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ORIGINAL ARTICLE

Study on Dormancy and Phenological Characteristics of wild barley (*Hordeum spontaneum* C. Koch.) in wheat fields, Iran

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ABSTRACT
In order to study on phenological characteristics of wild barley (Hordeum spontaneum c.koch) comparing to wheat (Triticum aestivum L.), and controlling of H. spontaneum by stale seed bed preparation, an experiment was conducted in the fields of Mahidasht research station of Kermanshah - Iran during 2009-2011. In the first year, wild barley and wheat were planted beside each other, and during growth period, their phenological stages were recorded according to Zadoks scale. At harvest stage, wheat was harvested, but wild barley seeds were allowed to pour down on the ground. Immediately after harvest, an experiment with nine treatments and four replications was conducted in a randomized complete block design to determine the best scheduling of irrigation for stale seed bed preparation on the reduction of weed density. Immediately after corn harvest, wheat was planted, and its yield along with wild barley density was recorded. Results indicated that a wild barley plant completes their phenological stages earlier than wheat (cultivar Sardari) in Kermanshah. Growing degree days for completion of wild barley growth stages in Kermanshah was 1060, while this parameter for Sardari wheat cultivar was 1552. At tillering stage, wild barley growth rate was faster than wheat up to stem elongation whereas wheat growth rate exceeded that of wild barley. Delaying of stale seed bed in summer, led to highest germination of wild barley and lowest population of this weed in the following wheat stand. Additionally, corn as second crop can decrease wild barley seed in seed bank.
Keyword: *GDD, Phenology, weed, Zadoks, Stale seed bed*

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INTRODUCTION

Wheat is the most important agricultural crop in Iran, so that every year million hectares are allocated to irrigated and rainfed wheat in cultivated area [1]. The average yield loss due to presence of weeds in wheat fields of Iran is estimated at 20 to 25% [2].

Chemical control is the most common approach to control the weeds in the wheat fields of Iran, so that more than 25% of the total pesticide consumption in Iran is devoted to the herbicide used in this crop. Indiscriminate using of herbicides cause changes in the flora of weeds and lack of efficiency on some species of weeds in wheat fields. Repetetive using of herbicides, has resulted in dominance of rye (*Secale cereale* L.) in cold regions , Little mallow (*Malva parviflora* L.) in the subtropical province of Khuzestan and Wild barley (*Horeum spontaneum* C. Koch.), in a majority parts of Iran [13].

H.spontaneum (wild barley) belongs to Poaceae family. This annual herbaceous plant is a winter weed and the ancestor of cultivated barley (*Hordeum vulgar*e L.). Wild barley is genetically diploid, self-pollinated and has high genetic diversity [17]. Because of little ecological needs, wide range of wheat fields is occupied by wild barley (2, 13).

Baghestani *et al*., [3] also reported that Wild barley in wheat production centers, such as Khuzestan, Fars, Kermanshah, and Khorasan Razavi is more dominant. The highest frequency of wild barley (87.44%) belongs to the Fars province that its mean density is 34.1 per square meter. For the first time in 1986, the

presence of this weed in wheat fields was reported from Abadeh region in Fars province [12]. Wild barley have also been reported in Greece, Egypt, and Southwest Asia to the East, Afghanistan, West Pakistan, and Southern Tajikistan [12, 2].

Gutterman and Nevo [7] demonstrated that wild barley seeds at harvest time require after ripening period germinating due to seed dormancy.

Wild barley seed dormancy is broken by putting in dry condition and 35˚c temperature for a few days [9, 12, 15]. Seeds that are put in natural conditions at temperature of 35˚c and dry condition, germinate after rainfall in the late summer or early autumn [6]. Jamali and Baghestani [8] in Fars showed that the application of fenoxaprop-p-ethyl and clodinafop proparghyl failed to reduce wild barley population.

June *et al*., [10] stated that there is high diversity between different ecotypes of wild barley dormancy, so that dormancy in ecotypes of humid regions was longer than arid regions. Another research showed that the maximum germination of wild barley seeds occurred at alternating temperature of 20˚c -25˚c and 15˚c -20˚c [11]. Baghestani *et al*., [4] and seidipur *et al*., [16] showed that irrigation for stale seed bed preparation (45 days before plant wheat) resulted in lowest wild barley population and biomass (90%) in wheat fields and this is due to breaking of dormancy in its seeds. The application of Sulfosulfuron at rate 27 $g.ha^{-1}$ plus irrigation for stale seed bed preparation provided up to 95 percent control of Wild barley. Baghestani *et al*., [5] reported that using sulfosulfuron at rate 54 $gr.ha^{-1}$ as a post-emergence (at tillering stage of wheat) and 68 $gr.ha^{-1}$ as pre-emergence is the best treatment for reducing wild barley loss in Khuzestan, Varamin, Karaj, and Kermanshah. Several greenhouse experiments by Baghestani *et al*., [2] showed that sulfosulfuron application at rate 27 $gr.ha^{-1}$ in two-leaf stage of mouse barely (*Hordeum murinum* L.), two- row barely (*Hordeum vulgar*e ssp. *Spontaneum*) and wild barley resulting in weed control at 100, 90, and 90 percentage respectively. Delay in spraying, decreased the effectiveness of this herbicide on two-row barley (*Hordeum vulgare* L.) and wild barley, but its performance on mouse barley was excellent.

Minbashi *et al*., [14] reported that in Varamin (Tehran province), wild barley and Rye (*S. cereal* L.) are simultaneously growing with wheat in a time range between 8 to 10 days after planting and heating units of 146 to 164 growing degree days.

The object of this experiment was comparative study of wheat and wild barley phenology and GDD and investigation on the effect of tillage and irrigation for stale seed bed to control wild barley in wheat fields.

MATERIALS AND METHODS

Field experiment was conducted in the 2009-2011 growing seasons at the research fields of Kermanshah, Iran. Wheat and wild barley were planted on 12 December at the same time. Site description, schedule of events, soil type and wheat variety used are shown in (table 1).

The seedbed preparation consisted of moldboard plowing and tandem disking followed by land leveler smoothing in fall. A field cultivator prepared the final seed bed with a row spacing of 60 cm (Fall 2009). The plots were 3×10 m. In order to survey of phenological stages, wild barley and wheat were intercropped. Density of wild barley was 40 seeds per meters. After first irrigation of wheat phenological stages of wheat and Wild barley were recorded based on zadoks scale once a week [18].

Based on W pattern, five points with equal intervals were chosen on each side and phenological stages on each point were registered. At the end of the season, wild barley seeds were allowed to drop down in the ground and wheat was harvested. According to local meteorological statistics (minimum and maximum daily temperature) GDD were calculated.

After wheat harvest, treatments were applied. Treatments included Plowing plus planting corn that was irrigated once a week, Plowing plus irrigation once a week, irrigation once a week, irrigation first, third, fifth, seventh, ninth and eleventh week after harvest (table2).

When irrigation without plowing was applied, the wild barley density was determined from one m^2 quadrat placed within the treated area at heading stage. The wild barley plants were then cut at soil level and oven-dried at 75°C for 72 h. When the plowing was applied, Wild barley density was determined at each irrigation stage. After corn harvest, the wild barley plants were then cut at soil level and oven-dried at 75°C for 72 h in the same quadrate.

After corn harvest, the entire ground was moldboard plowed and then plots were disked before wheat planting and wheat was planted in the same plots. Density, the number of heads and grown stems of wild barley were determined from one m^2 quadrat at heading stage. The wild barley spikes were harvested at physiological maturity stage from one m^2 quadrate and grain yield of wild barley was determined. At maturity stage, grain yield was determined.

RESULTS AND DISCUSSION

Comparative phenology of wheat and wild barley

Wheat and wild barley after 45 degree-days were began to emerge, but wild barley completed its seedling stage 4 days earlier than wheat. Barley and wheat seedling stage ended with 133 degree and 163 growing degree days respectively. Tillering stage of wheat, ended 113 days after planting (14 April), Wild barley tillering stage ended 113 days after planting (14 April), while wheat completed the stage 7 days after wild barley (21 April). Wheat stem elongation stage was started after ending of this stage in wild barley (398 GDD). Stem elongation stage of wheat continued to 4th April, which was equivalent to 531 GDD. It means that, the wild barley surpassed wheat at one stage. Heading stage in wild barley ended two weeks earlier than wheat, so that it occurred in wild barley and wheat in the range of 691 to 756 GDD and 531 to 628 GDD, respectively (table 3).

Flowering period of wild barley and wheat lasted 7 days, but this period in wild barley began and ended two weeks earlier than wheat. Barley surpassed wheat in the milky and dough grain stage for two weeks. Maturity stage of wild barley and wheat lasted one week in the range of 949 to 1060 GDD and two weeks in the range of 1279 to 1552 GDD respectively. Therefore, wild barley completed life cycle, three weeks earlier than wheat in Kermanshah. Wild barley growth period was lasted 176 days and received 1060 GDD, while these factors for wheat were 204 days and 1552 GDD (Table 3).

Table 1, Schedule of events, climate, soil texture, and wheat varieties used in experiment

Location	Climate	Soil type	Wheat Variety	Barley species	Date of planting
Kermanshah	Humid	Silty clay loam	Sardary	*Hordeum spontaneum*	12.12.2010

Table 2, Dates of irrigation in experiment

Treatment	Date of first irrigation
Plowing + planting corn + Irrigation once a week	11.7.2010
Plowing + irrigation once a week	11.7.2010
Irrigation once a week	Since 11.7.2010
Irrigation first week after harvest	11.7.2010
Irrigation third week after harvest	25.7.2010
Irrigation fifth week after harvest	9.8.2010
Irrigation seventh week after harvest	23.8.2010
Irrigation ninth week after harvest	7.9.2010
Irrigation eleventh week after harvest	21.9.2010

Table 3, Wild barley and wheat growth stages based on cumulative GDD and observed date in Kermanshah province.

Growth stages	Wheat			Wild barley		
	Observing date	Cumulative GDD	Days after planting	Observing date	Cumulative GDD	Days after planting
Planting	12.11.2009	0	0	12.11.2009	0	0
Germinatio	22.11.2009	45.5	10	22.11.2009	45.5	10
Seedling growth	29.11.2009-3.3.2010	54.2-163	17-92	28.11.2009-3.2010	51.6-133.2	16-88
Tillering	13.3. 2010-10.4.2010	163-398.4	92-120	9.2.2009-3.4.2010	133.2-46.1	88-113
Stem elongation	10.4. 2010-24.4. 2010	398.4-31.2	120-134	3.4.2010-0.4.2010	346.1-98.4	113-120
Booting	1.5. 2010-8.5.2010	628.9-91.8	141-148	17.4.2010-.4.2010	459.3-31.2	127-134
Heading	8.5.2010-15.5.2010	691.8-56.9	148-155	24.4.2010-.5.2010	531.2-28.9	134-141
Flowering	15.5.201022.5.2010	756.9-843	155-162	1.5.2010-8.5.2010	628.9-91.8	141-148
Milky grain	22.5.2008-29.5.2010	843-949.1	162-169	15.5.2010-.5.2010	756.9-843	155-162
Dough grain	29.5.2010-12.6.2010	949.1-71.9	169-183	22.5.2010 29.5.2010	843-949.1	162-169
Grain maturity	19.6.2010-3.7.2010	1279.9-552	190-204	29.5.2010-5.6.2010	949.1-1060	169-176

Investigating of wild barley in stale seed bed

Results showed that irrigation on 7 September resulted in highest wild barley growth, while irrigation on 11 July in unplowed plot resulted in lowest growth of wild barley. Irrigation stage nine week after harvest (7 September) showed statistically significant difference with all other treatments (table 4).

Wild barley population and dry weight four weeks after treatments

The results indicated that stale seed bed time significantly effects on population and dry weight of wild barley. The most population and dry weight of grown wild barley grown was obtained at the end of September (table 5). Based on these results, delaying irrigation until late September for stale seed bed (Makhar), depleted wild barley seeds from the soil seed bank (table 5).

Because of the secondary dormancy of wild barley in warm seasons [7], no reduction in wild barley seed bank occurs when irrigation (stale seed bed) is early. Also irrigation before planting should be delayed until the end of September.

Table 4, Mean comparison of growing wild barley (m^2) in Kermanshah

Treatment	kermanshah	
	Number(plant.m^{-2})	Date of first irrigation
Plowing + planting corn + Irrigation once a week	394.7c*	11.7.2010
Plowing + irrigation once a week	394.7c	11.7.2010
Irrigation once a week	50.75e	Since 11.7.2010
Irrigation first week after harvest	248.2d	11.7.2010
Irrigation third week after harvest	264.5d	25.7.2010
Irrigation fifth week after harvest	211.5d	9.8.2010
Irrigation seventh week after harvest	688.5b	23.8.2010
Irrigation ninth week after harvest	1016a	7.9.2010
Irrigation eleventh week after harvest	731b	21.9.2010

*Means within each column followed by same letter are not significantly different at 0.05 probability level according to Duncan multiple range test.

Table 5, Mean comparison of dry weight and wild barley population four weeks after the last irrigation**.**

Treatment	Dry weight (gr.m^{-2})	Number (plant.m^{-2})	Date of first irrigation
Irrigation once a week	17.75e*	61e	Since 11.7.2010
Irrigation first week after harvest	81.78d	332d	11.7.2010
Irrigation third week after harvest	166.63b	756c	25.7.2010
Irrigation fifth week after harvest	108.25c	263d	9.8.2010
Irrigation seventh week after harvest	147.18b	796bc	23.8.2010
Irrigation ninth week after harvest	232.25a	1261a	7.9.2010
Irrigation eleventh week after harvest	110.50c	902b	21.9.2010

*Means within each column followed by same letter are not significantly different at 0.05 probability level according to Duncan multiple range test.

Table 6, Mean comparison of density, number of spikes and stems of wild barley and wheat grain yield in 2011.

Treatment	Date of irrigation	Wheat grain yield	Wild barley			
			Stem No.m^{-2}	Grain gr.m^{-2}	Spike no.m^{-2}	Plant No.m^{-2}
Plowing + planting corn + Irrigation once a week	11.7.2010	2300e*	267.5b	60.38c	148.25c	136c
Plowing + irrigation once a week	11.7.2010	3120b	18.75f	3.77h	11.75g	8.5h
Irrigation once a week	11.7.2010	1930f	427.25a	98.46a	240.5a	221.75a
Irrigation first week after harvest	27.7.2010	2530d	216.5c	45.06e	125d	101.5e
Irrigation third week after harvest	6.8.2010	2595d	167.5d	36.07f	106.75e	81.25f
Irrigation fifth week after harvest	21.8.2010	2039f	267.25b	74.81b	179.75e	168.5b
Irrigation seventh week after harvest	4.9.2010	2327e	244.50b	51.06d	128.5d	115d
Irrigation ninth week after harvest	17.9.2010	3292a	3f	0.55h	1.75g	1.25h
Irrigation eleventh week after harvest	29.9.2010	2907c	82e	15.65g	42.75f	35.25g

*Means within each column followed by same letter are not significantly different at 0.05 probability level according to Duncan multiple range test.

Wild barley population in wheat

The results for wild barley population in wheat showed that the lowest weed density was belonged to stale seed bed in late September No significant difference was observed between unplowed plus irrigation eleventh week after harvest (late September) and irrigation in plowed plus irrigation once a week (table 6). Similar results on the number of spikes, stems and grain yield of wild barley were obtained. Results showed that the maximum germination rate of wild barley was observed under irrigation condition on 21 September (irrigation eleventh week after harvest).The lowest wild barley density was observed in wheat following stale seed bed that this was due to the discharge of wild barley seed bank during stale seed bed (table 5 and 6).

Despite the little growth of wild barley in sampling time two weeks after irrigation in Plowed plus irrigation once a week (table 4), this treatment was placed in the appropriate group for controlling wild barley in wheat (table 6) which is due to the large number of wild barley germinated seeds during irrigation or seed rot due to frequent irrigation.

Wheat yield

Mean comparison of wheat yield showed that unplowed plus irrigation nine week after harvest resulted in highest wheat yield, which consisted the least density of wild barley. According to the obtained results, late September is the best time for stale seed bed to discharge wild barley seed bank (table 6).

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