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Research Article

Effect of sulfonylurea herbicides residues on growth and yield of sunflower in rotation with wheat

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ABSTRACT-To evaluate the effect of residue of sulfonylurea herbicides and wheat residues on the growth and yield of sunflower, a split factorial experiment was conducted based on a randomized complete block design (RCBD) with four replications at the College of Agriculture, Shiraz University, Shiraz, Iran. The treatments included with and without wheat residues from the tested farm as the main plots, and a combination of three herbicides (Total, Apirus and Atlantis) and their concentrations (recommended and 30% overdose) which were considered as subplots. No herbicide treatment was used as control. The results showed that application of all herbicides reduced sunflower height, seed number and seed weight as well as seed yield of sunflower. The highest reduction in seed yield was recorded when Total followed by Apirus residues were applied, which caused 95% and 80.6% yield reductions, respectively. Also, the minimum reduction of seed yield (32.7%) observed in Atlantis treatment. Moreover, 30% increase in herbicides dose caused increasing adverse effects and decreasing grain and biological yield compared to the recommended dose. Wheat residues incorporated to the soil increased damage of Atlantis by maintaining it in the soil (reduced seed yield from 3932.3 to 3556.9 kg/ha) and reduced damage of Total and Apirus by further degradation of these herbicides (increased seed yield from 235.4 to 311.6 kg/ha in Total treatment, and from 996.6 to 1161.3 kg/ha in Apirus treatment). But overall, wheat residues increased seed yield (2.1%) in comparison to the removal of plant residue. Therefore, addition of wheat residues as organic matter in the soil can affect the biological changes of herbicides.

INTRODUCTION

Acetolactate synthase-inhibiting herbicides such as the imidazolinones and sulfonylureas consist of a very important group of new-generation herbicides, most of which remain active in the soil after use. This group of herbicides is used to control a wide range of grass and broad leaf weeds. High tolerance of agricultural plants, and appropriate weed control along with low consumption rate and low toxicity of these herbicides are among the factors most important in their acceptability across the globe (Ramezani, 2010). The Sulfonylurea family of herbicides (one of the acetolactate synthase-inhibiting groups) are weak acids and are present mainly in an anionic form in neutral and slightly acidic soils (Moyer & Hamman., 2001). Therefore, absorption of these herbicides onto soil particles is weak. Increasing the soil acidity due to the increased concentration of the anionic form of these herbicides in the soil solution, results in reduction of the absorption of this group. Studies have shown that degradation of sulfonylurea herbicides occurs slowly in alkaline, cold, dry, and low organic matter soils (Rice *etal.*, 2002). The residues of this family of herbicides can, in certain conditions, maintain their stability in the soil even for more than one growth season, and damage crops in subsequent rotations (Brown, 1990). Therefore, their low application rate does not guarantee the small environmental impact of these herbicides. According to a report by Moyer *et al* (1990), if the sulfonylurea herbicide residues are within the range of 0.01 to 0.07 ng/g soil, they may limit the growth of agricultural and rangeland species. Evaluation of the sensitivity of chickpea and lentil to the residues of chlorsulfuron, metsulforunmethyl, and thraysulfuron herbicides showed that lentil was more sensitive to the residues of the aforementioned herbicides than chickpea (Halloway *et al.*, 2006). Moyer in his studies in 1995, observed that alfalfa(*Medicago sativa*), canola (*Brassica napus*), corn(*Zea mays*), lentil (*Lens culinaris*), chickpea (*Cicer arietinum*), potatoes (*Solanum tuberosum*), and sugar beet (*Beta vulgaris*)were damaged as a result of using sulfosulfuron and triasulfuron in the previous crop, whereas barley (*Hordeum vulgare*), beans(*Phaseolus vulgaris*), flax (*Linum usitatissimum*), and wheat were not affected by the residues of these herbicides. In addition, a 10 to 75 percent reduction was reported in sunflower root length for doses of 0.25 to 5.7 ppb of the active ingredient of sulfosulfuron in two different soils, associated with the deformity of roots (Hernandez-Sevillano *et al*., 2001).

Organic amendment can cause changes in soil structure and transport characteristics, including increased porosity, decreased bulk density, increased water retention, and changes in pore size distribution. Soil amendment also affects pesticide binding, which can affect pesticide transport and ultimate distribution in the soil profile. The presence of dissolved organic matter has proved to enhance the aqueous solubility of organic pollutants to such an extent that transport through soil can be significantly influenced. On the other hand, the addition of humic substances could also increase retention of organic pollutants (Si *et al*., 2006; Marschaner *et al.*, 2003; Barriuso *et al.*, 1997).

Researchers consider use of soil organic matter as one of the effective methods for degrading pesticides in the environment to reduce their environmental impacts (Izadi *et al.*, 2011). Muller *et al*. (2003) stated that variation in the amount of soil organic matter affected the Atrazine degradation process. It is believed that soil organic matter alters the biodegradation of Atrazine through both herbicide absorption and dissipation processes and changes in the activity and microbial population of the soil (Briceno & Palma, 2007; Moorman *et al*., 2001). In a study conducted on the impact of chloridazon, application rates under the conditions of with/without an organic fertilizer, Rouchaud *et al*. (1997) observed that using an organic fertilizer increased the half-life of this herbicide from 30 days in the treatment without using organic matter, to 96 days in the treatment using an organic fertilizer.

Based on the latest statistics available, approximately 12 herbicides from the sulfonylureas group are used in different crops such as sugar beet, rice, corn, cotton, and especially wheat in Iran (Mousavi *et al.*, 2005). Despite the damaging potential of these herbicides on sensitive crops that are involved in rotation, few studies have been conducted on the effect of sulfonylurea herbicides residues in Iran. This study was conducted with the aim of evaluating the damages caused by sulfonylurea herbicide residues to the growth and yield of sunflower cultivated in rotation with wheat, with or without plant residues.

MATERIALS AND METHODS

The split factorial experiment of this study was carried out in the form of a randomized complete block design with four replications in the research farm at the faculty of Agriculture in Shiraz University in 2011-2012 growing season. The main plots included wheat residues (with residues and without residues), and the subplots included a combination of type and dose of Total herbicide (metsulfuron + sulfosulfuron, 80% WG) at the application rates of 40 and 50 g a.i. ha^{-1}, Apirus herbicide(sulfosulfuron, 75% WG) at the rate of 26.6 and 35 g a.i. ha^{-1}, and Atlantis herbicide(mesosulfuron + iodosulfuron + mefenpyr, 1.2% OD) at the rate of 1.5 and 2 L a.i. ha^{-1}; and a treatment without herbicides as control in the plan. The field had been under wheat cultivation during the year before the experiment; and after harvesting; the wheat residues (approximately 1,850 kg ha^{-1}) were left in half of the field, and were completely removed in the other half. After the seed preparation operations, wheat (Shiraz cultivar) was cultivated by using a grain drill at a rate of 220 kg ha^{-1} in mid-October. After the germination of wheat, at late tillering, herbicides were applied to the farm using a 15-liter backpack sprayer with a T-jet nozzle and under a pressure of two bars. After the wheat was harvested, the farm was plowed again and prepared for the cultivation of sunflower. Sunflower seeds (cultivar Nemat1) were planted manually 15 cm apart on five lines spaced 75 cm apart from each other.

Two weeks after planting, the farm was thinned. At the end of the growth season, ten plants were randomly selected from each subplot, and were cut off near the surface of the ground. Then, parameters like plant height, number of seeds per head, 1000-grain weight, seed yield, biological yield, and harvest index were measured. The analysis of variance of the data was carried out using SAS software V 8.0 and the charts were plotted using MS Excel.

Researchers sometimes perform experiments with factorial treatments and include a control or other relevant treatment(s) that do not fit the factorial structure. Experiments having a complete factorial set of treatments plus one or more additional treatments are sometimes called “augmented factorials” or “factorial plus” (Lentner and Bishop, 1993). Data from experiments with augmented factorial structure are sometimes analyzed with a one-way analysis of variance (ANOVA) and means of treatment combinations are separated with post hoc multiple comparison tests such as least significant difference (LSD), Waller Duncan LSD, or Tukeys honestly significant difference (HSD) (Marini, 2003).

Considering that the experimental design used in this study was a factorial plus type, control treatment did not been counted in analysis of variance, but re-added in mean comparison. Finally all the treatments were compared together.

RESULTS AND DISCUSSION

Plant Height

The effects of type, dose of the herbicide and their dual interactions were significant on the height of sunflower (Table 1). When investigating the herbicides, it was found that the residues of all the three herbicides being tested significantly reduced the plant height in comparison to that in the control treatment (Table 2). This decrease can be considered to be due to the adverse effects of sulfonylurea herbicides on the growth of the stem and root of sensitive plants. Kelley and Peeper (2003) reported that the height of the sunflower plants grown in sulfosulfuron herbicide residues, decreased 17 months after application of this herbicide. Moreover, the results of the application of two different doses of herbicides showed that their additive dose (30% higher than the recommended dose), significantly reduced the plant height by 5% in comparison to the recommended dose (Table 2). In this regard, Grey *et al.* (2005) stated that increasing the amount of imazapic residues in the soil; caused a decrease in the plant height of cotton. Due to the interaction of the herbicide types and herbicide application rates, the additive dose of Total accounted for stem height and caused the greatest damage to sunflower plant in comparison to the other herbicides (Fig. 1). Lenardon *et al*. (2002) investigated the effect of Total residues, and reported that the residues of this herbicide had an adverse effect on the growth of soybean. The greatest plant height was observed in the control treatment without using any herbicides (Fig. 1). In addition, like Total, using the additive dose of Apirus significantly reduced the plant height of sunflower compared to the recommended dose. This is while increasing the amount of Atlantis to two liters per hectare had not significant effect on plant height over its recommended dose (1.5 liters per hectare) (Fig. 1). Mansoori *et al*. (2012) observed that increasing the amount of Atlantis, did not increase its negative effects on the total weight of sunflower plant, and had little impact on plant height. This could be due to the short half-life and the rapid decomposition of Atlantis in the soil.

The Number of Seeds per Head of Sunflower

The effects of plant residues, type of herbicide, dose of herbicide, the dual interaction of herbicide with herbicide dose, and herbicide with plant residues on the number of seeds per head of sunflower were significant (Table 1). A comparison between the mean values showed that under the influence of adding wheat residues to the soil, the number of seeds per head of sunflower increased by 3% over the treatment without residues (Table 2). Among the herbicides, Total residues with a 67% decrease in the number of seeds per head in comparison to those in the control treatment caused the greatest damage to sunflower (Table 2). The residues of Atlantis and Apirus also reduced the number of seeds by 15.5% and 48.7% compared to that in control treatment, respectively. It seems that the toxic effects of sulfonylureas on the yield components of sensitive plants such as sunflower are caused by the primary compounds of this group of herbicides.

Table 1. The ANOVA of the effects of plant residues, and the type and dose of herbicides on some of the measured traits in sunflowers

Sources of variation	df	Height (cm)	Number of Grain	1000 Grain weight (g)	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})	HI(%)
Block	3	16.1^{ns}	218^{ns}	1.2^{ns}	1888.1^{ns}	937534.8*	44.2^{ns}
Wheat residue	1	30.4^{ns}	4925.4**	42.7**	24118.5**	22232.7*	28.5^{ns}
Main plot error	3	9.6	89.4	0.21	1496.5	262535.9	37.1
Herbicide	2	5047.8**	1775546.8**	1954.5**	52808431.4**	450307136.9**	1599.6**
Dose	1	1064.5**	70639.9**	39.8**	2147478**	14656433**	9.1^{ns}
Wheat residue × Herbicide	2	72.5*	20503.2**	32.4**	335713.2**	352635.6**	55.9^{ns}
Herbicide × Dose	2	6.4^{ns}	1557.8*	1.2^{ns}	7456.1*	9673^{ns}	99.2^{ns}
Wheat residue × Dose	1	200.1**	8270.34**	2.5**	582464.9**	2919271.8**	1.7^{ns}
Wheat residue × Herbicide × Dose	2	24.8^{ns}	1518.9**	0.70^{ns}	13432.2**	168282.6^{ns}	37.9^{ns}
Sub split error	30	16.4	242.8	0.45	1003.3	393729.4	26.8

Ns Non-significant, ∗ Significant at the 5% level and ∗∗ Significant at the 1% level

Table 2. The effects of wheat residues, and the type and dose of herbicides on some properties of sunflowers

Treatment		Height (cm)	Biological yield(kg ha^{-1})	Number of grain	1000 Grain Weight(gr)	Grain yield (kg ha^{-1})	HI(%)
Wheat residue	with	140.7^{a}	871.9^{a}	39.9^{a}	2694.6^{a}	7782.1^{a}	34.4^{a}
	without	139.4^{a}	843^{b}	38.3^{b}	2637.8^{b}	7374.9^{b}	33.5^{b}
Herbicide	Control	165.3^{a}	1276.2^{a}	54.1^{a}	5567.7^{a}	15491.5^{a}	42.7^{a}
	Atlantis	148.2^{b}	1078.1^{b}	45.1^{b}	3744.6^{b}	11016.5^{b}	36^{b}
	Apyrus	133.9^{c}	654.4^{c}	34^{c}	1078.9^{c}	2580.4^{c}	34.1^{b}
	Total	112.9^{d}	421d^{d}	23^{d}	273.5^{d}	1225.6^{d}	22.8^{c}
Dose of herbicide	recommended	143.6^{a}	886.2^{a}	39.8^{a}	2824.8^{a}	7992.9^{a}	34.2^{a}
	additive	136.5^{b}	828.7^{b}	38.4^{b}	2507.5^{b}	7164.1^{b}	33.6^{a}

Means with the same letter for each trait in column and for each factor are not significantly different (Duncan%5).

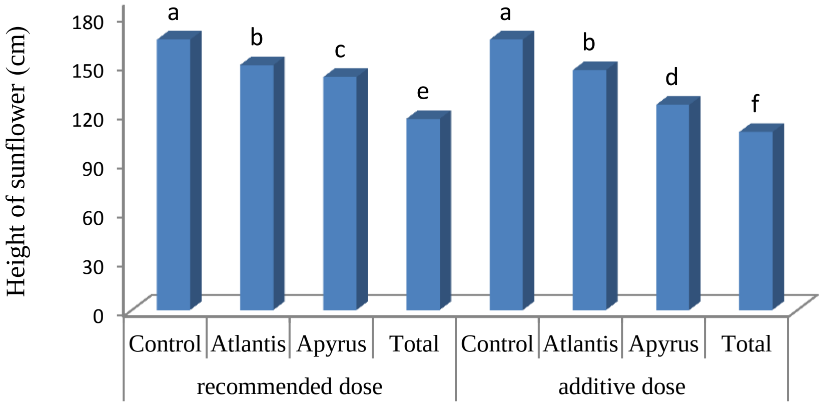

Fig. 1. Interaction effects of the dose (recommended vs additive) and type of herbicides (Atlantis, Apirus & Total) on height of sunflower plants.
Means with the same letters are not significantly different from each other (Duncan %5).

Similarly, Ye *et al.* (2002) reported that the toxicity of metsulfuron-methyl in the soil was due to the primary compounds of this herbicide. The mean comparison of applying the additive dose of herbicides showed that it reduced the number of seeds per head by 6.5% more than the recommended dose. It is conceivable that the increased dose in Total, Apirus, and Atlantis intensify their harmful effects on sunflower. Results of this study revealed that the number of seeds per head was higher in the recommended dose of all herbicides than in their additive dose (Table 3). The additive dose of Total and the recommended dose of Atlantis had the lowest and highest number of seeds, respectively, among the herbicide residue treatments. However, when comparing all the treatments, the control treatment without using any herbicides produced the highest number of seeds (Table 3). In the dual interaction between wheat plant residues and the herbicide type, the control treatment produced more seeds in plots, to which wheat residues were added, than in plots without wheat residues (Table 4). This could be due to the similar effect of plant residues on the growth of agricultural plants as well as on weeds. Researchers have stated that plant residues, in addition to their effects on the soil, can also affect the germination, survival, growth, and competitive abilities of weeds and agricultural plants (Duppong *et al.*, 2004. Jones *et al.*, 1999. Maldonado *et al.*, 2001). Among all the treatments, the lowest number of seeds per head was obtained under the influence of Total residues in the presence and absence of wheat residues (Table 4); and Apirus produced a lower number of seeds in the absence of wheat residues than in the presence of residues, and showed an 11.8% decrease relative to it. In a study on investigating the role of organic matter on the degradation of Metribuzin in the soil, Khoury *et al.* (2003) observed that with an increase in manure application rate, the half-life of Metribuzin in the soil decreased exponentially. However, various studies have shown different results regarding the application of organic matter in the herbicide degradation process. In an investigation on the degradation of Atrazine in field conditions, Izadi *et al.* (2008) reported higher Atrazine stability with the increased amount of organic fertilizer. In this experiment, too, unlike Total and Apirus, Atlantis produced a higher number of seeds in plots without residues (Table 4). This could be due to an increase in the absorption rate of the pesticide by organic matter in the surface layer of the soil, thus preventing it from leaching (Gu *et al.*, 2003).

1000-Grain Weight

The 1000-grain weight was significantly affected by the treatments of wheat residues, herbicide type, herbicide dose, and interaction of herbicide type with wheat residues and with the herbicide dose (Table 1). The results showed that the 1000-grain weight of sunflower was 4% higher in the soil containing wheat residues than that in the treatment without residues (Table 2). In addition, the additive dose decreased the 1000-grain weight by 3.4% relative to the recommended dose (Table 2). Mansoori et al. (2010) stated that increasing the dose of Apirus caused a significant decrease in the number of pods per plant and the 1000-grain weight of canola. In the case of herbicide residues, the highest and lowest full-1000-grain weights belonged to the control treatment (54.1 g) and Total residues (23 g), respectively (Table 2).

Apirus, with a reduction of 37.1% in 1000-grain weight, caused the greatest damage after Total; and Atlantis reduced the 1000-grain weight of sunflower by 16.6% relative to the control treatment. The results of studies conducted by other researchers also indicated that the greatest reduction effect on the 1000-grain weight of canola belonged to Total followed by Apirus and Megaton (Mansoori *et al.*, 2010). With increasing the rate of all three sulfonylurea herbicides, the 1000-grain weight was decreased. This reduction by Total and Apirus was significant compared to those caused by their recommended doses; but there were no significant differences between the two doses in Atlantis, which could be due to the lower half-life of this herbicide (60 days) compared to those of the other two herbicides (Table 3).

Table 3. The interaction effects of doses and herbicides on the yield and yield components of sunflowers

Treatment	Herbicide type	Number ofgrain	1000 Grain weight (gr)	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})
Recommended dose	Control	1276.2^{a}	54.1 ^{a}	5567.7 ^{a}	15491.5 ^{a}
	Atlantis	1127.9^{b}	45.6 ^{b}	4174.6 ^{b}	12059.9 ^{b}
	Apyrus	666.6 ^{d}	35.1 ^{c}	1205.9 ^{d}	2845.5^{d}
	Total	474.2e	24.2^{e}	351.1 ^{f}	1574.8^{ef}
Additive dose	Atlantis	1028.4 ^{c}	44.7b	3314.7 ^{c}	9973.1^{c}
	Apyrus	642.2d	33 ^{d}	951.9e	2315.2^{de}
	Total	367.8 ^{f}	21.8 ^{f}	195.9 ^{f}	876.5^{f}

Means with the same letter for each trait in column are not significantly different (Duncan%5).

Table 4. The interaction effects of residues and herbicides on the yield and yield components of sunflowers

Treatment	Herbicide type	Number ofgrain	1000 Grain weight (gr)	Grain yield (kg ha^{-1})	Biological yield (kg ha^{-1})
With residue	Control	1303.7^{a}	54.3 ^{a}	5748.4 ^{a}	16241.3 ^{a}
	Atlantis	1049.1^{d}	44.4^{c}	3556.9^{d}	10869.3 ^{c}
	Apyrus	695.6^{e}	35.7^{d}	1161.3^{e}	2712.6^{d}
	Total	439.2^{g}	24.9^{f}	311.6 ^{f}	1305.1 ^{e}
Without residue	Control	1248.8b	53.8a	5386.9b	14741.7b
	Atlantis	1107.1c	45.8b	3932.3c	11163.7c
	Apyrus	613.2 ^{f}	32.4e	996.6e	2448.1d
	Total	402.8h	21.1g	235.4f	1146.2e

Means with the same letter for each trait in column are not significantly different (Duncan%5).

The results of the interaction effects of wheat residues and herbicides showed that the lowest 1000-grain weight (21.1 g) was achieved in the Total treatment, which showed a decrease of 54% and 61% in the presence of and absence of wheat residues, respectively, compared to that in the control treatment. In general, Total and Apirus caused greater damage to the crop in the absence of residues, and reduced its 1000-grain weight more than that of the treatment in the presence of residues. On the contrary, Atlantis showed a higher 1000-grain weight in the treatment without residues (Table 4).

Grain Yield

The grain yield was significantly influenced by the effects of treatments and their dual interactions (Table 1). The interaction effects of the type and dose of the herbicides showed that the effect of the residues of all herbicides used, reduced the grain yield significantly relative to that in the control treatment; and the highest reduction belonged to Total residues, which significantly reduced the grain yield of the sunflower by 93.7% and 96.5% in the recommended and additive doses, respectively (Table 3)compared to the control treatment, Apirus with a reduction of 78.3% and 82.9% in grain yield in recommended and additive doses, respectively, caused the greatest damage to the grain yield after Total.

Atlantis residues reduced the grain yield in both doses. The reductions were significant in the two doses used, and a lower yield was achieved in the additive dose (Table 3). In general, the grain yield was significantly higher in the presence of wheat residues than in the absence of residues (Table 2). Increasing grain yield of sunflower in the presence of residues is indicative of the positive effect of plant residues on the growth of sunflower through reducing either the amount of herbicide residues in the soil or the growth of weeds. The lowest grain yield was observed in the interaction between Total residues and the treatment without residues, which showed a decrease of 95% relative to that in the control treatment (Table 4); and Apirus reduced the grain yield by 79.8% and 81.5% in the presence and absence of residues compared to that in the control treatment; but no statistically significant differences were observed between these two treatments. Achieving such a result indicated that although the presence of wheat residues in the soil reduced the adverse effects of sulfonylurea herbicide residues, the negative effects of the two herbicides: Total and Apirus, were so high that no significant differences were observed between the treatments in the presence and absence of their residues. Atlantis showed a higher yield in the treatment without residues than with residues, which can be explained by its different formulation (mesosulfuron + iodosulfuron + mefenpyr) from those of Total (metsoulfuron + sulfosulfuron) and Apirus (sulfosulfuron).

Studies on the effects of sulfosulfuron herbicide residues on corn, flax, grain sorghum, and sunflower showed that all these plants sustained damage 12 months after the application of the herbicide even at the lowest dose (Peterson & Arnold, 1985).

The durability of sulfonylureas in the soil varies depending on soil conditions such as organic matter, pH, moisture, and temperature. It was reported that the higher organic matter content of soil caused the higher surface absorption rate of herbicides in soil; and the lower pH caused the lower the stability of this group of herbicides (Mousavi *et al.*, 2005). When evaluating the effect of sulfosulfuron herbicide on wheat, Kelley and Peeper (2003) stated that the grain yield of sorghum and sunflower decreased by 58% and 17%, respectively, in an area where the soil acidity was higher, and at higher doses (70 and 140 g per hectare).

Biological Yield

The biological yield of sunflower was also affected by the residues of herbicides, and the Total treatment showed the highest yield loss. The increased dose also resulted in a reduction of 10.4% in the biological yield relative to that resulted from the recommended dose; and wheat residues increased the biological yield of sunflower by 5% relative to that in the treatment without residues (Table 2). Shinn et al. (1998) reported a 35% reduction in canola biomass by sulfosulfuron at a dose of 72 g of effective ingredient per hectare a year after the application of this herbicide. Moyer (1995) referred to a reduction in the biological yield of rapeseed due to using triasulfuron. Regarding the interaction between the dose and type of the herbicide, the additive dose of Total showed the highest adverse effect and the highest reduction in the biological yield (Table 3). Due to having the effective ingredient of Apirus (the ED_{50}^{*} of sulfosulfuron is 70% in Apirus, and 75% in Total) in addition to 5% metsoulfuron-methyl, Total had a higher negative effect than Apirus does. The recommended dose of Atlantis, with a 22.1% reduction relative to the control treatment, had the highest biological yield among the herbicides (Table 3). The results of the interaction effects of residues and herbicides on the biological yield of sunflower showed that in the presence and/or absence of wheat residues, the residues of Apirus, Total, and Atlantis significantly affected the biological yield, and the smallest damage was caused by Atlantis residues in the treatment without the application of wheat plant residues (Table 4).

Harvest Index

In the ANOVA of the harvest index, only the herbicide effect was significant (Table 1). The highest and the lowest harvest indices belonged to the Apirus and Total treatments with 42% and 22% reductions, respectively (Fig. 2).

Therefore, among all the herbicide treatments, Total with a 95.1% reduction in the grain yield, and 92.1% reduction in the biological yield relative to those in the control treatment, caused the greatest damage to sunflower plant. Apirus and Atlantis reduced the grain yield of sunflower by 80.6% and 32.7%, and the biological yield by 83.3% and 28.9%, respectively (Fig. 2).

Higher damages to the grain yield of sunflower than to their biological yield under the influence of the Total and Atlantis residues resulted in decreased harvest indices in these treatments. However, the damage occurred in the biological yield of sunflower was more severe than that to the grain yield in Apirus treatment, and caused this treatment to account for the highest harvest index among all experimental treatments.

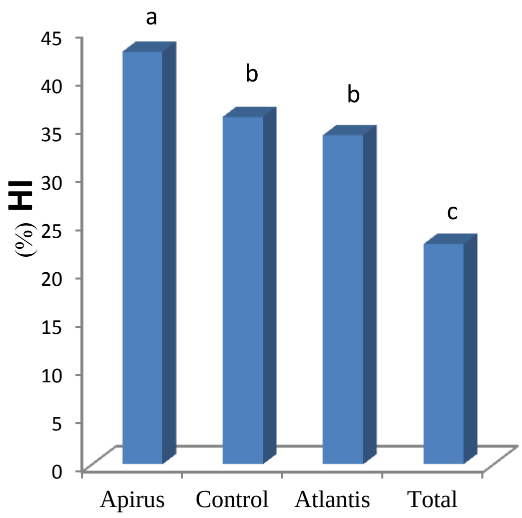

Fig. 2. Effect of herbicide type on the harvest index of sunflowers Means with the sameletters are not significantly different from each other.

CONCLUSIONS

Although most herbicides existing in a family share a similar mode of action, the differences in the chemical composition of herbicides existing in a family and their half-life cause differences in the responses of plants to herbicides. In the experiment of this study differences between the three herbicides in the sulfonylurea family were also found in terms of damages to sunflowers cultivated in rotation with wheat. Among these herbicides, Atlantis showed the lowest negative effect on the yield of sunflower, and on the contrary, Total caused severe damage to this crop. Because increasing the doses of sulfonylurea herbicides increased their adverse effects on susceptible plants, it is recommend that the time interval for planting after the harvest of wheat or other crop treated with described herbicides be considered to reduce herbicides damages. Moreover, taking into consideration the type of weeds present in the field and the use of herbicides with shorter half-life in the soil, the adverse effects of herbicides on subsequent plants can be reduced.

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اثر بقایای علف‌کش‌های سولفونیل اوره بر رشد و عملکرد آفتابگردان در تناوب با گندم

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علف‌کش توتال

چکیده-به منظور ارزیابی اثر بقایای علف‌کش‌های سولفونیل اوره و بقایای گندم بر رشد و عملکرد آفتابگردان، آزمایشی به صورت اسپلیت فاکتوریل در قالب طرح بلوک‌های کامل تصادفی با ۴ تکرار در مزرعه تحقیقاتی دانشکده کشاورزی دانشگاه شیراز انجام شد. فاکتور اصلی شامل تیمار های با و بدون بقایای گندم و فاکتور های فرعی شامل کاربرد علف‌کش‌های توتال، آپیروس و آتلانتیس در دو مقدار توصیه شده و ۳۰ درصد بیشتر از مقدار توصیه شده بود. تیمار بدون علف‌کش نیز به عنوان شاهد در نظر گرفته شد. نتایج نشان داد که تمامی علف‌کش ها باعث کاهش ارتفاع، تعداد دانه، وزن دانه، عملکرد بیولوژیک و عملکرد دانه آفتابگردان شدند. بیشترین کاهش عملکرد دانه نسبت به شاهد در تیمار کاربرد علف‌کش توتال (۹۵٪) و پس از آن در تیمار آپیروس (۸۰/۶٪) مشاهده شد. کمترین میزان کاهش عملکرد دانه نیز مربوط به تیمار آتلانتیس با ۳۲/۷٪ بود. علاوه بر این، افزایش دوز علف-کش باعث افزایش اثرات جانبی و کاهش عملکرد دانه و عملکرد بیولوژیک نسبت به دوز توصیه شده گردید.بقایای گندم در خاک باعث افزایشخسارت علف‌کش آتلانتیساز طریق نگهداری آن در خاک (کاهش عملکرد دانه از ۳۹۳۲/۳ به ۳۵۵۶/۹ کیلوگرم در هکتار) و کاهش خسارت علف‌کش‌های توتال و آپیروس از طریق تجزیه بیشتر آنها (افزایش عملکرد دانه از ۲۳۵/۴ به ۳۱۱/۶ کیلوگرم در هکتار در تیمار توتال، و از ۹۹۶/۶ به ۱۱۶۱/۳ کیلوگرم در هکتار در تیمار آپیروس) شد. اما به طور کلی، تیمار بقایای گندم در مقایسه با تیمار بدون بقایا، عملکرد دانه را ۲/۱٪ افزایش داد. بنابراین افزودن بقایای گندم به عنوان ماده آلی در خاک،می تواند بر تغییرات بیولوژیک علف‌کش‌ها تاثیر گذارد.