INT. J. BIOL. BIOTECH., 3 (2): 367-373, 2006.

GROWTH DYNAMICS OF POACEOUS WEEDS INFLUENCED BY HERBICIDES WITH DIFFERENT MODES OF ACTION

I. H. Shamsi[1,2*], K. B. Marwat[2], Ghulam Jilani[3], Qaisar Mahmood[4], Shahida Khalid[5] and Muhammad Akram[6]

[1]*Department of Agronomy, College of Agriculture and Biotech., Zhejiang University, Hangzhou, China.*
[2] *Department of Weed Science, N.W.F.P. Agricultural University, Peshawar, Pakistan.*
[3]*Department of Soil Science, University of Arid Agriculture, Rawalpindi, Pakistan.*
[4]*Department of Botany, F.G. College for Men, H-8, Islamabad.*
[5]*Weed Science Program, National Agricultural Research Center Islamabad, Pakistan.*
[6]*British Cotton Growers Association (BCGA), Khanewal, Pakistan*

ABSTRACT

Poaceous weeds are the most troublesome grass weeds in temperate climates, mostly infesting winter cereals, like wheat and barley. The use of mechanical cultivation to eradicate them in fields is ineffective, because of the unequal germination of seeds. Continuous use of herbicides with the same mode of action may lead to the resistance in weeds. Therefore, an investigation was carried out to study the effects of different herbicides viz. Isoproturon, Topik and Puma Super on three weeds of wheat viz. *Phalaris minor*, *Avena fatua* and *Lolium temulentum*, using CRD factorial design with eight replications. The data were recorded on weed density, shoot length, leaves count and mortality rate at three stages viz. 14, 21 and 28 days after herbicides treatment. Fresh biomass yield of weeds was also recorded after 30 days of herbicides treatment. All the parameters were significantly affected over the period of time. Minimum weed density (3.9 plants pot^{-1}) was recorded after 28 days of treatment. Comparatively more reduced shoot length, leaves count and fresh biomass weight of weeds were observed under the treatment with Topik (Clodinafop-p). Maximum percent mortality (31.10) was recorded at 21 days after the application of herbicides. For the most effective control of *P. minor, A. fatua* and *L. temulentum* weeds of wheat crop, Topik @ 0.37 kg a.i./ha was found the most suitable herbicide applied at 3-4 foliar stage.

Key words: Wheat, Poaceous weeds, *Phalaris minor*, *Avena fatua*, *Lolium temulentum*, herbicides, resistance

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important component of Pakistan's agricultural system. It occupies about 17 % of the world's cropped land and contributes 35 % of the staple food (Pingali, 1999), and 20 % of the calories (WORC, 2002). It is a staple food for a large population, and its increased production is essential for food security (Chhokar *et al.*, 2006). In Pakistan, wheat is cultivated on an area larger than 8 million hectares producing over 22 million tones of grain (GOP, 2005); however, the average yield is still very low. Among the yield limiting factors, weeds constitute the major share causing losses ranging from 17.3 % (Pervaiz and Quazi, 1992) to 30 % (Khan and Noor 1995) to the wheat crop. Weeds not only reduce the yield and quality of crops but also utilize scarce and essential nutrients and moisture (Singh *et al.*, 1999). The deteriorated quality of farm produce results in decreased market value. Poaceous weeds (annual grasses) occur in several winter crops, but they have become more pernicious in wheat due to their morphology and growth requirements similar to wheat during the early stages of development (Singh *et al.*, 1999). Among them, *Phalaris minor* Retz, *Avena fatua* L. and *Lolium temulentum* L. having Mediterranean origin are the noxious ones in wheat.

Phalaris minor (littleseed canary grass; vernacular name dumbi siti) was reported to be the most dominant among the ten important weeds in Pakistan (Ghafoor *et al.* 1987), and it has spread as far as India, Australia and America. Singh *et al.*, (1999) and Chhokar *et al.* (2006) reported that *P. minor* has become resistant to the phenyl urea herbicide isoproturon applied to wheat crop. *Avena fatua* (wild oats; vernacular name jungli jai) also has Mediterranean origin and history. It is widely spread through out the world, a weed of over 20 crops in 55 countries. As a consequence of its persistence and its impact upon yields, *A. fatua* leads to significant economic losses in the grain growing regions (Jones and Medd, 1997). *A. fatua* is highly resistant to a number of herbicides (Stokłosa *et al.*, 2006). *Lolium temulentum* (Italian grass; vernacular name khiwi) is another important weed which is on the increase as it is spreading with the crop seed.

The scarce and costly labour has made herbicides popular among wheat growers. The dependence on herbicides has further increased with the development of high yielding, but less competitive, cultivars (Chhokar *et al.*, 2006).

[*]Corresponding author Email: syedimranshamsi@yahoo.com

Chemical weed control out performs mechanical and manual methods, except with resistant weed biotypes. Shamsi *et al.* (2001) advocated that herbicides are the most effective formulation, reducing weed density and dry matter accumulation, giving highest grain yield of wheat. The increased yield obtained under herbicide treated fields was a function of 59, 50 and 46 % higher uptake of N, P, and K / ha by wheat compared with unweeded conditions; application of herbicides increased nitrogen efficiency of wheat from 50 to 90 % (Singh and Malik, 1992). The herbicide performance depends upon plant response, selectivity and translocation pattern. The application of recommended rates of fertilizer and herbicide gave 85 % higher gross margin compared to unweeded (Walia and Gill, 1985).

The herbicide performance depends upon plant response, selectivity and translocation pattern. In Isoproturon inhibition of electron transport takes place during the process of photosynthesis and plant exhibits paleness or chlorosis of foliage leading to necrosis. Fenoxaprop-*P*-ethyl (Puma Super) and Clodinafop-p (Topik) are member of the aryloxyphenoxypropionate (AOPP) herbicide family. These herbicides inhibit acetyl Co-enzyme A carboxylase (ACCase) and are used to control annual grass weeds (Cocker *et al.,* 1999). Inhibition of the enzyme ACCase takes place by Topik and Puma Super application finally inhibiting the biosynthesis of fatty acids resulting in the failure of membrane formation and ultimate senescence of susceptible plants. The continuous dependence on a single herbicide for a long time, besides resistance development, also leads to a shift in the weed flora (Chancellor, 1979). The dependence on isoproturon led to development of resistance in *P. minor* against this herbicide (Malik and Singh, 1995). For decreasing selection pressure in favour of resistant biotypes/tolerant weed species and to sustain wheat production, the use of new herbicides and mixtures having different modes of action is necessary (Chhokar *et al.*, 2006). Significant differences were recorded by (Khan *et al.,* 2003) for various herbicides in the traits like weed density and wheat tillers count.

Due to above mentioned considerations; this study was envisaged to find the impact of different herbicides on the growth pattern of these weeds. Further, there was also an aim to determine the period during which these herbicides show their maximum effectiveness on weeds.

MATERIALS AND METHODS

This greenhouse study was undertaken at National Agricultural Research Centre (NARC), Islamabad. It was laid out according to two factors factorial completely randomized design (CRD) with combination of three weed species and three herbicides, having eight replications. Sixteen (16) seeds of each weed were sown in respective treatment pots, and twelve (12) healthy seedlings were maintained in each pot to apply herbicide treatments at 3-4 leaf stage. The chemical / brand names, and relative concentrations of herbicides applied during the experiment are presented in Table 1.

The two factors treatments (**weed species and herbicides**)were applied in combination making a total of nine treatments. Data were collected at the time intervals of 14, 21 and 28 days after the application of herbicides treatments. Therefore, time interval was considered as **Factor 3** while statistical analysis of the data recorded at these stages. Irrigation and all other agronomic practices were employed equally to all the treatments. Following observations on weeds were recorded at 14, 21 and 28 days after herbicides application except dry biomass weight which was recorded only once at 30 days.

i Weeds density ii Shoot length iii Plant leaves count
iv Weeds mortality v Fresh biomass weight

Mortality rate (%) of weeds was determined by employing the following equation:
Mortality (%) = No. of weeds died after treatment × 100 / No. of weeds before treatment

Table 1. Description of herbicides used in the experiment.

Trade name	Common name	Chemical name	Rate (kg a.i*/ha)
Isoproturon (75WP)	Isoproturon (PS - inhibiting)	N-(4-Isopropyl phenyl)-N, N-dimethyl urea	1.12
Topik (15WP)	Clodinafop-p (ACCase-inhibiting)	2-Propynl-(R)-2-(4-5-Chloro-3-fluoro-2-Pyridyloxy-Phenoxy) propionate	0.37
Puma Super (75EW)	Fenoxaprop-p (ACCase inhibiting)	Ethyl,(D+)-ethyl-2-(4-(6chloro-2-benzoxazolyloxy)-phenoxy)-propionate	0.75

* Active ingredient

The data collected on different weed characteristics as affected by time interval, weed species and herbicides were subjected to statistical analysis by using ANOVA technique under CRD three factors factorial design (Steel and Torrie, 1980). Least significant difference (LSD) test at $p<0.05$ was applied to decide the best herbicide for the control of subject weeds.

RESULTS AND DISCUSSION

Growth pattern of weeds under the use of traditional post-emergence herbicides was studied through observations on the weeds density and mortality compared with the total original population of weeds as twelve (12) plants in each treatment pot. Further, the reduced shoot growth, leaves bearing and fresh biomass yield were taken as an indicator for the effectiveness of herbicides to control weeds. Following paragraphs discussed the results of all the parameters separately.

Weeds Density

The time interval, weed species, herbicides and all interactions of the three factors were having significant difference ($p<0.05$) for weed density (Table 2). Amongst time interval, highest population (9.01 plants) was recorded after 14 days of the treatment followed by 21 days (6.05) and 28 days (3.89). Within three weed species, *P. minor* gave highest population density of 6.625, followed by *L. temulentum* and *A. fatua*. However, the later two were not significantly different from each other. The highest weed density of 9.58 was observed in control followed by Isoproturon and Puma Super which were found to be at par. The lowest density (4.48) was observed in those pots where Topik was applied. Nadeem *et al.* (2003) reported that weeds were most effectively controlled by Buctril-M + Topik, Isoproturon alone and Logran + Topik.

The interaction of time interval and weed species showed that all the three weed species were more affected after 28 days of the treatment as minimum population of *A. fatua* (3.25) was recorded while *P. minor* and *L. temulentum* were found at par. The interaction of time interval and herbicides revealed that after 28 days of treatment Topik was most affective as only 1 plant was recorded while Isoproturon and Puma Super were found non significantly different from each other. Interaction of weed species and herbicides showed the minimum density of *L. temulentum* (3.875) was recorded in pots where Topik was applied. For *A. fatua*, Puma Super was most effective as minimum of 4.417 plants were observed followed by 4.625 plants of *Phalaris minor* in the pots where Topik was applied. Salarzai *et al*. (1999) evaluated five herbicides for the control of weeds in wheat, all of them decreased weed density / biomass, and increased the yield of wheat by 19%. The herbicides caused significant reduction in the density of three weeds at different time periods. On the 14th day Topik brought significant reduction in *P. minor* and *L. temulentum* populations, while Puma super posed significant reduction in the population of *A. fatua*. Khan *et al.* (2001) also found that Puma Super controlled *P. minor* and *A. fatua* successfully by reducing their density in wheat to a maximum. Similar results were recorded on the 21st day; on 28th day Topik caused complete eradication of *L. temulentum*, and a significant reduction in the population of *P. minor*. Puma Super was found most effective against *A. fatua*. Khan *et al.* (2003) also found the lowest weeds count in Puma Super treated plots of wheat.

Shoot Length

Statistically significant effect of time interval, weed species, herbicides and their interaction on shoot length of weeds was observed (Table 3). As far as time interval is concerned, maximum shoot length (21.88 cm) was recorded after 21 days of treatment. Amongst the weeds species, *P. minor* possessed maximum shoot length (22.34 cm) which was statistically at par with that of *A. fatua* (21.80 cm). Minimum shoot length (18.87) cm was recorded in Topik among herbicide treatments. The interaction of time interval and weed species shows that *A. fatua* had maximum shoot length of 22.94 cm followed by *P. minor* (22.04 cm) after the 14 days of treatment. Interaction of weed species and herbicides shows maximum of 24.24 cm shoot length in *Avena fatua* pots, while minimum of 13.06 cm was recorded in *L. temulentum* pots where Topik was applied. The interaction of time interval, weed species and herbicides, maximum shoot length (24.51 cm) was recorded in control pots of *A. fatua* while minimum (11.33 cm) was observed in *A. fatua* pots where Puma Super was applied 28 days after the treatment. No weed was seen in *L. temulentum* pots treated with Topik as all weeds became ultimately dead. Shoot length is a function of genetic as well as the environmental conditions; it is evident from the data that with the passage of time herbicides affected growth rate of all the three weeds. The results are in line with Starchan (1995) and Ormeno and Diaz (1995) who concluded that Clodinafop (Topik) suppressed the growth rate of grassy weeds in wheat crop.

Table 2. Weed density (# of plants pot^{-1}) as influenced by various herbicides w.r.t. time.

Treatments	**Factor C (Herbicides = H)**				**Average**
	Isoproturon	Topik	Puma Super	Control	
Factor A (Days = D)	**Interaction A × C**				**A**
D14	9.042 a	8.292 b	9.125 a	9.583 a	**9.010 a**
D21	5.417 c	4.167 d	5.042 c	9.583 a	**6.052 b**
D28	2.502 e	1.000 f	2.458 e	9.583 a	**3.896 c**
Factor B (Weeds = W)	**Interaction B × C**				**B**
W1 *Phalaris minor*	6.708 c	4.625 f	6.167 cd	9.000 b	**6.625 a**
W2 *Avena fatua*	4.875 ef	4.958 ef	4.417 fg	10.000 a	**6.063 b**
W3 *Lolium temulentum*	5.417 e	3.875 g	6.042 d	9.750 a	**6.271 b**
Factor A × Factor B	**Interaction A × B × C**				**A × B**
D14 × W1	8.625 cd	7.125 e	8.875 bcd	9.000 abc	**8.406 b**
D14 × W2	9.250 abc	9.125 abc	8.875 bcd	10.000 a	**9.313 a**
D14 × W3	9.250 abc	8.625 cd	9.625 abc	9.750 ab	**9.313 a**
D21 × W1	7.875 de	5.000 f	6.875 e	9.000 abc	**7.188 c**
D21 × W2	4.250 fg	4.500 fg	3.750 ghi	10.000 a	**5.625 d**
D21 × W3	4.125 fg	3.000 hi	4.500 fg	9.750 ab	**5.344 d**
D28 × W1	3.625 ghi	1.750 jk	2.750 ij	9.000 abc	**4.281 e**
D28 × W2	1.125 kl	1.250 kl	0.625 lm	10.000 a	**3.250 f**
D28 × W3	2.875 i	0.000 m	4.000 fgh	9.750 ab	**4.156 e**
Average C	**5.667 b**	**4.486 c**	**5.542 b**	**9.583 a**	

* Average values in a column or row, and interactions bearing dissimilar letters have a statistically significant difference at 5 % probability level.

Leaves Count

Two factor treatments and their interactions were significant over the period of time (Table 4). Amongst time interval, maximum leaves (4.49) were recorded at 21 days after the treatment which were at par with 4.371 leaves at 14 days. Amongst the weed species, *P. minor* possessed maximum number of 4.534 leaves followed by *A. fatua* and *L. temulentum* which both were at par. The highest number of leaves (4.636) was recorded in control while minimum (3.91) were observed in Topik treatment. *Phalaris minor* had 4.731 leaves compared to 3.569 of *L. temulentum* at 28 days after the treatment. After 28 days of treatment maximum of 4.983 leaves were recorded in control while minimum of 2.9 were observed in Topik treated plants. Interaction of weed species and herbicides shows that in control, *P. minor* had maximum number of leaves (4.658) which were at par with *L. temulentum*, while minimum (2.971) leaves were recorded in Topik treated plants of *L. temulentum*. The highest number (5 leaves) was observed in control pots of *P. minor* and *L. temulentum* while minimum leaves count was observed in *A. fatua* (2.063) treated with Puma Super (Fenoxaprop-p) at 28 days after the application of herbicides. Fenoxaprop-*P*-ethyl is a member of the aryloxyphenoxypropionate (AOPP) herbicide family. These herbicides inhibit acetyl Co-enzyme A carboxylase (ACCase) and are used to control annual grass weeds such as wild-oats (*Avena* spp.). According to Cocker *et al.* (1999) there are two principal biochemical mechanisms that are likely to confer this resistance. One is an alteration in the target site enzyme (ACCase) that reduces sensitivity to the herbicide (target site resistance); the other is an increase in the rate of herbicide detoxification (enhanced metabolism).

Mortality Rate

The time intervals, weed species, herbicides and interactions of these factors had statistically significant difference in the mortality percentage of weeds (Table 5). Within time interval, the highest mortality (31.1 %) was recorded at 21 days after treatment, followed by 22.92 % and 5.42 % mortality at 28 and 14 days, respectively. Among weed species, *A. fatua* showed maximum mortality (22.28 %) followed by *L. temulentum* and *P. minor* both of which were non significant with each other. As herbicides were concerned, the highest mortality rate (29.615 %) was recorded with Topik, while no mortality was seen in control.

The time interval and weed species interaction showed the maximum mortality (41.55 %) of *L. temulentum* at 21 days after the treatment; while minimum of 2.83 % was recorded 14 days after the treatment in *L. temulentum* pots. After 21 days of treatment maximum of 43.17 % mortality was recorded in Puma Super treatment as compared to no mortality in control. The effect of Puma Super was at par with Topik at 21 days after the treatment. Maximum of 32.87 % mortality was recorded in *L. temulentum* treated with Topik followed by 31.76 % mortality in *A. fatua* under Puma Super as compared to no mortality in control. Chhokar *et al.* (2006) also found that isoproturon at 1 and 2 kg a.i. ha^{-1}) provided only 10.5 % and 51.8 % *P. minor* control, respectively. Maximum of 59.961 percent mortality was observed in *L. temulentum* pots where Topik was applied 21 days after the treatment followed by 53.456 percent mortality in *A. fatua* where Puma Super was applied as compared to no mortality in control. The results coincide with those of Tysoe (1975) and Manning *et al.* (1993). A small number of plants in any weed population are likely to be naturally resistant to a given herbicide.

Table 3. Shoot length (cm) of weeds as influenced by various herbicides w.r.t. time.

Treatments		**Factor C (Herbicides = H)**			**Average**
	Isoproturon	Topik	Puma Super	Control	
Factor A (Days = D)		**Interaction A × C**			**A**
D14	21.49 b	21.32 b	21.35 b	22.55 ab	**21.67 a**
D21	21.42 b	21.28 b	21.25 b	23.58 a	**21.88 a**
D28	21.88 b	14.01 d	17.78 c	23.45 a	**19.28 b**
Factor B (Weeds = W)		**Interaction B × C**			**B**
W1 *Phalaris minor*	22.00 c	21.85 c	21.92 c	23.60 ab	**22.34**
W2 *Avena fatua*	22.67 bc	21.70 c	18.62 e	24.24 a	**21.80**
W3 *Lolium temulentum*	20.13 d	13.06 f	19.84 de	21.73 c	**18.69**
Factor A × Factor B		**Interaction A × B × C**			**A × B**
D14 × W1	21.78 d-i	21.68 d-i	21.61 d-i	23.10 a-d	**22.04 a**
D14 × W2	22.88 a-e	22.65 a-e	22.50 a-e	23.81 a-d	**22.94 a**
D14 × W3	19.90 ghi	19.63 hi	19.93 f-i	20.73 e-i	**20.04 b**
D21 × W1	21.85 c-h	21.73 d-i	22.03 c-g	24.05 abc	**22.41 a**
D21 × W2	22.48 a-e	22.56 a-e	22.03 c-g	24.40 ab	**22.87 a**
D21 × W3	19.94 f-i	19.55 i	19.70 hi	22.29 a-e	**20.37 b**
D28 × W1	22.36 a-e	22.15 c-f	22.11 c-g	23.65 a-d	**22.57 a**
D28 × W2	22.71 a-e	19.88 ghi	11.33 j	24.51 a	**19.60 b**
D28 × W3	20.55 e-i	0.00 k	19.90 ghi	22.19 b-e	**15.66 c**
Average C	**21.59 b**	**18.87 d**	**20.13 c**	**23.19 a**	

* Average values in a column or row, and interactions bearing dissimilar letters have a statistically significant difference at 5 % probability level.

Table 4. Leaves count (# plant^{-1}) of weeds as influenced by various herbicides w.r.t. time

Treatments		**Factor C (Herbicides = H)**			**Average**
	Isoproturon	Topik	Puma Super	Control	
Factor A (Days = D)		**Interaction A × C**			**A**
D14	4.350 c	4.338 c	4.400 c	4.396 c	**4.371 a**
D21	4.512 bc	4.492 bc	4.463 c	4.529 bc	**4.499 a**
D28	4.750 ab	2.900 e	3.729 d	4.983 a	**4.091 b**
Factor B (Weeds = W)		**Interaction B × C**			**B**
W1 *Phalaris minor*	4.462 ab	4.529 a	4.488 ab	4.658 a	**4.534 a**
W2 *Avena fatua*	4.637 a	4.229 b	3.642 c	4.642 a	**4.288 b**
W3 *Lolium temulentum*	4.512 a	2.971 d	4.463 ab	4.608 a	**4.139 b**
Factor A × Factor B		**Interaction A × B × C**			**A × B**
D14 × W1	4.300 ef	4.413 de	4.450 de	4.400 de	**4.391 b**
D14 × W2	4.413 de	4.263 ef	4.413 de	4.450 de	**4.384 b**
D14 × W3	4.338 def	4.338 def	4.338 def	4.338 def	**4.338 b**
D21 × W1	4.450 de	4.413 de	4.488 cde	4.575 a-e	**4.481 ab**
D21 × W2	4.563 a-e	4.488 cde	4.450 de	4.525 b-e	**4.506 ab**
D21 × W3	4.525 b-e	4.575 a-e	4.450 de	4.488 cde	**4.509 ab**
D28 × W1	4.638 a-e	4.763 a-e	4.525 b-e	5.000 a	**4.731 a**
D28 × W2	4.938 abc	3.938 f	2.063 g	4.950 ab	**3.972 c**
D28 × W3	4.675 a-e	0.000 h	4.600 a-e	5.000 a	**3.569 d**
Average C	**4.537 a**	**3.910 c**	**4.197 b**	**4.636 a**	

* Average values in a column or row, and interactions bearing dissimilar letters have a statistically significant difference at 5 % probability level.

Fresh Biomass

The difference among weed species, herbicides and their interaction was highly significant for weeds fresh biomass weight at 30 days after treatment (Table-6). Data revealed that *P. minor* produced more weight (14.54 g pot^{-1}) as compared to *A. fatua* and *L. temulentum* having nearly the equal weight. Amongst herbicides, Topik was significantly superior and its treatment caused minimum weeds fresh weight of 3.286 (g pot^{-1}). Maximum weight (32.15 g pot^{-1}) was recorded in control plots. Interaction was also significant as minimum weight (4.03 g pot^{-1}) was recorded for *A. fatua* treated with Isoproturon which was at par with that of *P. minor* and *A. fatua* treated with Topik. All the plants of *L. temulentum* treated with Topik were died untill 30 days. Maximum weight of 34.69 and 33.144 (statistically non significant) were observed in control treatment for *A. fatua* and *P. minor*, respectively. Similar results were also obtained by Nadeem *et al*. (1999) and Attri and Saini (2000) who had the observation of less weed fresh matter / unit area by herbicidal application in their studies. It is evident that proper nutrients availability and photosynthetic activity increased weeds biomass when these plants were not subjected to herbicides, while spray of herbicides affected the physiological development of weeds.

Table 5. Mortality rate (%) of weeds as influenced by various herbicides w.r.t. time.

Treatments	Factor C (Herbicides = H)				**Average**
	Isoproturon	Topik	Puma Super	Control	
Factor A (Days = D)		**Interaction A × C**			**A**
D14	5.896 f	10.823 e	4.991 f	0.000 g	**5.428 c**
D21	37.355 b	43.871 a	43.174 a	0.000 g	**31.100 a**
D28	30.185 d	34.151 c	27.380 d	0.000 g	**22.929 b**
Factor B (Weeds = W)		**Interaction B × C**			**B**
W1 *Phalaris minor*	20.324 d	26.091 c	24.247 c	0.000 e	**17.665 b**
W2 *Avena fatua*	29.503 b	29.886 b	31.758 ab	0.000 e	**22.287 a**
W3 *Lolium temulentum*	23.610 c	32.868 a	19.540 d	0.000 e	**19.004 b**
Factor A × Factor B		**Interaction A × B × C**			**A × B**
D14 × W1	6.666 h	21.449 f	8.794 gh	0.000 i	**9.227 e**
D14 × W2	5.953 h	4.773 hi	6.180 h	0.000 i	**4.226 f**
D14 × W3	5.069 hi	6.249 h	0.000 i	0.000 i	**2.829 f**
D21 × W1	8.474 gh	20.646 f	20.304 f	0.000 i	**12.356 d**
D21 × W2	50.818 bc	51.005 b	55.763 ab	0.000 i	**39.396 a**
D21 × W3	52.775 b	59.961 a	53.456 b	0.000 i	**41.548 a**
D28 × W1	45.831 cd	36.178 e	43.643 d	0.000 i	**31.413 b**
D28 × W2	31.740 e	33.881 e	33.333 e	0.000 i	**24.738 c**
D28 × W3	12.985 g	32.394 e	5.164 h	0.000 i	**12.636 d**
Average C	**24.479 b**	**29.615 a**	**25.182 b**	**0.000 c**	

* Average values in a column or row, and interactions bearing dissimilar letters have a statistically significant difference at 5 % probability level.

Table 6. Fresh weight (g pot^{-1}) of weeds as influenced by various herbicides after 30 days.

Herbicides	Weed species			Mean
	P. minor	*A. fatua*	*L. temulentum*	
Isoproturon	10.668 c	4.029 e	9.078 cd	7.925 b
Topik	5.706 e	4.151 e	0.000 g	3.286 c
Puma Super	8.674 d	2.163 f	10.702 c	7.180 b
Control	33.144 a	34.690 a	28.612 b	32.149 a
Mean	14.548 a	11.258 b	12.098 b	

* Average values in a column or row, and interactions bearing dissimilar letters have a statistically significant difference at 5 % probability level.

Conclusion

It is cloncluded that For the effective control of *P. minor, A. fatua* and *L. temulentum* weeds of wheat crop, Topik (15WP) 0.37 kg a.i./ha was proved to be the most suitable herbicide applied at 3-4 foliar stage. The maximum mortality rate of weeds was observable at 21 days after the application of pesticides. *Phalaris minor* was found more resistant while *Avena fatua* was most likely to be sensitive to herbicides..

REFERENCES

Angiras, N.N., V. Sharma and V. Sherma (1996). Influence of row orientation, row spacing and weed control methods & physiological performance of irrigated wheat *(Triticum aestivum* L.). *Indian J. Agri.l Sci.,* 41(1): 41-47.

Chancellor, R.J. (1979). The long-term effects of herbicides on weed populations. *Annals of Applied Biol.,* 91: 141–

144.
Chhokar, R.S., D.S. Chauhan, R.K. Sharma, R.K. Singh and R.P. Singh (2002). Major Weeds of Wheat and Their Management. *Research Bulletin* No. 13, Directorate of Wheat Research, Karnal, India.16 pp.
Chhokar, R.S., R.K. Sharma, D.S. Chauhan and A.D. Mongia (2006). Evaluation of herbicides against *Phalaris minor* in wheat in north-western Indian plains. *Weed Res.,* 46: 40–49.
Ghafoor, A., R.A. Shad, and M.A. Sher (1987). Ten most important weeds in Pakistan. *Prog. Farming,* 7: 17-20.
GOP (2005). *Agricultural Statistics of Pakistan 2004-05*. Ministry for Food, Agriculture and Livestock (MINFAL), Govt. of Pakistan, Islamabad.
Jones, R. and R. Medd (1997). Economic analysis of integrated management of wild oats involving fallow, herbicide and crop rotational options. *Aust. J. Expt. Agri.,* 37: 683-691.
Khan, M. and H. Noor (1995). *Weeds of wheat crop and their control.* Div. of Com. Services. NWFP Agric. Univ. Peshawar.
Khan, N., G. Hassan, M.A. Khan and I. Khan (2003). Efficacy of different herbicides for controlling weeds in wheat crop at different times of application–I. *Asian J. Plant Sci.,* 2: 305-309.
Malik, R.K and S. Singh (1995). Littleseed canarygrass (*Phalaris minor* Retz.) resistance to isoproturon in India. *Weed Tech.,* 9: 419–425.
Nadeem, M.A., I.U. Awan, M.A. Khan, and K.W. Khan. 1999. Effect of Post-emergence application of herbicides on weed control. *Pakistan J. Biological Sciences*, 2: 1455-1457.
Pervaiz, K. and M.H. Quazi (1992). Status of food production in Pakistan. *Prog. Farming,* 12: 5.
Pingali, P.L. (1999). *CIMMYT 1998-99*. World Wheat Facts and Trends. Global Wheat Research in a Changing World: Challenges and Achievements. Mexico, D.F.: CIMMYT.
Singh, S., R.C. Kirkwood and G. Marshall (1999). Biology and control of *Phalaris minor* Retz. (littleseed canarygrass) in wheat. *Crop Protection,* 18: 1-16.
Singh, S. and R.K. Malik (1992). Weed management and fertiliser utilization. *Fert. News,* 37: 59-63.
Shamsi, I.H., S. Khan, S. Farid and S.Z. Hussain (2001). Effect and economics of weed management practices on yield and yield components of wheat. *Pak. J. Biol. Sci.,* 1: 20-22.
Salarzai, A.U., Wajid, Shawani and Ahmad (1999). Effect of different herbicides on weed population and yield of wheat (*Triticum aestivum* L.). *Pak. J. Biol. Sci.,* 2: 350-351.
Steel, R.G.D. and J.H. Torrie (1980). *Principles and Procedures of Statistics*. McGraw Hill Book Co., New York, USA.
Stokłosa, A., A. Janeczko, A. Skoczowski, J. Kie (2006). Isothermal calorimetry as a tool for estimating resistance of wild oat (*Avena fatua* L.) to aryloxyphenoxypropionate herbicides. *Thermochimica Acta,* 441: 203–206.
Walia, U.S., and H.S. Gill (1985). Interactions between herbicides and nitrogen in the control of *Phalaris minor* in wheat. *Trop. Pest Management,* 31: 226-231.
WORC (2002). *World wheat facts. Fact Sheet November 2002.* Western Organization of Resource Councils WORC), Washington, D.C., USA.
Web page: http://www.worc.org/pdfs/world/wheat_facts.pdf.

(*Accepted for publication April 2006*)