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EFFECT OF SIX PROBLEMATIC WEEDS ON GROWTH AND YIELD OF WHEAT

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Abstract

A field study was carried out at the Botanical Garden of the University of Punjab, Pakistan, to investigate the yield losses by 6 commonly occurring and most abundant weeds in wheat field viz., *Phalaris minor* Retz., *Rumex dentatus* L., *Coronopus didymus* (L.) Sm., *Medicago denticulata* Willd., *Chenopodium album* L., and *Poa annua* L. These weeds were grown with two commercially grown wheat varieties viz., Inqalab 91 and Punjab 96 in 1:1 weed-crop ratio. Maximum yield losses of 76% in Inqalab 91 were caused by *P. annua* followed by 75% by *C. didymus*, whereas other weeds caused 60-70% yield losses. In case of Punjab 96, maximum yield reduction of 55% was caused by *R. dentatus* followed by *P. minor* (28%), *M. denticulata, C. album* (23%), *C. didymus* (10%) and *P. annua* (0%). Punjab 96 proved to be the comparatively resistant against weeds than Inqalab 91.

Introduction

Weeds are undesirable plants, which infest different crops and inflict negative effect on their yield. There are innumerable reports on the inhibitory effects of weeds on crop plants (Bhowmik & Doll, 1992; Javaid *et al.,* 2007). Generally weed-crop competition is complicated as weeds compete with the crop plants by occupying a space, which would otherwise be available to the crop plant. Anything that reduces this space reduces the plant growth (Wright *et al*., 2001). Water requirement for the growth of weeds is primarily of interest from the stand-point of competition with the crop plant for the available moisture (Gibson, 2000). It has been reported that wild mustard transpires about four times more water than a crop plant (Thakur, 1984). Studies show that weed and canopy architecture especially plant height, location of branches and height of maximum leaf area determine the impact of competition for light and thus have a major influence on crop yield (Cudeny *et al*., 1991). Increased uptake of mineral nutrients in weeds often results in a significant competitive advantage over crop species. Weeds serve as alternate hosts to insects, nematodes and pathogenic fungi. *Fusarium* species pathogenic to winter wheat have been isolated from common broad-leaved weeds (Jenkinson & Parry, 1994).

About 80% of the global cereal production comes from wheat, maize and rice but their yield is greatly affected by these unwanted plants. Wheat (*Triticum aestivum* L.) is the most important cereal throughout the world. It has been estimated that globally yield reduction in wheat due to weeds is 13.1% (Oerke *et al*., 1994) or even more in some cases which is indeed a great loss towards food self sufficiency. Pakistan is an agricultural country and wheat is one of its major crops that was cultivated on an area of 8.0339 m ha during 2002-2003 with grain production of 19.183 m tons with average grain yield 2388 kg ha^{-1} (Anon., 2008). Among the various factors responsible for low yield in Pakistan, weeds play a major role. Up to 45 weeds species have been reported in wheat field in different wheat-growing areas of the country (Qureshi & Bhatti, 2001). *Phalaris minor* Retz., *Rumex dentatus* L., *Coronopus didymus* (L.) Sm., *Medicago denticulata* Willd., *Chenopodium album* L., and *Poa annua* L., have been reported as the frequently occurring and densely populated weeds of wheat in the country (Siddiqui & Bajwa, 2001). The present study was, therefore, undertaken to investigate the effect of infestation of these weeds on growth and yield of two commonly cultivated wheat varieties viz., Inqalab 91 and Punjab 96.

Materials and Methods

Selection of wheat varieties and weed species: Two commonly grown wheat varieties viz. Inqalab 91 and Punjab 96 were selected for the experiment. Certified seed of these varieties were obtained from Provincial Seed Certification Department, Lahore, Pakistan. Six frequently occurring weeds of wheat in Pakistan namely *C. album, C. didymus, M. denticulata, P. minor, P. annua* and *R. dentatus* were selected for the present study (Siddiqui & Bajwa, 2001).

Field experiment: Experiment was conducted in Botanical Garden, University of the Punjab, Quaid-e-Azam Campus, Lahore, Pakistan. Soil of the experimental field was sandy loam in texture having organic matter 0.69%, pH 7.8, nitrogen 0.035%, available phosphorus 6.3 mg kg^{-1} and available potassium 100 mg kg^{-1}. The micronutrient B, Mn, Fe, Cu and Zn were 1.06, 22.8, 10.8, 1.9 and 1.3 mg kg^{-1} of soil respectively. A basal recommended dose of N, P_2O_5 and K_2O at 35:50:50 kg ha^{-1} in the form of urea, diammonium phosphate and sulphate of potash was applied three days before sowing. N @ 35 kg ha^{-1} as urea was top dressed at initiation of flowering. These chemical fertilizers were applied as per recommendation of the Agriculture Department of Punjab, Pakistan. Weather data during the experimental period is presented in Table 1.

Experiment was conducted in a split plot design. Wheat varieties were kept in main plots and weed species in subplots. Each subplot measured 2.5×1.4 m^2. Seeds of wheat varieties Inqalab 91 and Punjab 96 were sown on November 25, 2005 with inter and intra row spacing of 22 cm. Seeds of selected weed species were sown between the wheat seeds with 1:1 weed:wheat ratio. Plots without weeds served as control. Each treatment was replicated thrice. Plots were irrigated with ground water of good quality whenever required.

Harvesting schedule and data analysis: Wheat plants were harvested after 90, 120 and 150 days of sowing. At each harvest, plants were carefully uprooted, thoroughly washed under tap water and roots were separated from shoots. Numbers of total tiller, fertile tillers, and shoot and root dry weights were recorded. At final harvest, grains were separated from ears and weighed. All the data were analyzed statistically by applying t-test using computer software COSTAT. Percentage losses in grain yield due to weed competition were also calculated.

Table 1. Weather data during the experimental period.

Months	Temperature (°C)					Precipitation (mm)	Relative humidity (%)
	Daily	Maximum		Minimum			
	mean	Mean	Highest	Mean	Lowest		
January	14.1	19.9	25.2	8.4	3.6	18.9	64
February	20.7	26.7	29.1	14.7	11.6	4.9	61
March	21.5	27.0	34.0	16.1	13.9	42.1	57
April	29.2	35.7	41.8	22.7	16.5	0.01	29
November	21.1	26.0	29.6	16.1	10.8	9.0	67
December	15.1	20.2	23.4	9.9	6.7	30.8	71

Source: Pakistan Meteorological Department, Islamabad, Pakistan.

Results

Effect of weeds on tillering: Data regarding the effect of different weeds on tillering is given in Table 2 and Fig. 1. In both the wheat varieties, tillering was markedly reduced by weeds. However, negative effect on tillering varied with weed species. Furthermore, the two tested wheat varieties showed different response to weeds infestation. Inqalab 91 was found to be more susceptible to weed infestation than Punjab 96. All the tested weed species significantly suppressed the number of tillers in Inqalab 91 at all the three harvest stages. *P. annua* found to be the most damaging weed resulting in 72, 72 and 76% reduction in tillering followed by *C. didymus* that caused 68, 69 and 65% decline in tillering at 90, 120 and 150 days after sowing (DAS), respectively. Other weed species resulted in 36-64, 41-59 and 50-59% reduction in the studied parameter at 90, 120 and 150 DAS, respectively. In Punjab 96, although all the weeds significantly suppressed tillering capacity at final harvest, however, negative effect of weeds was not as much pronounced as in Inqalab 91. There were only 14-33, 25-40 and 15-32% reduction in tillering capacity at 90, 120 and 150 DAS, respectively.

Effect of weeds on shoot dry weight: Data regarding the effect of different weeds on shoot biomass is demonstrated in Table 2 and Fig. 2. Shoot biomass in both the wheat varieties was adversely affected by weeds infestation. Effect of weeds was less pronounced 90 DAS than at two later harvests. Inqalab 91 was highly susceptible to various weeds. *P. annua* and *P. minor* consistently and significantly reduced shoot biomass at all the three growth stages. Other weed species exhibited significant adverse impact on the studied parameter only at two later growth stages viz. 120 and 150 DAS. Different weed species exhibited 20-75% and 59-77% reduction in shoot biomass in Inqalab 91 after 120 and 150 days of sowing, respectively. *P. annua* caused highest reduction in shoot biomass at both of these growth stages.

Punjab 96 was found to be more tolerant to weed infestation than Inqalab 91. Shoot biomass in Punjab 96 was suppressed consistently and significantly by *M. denticulata, P. minor* and *C. album.* This variety showed tolerance to *R. dentatus* up to 120 days growth stage. Different weed species caused 14-32% and 18-28% reduction in shoot biomass in this wheat variety 120 and 150 DAS, respectively (Fig. 2).

Table 2. Percentage reduction in different growth and yield parameters of wheat variety Inqalab 91 and Punjab 96 due to weeds competition at 120 and 150 days growth stages.

Weed species	Reduction over control (%)							
	Inqalab 91				Punjab 96			
	Tillers	Shoot biomass	Root biomass	Grain yield	Tillers	Shoot biomass	Root biomass	Grain yield
120 days after sowing								
R. dentatus	41	36	37	-	33	14	87	-
M. denticulate	59	58	62	-	34	31	62	-
P. annua	72	75	75	-	25	28	87	-
C. didymus	69	70	75	-	39	28	25	-
P. minor	45	47	25	-	40	32	62	-
C. album	55	57	50	-	25	22	62	-
150 days after sowing								
R. dentatus	50	70	49	67	32	27	45	48
M. denticulate	56	60	31	60	30	21	2.4	23
P. annua	76	77	13	76	15	18	15	0.3
C. didymus	65	65	47	75	25	29	40	10
P. minor	53	65	57	68	30	29	27	33
C. album	59	63	16	65	31	28	18	24

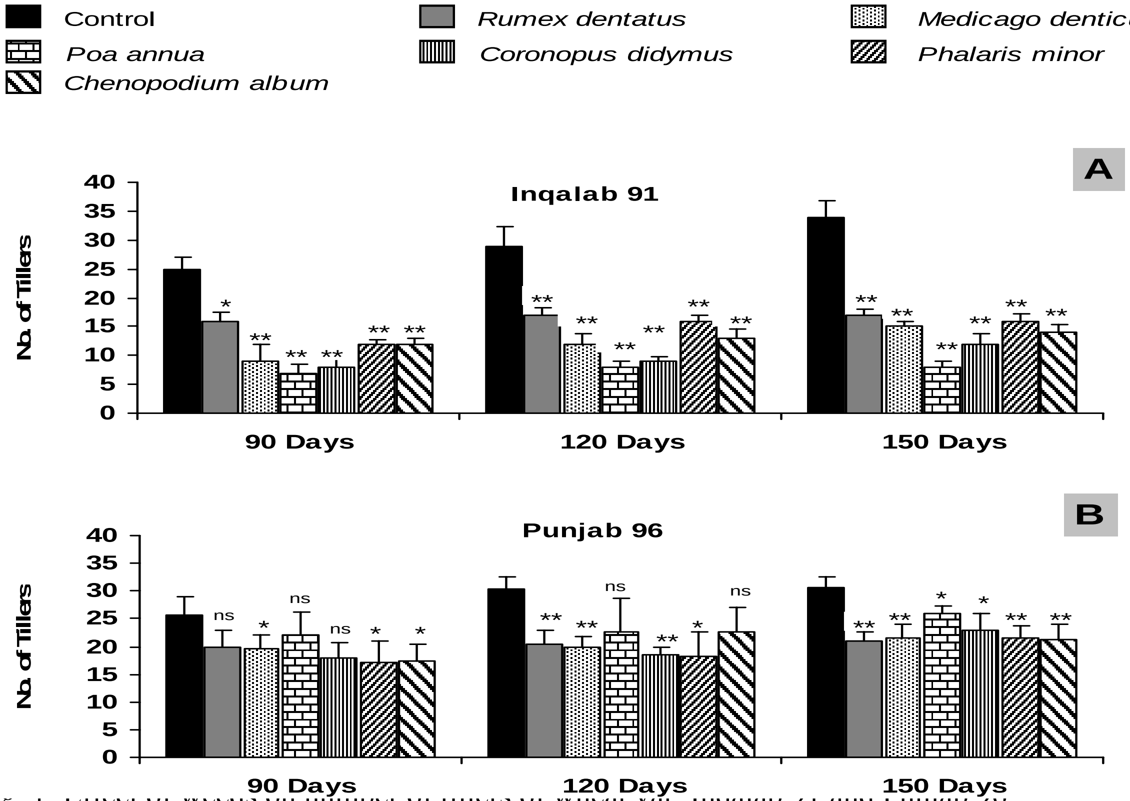

Fig. 1. Effect of weeds on number of tillers of wheat var. Inqalab 91 and Punjab 96. Vertical bars denote standard errors of the means of 3 replicates. *, ** show significant difference from control at p≤0.05 and p≤0.01 respectively as determined by t-test.

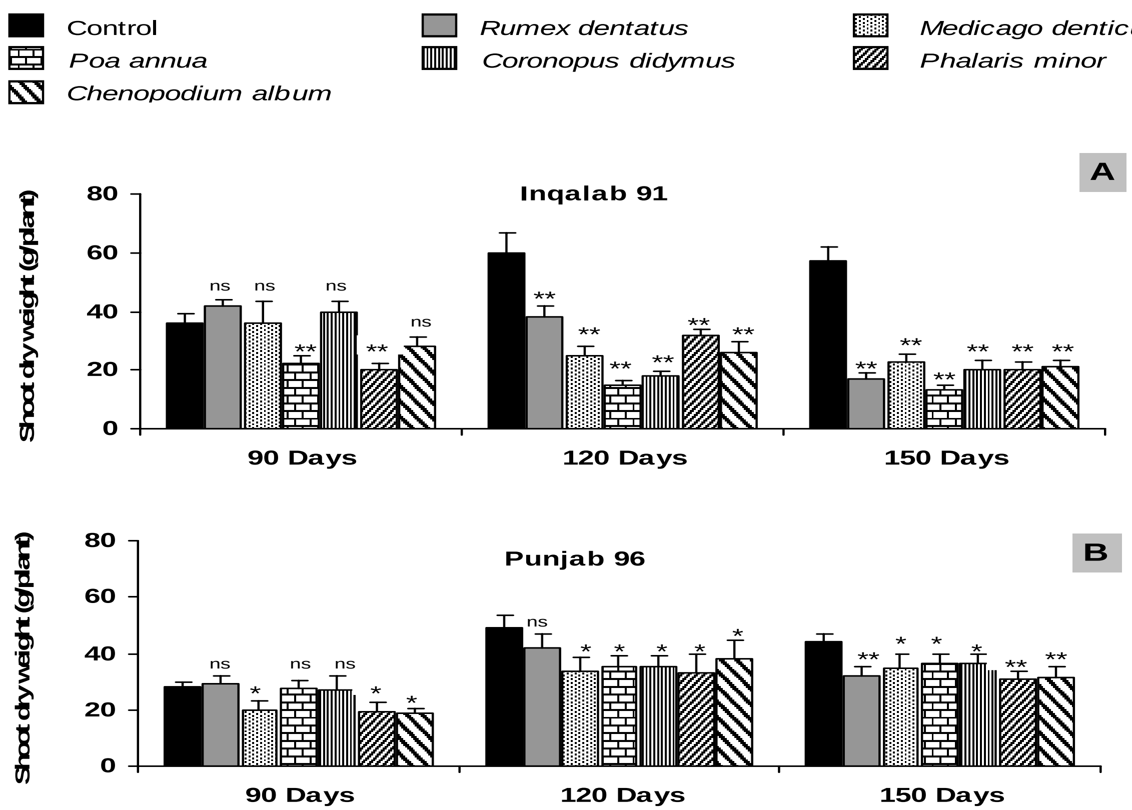

Fig. 2. Effect of weeds on shoot dry weight of wheat var. Inqalab 91 and Punjab 96. Vertical bars denote standard errors of the means of 3 replicates. *, ** show significant difference from control at p≤0.05 and p≤0.01 respectively as determined by t-test.

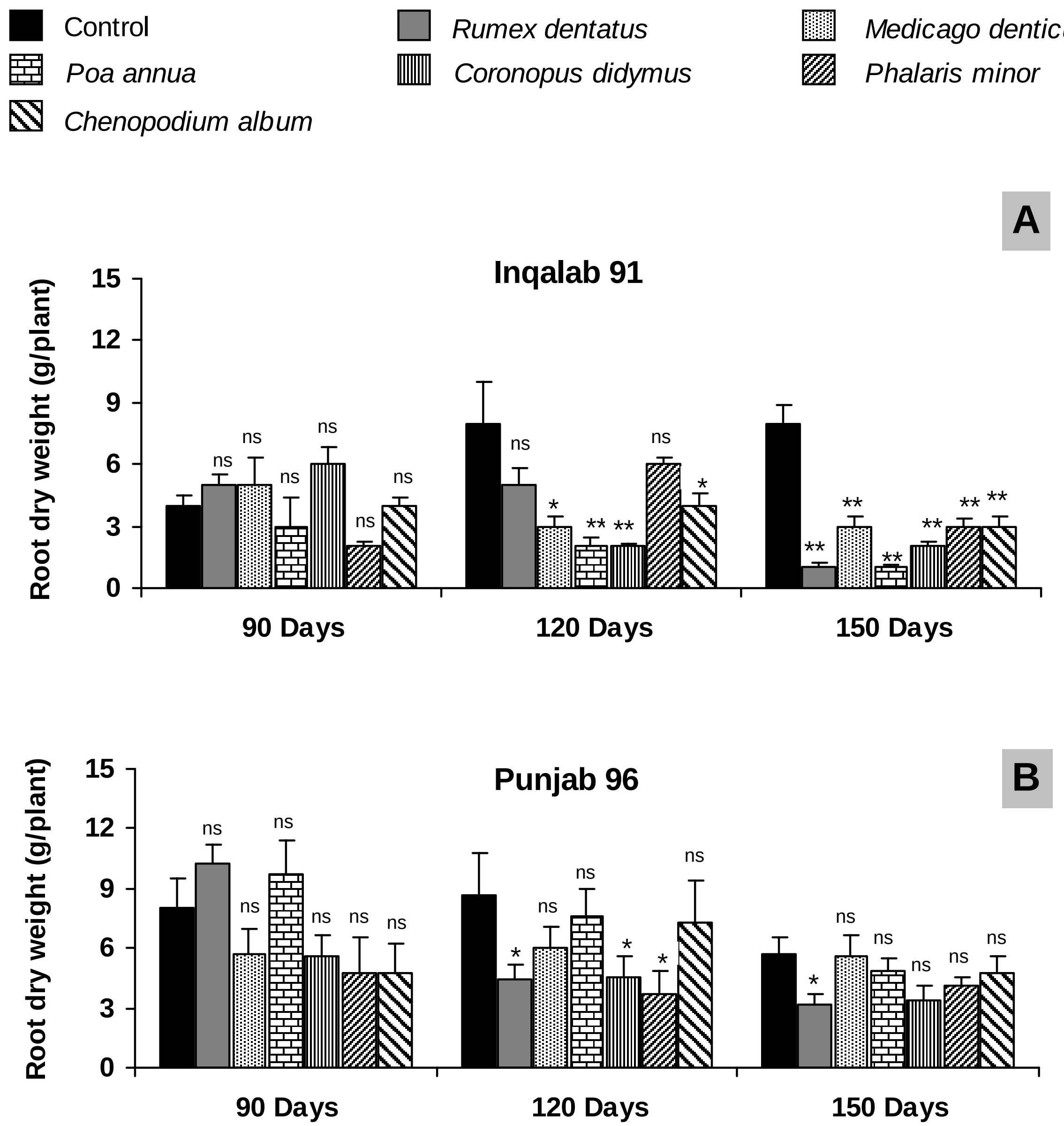

Fig. 3. Effect of weeds on root dry weight of wheat var. Inqalab 91 and Punjab 96.
Vertical bars denote standard errors of the means of 7 replicates. *, ** show significant difference from control at p≤0.05 and p≤0.01 respectively as determined by t-test.

Effect of weeds on root dry weight: Data regarding the effect of different weeds on root biomass of two wheat varieties at different growth stages is presented in Table 2 and Fig. 3. Root biomass in Inqalab 91 was more susceptible to weed infestation than root biomass in Punjab 96. Up to 90 days growth, effect of different weeds on root biomass was nonsignificant in both the wheat varieties except *P. minor* on root biomass in Inqalab 91. At 120 days growth stage, all the weeds markedly suppressed root biomass in Inqalab 91. Effect of *M. denticulata, P. annua, C. didymus* and *C. album* was significant. There was 25-75% reduction in root biomass of Inqalab 91 due to different weeds at this growth stage. In contrast, in Punjab 96, there was 13-57% reduction in root biomass due to different weeds infestation. Effect of *R. dentatus, C. didymus* and *P. minor* was significant. Effect of weed infestation on root biomass was markedly different in the two wheat varieties 150 DAS i.e. at the maturing stage. All the weeds significantly reduced root biomass by 37-87% in Inqalab 91. Conversely, in Punjab 96, only the effect of *R. dentatus* was significant and different weeds caused on 2-45% reduction in the studied parameter.

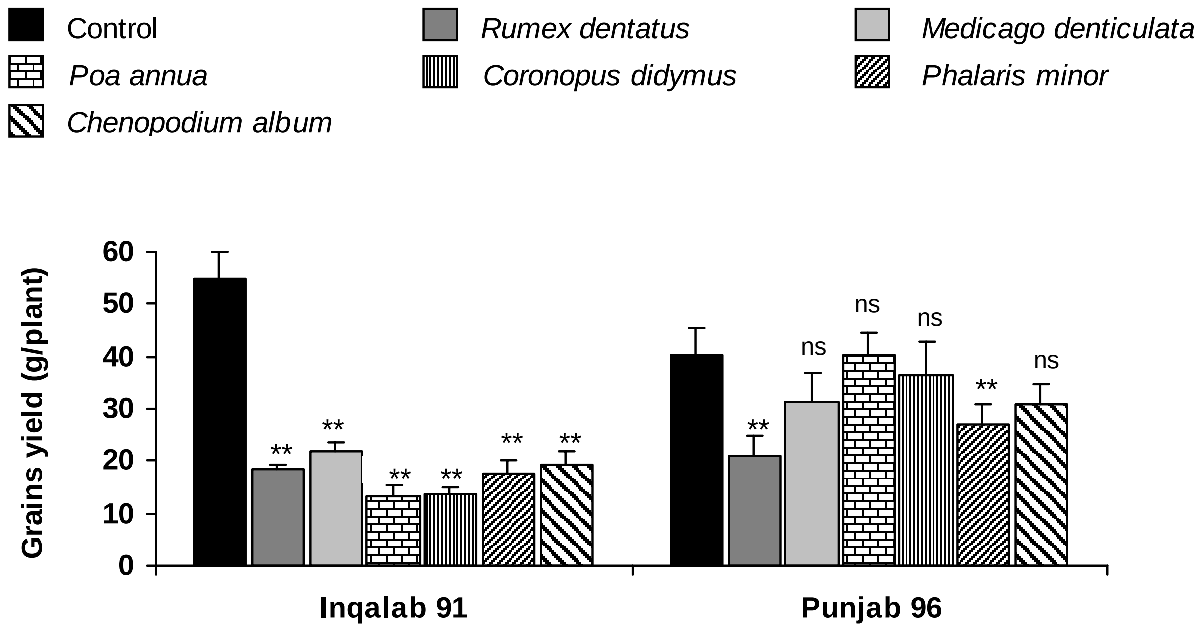

Fig. 4. Effect of weeds on grain yield of wheat var. Inqalab 91 and Punjab 96.
Vertical bars denote standard errors of the means of 3 replicates. *, ** show significant difference from control at $p \leq 0.05$ and $p \leq 0.01$ respectively as determined by t-test.

Effect of weeds on grain yield: Data concerning the effect of weeds on grain yield in two wheat varieties is shown in Table 2 and Fig. 4. In Inqalab 91, all the weeds invariably and significantly reduced grain yield by 60-76%. Conversely, in Punjab 96 highly variable yield response to different weed species was recorded. *R. dentatus* infestation resulted in maximum and significant yield losses of 48% followed by *P. minor* where 33% reduction in grain yield compared to weed free control was recorded. Effect of other weeds on grain yield in this wheat variety was not significant.

Effect of weeds on 100-grains weight: Data concerned with effect of weeds on 100-grains weight is expressed in Fig. 5. In Inqalab 91, none of the weed species exhibited significant effect on 100-grains weight. On the other hand, this studied parameter showed variable response to various weed species in Punjab 96. In this variety, *R. dentatus, C. didymus* and *P. minor* significantly reduced 100-grains weight while the effect of other weed species was insignificant.

Discussion

In the present study, two commonly grown wheat varieties viz. Inqalab 91 and Punjab 96 were cultivated in competition with six commonly occurring weeds of wheat in 1:1 crop-weed ratio. Results indicated that all the weeds were competitive and caused substantial reduction in the vegetative growth and grain yield in both the tested wheat varieties. The adverse effects of various weeds on growth and yield of crops may be attributed to the fact that weeds compete with crops for important factors such as nutrients, water, light and space for their growth and reproduction (Panneerselvam & Lourduraj, 2000; Chandramohan *et al*., 2002).

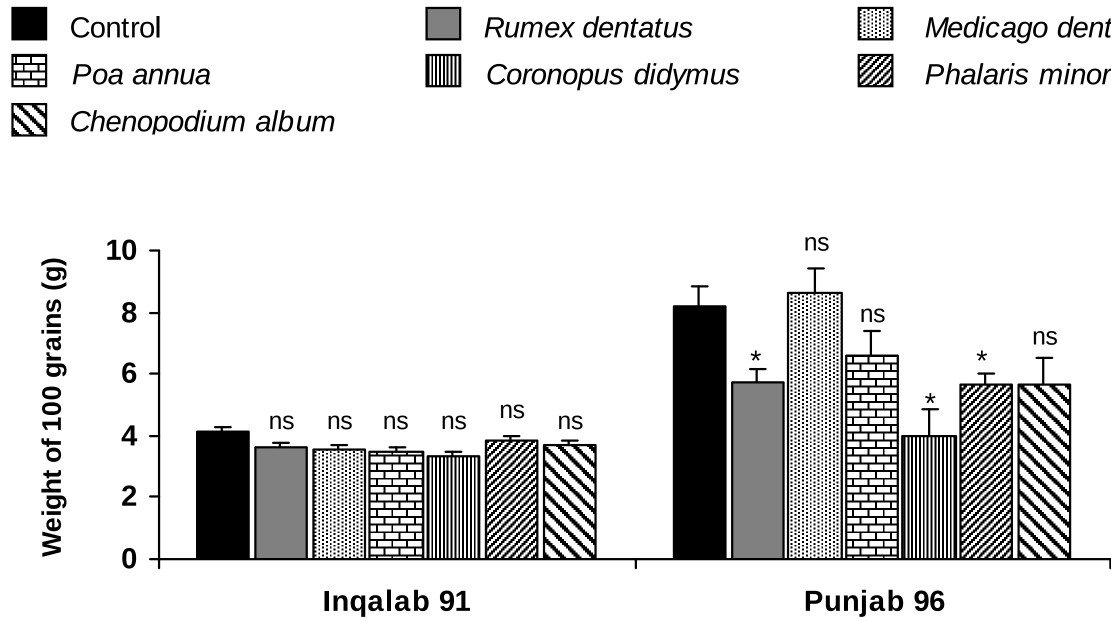

Fig. 5. Effect of weeds on grain weight of wheat var. Inqalab 91 and Punjab 96.
Vertical bars denote standard errors of the means of 3 replicates. *, ** show significant difference from control at p≤0.05 and p≤0.01 respectively as determined by t-test.

In the present study, response to various weeds was highly variable between the two wheat varieties. The wheat variety, Inqalab 91 incurred greater loss both in growth and yield traits than Punjab 96. Different weeds caused 60-76% reduction in grain yield in Inqalab 91 as compared to 0.3-48% yield losses in Punjab 96. Genotypic variation in response to weed infestation has also been reported for other crops (Javaid *et al..,* 2007). Improved crop tolerance and weed suppressing ability (crop competitiveness) are tactics that may reduce the negative effect of weeds on crop yield (Linquist & Kropff, 1996). Earlier studies have shown that competition for environmental resources between weeds and cereals can be attributed mainly to morphological and physiological traits of plants (Didon, 2002). Important traits, primarily affecting photosynthetic active radiation interception, are leaf inclination, early vigour, plant height, tillering capacity, seed size, and initial shoot and root growth rates (Bertholdsson, 2004; O'Donovan *et al*., 2000). Plant height plays a role in the competitive ability of wheat (Korres & Williams 2002). In a study of Canadian spring wheat cultivars, crop height appeared to have the greatest impact on competitive ability, with the shortest wheat cultivars experiencing the largest yield reductions and allowing the greatest weed growth (Huel & Hucl 1996). Wicks *et al.,* (1986), however, suggested that height alone does not explain competitive ability, since some shorter cultivars have been found to be good competitors. Canopy structure may also have an influence on competitive ability. Champion *et al.,* (1998) found that a tall cultivar that intercepted a greater proportion of PAR was more effective at suppressing weed growth than a short cultivar with low light interception capabilities. In addition to height and canopy structure, tillering capacity (measured as the number of fertile tillers/unit area) has often been reported to confer greater competitive ability in wheat (Korres & Froud-Williams, 2002). Among other traits, high tiller numbers were found in the most competitive wheat varieties around the world (Lemerle *et al.,* 1996). Furthermore, variation in allelopathic potential of wheat varieties could be a possible factor responsible for variable genotypic response to weed infestation (Oueslati, 2003).

Among the various test weed species, *P. annua* caused greatest adverse impact on root and shoot growth in Inqalab 91. Consequently, highest grain yield losses of 76% were recorded in this wheat variety. The highly competitive nature of this grassy weed could be attributed to its rapid and luxurious growth in wheat field. Furthermore, being a member of the same family Poaceae to which wheat belongs, this weed may have same nutrient requirements as that of wheat.

C. didymus was found to be the second most damaging weed resulting in 75% reduction in grain yield and also substantial losses in plant vegetative growth. The weed belongs to family Brassicaceae. The weeds of this family are generally believed to have adverse effect on crop growth due to the vigorous growth and the resulting competition for light, water and minerals (Waller, 1982; Waddington & Bittman, 1984). In addition to that, members of this family also exhibit allelopathic interference and adversely affect the growth and yield of associated plant species by release of volatile allelochemicals (Waddington, 1978; Oleszek, 1987). Mason-Sedun *et al.,* (1986) published results presenting differential allelopathic potential of some brassicaceous species on wheat in laboratory and field trials. It was strongly suggested that those species contained different quantities of water-soluble phytotoxins inhibiting wheat seedling growth. Members of family Brassicaceae generally produce sulfur compounds glucosinolates. Allyl glucosinolate is one of the predominant glucosinolates in many brassicaceous species. In soil this compound is hydrolyzed into allyl isothiocyanate, a volatile compound (Mayton *et al.,* 1996), which may be responsible for allelopathic interference.

P. minor caused 68 and 33% reduction in Inqalab 91 and Punjab 06, respectively. The high yield losses in the two wheat varieties due to *P. minor* could be attributed to rapid and luxurious growth of this weed in wheat field in Pakistan. Generally, *P. minor* plants become taller than the wheat plants and compete for light and space. In addition, being a member of the Poaceae family and closely related to wheat in morphology, it may have same nutrient and water requirements, resulting in huge yield losses of the crop. Earlier Mehra & Gill (1988) found that competition of 50 and 250 *P. minor* plants m^{-2} reduced wheat yield by 8% and 44%, respectively. Dhaliwal *et al.,* (1997) found that 60–70 *P. minor* plants m^{-2} reduced wheat yield by 10%, while yield losses exceeded 50% when wheat was grown with 500 *P. minor* plants m^{-2}. According to Dhima & Eleftherohorinos (2003) grain yield of wheat was reduced 48% by season-long competition of 400 *P. minor* plants m^{-2}.

R. dentatus and *C. album* caused a substantial decrease in growth and yield of the two tested wheat varieties. Both of these broad-leaf weeds have a very rapid growth generally grow taller than wheat and compete for nutrient, water, light and space consequently cause huge losses in yield of the crop. In addition, *C. album* also interfere through allelopathic interactions (Bhatia *et al.,* 1984; Namvar *et al*., 2009).

The present study concludes that both monocot and dicot weeds cause substantial reduction in growth and yield of wheat. These losses can be reduced by cultivating competitive wheat varieties. In the present study, Punjab 96 was found highly competitive variety against all the commonly occurring weeds of wheat. Further studies are suggested to screen more competitive wheat varieties against weed infestation to reduce the reliance on synthetic herbicides.

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