greatly in the development of healthy wheat crop, which in turn produced bigger, well-filled and heavy grains, when compared to other control treatments. These results are in agreement with those reported by Qureshi et al, (2002).

Table 9. Thousand grain weight (g) as affected by weed management methods at various growth stages of wheat.

Method of weed management	Stages of growth of wheat				Mean
	Stage 1	Stage 2	Stage 3	Stage 4	
Weedy check	37.99	38.03	37.00	36.25	37.31 C
Mowing	50.77	50.67	52.10	54.01	51.88 A
Hoeing	52.29	50.99	50.81	53.26	51.83 A
Interculture	48.81	48.48	46.85	46.76	47.72 AB
Tribunil	44.76	41.87	44.12	37.31	42.01 BC
Mean	46.92	46.00	46.17	45.51	

LSD value at 5 % for methods = 8.549

Mean followed by different letters are significantly different each other at $P \leq 0.05$.

Harvest index (%)

Statistical analysis of the data revealed that harvest index was significantly affected by different control methods, stages of growth and their interaction (Table 10). It can be seen from the data presented in Table 10, that highest harvest index (34.80 and 33.90 %) was recorded in chemical and hoeing receiving methods, while the lowest harvest index was observed in weedy check plots. The probable reason for this increase in harvest index by chemical control could be the food manufacturing factories i.e. leaves were damaged and uptake of nutrients and moisture was reduced which could be spared for the growth and development of wheat plants. These results are supported by Khan et al. (2002). Harvest index was at par in the range of 41.50 to 33.75 % in all stages of wheat growth. Similarly, maximum harvest index of 37.00 % was noted both by the hoeing and chemical method of weed control, while minimum harvest index of 29.00 were recorded in control plots.

Table 10 Harvest index (%) as affected by weed management methods at various growth stages of wheat.

Method of weed management	Stages of growth of wheat				Mean
	Stage 1	Stage 2	Stage 3	Stage 4	
Weedy check	29.00 g	30.00 fg	31.00 d-g	30.00 fg	30.00 FG
Mowing	35.75 ab	30.25 efg	31.50 c-g	30.50 d-g	32.00 AB
Hoeing	37.00 a	32.00 b-g	33.75 a-f	32.75 b-g	33.90 A
Interculture	30.00 fg	33.00 b-f	35.25 abc	34.00 a-e	33.10 AB
Tribunil	37.00 a	32.25 b-g	35.75 ab	34.25 A-D	34.80 A
Mean	33.75 a	31.50 a	33.45 a	32.30 A	

LSD value at 5 % for Stages =3.373
LSD value at 5 % for S x M = 3.771
LSD value at 5 % for methods = 3.771

Grain yield (t ha^{-1})

Analysis of the data showed that weed management at different stages of growth had significantly affected yield (t. ha^{-1}) of wheat, whereas different weed management methods showed non-significant differences. The maximum grain yield of 3.28 t. ha^{-1} was recorded when weeds were controlled at 2-5 leaf stage and other two stages were at par with each other. Minimum grain yield (2.27 t. ha^{-1}) was realized when weeds were controlled at soft dough grain to maturity stage (Table 11). The possible explanation for this increase in grain yield at 2-5 leaf stage could be that weeds controlled at early stages were perished in their early life and thus could not compete with wheat plants and spared nutrients and moisture which were utilized throughout the growth period by wheat successfully which in turn resulted in increased grain yield. These results are supported by Sharma *et al.* (1991), who reported that best weed control and highest grain yield of wheat was obtained with hand weeding at 3 and 4 weeks after sowing. These results are also in conformity with Tanner et al. (1993), who reported that weed control by herbicides increased grain yield by 78 % relative to current farming practices of selective and partial hand weeding.

Table 11. Grain yield (t ha^{-1}) as affected by weed management methods at various growth stages of wheat.

Method of weed management	Stages of growth of wheat				Mean
	Stage 1	Stage 2	Stage 3	Stage 4	
Weedy check	2.56	2.50	2.43	2.50	2.49
Mowing	3.10	2.87	2.65	2.15	2.69
Hoeing	3.40	2.85	2.51	2.21	2.74
Interculture	3.75	3.29	2.82	2.01	2.96
Tribunil	3.59	2.95	1.82	2.50	2.71
Mean	3.28 A	2.89 A	2.45 A	2.27 A	

LSD value at 5 % for stages = 1.331
Means followed by different letters are significantly different from one another at $P \leq 0.05$.

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