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# INTEGRATED WEED MANAGEMENT IN WHEAT-II TILLERS $M^{-2}$, PRODUCTIVE TILLERS $M^{-2}$, SPIKELETS $SPIKE^{-1}$, GRAINS $SPIKE^{-1}$, 1000 GRAIN WEIGHT AND GRAIN YIELD

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**ABSTRACT**

*The effect of herbicides and spacing on yield and yield components of wheat at two locations i.e., Peshawar and D.I.Khan, Pakistan for two consecutive seasons was studied in a replicated split – split plot design. The factors included were two years (1998-99 and 1999-2000), three varieties (Bakhtawar-92, Ghaznavi-98, and Inqilab-91), three types of herbicides; broad-spectrum (2,4-D + Isoproturon), broad leaf (2,4-D), grasses herbicide (Isoproturon), and weedy check and row spacings of 18, 25 and 32 cm. The tillers $m^{-2}$, productive tillers $m^{-2}$, spikelets $spike^{-1}$, number of grains $spike^{-1}$, 1000 grain weight, and grain yield were significantly affected by varieties, herbicides, row spacings, interaction of varieties with herbicides and row spacings. Among varieties Bakhtawar-92 was more productive and profitable as compared to Ghaznavi-98 and Inqilab-91. It possessed higher number of tillers $m^{-2}$ (6% & 13%), productive tillers $m^{-2}$ (3 & 10%), spikelets $spike^{-1}$ (1 & 6%), and grain yield (5 & 10%) over Ghaznavi-98 and Inqilab-91, respectively. Among herbicides, broad spectrum herbicide (2,4-D + Isoproturon) produced higher number of tillers $m^{-2}$ (5, 9 & 17%), productive tillers $m^{-2}$ (4, 8 & 18%), spikelets $spike^{-1}$ (less than 1% each & 5%), grains $spike^{-1}$ (3, 5 & 9%), and grain yield (3, 9 & 21%) over broad leaf herbicide, grasses herbicide and weedy check. Within row spacing, 18 cm row space had more number of tillers $m^{-2}$ (5 & 9%), number of productive tillers $m^{-2}$ (4 & 9%), and grain yield (5 & 10%) over 25 and 32 cm row spacing. In the interaction of variety Bakhtawar-92 with broad-spectrum herbicide, highest grain yield (5.07 t $ha^{-1}$) was recorded, which was 24% higher than the same variety x control. In the interaction of variety Bakhtawar-92 x 18 cm row spacing, grain yield of 4.88 t $ha^{-1}$ was the highest, which was 11% higher than the same variety x 32 cm row spacing. It is concluded that for integrated weed management in wheat, variety Bakhtawar-92 and broad-spectrum herbicide may be integrated with 18 cm spacing.*

## INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important cereal crop and is the staple food of the people of Pakistan, and serves as backbone in the economy of the country. In Pakistan, it ranks first among the cereal crops and occupies about 66% of the annual food crop area (Anonymous, 1996). Increasing the area under wheat crop or maximizing yield per unit area can achieve the required target of increasing wheat production. To increase area under wheat crop is difficult, because of the pressing needs for other agricultural commodities under the existing condition. To increase production $ha^{-1}$, cultural management plays a significant role in wheat production. Among which weed control, row spacing and quality seed can improve yield by about 50 - 70 percent (Burns, 1944). Weed control is a basic and major component of management in crop production systems (Young et al,. 1994; Norris, 1982; Triplett, 1976). Freyman et al., (1982) suggested that the main factor contributing to increased wheat yield since 1963 was chemical weed control. In another study an intensity of 9 to 17 weeds $feet^{-2}$ decreased wheat yield by 10% (Chatta, 1973). Wheat is generally planted by broadcast method by most of the farmers in our country and only progressive farmers and research scientists use line sowing. Line sowing facilitates inter-culture and herbicides application. It will also help in intercropping and reducing seed rate per hectare without any adverse effect on the grain yield. Proper row spacing is one of the most important management factors affecting wheat production. Narrow row spacing produces high leaf area index (LAI), which results in more interception of photo-synthetically active radiation (PAR) and dry matter accumulation (DMA) [Tollenaar and Auguilera, 1992]. Narrow row spacing also causes higher leaf photosynthesis and suppresses weeds growth compared with wider row spacing (Dwyer et al., 1991).

A limited research has been reported in Pakistan, especially on the integrated system of wheat production. In order to ascertain the integrated use of crop management practices, the instant studies were undertaken in the irrigated plains of Peshawar and Dera Ismail Khan (D.I.Khan) with the following objectives:

i. Integrate the chemical and cultural weed control in wheat.
ii. Row spacing and cultivars effect on wheat production.

## MATERIALS AND METHODS

The experiment was conducted at Malakandehr Research Farm, NWFP Agricultural University, Peshawar and Research Farm, Faculty of Agriculture, Gomal University, D.I.Khan, Pakistan, for two consecutive seasons (1998-1999 and 1999-2000). The experiment was laid-out according to split-split plot arrangement. The factors included

were: two years, three varieties (Bakhtawar-92, Ghaznavi-98, Inqilab-91), three herbicides viz. Broad-spectrum (2,4-D Butyl Ester: 72% EC + Isoproturon 75% WP), Broad leaf (2,4-D Butyl Ester: 72% EC), Grasses herbicide (Isoproturon 75% WP), and weedy check (no herbicide), and 3 Row spacings (18, 25 and 32 cm). Varieties were allotted to main plots, while herbicides were assigned to sub-plots and row spacings were kept in sub-sub-plots. Experiment was replicated three times. A standard seed rate of 110 kg $ha^{-1}$ was used for all the treatments. A standard dose of 100:60 kg N: P $ha^{-1}$ was also used in the form of urea and di-ammonium phosphate (DAP). The data were statistically analyzed according to split-split plot design. Data on individual observations were collected using the following procedure: Number of tillers of wheat per unit area (3x1 m) was recorded in each sub-plot at harvest and converted to $m^{-2}$. Productive tillers per unit area (3 x1 m) were counted having spike in each sub-plot at harvest and calculated $m^{-2}$. For spikelets $spike^{-1}$, fertile spikelets $spike^{-1}$ were counted at the time of harvest from ten randomly selected spikes in each treatment and then averaged and recorded. Number of grains $spike^{-1}$, ten spikes were taken randomly from each treatment, threshed and the number of grains counted and the mean of grains $spike^{-1}$ were calculated. For 1000 grains weight, five samples of thousand grains were taken at random from a total lot of each plot, and weighed on an electronic balance in the laboratory, averaged and recorded. Grain yield was recorded on a per plot basis and then converted into tons $ha^{-1}$.

The data for all the traits were individually subjected to the analysis of variance and the significant means were subsequently separated (Steel and Torrie, 1984) by the least significance difference (LSD) test by using the MSTATC computer software package.

## RESULTS AND DISCUSSION

### Tillers and productive tillers $m^{-2}$

The highest number of tillers and productive tillers $m^{-2}$ respectively were recorded in variety Bakhtawar-92 (223.15 and 207.33), broad-spectrum herbicide (225.43 and 213.51) and 18 cm row space (219.54 and 207.01)[Table 1-3]. The lowest number of tillers and productive tillers $m^{-2}$ were counted in variety Inqilab-91 (197.35 and 188), control (193.26 and 180.75) and 32 cm row spacing (201.64 and 190.19), respectively. The higher number of tillers and productive tillers $m^{-2}$ in variety Bakhtawar-92 might be due to its more tillering capacity as compared to other two varieties (Ghaznavi-98 and Inqilab-91). Maximum tillers and productive tillers were recorded in plots treated with broad-spectrum herbicide, which might be due to effective weed control and hence wheat crop utilized available resources (nutrients, water, light and space) more efficiently and consequently more tillers were produced. These results were in agreement with the work of Khan, (1999), who reported that application of grasses and broad-leaved herbicides increased tillers and productive tillers $m^{-2}$. The higher number of tillers and productive tillers $m^{-2}$ found in 18 cm row spacing was probably due to better light interception and crop growth rate in narrow as compared to wider row spacing. These findings were in agreement with the results of Johnson et al., (1988), Wright et al., (1990), Freeze and Bacon (1990), Sarir (1998) and Ahmad et al., (1999), who found that narrow row spacing produced greater number of tillers and productive tillers $m^{-2}$ as compared to wider row spacing.

Table 1. Effect of varieties on tillers and productive tillers $m^{-2}$ during 1998-99 and 1999-2000 at Peshawar and D.I. Khan.

| Variety | Variety Mean | |
|---|---|---|
| | Tillers $m^{-2}$ | Productive Tillers $m^{-2}$ |
| Bakhtawar-92 | 223.15 a | 207.33 a |
| Ghaznavi-98 | 210.01 b | 200.36 b |
| Inqilab-91 | 197.35 c | 188.00 c |
| LSD at alpha 0.01for variety (tillers) = 5.24 | | |
| LSD at alpha 0.01for variety (productive tillers) = 6.36 | | |

Table 2. Effect of herbicides on tillers and productive tillers $m^{-2}$ during 1998-99 and 1999-2000 at Peshawar and D.I.Khan.

| Herbicide | Herbicide Mean | |
|---|---|---|
| | Tillers $m^{-2}$ | Productive Tillers $m^{-2}$ |
| Broad Spectrum | 225.43 a | 213.51 a |
| Broad Leaf | 214.90 b | 204.34 b |
| Grasses | 207.11 c | 195.66 c |
| Control | 193.26 d | 180.75 d |
| LSD at alpha 0.01for herbicide (tillers) = 4.80 | | |
| LSD at alpha 0.01for herbicide (Productive tillers) = 4.47 | | |

Table 3. Effect of row spaces on tillers and productive tillers $m^{-2}$ during 1998-99 and 1999-2000 at Peshawar and D.I.Khan.

| Row Spacing (cm) | Row Spacing Mean | |
|---|---|---|
| | Tillers $m^{-2}$ | Productive Tillers $m^{-2}$ |
| 18 | 219.54 a | 207.01 a |
| 25 | 209.34 b | 198.49 b |

| | | |
|---|---|---|
| 32 | 201.64 c | 190.19 c |
| LSD at alpha 0.01 for row space (tillers) = 4.16 | | |
| LSD at alpha 0.01for row space (Productive tillers) = 3.93 | | |

**Number of spikelets spike$^{-1}$**

Maximum spikelets spike$^{-1}$ among varieties were recoded in Bakhtawar-92 (20.35), while minimum in variety Inqilab-91 (19.19), respectively (Table 4). The highest number of spikelets in variety Bakhtawar-92 was however statistically at par with variety Ghaznavi-98. The maximum spikelets spike$^{-1}$ were recorded in plot treated with broad-spectrum herbicide (20.29), followed by broad leaf (20.25), grasses (20.07) and control (19.40), respectively (Table 4). The maximum spikelets spike$^{-1}$ were observed in plots treated with Isoproturon + 2,4-D; thus giving a broad spectrum control of broad leaf and grassy weeds population, that enabled wheat crop to make use of available resources, which resulted in increased spikelets spike$^{-1}$. These findings are in accordance with the work of Khan (1999), who reported that maximum spikelets spike$^{-1}$ were the result of application of broad-spectrum herbicide (Puma + Logran).

Table 4. Effect of Herbicides and Varieties on Spikelets Spike$^{-1}$ during 1998-99 and 1999-2000 at Peshawar and D.I. Khan.

| Herbicide | | Variety | |
|---|---|---|---|
| Name | Herbicide Mean | Name | Variety Mean |
| Broad Spectrum | 20.29 a | Bakhtawar-92 | 20.35 a |
| Broad Leaf | 20.25 a | Ghaznavi-98 | 20.23 a |
| Grasses | 20.07 a | Inqilab-91 | 19.19 b |
| Control | 19.40 b | | |
| LSD at alpha 0.01for herbicide = 0.33 | | | |
| LSD at alpha 0.01for variety = 0.28 | | | |

**Number of grains spike$^{-1}$**

The maximum grains spike$^{-1}$ were recorded in plots having variety Ghaznavi-98 (58.97), followed by variety Bakhtawar-92 (58.26), and Inqilab-91 (49.31), respectively (Table 5). Variety Ghaznavi-98 and Bakhtawar-92 did not differ significantly (Table 5). The highest number of grains spike$^{-1}$ were found in plots treated with broad spectrum herbicide (57.89), followed by plots treated with broad leaf (56.20), and grasses (54.91), while lowest grains spike$^{-1}$ were recorded in control (53.05) treatment (Table 5). The highest grains spike$^{-1}$ were recorded in rows spaced 25 cm (55.95) apart, followed by 32 cm (55.72), and the lowest (54.87) in 18 cm row spacing, respectively. The grains spike$^{-1}$ in row spaces did not differ significantly (Table 5). The maximum grains spike$^{-1}$ were observed in variety Ghaznavi-98. The seed of Ghaznavi-98 variety was small (least 1000 grain weight) as compared to other two varieties i.e., Bakhtawar-92 and Inqilab-91, hence higher number of grains spike$^{-1}$ were produced within the almost same kernel weight spike$^{-1}$. The highest number of grains spike$^{-1}$ were recorded in plots treated with broad-spectrum herbicide, which controlled both grassy and broad leaf weeds. Among row spacings, the maximum grains spike$^{-1}$ were recorded in 25 cm row space, which might be the optimal row space for maximum grains spike$^{-1}$. The higher grains spike$^{-1}$ in broad spectrum treatments was the effective control of grasses and broadleafs, while maximum grains spike$^{-1}$ in the wider row space was due to lesser competition for nutrients as compared to narrow row spacing. These findings are in accordance with the work of Khalil et al., (2000), Khan, (1999), Sarir (1998), and Wright et al., (1990), who reported that application of broad spectrum herbicides in plots having wider row space, produced maximum grains spike$^{-1}$.

**Table 5. Effect of Herbicides, Varieties and Row spacing on Grains Spike$^{-1}$ during 1998-99 and 1999-2000 at Peshawar and D.I. Khan.**

| Herbicide | | Variety | | Row spacing (cm) | |
|---|---|---|---|---|---|
| Name | Herbicide Mean | Name | Variety Mean | Name | Row spacing Mean |
| Broad Spectrum | 57.89 a | Bakhtawar-92 | 58.26 a | Row space-18 | 54.87 a |
| Broad Leaf | 56.20 b | Ghaznavi-98 | 58.97 a | Row space-25 | 55.95 a |
| Grasses | 54.91 b | Inqilab-91 | 49.31 b | Row space-32 | 55.72 a |
| Control | 53.05 c | | | | |
| LSD at alpha 0.01for herbicide = 1.31 | | | | | |
| LSD at alpha 0.01for variety = 1.22 | | | | | |
| LSD at alpha 0.01for row space = 1.19 | | | | | |

**1000-grain weight (g)**

The lowest 1000-grain weight (35.83 g) was recorded in variety Ghaznavi-98, followed by Bakhtawar-92 (36.22 g) and Inqilab-91 (44.37 g) [Table 6]. Among herbicides, maximum 1000-grain weight (39.20 g) was found in broad-spectrum treated plots, while minimum 1000-grain weight (37.81 g) was recorded in control plot (Table 6). However,

the differences among broad spectrum, broad leaf and grasses herbicides were not significant (Table 6). The minimum 1000-grains weight (38.57 g) was observed in 18 cm row spacing, followed by 25 cm and 32 cm row spacing, respectively (Table 6). The maximum 1000-grain weight was observed in variety Inqilab-91, broad-spectrum herbicide and row space 32 cm. The seed of Inqilab-91 variety is significantly heavier as compared to the other two varieties i.e., Bakhtawar-92 and Ghaznavi-98, while seed of Bakhtawar-92 is heavier than Ghaznavi-98. Varieties Bakhtawar-92 and Ghaznavi-98 are genetically same and that is why there was statistically no difference in their 1000-grain weight. In case of broad-spectrum herbicide, effective weed control may have resulted in heavier grain weight and minimum 1000-grain weight in control plot might be due to the competition of weeds in the plots, for food, light, water etc. that adversely affected grain weight. These results are in agreement with the work of Jalis and Muhammad (1980), Khalil et al., (1993), and Saini and Angiras (1998), who found that the use of herbicides Isoproturon + Buctril M 40 EC better controlled weeds and increased 1000-grain weight. The maximum 1000-grains weight observed in 32 cm row space may be that in 32 cm row space, more space was available for better light harvesting and more nutrients were available for grain development, as compared to narrow row spacing. These findings are in agreement with the work of Shaukat, et al., (1999), who reported that row geometry had significant effects on 1000-grain weight.

**Table 6. Effect of herbicides, varieties and row spacing on 1000 grains weight (g) during 1998-99 and 1999-2000 at Peshawar and D.I. Khan.**

| Herbicide | | Variety | | Row spacing (cm) | |
|---|---|---|---|---|---|
| Name | Herbicide Mean | Name | Variety Mean | Name | Row spacing Mean |
| Broad Spectrum | 39.20 a | Bakhtawar-92 | 36.22 b | Row space-18 | 38.57 b |
| Broad Leaf | 39.19 a | Ghaznavi-98 | 35.83 b | Row space-25 | 38.74 ab |
| Grasses | 39.07 a | Inqilab-91 | 44.37 a | Row space-32 | 39.11 a |
| Control | 37.81 b | | | | |
| LSD at alpha 0.01for herbicide = 0.75 | | | | | |
| LSD at alpha 0.01for variety = 0.58 | | | | | |
| LSD at alpha 0.01for row space = 0.54 | | | | | |

**Grain yield (t ha$^{-1}$)**

Economic yield is the ultimate goal of all crop production pursuits. The grain yield for different years, herbicides and years x herbicides interaction was significant. The higher grain yield (4.50 t ha$^{-1}$) was observed in 1999-2000, while lower grain yield (4.40 t ha$^{-1}$) was recorded in 1998-99 (Table 7). Among the herbicides, the highest grain yield (4.79 t ha$^{-1}$) was recorded in the plots treated with broad spectrum, followed by plots treated with broad leaf (4.66 t ha$^{-1}$), whereas lowest yield was observed in control plot. In years x herbicides interaction, maximum grain yield (4.91 t ha$^{-1}$) was recorded in the treatment year 1999-2000 x broad spectrum herbicide, followed by the same year x broad leaf herbicide, while minimum grain yield (3.92 t ha$^{-1}$) was observed in the year 1999-2000 x control plot (Table 7). The effect on grain yield for varieties and varieties x herbicides was significant. The maximum grain yield (4.67 t ha$^{-1}$) was recorded in the variety Bakhtawar-92, while minimum (4.23 t ha$^{-1}$) was observed in variety Inqilab-91 (Table 8). In varieties x herbicides interaction, the highest grain yield (5.07 t ha$^{-1}$) was recorded in variety Bakhtawar-92 x broad spectrum herbicide, followed by the same variety x broad leaf herbicide (4.93 tha$^{-1}$), while minimum(3.87 tha$^{-1}$) was observed in variety Inqilab-91xcontrol treatment (Table 8)

The effect of locations x varieties interaction on grain yield was significant. The highest grain yield (4.67 t ha$^{-1}$) was recorded at Peshawar with variety Bakhtawar-92 interaction, followed by location D.I.Khan x the same variety. In both locations there was little difference in grain yield for variety Bakhtawar-92, and differences were non significant, which shows the stability of Bakhtawar-92 under varying agro-ecological conditions. While, minimum grain yield (4.09 t ha$^{-1}$) was observed at Peshawar with variety Inqilab-91 (Table 9). The effect on grain yield for different row spaces and varieties x row spaces was significant. The maximum grain yield (4.67 t ha$^{-1}$) was observed in treatments with 18 cm row spaces, followed by 25 cm (4.44 t ha$^{-1}$) and 32 cm (4.23 t ha$^{-1}$), respectively (Table 10). Among variety x row spacing interaction, the highest grain yield (4.88 t ha$^{-1}$) was recorded in variety Bakhtawar-92 x 18 cm row spacing, while lowest (4.08 t ha$^{-1}$) was observed in the plot planted with variety Inqilab-91 with 32 cm row spacing (Table 10).

The maximum grain yield in variety Bakhtawar-92 and variety Bakhtawar-92 treated with broad-spectrum herbicide is probably due to the fact that genetically variety Bakhtawar-92 is high yielding as compared to other two varieties, while variety Bakhtawar-92 x broad spectrum herbicide interaction was also a good combination, as variety Bakhtawar-92 itself was high yielding and coupled with broad spectrum herbicide further increased its yield. These results are in analogy with the findings of Boparai et al., (1991), Panwar et al., (1995), Prasad and Singh (1995), Prasad and Rafey (1996), Singh and Singh (1996), Azad et al., (1997), and. Kotru et al., (1999), who reported that post-emergence application of 2,4-D + Isoproturon was the best treatment combination in reducing dry matter yield of weeds and producing the greatest straw and grain yields (5.93 and 3.96 t ha$^{-1}$, respectively) compared to 2.74 and

1.66 t $ha^{-1}$ in the un-weeded control). The maximum grain yield recorded in 18 cm row spacing and interaction of variety Bakhtawar-92 x 18 cm row spacing was due to the more productive tillers in variety Bakhtawar-92 and 18 cm row spacing as compared to other two varieties and row spacings. These results are in line with the work of Rath et al., (1990), Marko (1994), Behera, (1995), Ercoli and Masoni (1995), and Malik et al., (1996). They found that grain yield was the highest in 6 cm and 15 cm row spacing and decreased in wider row-spacings in their studies.

Table 7. Effect of herbicides and years x herbicides on grain yield (t $ha^{-1}$) during 1998-99 and 1999-2000 at Peshawar and D.I. Khan.

| Year | Broad Spectrum | Broad Leaf | Grasses | Control | Year Mean |
|---|---|---|---|---|---|
| 1998-99 | 4.66 bc | 4.58 cd | 4.35 e | 3.99 f | 4.40 b |
| 1999-2000 | 4.91 a | 4.75 ab | 4.42 de | 3.92 f | 4.50 a |
| Herbicide Mean | 4.79 a | 4.66 b | 4.38 c | 3.95 d | |
| LSD at alpha 0.01 for herbicide = 0.12 | | | | | |
| LSD at alpha 0.01 for year x herbicide = 0.17 | | | | | |

Table 8 Effect of varieties and varieties x herbicides on grain yield (t $ha^{-1}$) during 1998-99 and 1999-2000 at Peshawar and D.I. Khan.

| Variety | Herbicide | | | | Variety Mean |
|---|---|---|---|---|---|
| | Broad Spectrum | Broad Leaf | Grasses | Control | |
| Bakhtawar-92 | 5.07 a | 4.93 ab | 4.58 de | 4.09 gh | 4.67 a |
| Ghaznavi-98 | 4.84 bc | 4.67 cd | 4.34 f | 3.91 hi | 4.44 b |
| Inqilab-91 | 4.44 ef | 4.39 ef | 4.23 fg | 3.87 I | 4.23 c |
| LSD at alpha 0.01 for variety = 0.16 | | | | | |
| LSD at alpha 0.01 for variety x herbicide = 0.21 | | | | | |

Table 9. Effect of Locations x Varieties on Grain Yield (t $ha^{-1}$) during 1998-99 and 1999-2000 at Peshawar and D.I. Khan.

| Location | Varieties | | |
|---|---|---|---|
| | Bakhtawar-92 | Ghaznavi-98 | Inqilab-91 |
| Peshawar | 4.67 a | 4.46 ab | 4.09 c |
| D.I.Khan | 4.66 a | 4.41 b | 4.37 b |
| LSD at alpha 0.01 for location x variety = 0.23 | | | |

Table 10. Effect of row spaces and locations x varieties on grain yield (t $ha^{-1}$) during 1998-99 and 1999-2000 at Peshawar and D.I. Khan.

| Row space (cm) | Variety | | | Row Space Mean |
|---|---|---|---|---|
| | Bakhtawar-92 | Ghaznavi-98 | Inqilab-91 | |
| 18 | 4.88 a | 4.72 b | 4.42 c | 4.67 a |
| 25 | 4.72 b | 4.39 c | 4.22 d | 4.44 b |
| 32 | 4.40 c | 4.21 d | 4.08 d | 4.23 c |
| LSD at alpha 0.01 for row space = 0.08 | | | | |
| LSD at alpha 0.01 for variety x row space = 0.14 | | | | |

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