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Research Article

Post-emergence herbicides efficacy as affected by factory and climatic conditions in wheat *Triticum aestivum*

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Abstract: The current study assessed the effects of common herbicides produced by different companies on broadleaved and grass weed control and quantitative traits of irrigated wheat. A two-year experiment (2013-2014 and 2014-2015) was designed as an RCBD with three replications. Experimental treatments included two control treatments (weedy and weed-free) and 15 herbicides produced by three Iranian companies (Ghazal, Golsam-Gorgan, and Gyah) and three international companies (BASF, Nufarm, and Syngenta). The results showed that H13 (bromoxynil + MCPA from BASF tank-mixed with clodinafop propargyl from Golsam Gorgan) and H14 (bromoxynil + MCPA from BASF tank mixed with clodinafop propargyl from Ghazal) treatments in 2014 and H5 (tribenuron methyl from Gyah) and H9 (clodinafop propargyl tank-mixed with tribenuron methyl from Golsam Gorgan) in 2015 almost completely controlled broadleaved and grass weeds. In 2014, H4 (2,4-D + MCPA from Nufarm) and H13 treatments with the averages of 7505 and 7338 kg ha^{-1} ranked first and second in grain yield, while H9 and H12 (bromoxynil + MCPA from BASF tank-mixed with clodinafop propargyl from Gyah) with the averages of 7966 and 7917 kg ha^{-1} were known as superior treatments in 2015. Averaged by years, the grain yield was 3185 kg ha^{-1} at weedy treatment (H17). Although there were no significant differences between herbicides, the grain yield (averaged by years and herbicides) was boosted by 88% compared with the weedy treatment. It was concluded that more rainfall and desirable air temperature positively affected the efficacy of the herbicides.

Keywords: herbicide performance; interspecific competition; manufacturer; wheat-weed relationship

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Introduction

Wheat *Triticum aestivum* L. belongs to the Poaceae or Gramineae family and is the most widely grown for feeding humans and animals in the overall world. It is cultivated over 215 million ha globally (F. A. O., 2019). Wheat is also one of the significant cultivated crops in the Iranian agroecosystems, as in many other countries globally, with an average grain yield of 3100 kg ha^{-1} for irrigated and 900 kg ha^{-1} for rainfed crops (Deihimfard *et al.*, 2018). Wheat plays an

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undeniable role in the human diet due to its agronomic adaptability, grain characteristics, easy storage and transport, and ready conversion into flour (Oleson, 1996; Ranhotra, 1996). At the global level, it provides approximately 20 and 21% of humans' daily dietary calorie and daily dietary protein intake, respectively (Shiferaw *et al*., 2013; van der Meulen and Singh Chauhan, 2017).

A reduction in yield quantity and quality of crops caused by weeds infestation (Hance and Holly, 1990) is observed as a result of competition between crops and weeds for environmental sources, including water, nutrients, light, and CO_2, as well as allelopathy (Monaco *et al*., 2002). It is worth noting that yield losses differ because crops have different competitive abilities against weeds (van Heemst, 1985). Altogether, weeds can reduce crop yields by up to 38%; a greater decrement than pests and diseases (Oerke, 2006). Weeds adversely affect the wheat systems' productivity, including costs of labor, equipment, chemicals, and other management inputs (van der Meulen and Singh Chauhan, 2017). Zimdahl (2013) reported that weeds indirectly affect wheat production by competing with the crop for resources, harboring crop pests, interfering with water management, decreasing the grain yield quantity and quality, and increasing the cost of processing.

Crop yield losses due to competition with weeds can considerably be minimized if diverse and effective weed management operations are implemented (Swanton *et al*., 2015; Jha *et al*., 2017). Herbicides are considered for controlling weed in the agriculture section, and an annual worldwide herbicide sale is projected to be about the U. S. $27 billion (Kraehmer, 2012). Herbicides control weeds efficaciously, with increased water conservation, reduced damage to soil structure, lower fuel costs, and decreased greenhouse gas emissions compared to conventional tillage (Gianessi, 2013). Furthermore, herbicide use has low labor requirements (Chauhan *et al*., 2012). But sometimes, farmers are dissatisfied due to the efficiency of herbicides produced by different companies. Also, due to the continued application of some herbicides and the lack of alternation in their use in wheat fields, there may be risks such as herbicide-resistance weeds, increased dose, and reduced wheat yield. By taking into account the above, the aim of this research was to determine the most appropriate herbicide to maximize the quantitative yields of irrigated wheat in Iran.

Materials and Methods

A two-year field experiment was designed to investigate the effects of common herbicides developed by different companies on broadleaved and grass weeds control as well as quantitative traits of irrigated wheat at the research field of Ferdos Agro-Industrial Complex in Abyek county, Iran (Altitude: 1227 masl, Latitude: 36˚4′ N, Longitude: 50˚22′ E), during 2013-2014 and 2014-2015 growing seasons (referred hereafter as 2014 and 2015, respectively). The mean monthly climatic data (rainfall, minimum and maximum air temperatures) over the two growing periods were obtained from the Abyek weather station. The meteorological data recorded over the two experiment periods are given in Fig. 1.

Soil sampling was carried out to determine some physicochemical characteristics at two depths of 0-30 and 30-60 cm. The soil texture was silty clay loam. The physical and chemical properties of the two layers of the experimental soil are given in Table 1.

The experiment was designed as a randomized complete block design (RCBD) with three replications. Experimental treatments included two control treatments (weedy and weed-free) and 15 herbicides developed by different companies. A description of the treatments and herbicides used is presented in Table 2. Each plot area was 27.3 m^2 (13 × 2.1 m), divided into two parts; One-half of each plot was considered for experimental treatment, and the other half was considered as its control (weedy). A 1 m alley was kept between all plots. The weed composition and some biological and physiological features in the experimental plots are presented in Table 3.

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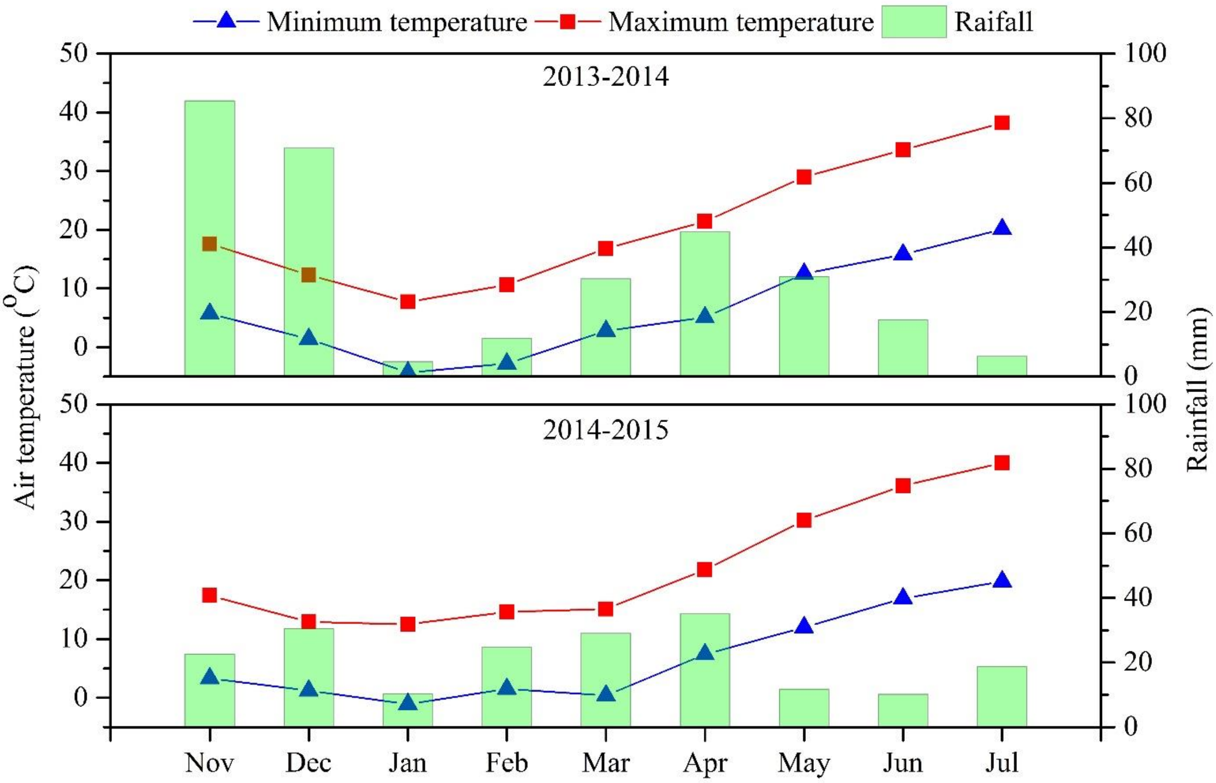

Figure 1 Monthly maximum and minimum air temperatures (°C), and rainfall (mm) recorded over the growing period in 2013-2014 and 2014-2015 in Abyek county, Iran.

Table 1 Physical and chemical properties of two layers (0-30 and 30-60 cm) of the experimental soil and characteristics of irrigation water used.

Soil properties	0-30 depth (cm)	30-60 depth (cm)	Water characteristics	Values
Sand (%)	20	19	EC (EC × 10^6)	614
Silt (%)	50	50	Total dissolved solids (mg l^{-1})	402
Clay (%)	30	31	pH	7.9
pH	8.20	8.21	CO_3^{2-} (mequiv l^{-1})	0
T. N. V (%)	10	10	HCO_3^- (mequiv l^{-1})	3.6
Saturation percentage	44	47	Cl (mequiv l^{-1})	2.4
EC (dS m^{-1})	1	1.4	SO_4^{2-} (mequiv l^{-1})	1.3
Organic matter (%)	0.66	0.78	Total anion (mequiv l^{-1})	7.3
Total nitrogen (%)	0.07	0.08	Ca^{2+} (mequiv l^{-1})	0.8
Available P (mg kg^{-1})	328	360	Mn^{2+} (mequiv l^{-1})	1.2
Available K (mg kg^{-1})	3.6	3.2	Na^{2+} (mequiv l^{-1})	5
			Total cation (mequiv l^{-1})	7
			Sodium adsorption ratio	5
			Na_2CO_3 (mg l^{-1})	1.6

T. N. V: Total neutralizing value; E. C.: Electrical conductivity.

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Table 2 Treatments and herbicides used in the experiment.

Treatment	Company, Country	Trade name	Common name	Dose	Target weeds
H1	Ghazal, Iran	Puma super	Phenpxaprop-p-ethyl	1 L (EW 7.5%)	Grass
H2	Golsam Gorgan, Iran				
H3	Golsam Gorgan, Iran	Puma super + Bromicide MA	Phenpxaprop-p-ethyl	1 L (EW 7.5%)	Grass
	BASF, Germany		Bromoxynil + MCPA	1.5 L (EC 40%)	broadleaved
H4	Nufarm, Australia	U46 Combi Fliud	2,4-D + MCPA	1.5 L (SL 67.5%)	broadleaved
H5	Gyah, Iran				
H6	Golsam Gorgan, Iran	Granstar	Tribenuron methyl	15-20 g (SL (72%)	broadleaved
H7	Ghazal, Iran				
H8	BASF, Germany	Bromicide MA	Bromoxynil + MCPA	1.5 L (EC 40%)	broadleaved
H9	Golsam Gorgan, Iran	Topik + Granstar	Clodinafop propargyl	1 L (EC 8%)	Grass
			Tribenuron methyl	15-20 g (SL (72%)	broadleaved
H10	Golsam Gorgan, Iran	Puma super + Granstar	Phenpxaprop-p-ethyl	1 L (EW 7.5%)	Grass
			Tribenuron methyl	15-20 g (SL (72%)	broadleaved
H11	Gyah, Iran	Topik + Granstar	Clodinafop propargyl	1 L (EC 8%)	Grass
			Tribenuron methyl	15-20 g (SL (72%)	broadleaved
H12	BASF, Germany	Bromicide MA + Topik	Bromoxynil + MCPA	1.5 L (EC 40%)	broadleaved
	Gyah, Iran		Clodinafop propargyl	1 L (EC 8%)	Grass
H13	BASF, Germany	Bromicide MA + Topik	Bromoxynil + MCPA	1.5 L (EC 40%)	broadleaved
	Golsam Gorgan, Iran		Clodinafop propargyl	1 L (EC 8%)	Grass
H14	BASF, Germany	Bromicide MA + Topik	Bromoxynil + MCPA	1.5 L (EC 40%)	broadleaved
	Ghazal, Iran		Clodinafop propargyl	1 L (EC 8%)	Grass
H15	Syngenta, Switzerland	Dialen super	Dicamba + 2,4-D	1.5 L (SL 464)	broadleaved
H16		Control (weed-free)			
H17		Control (weedy)			

Table 3 Scientific name and some biological and physiological features of recognized weeds in the experimental field.

Scientific name	Bayer code	Life cycle	Group	Photosynthesis pathway	Family
Anchusa italica retz.	EHIVU	Annual, winter	Dicotyledon	C_3	Boraginaceae
Sophora alopecuroides L.	SOBSR	Perennial	Dicotyledon	C_3	Fabaceae
Avena ludoviciana durieu.	AVEST	Annual, winter	Monocotyledon	C_3	Poaceae
Descurainia sophia L.	DESSO	Annual, winter	Dicotyledon	C_3	Brassicaceae
Convolvulus arvensis L.	CONAR	Perennial	Dicotyledon	C_3	Convolvulaceae
Turgenia latifolia L.	TURLA	Annual, winter	Dicotyledon	C_3	Apiaceae

Wheat seeds (Pishtaz as a dominant commercial cultivar) were sown with an inter-row space of 15 cm on 1-Nov-2013 and 5-Nov-2014 by cereal drill (developed by Machin Zeraat Hamedan, FK_3-20/4 model). The device was calibrated according to 200 kg ha^{-1} of seed.

A sprinkler irrigation system was applied to irrigate the experimental field. Some characteristics of irrigation water used are given in Table 1. The first irrigation was carried out at sowing time. The second irrigation was conducted 20 days later. The next irrigations were adjusted regularly and according to the water requirement of wheat from April onwards. The water entering the farm was 69.1 mm ha^{-1} in each irrigation.

Accordingly, the number of irrigation frequencies was 8 times over the growing periods in two years (2014 and 2015).

Deltamethrin (0.5 L ha^{-1}) was used to control the sunn pest (*Eurygaster integriceps*). Applied fertilizers based on recommendations and soil test were: urea (250 kg ha^{-1}) in three splits (tillering, booting, and flowering stages), triple superphosphate (150 kg ha^{-1}), potassium sulfate (50 kg ha^{-1}), and (4): sulfate (250 kg ha^{-1}) at pre-plant.

To determine the herbicide value at each treatment, the value required for the studied treatments was calculated based on the determined dose (refer to Table 2). Herbicides were applied at wheat tillering stage (Zadoks 25; Zadoks *et al*., 1974) in which weeds had 2 to 3 leaves at this time. To do this, a pump knapsack sprayer equipped with Teejet nozzle (Kingjet, China) and a pressure of 2 bar was used.

Wheat biomass was measured after oven drying at 70 °C to a constant weight. Leaf area was determined by a leaf area meter (Delta-T Devices L.T.D., Cambridge, UK), and then leaf area index (LAI) was calculated. Wheat harvest was conducted by cutting from the soil surface (an area of 1.5 m^2) at the physiological maturity stage, and grain yield, biomass, 1000-grain weight, the number of grain m^{-2}, and harvest index were determined. Sampling and determination of weeds biomass were performed according to the best time to identify weeds in the study area in which it coincided with ear emergence (Zadoks 55; Zadoks *et al*., 1974). To do this, weed plants were cut at ground level in each plot, and biomass was determined (oven-dried at 70 °C for 48 h).

Due to the non-uniform growth of weeds in the field, weed biomass weight in control plots (one-half of each plot that is untreated) was considered a covariate. Thus, at first, an analysis of covariance (ANCOVA) was conducted for the data set using the general linear model (G. L. M.) procedure in statistical analysis system (S. A. S.) version 9.1.3. There was no significant effect of the covariate on all traits measured; therefore, a one-way analysis of variance (ANOVA) was applied. The assumptions of variance analysis were tested by ensuring that the residuals were random, homogenous, with a normal distribution about a mean of zero. The means comparison was performed using LSMEANS (adjusted by Tukey test) with PDIFF option.

Results

Weed control

The ANOVA indicated that the treatments had a significant effect on weed biomass in both years (Table 4). There was large variability between the efficacy of the different herbicides in terms of weeds biomass in 2014 and 2015 (Table 5). All herbicides had a significant effect on weed control in both years (Table 5). The H4, H13, H14, and H7 treatments in 2014 growing season and the H5, H9, H2, H3, H10, and H12 in the second growing season provided strong control (greater than 94%) of weeds (Table 5).

Averaged across weedy and weed-free plots, although there was no significant difference between 2014 and 2015 growing seasons concerning weeds biomass, the value for this trait was higher in the second year (29.77 g m^{-2}) than the first year (25.21 g m^{-2}) (data not shown).

Wheat grain yield

The ANOVA showed that although the effect of treatment was not statistically significant on grain m^{-2}, 1000-grain weight, grain yield, wheat biomass, and harvest index in both years (except for wheat biomass and grain yield in 2014 and 2015, respectively) (Table 4), weedy treatment (H17) had the lowest values of mentioned traits (Table 5). In the first year, H4 and H13 treatments with the averages of 7505 and 7338 kg ha^{-1} ranked first and second in grain yield among the treatments. In contrast, H9 and H12 with the averages of 7966 and 7917 kg ha^{-1} were known as superior treatments concerning wheat grain yield in the second year because they controlled the dominant weeds (Table 5).

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Table 4 Analysis of variance of traits measured in two experimental years (2014 and 2015) in Abyek county, Iran.

Year	S. O. V	DF	Mean of Squares					
			Number of grain per m^2	1000-grain weight	Grain yield	Wheat biomass	Harvest index	Weed Control (%)
2014	Block	2	113025885*	7.00^{ns}	12078517*	96485463**	0.0017^{ns}	27.71^{ns}
	Treatment	16	37925357^{ns}	14.09^{ns}	3910996^{ns}	38200178*	0.0038^{ns}	23.38**
	Error	31	21162449	11.31	2339994	17132931	0.0022	8.45
	CV (%)		24.49	11.58	27.84	23.95	14.71	3.55
2015	Block	2	35965900^{ns}	603.10**	17307254**	6153068^{ns}	0.0946**	97.19**
	Treatment	16	27494864^{ns}	34.30^{ns}	3119447*	12158380^{ns}	0.0040^{ns}	20.07*
	Error	31	20044650	32.68	1556459	11176028	0.0046	7.70
	CV (%)		26.75	15.09	20.06	24.68	14.65	3.47

ns: not significant at the 0.05 probability level, * Significant at P ≤ 0.05, ** Significant at P ≤ 0.01.

Table 5 Effect of herbicides on the wheat and weed traits measured in two experimental years (2014 and 2015) in Abyek county, Iran.

Treat-ment	Number of grain per m^2		1000-grain weight (g)		Grain yield (kg ha^{-1})		Wheat biomass (kg ha^{-1})		Harvest index		Weed control (%)[a]	
	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015	2014	2015
H1	17277ab	14924a	28.76a	41.86a	4888ab	6197ab	15996ab	12897a	0.30a	0.47a	89ab	91ab
H2	17621ab	18797a	29.00a	36.21a	5111ab	6822ab	15329ab	14244a	0.34a	0.50a	72b	99a
H3	19305ab	18779a	28.06a	37.10a	5520ab	6696ab	16607ab	13916a	0.33a	0.48a	91ab	96a
H4	26213a	16355a	28.84a	39.32a	7505a	6464ab	19481ab	14537a	0.36a	0.43a	99a	80b
H5	15619ab	21729a	27.55a	33.50a	4347ab	6991ab	12350ab	13965a	0.35a	0.49a	70b	99a
H6	16862ab	15461a	25.54a	39.87a	4356ab	6306ab	17450ab	13009a	0.24a	0.48a	71b	81b
H7	17417ab	12966a	29.54a	41.98a	5221ab	5582ab	17002ab	12881a	0.30a	0.44a	98a	75bc
H8	31976ab	14717a	30.49a	38.53a	6084ab	5681ab	19575ab	12254a	0.30a	0.46a	92ab	80b
H9	19857ab	22191a	26.91a	37.67a	5357ab	7966a	17555ab	13912a	0.31a	0.57a	76b	99a
H10	16956ab	20315a	30.91a	36.17a	5284ab	7137ab	15321ab	14781a	0.34a	0.48	92ab	96a
H11	18576ab	11115a	31.53a	40.20a	5962ab	4683ab	22557a	11576a	0.25a	0.42a	70b	60c
H12	18068ab	20878a	33.16a	41.51a	6048ab	7917a	18421ab	18767a	0.33a	0.43a	90ab	94a
H13	24851a	12253a	29.74a	35.76a	7338a	4184ab	20731a	11446a	0.35a	0.37a	99a	52c
H14	23259ab	15085a	27.21a	35.74a	6337ab	5331ab	23415a	11186a	0.27a	0.45a	99a	70bc
H15	20549ab	16979a	30.94a	37.98a	6346ab	6206ab	19029ab	13461a	0.33a	0.46a	85ab	90ab
H16	17354ab	19657a	30.36a	38.84a	5259ab	7614ab	16070ab	16795a	0.32a	0.48a	100a	100a
H17	9717b	12311a	25.03a	31.72a	2445b	3925b	6903b	10570a	0.35a	0.37a	0c	0d

Any two means sharing a common letter do not differ significantly from each other at 5% probability.
[a] Rating scale: 0%, weedy; 100%, weed-free.

Discussion

Weed control

Since most weeds were broadleaved and grasses had less biomass, a combination of broadleaved and grass herbicides was performed much better in controlling weeds at the field level (Habib *et al*., 1986; Baghestani *et al*., 2008; Pala, 2020).

From the weed control perspective, variability in efficacy of herbicides in two years (2014 and 2015) could be attributed to climatic conditions, especially rainfall and temperature at their application time. As seen in Fig. 1, cumulative rainfall over the growing period was higher in 2014 compared with 2015, which resulted in better efficacy of herbicides for weed control. By contrast, the air temperature was cooler in 2014 than 2015. Furthermore, environmental conditions during 1 to 2 weeks before and after application affect herbicide absorption, so that low relative humidity causes cuticle water losses and reduces the absorption of water-soluble herbicides

(Stagnari, 2007). In this regard, Zand *et al*. (2010) stated that the success of herbicides in controlling weeds depends on their interaction with crop genotype, weed type, and the environment (climate and soil), and more even distribution of rainfall may improve herbicide performance.

Wheat grain yield

Interestingly, three treatments (H4, H12, and H13) of herbicides mentioned earlier were a mixture of grass and broadleaved herbicides. Regarding their manufacturing company, two treatments named H12 and H13 differed from each other in the grass herbicide (Table 2). Baghestani *et al*. (2008) found that synergistic reactions were more distinct in some cases, and better performance was obtained when grass with broadleaved herbicides was used in a mixture form. In another study, Baghestani *et al*. (2007) showed that an increase in wheat grain yield was observed when grass and broadleaved weeds were controlled by sulfosulfuron (as a new dual-purpose herbicide) with full-season weed-infested treatment. All in all, H4 and H12 treatments (averaged across two years) had a high efficacy with averages of 6985 and 6983 kg ha^{-1} compared with other herbicides, respectively (Table 5). On the one hand, the higher population of broadleaved weeds in the field (Table 1) and the lower resistance of weeds to H4 treatment due to its lower use in the study region led to acceptable efficacy in weeds control and higher yield production (Table 5).

As seen in Table 5, the wheat grain yield substantially decreased at the weedy treatment (H17) compared with other treatments. Crop performance is affected by weed interference due mainly to competition for water, light, and nutrients resources (Evans *et al*., 2003). Under these conditions, photosynthesis processes followed by the accumulation of dry matter are adversely affected during the growing period (Acciaresi and Chidichimo, 2007), and eventually crop grain yield is decreased. Didon and Boström (2003) concluded that the grain yield of spring barley (*Hordeum vulgare*), oat (*Avena sativa* L.), and wheat was increased by 19–37% following herbicide application. The wheat biomass and LAI for full season weed-free conditions were higher than the full season weed-infested conditions (Fig. 2), indicating the interspecific competition among wheat and weeds for resources. Moreover, the results of regression analysis illustrated a negative correlation between weeds biomass and wheat yield components (grain number/m^2 and 1000-grain yield), biomass, grain yield, and harvest index (Fig. 3). These results are similar to those of Khaliq *et al*. (2013) and Fahad *et al*. (2015), who reported a negative correlation between weed biomass and wheat grain yield.

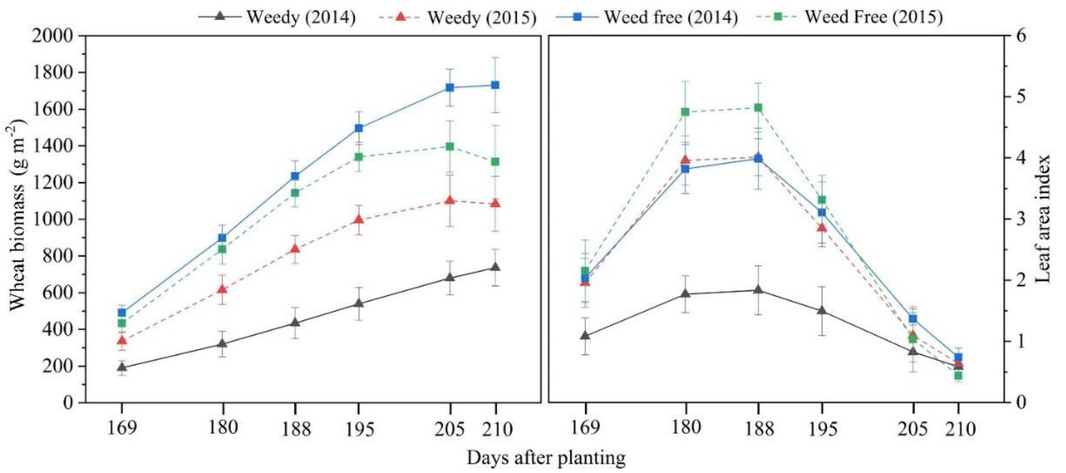

Figure 2 Trend of changes in wheat biomass and LAI during the growing period under weedy and weed-free conditions in 2013-2014 and 2014-2015. The error bars represent standard error.

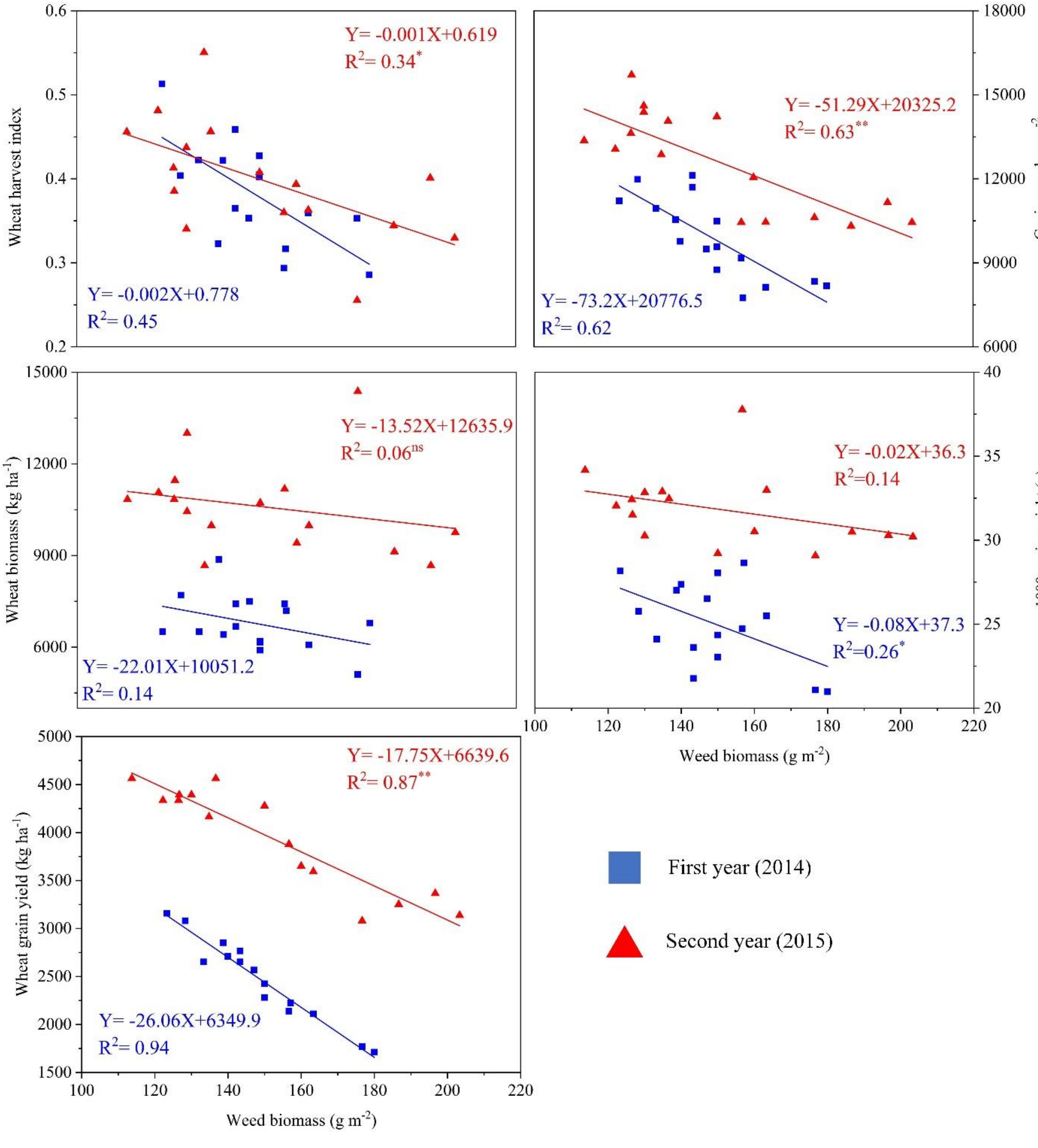

Figure 3 Regression analysis between weed biomass with some wheat agronomic traits in 2013-2014 and 2014-2015.

Conclusion

As a general result, there was large variability between the efficacy of the herbicides developed by different companies in controlling weeds. Still, a combination of broadleaved and grass herbicides was performed much better in controlling weeds at field level. Averaged by years, the wheat grain yield was 3185 kg ha^{-1} at weedy treatment, and although there were no significant differences between herbicides studied, the wheat grain yield (averaged across years and herbicides) was boosted by 88% compared with weedy treatment. Finally, it was observed that more rainfall and desirable air temperature positively affected the efficacy of the herbicides.

Declaration of conflicting interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Authors' contributions

Mohammad Hasan Ebrahimpour: Investigation, Field practices; Ali Mokhtassi-Bidgoli: Conceptualization, Project administration, Methodology, Formal analysis, Writing-Original draft preparation; Majid AghaAlikhani: Conceptualization, Methodology; Hamed Eyni-Nargeseh: Software, Writing-Original draft preparation.

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References

F. A. O. 2019. Food and Agriculture Organization of the United Nations. FAOSTAT Data. Available from: www.faostat.fao.org.

Acciaresi, H. A. and Chidichimo H. O. 2007. Spatial pattern effect on corn (*Zea mays*) weeds competition in the humid Pampas of Argentina. International Journal of Pest Management, 53(3): 195-206. https://doi.org/10.1080/09670870701288116.

Baghestani, M. A, Zand, E., Soufizadeh, S., Beheshtian, M., Haghighi, A., Barjasteh, A., Ghanbarani Birgani, D. and Deihimfard R. 2008. Study on the efficacy of weed control in wheat (*Triticum aestivum* L.) with tank mixtures of grass herbicides with broadleaved herbicides. Crop Protection, 27: 104-111. https://doi.org/10.1016/j.cropro.2007.04.013.

Baghestani, M. A., Zand, E., Soufizadeh, S., Jamali, M. and Maighany F. 2007. Evaluation of sulfosulfuron for broadleaved and grass weed control in wheat (*Triticum aestivum* L.) in Iran. Crop Protection, 26: 1385-1389. https://doi.org/10.1016/j.cropro.2006.11.011.

Chauhan, B. S., Singh, R. G. and Mahajan G. 2012. Ecology and management of weeds under conservation agriculture: a review. Crop Protection, 38: 57-65. https://doi.org/10.1016/j.cropro.2012.03.010.

Deihimfard, R., Eyni-Nargeseh, H. and Mokhtassi-Bidgoli A. 2018. Effect of future climate change on wheat yield and water use efficiency under semi-arid conditions as predicted by APSIM-wheat model. International Journal of Plant Production, 12(2): 115-125. https://doi.org/10.1007/s42106-018-0012-4.

Didon, U. M. E. and Boström, U. 2003. Growth and development of six barley (*Hordeum vulgare* ssp. *vulgare* L.) cultivars in response to a model weed (*Sinapis alba* L.). Journal of Agronomy and Crop science, 189: 409-417.

Evans, P. S, Knezevic, Z. S., Lindquist, J. L., Shapiro, A. C. and Blankenship E. E. 2003. Nitrogen application influences on the critical period for weed control in corn. Weed Science, 51: 408-412. https://doi.org/10.1614/0043-1745(2003)051[0408:NAITCP]2.0.CO;2.

Fahad, Sh., Hussain, S., Chauhan, B. S, Saud, Sh., Wu, Ch., Hassan, Sh., Tanveer, M., Jan, A. and Huang J. 2015. Weed growth and crop yield loss in wheat as influenced by row spacing and weed emergence times. Crop Protection, 71: 101-108. http://dx.doi.org/10.1016/j.cropro.2015.02.005.

Gianessi L. P. 2013. The increasing importance of herbicides in worldwide crop production. Pest Management Science, 69(10): 1099-1105. https://doi.org/10.1002/ps.3598.

Habib, Sh. A, Abdul-Rahman, A. A. and Abadi, Kh. W. 1986. Herbicide mixtures for the control of broadleaf and grassy weeds in barley (*Hordeum vulgare*). Journal of Agricultural Water Resource Research, 5(2): 21-35.

Hance, A. J. and Holly K. 1990. Weed Control Handbook: Principles. Blackwell Scientific Publications, Oxford. 582 p.

Jha, P., Kumar, V., Godara, R. K. and Chauhan B. S. 2017. Weed management using crop competition in the United States: A review. Crop Protection, 95: 31-37. https://doi.org /10.1016/j.cropro.2016.06.021.

Khaliq, A., Shakeel, M., Matloob, A., Hussain, S., Tanveer, A. and Murtaza Gh. 2013. Influence of tillage and weed control practices on growth and yield of wheat. Philippine Journal of Crop Science, 38(3): 12-20.

Kraehmer H. 2012. Innovation: changing trends in herbicide discovery. Outlooks on Pest Management, 23: 115-118. https://doi.org/ 10.1564/23jun06.

Monaco, T. J., Weller, S. C. and Ashton F. M. 2002. Weed Science: Principles and Practices. John Wiley & Sons, Inc, New York. 671 p.

Oerke E. C. 2006. Crop losses to pests. Journal of Agricultural. Science, 144: 31-43.

Oleson B. T. 1996. World wheat production, utilization and trade. In: Bushuk W, Rasper VF. (Eds), Wheat: Production, Properties and Quality, Springer, Boston, MA. 1e11. http://dx.doi.org/10.1007/978-1-4615-2672-8_1.

Pala F. 2020. The effect of post emergence herbicides and their mixtures on grass and broadleaf weed control in barley (*Hordeum vulgare* L.). Fresenius Environmental Bulletin, 29(2): 1206-1213.

Ranhotra G. S. 1996. Wheat: contribution to world food supply and human nutrition. In: Bushuk W, Rasper VF. (Eds), Wheat Production, Properties and Quality, Springer, Boston, MA. 12e24. http://dx.doi.org/ 10.1007/978-1-4615-2672-8.

Shiferaw, B., Smale, M., Braun, H. J., Duveiller, E., Reynolds, M. and Muricho G. 2013. Crops that feed the world 10. Past successes and future challenges to the role played by wheat in global food security. Food Security, 5(3): 291-317. http:// dx.doi.org/10.1007/ s12571-013-0263-y.

Stagnari F. 2007. A review of the factors influencing the absorption and efficacy of lipophilic and highly water-soluble post-emergence herbicides. European Journal of Plant Science Biotechnology, 1(1): 22-35.

Swanton, C. J., Nkoa, R. and Blackshaw R. E. 2015. Experimental methods for crop-weed competition studies. Weed Science, 63(1): 2-11.

Van Heemst, H. D. J. 1985. The influence of weed competition on crop yield. Agricultural Systems, 18: 81-93.

Van der Meulen, A. and Singh Chauhan B. 2017. A review of weed management in wheat using crop competition. Crop Protection, 95: 38-44. http://dx.doi.org/10. 1016/j.cropro.2016.08.004.

Zadoks, J. C., Chang, T. T. and Konzak C. F. 1974. A decimal code for the growth stages of cereals. Weed Research, 14: 415-421.

Zand, E., Baghestani, M. A., AghaAlikhani, M., Soufizadeh, S., Khayami, M. M., PourAzar, R., Sabeti, P., Jamali, M., Bagherani, N. and Forouzesh S. 2010. Chemical control of weeds in wheat (*Triticum aestivum* L.) in Iran. Crop Protection, 29: 1223-1231. https://doi.org /10.1016/j.cropro.2010.07.004.

Zimdahl R. L. 2013. Fundamentals of Weed Science, fourth ed. Academic Press.

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کارایی علف‌کش‌های پس‌رویشی تحت تأثیر کارخانه و شرایط اقلیمی در گندم (*Triticum aestivum*)

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چکیده: مطالعه حاضر اثرات علف‌کش‌های رایج تولید شده توسط شرکت‌های مختلف را بر کنترل علف‌های هرز باریک‌برگ و پهن‌برگ و هم‌چنین صفات کمّی گندم آبی مورد ارزیابی قرار داد. یک آزمایش دو ساله (۱۳۹۲-۱۳۹۳ و ۱۳۹۴-۱۳۹۳) به‌صورت بلوک کامل تصادفی با سه تکرار طراحی شد. تیمارهای آزمایشی شامل دو تیمار شاهد (عاری از علف هرز و عدم‌کنترل علف هرز) و ۱۵ علف‌کش تولید شده توسط سه شرکت ایرانی (غزال، گل سم گرگان و گیاه) و سه شرکت بین‌المللی (BASF، Nufarm و Syngeta) بودند. نتایج نشان داد که تیمارهای H13 (بروموکسیبنیل + ام‌سی‌پی‌آ (برومایسیدام‌آ) تهیه شده از شرکت BASF + کلودینافوپ-پروپارژیل (تاپیک) از شرکت گل سم گرگان) و H14 (بروموکسینیل- سی‌پی‌آ (برومایسیدام‌آ) + کلودینافوب-پروپارژیل (تاپیک) به‌ترتیب از شرکت‌های BASF و غزال) در سال اول و تیمارهای H5 (تری بنورون متیل تهیه شده از شرکت گیاه) و H9 (کلودینافوپ-پروپارژیل (تاپیک) + تریبنورون متیل (گرانستار) تهیه شده از شرکت گل سم گرگان) در سال دوم تقریباً به‌طور کامل علف‌های هرز باریک‌برگ و پهن‌برگ را کنترل کردند. در سال اول، تیمارهای H4 (توفوردی + ام‌سی‌پی‌آ (یو ۴۶ کمبی فلوئید) تهیه شده از شرکت Nufarm اتریش) و H13 با میانگین‌های ۷۵۰۵ و ۷۳۳۸ کیلوگرم در هکتار در رتبه‌های اول و دوم ازنظر عملکرد دانه قرار گرفتند، درحالی‌که تیمارهای H9 و H12 (بروموکسینیل + ام‌سی‌پی‌آ (برومایسیدام‌آ) تهیه شده از شرکت BASF + کلودینافوپ-پروپارژیل (تاپیک) از شرکت گل سم گرگان) با میانگین‌های ۷۹۶۶ و ۷۹۱۷ کیلوگرم در هکتار به‌عنوان تیمارهای برتر در سال دوم شناخته شدند. میانگین دو سال، عملکرد دانه در تیمار عدم کنترل علف هرز (H17) ۳۱۸۵ کیلوگرم در هکتار بود و اگرچه تفاوت معنی‌داری بین علف‌کش‌ها وجود نداشت، عملکرد دانه (میانگین سال و علف‌کش) در مقایسه با تیمار عدم کنترل علف هرز تا ۸۸ درصد افزایش یافت. نتیجه‌گیری شد که میزان بارندگی بیش‌تر و دمای مطلوب هوا اثرات مثبتی بر کارایی علف‌کش‌ها دارند.

واژگان کلیدی: رابطه گندم-علف هرز، رقابت درون گونه‌ای، شرکت تولید کننده، عملکرد علف‌کش

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