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Residual Effect of Thiobencarb and Oxadiargyl on Spinach and Lettuce in Rotation with Rice

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ABSTRACT

Field experiments were conducted to evaluate the effect of thiobencarb and oxadiargyl herbicides on rice (*Oryza sativa* L.) and their possible residual effects on spinach (*Spinacea oleracea* L.) and lettuce (*Lactuca sativa* L.) at Dashtnaz and Gharakhil Agricultural Research Stations, Iran. Treatments included thiobencarb at 3.16 and 6.33 kg a.i. ha^{-1}, oxadiargyl at 0.15 and 0.30 kg a.i. ha^{-1} and a non-treated control. After harvesting rice, trial plots were kept undisturbed until late September when spinach was seeded in half of each plot. In November lettuce was transplanted in another half of the plots. Soil residual oxadiargyl at 0.30 kg a.i. ha^{-1} stunted rice up to 31%, but this injury was transient and did not reduce yield. The adverse effect of oxadiargyl on rice was lower at Gharakhil possibly due to the greater binding by soil organic matter (OM). At Dashtnaz, spinach fresh yield was significantly affected by soil residues of oxadiargyl. Whereas lettuce fresh yield was significantly reduced in both thiobencarb and oxadiargyl treated plots. At Gharakhil, fresh yield of lettuce was not affected significantly. The experimental results revealed that soil characteristics, in particular OM content, are the main factors controlling the effect of thiobencarb and oxadiargyl residues. Furthermore, it could be concluded that oxadiargyl affected rice and spinach fresh yield greater than thiobencarb. Since no statistically significant differences were found in rice, spinach, and lettuce yield between the two applied doses of thiobencarb, from economical and environmental point of view, the lower thiobencarb dose is recommended to be used in paddy fields of northern Iran.

Keywords: Herbicides, Herbicide injury, Residual effects, Soil contamination.

INTRODUCTION

Thiobencarb [5-tert-butyl-3-(2,4-dichloro-5-propargyloxyphenyl)-1,3,4oxadiazol-2-(3H)-one] and oxadiargyl [5-tert-butyl-3-(2,4-dichloro-5-propargyloxyphenyl)-1,3,4oxadiazol-2-(3H)-one] herbicides are widely used to control weeds in paddy fields of northern part of Iran. Thiobencarb and oxadiargyl belong to carbamothioates and oxadiasols, respectively. Thiobencarb is a systemic pre-emergence herbicide that is used to control broadleaved weeds, annual grasses, and sedge. It is absorbed by roots and shoots of grass seedlings and then translocated upward through apoplast to locations where it inhibits lipid synthesis (HRAC, 2005). In contrast, oxadiargyl is used as pre- and post-emergence to control broadleaved and grass weeds. Oxadiargyl blocks porphyrin biosynthesis by inhibiting protoporphyrinogen oxidase (Hwang *et al*., 2004).

Spinach, lettuce, wheat (*Triticum aestivum* L.), rapeseed (*Brassica napus* L.) and soybean (Glycine max L.) are the common crops in rotation with rice in Mazandaran, northern Iran (Filizadeh *et al*., 2007; Peykani *et al*., 2009). Under these cropping patterns, the effect of herbicides used in rice should be considered

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on the rotational crops. This potential for herbicide injury depends mainly on the herbicide persistence in soil and the sensitivity of the rotational crop, which in turn influences the choice of herbicide. Sometimes, rotational crops recover without a yield reduction (Johnson and Talbert, 1996).

The ability of plants to absorb herbicide residues has been studied using radioactive markers (Suss and Grampp, 1973; Fuhr and Mittelstaedt, 1980). Traces of clopyralid, dicamba, and 3,6-dichlorosalicylic acid have been found in straw and/or grain of rye (*Secale cereale* L.) (Sakaliene *et al*., 2009). Theoretically, Papiernik *et al*. (2007) predicted that uptake of isoxaflutole by the plant and its phytotoxic diketonitrile metabolite (DKN), [2-cyano-3-cyclopropyl-1-(2-methylsulfonyl-4-trifuoromethylphenyl) propan-1, 3-dione], account for about 50% of the applied mass.

The visual damage and yield reduction due to the carryover of many herbicides have been reported on different plants. In Arkansas, cotton (*Gossypium hirsutum* L.) injury was noted in fields treated with imazaquin in the previous year (Barnes *et al*., 1989). Carryover of imazaquin also showed injury symptoms on the corn (*Zea mays* L.) (Renner *et al*., 1988; Mills and Witt, 1989; Curran *et al*., 1991), which caused yield reductions in some cases (Curran *et al*., 1992). Imazaquin and imazethapyr residues reduced spinach yield planted 3 to 4 months after cowpeas (*Vigna unguiculata* (L.) Walp.) (Johnson and Talbert, 1993).

In a study by Miller (2003), no adverse effect was observed on spinach, planted 12 months after sulfentrazone application. However, Brandenberger *et al*. (2007) reported that sulfentrazone applied at 224g a.i. ha^{-1} in watermelon (*Citrullus lanatus* Thunb.) severely reduced spinach emergence, when it was planted 14 to 17 weeks after application. Sulfentrazone soil residues also stunted growth of spinach and reduced its yield. Residues of sulfentrazone applied to watermelon at 450 g ha^{-1} also stunted growth of broccoli (*Brassica oleracea* (L.) var. botrytis) and cabbage (*Brassica oleracea* (L.) var. capitata) (Brandenberger *et al*., 2007).

Ramamoorthy (1991) applied 1 kg ha^{-1} thiobencarb in rice field and found no negative impact on cowpea and greengram bean (*Phaseolus radiatus* L.). Nepalia and Jain (2000) studied the carryover of oxadiazon and observed no reduction either in dry matter or yield of greengram bean. Pannacci (2006) reported that the risk of lettuce injury from imazamox was very high when this herbicide was applied to the previous crop.

In a greenhouse experiment, thiobencarb residues did not significantly affect root and stem of lettuce, while root and stem length were affected by oxadiargyl (Valioalahpor *et al*., 2008).

Lettuce and spinach are two common rotational crops with rice in Mazandaran province. However, little is known about possible effects of thiobencarb and oxadiargyl herbicides applied in rice fields on the rice and subsequent crops. Thus, this research was conducted to evaluate the effects of the herbicides on rice and to determine their possible carryover on the two rotational crops.

MATERIALS AND METHODS

Field experiments were conducted at Dashtnaz and Gharakhil research stations in Mazandaran province during 2008 and 2009. Dashtnaz is located at 36º 42' 7.8" N latitude and 53º 12' 29.1" E longitude and Gharakhil is at 36º 29' 25" N and 52º 46' 17" E. The climate at both sites is subtropical, typified by relatively high humidity and with mean annual precipitation of 668 mm for Dashtnaz and 735 mm for Gharakhil. Monthly precipitation and air temperature at the two sites are shown in Figure 1. Soil characteristics are presented in Table 1. At Gharakhil, soil had a slightly higher pH, and much higher OM and calcium carbonate equivalent (CCE) than Dashtnaz. There was no record of thiobencarb or oxadiargyl use at either site for at least the three years prior to onset of these trials.

Experimental plots were arranged in a randomized complete block design with five treatments and four replications. Plots

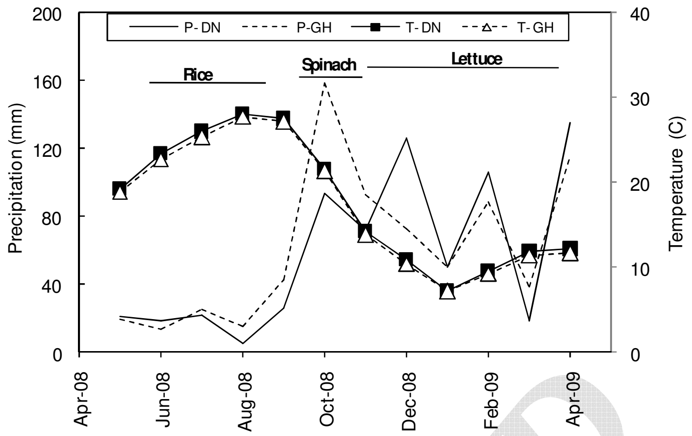

Figure 1. Monthly precipitation (P) and temperature (T) at Dashtnaz (DN) and Gharakhil (GH) in 2008-2009. The horizontal lines represent the growth period of rice, spinach and lettuce.

consisted of fifteen 4-meter rows spaced 0.30 m apart. The distance between plants within the rows was 0.25 m. A 1-m buffer was used between plots and a 2-m buffer between blocks. Layout levees were covered by plastic sheets, and rows of plots were separated by alternating irrigation and drainage ditches to prevent herbicide movement between the plots. Rice (Tarom cultivar) was transplanted on June 1, 2008 at Dashtnaz and on May 27, 2008, at Gharakhil. Treatments included a non-treated weedy control, pre-emergence applications of thiobencarb (Arysta LifeScience, Akashicho, Chuo-Ku Tokyo 104-6591, Japan) at 3.16 and 6.33 kg a.i.ha^{-1}, and oxadiargyl (Bayer CropScience, Monheim am Rhein, Germany) at 0.15 and 0.30 kg a.i. ha^{-1}. The lower doses were based on the manufacturer's recommendation and the higher doses were closer to the amount used by the farmers. Thiobencarb and oxadiargyl were respectively applied 6 and 5 days after transplanting. The herbicides were applied with a backpack sprayer (400 L ha^{-1} at 170 kPa with flat fans nozzles) when water depth in the rice plots was about 5 cm. Fertilizers were used based on soil testing of sampled plots. Top dressing and pests and diseases control were done according to the local farmers' common practice. Rice was manually harvested on August 25, 2008, at Gharakhil and the next day at Dashtnaz. Plots were kept undisturbed until September 24 (Dashtnaz) and September 25, 2008 (Gharakhil) when spinach (cultivar, Barg Pahn Holandy) was planted (250 g 100 m^{-2}) in half of each plot (10 m^{2}). Land preparation was done by hand and spinach was seeded in 10 rows with 0.2 cm interval between the rows. On November 26 (Dashtnaz) and November 15, 2008 (Gharakhil), lettuce (cultivar, Kahoo Pich Babol) was transplanted at 0.2 m spacing into 4 m long rows that were 0.5 m apart. Four rows were considered in each plot. For

Table 1. Soil characteristics in Dashtnaz and Gharakhil research sites.

Site	Series	Classification	pH	OM	TNV	Silt	Clay	CEC	Texture
				%				cmol$_c$ kg^{-1}	
Dashtnaz	Varendan	Typic Calcixerolls	7.3	3.42	20.25	37.9	39.4	22.6	Silty Clay Loam
Gharakhil	Ganj Afrooz	Typic Calciaquolls	7.7	5.55	60.5	41.4	39.4	21.7	Clay Loam

both spinach and lettuce, slug (*Agriolimax agrestis* L.) activity and weeds were effectively controlled by means of chemical and hand, respectively. In case of lettuce, nitrogen (25 kg ha^{-1}) was top dressed.

Data Collection and Statistical Analysis

Rice

Herbicide injury was visually assessed at 30 days after application. A scale of 0 (no injury) to 100% (dead) was used to evaluate the injury. Rice was harvested from the whole plots after excluding the border effects, and grain yield (adjusted to 12% moisture) and 1000-seed weight were determined. Analysis of variance was conducted using the GLM procedure in SAS (SAS Institute, 2001) and the mean values were compared by the Tukey test at P= 0.05 level of significance. Rice yield and yield components data were subjected to a *log(x+1)* transformation where required. Logarithmic and inverse data transformations were done simultaneously for spinach. Data for each location was analyzed separately since weather conditions, soil characteristics, planting dates, and weed species were somewhat different at each site.

Spinach

Spinach was harvested at Dashtnaz November 12, 2008. Spinach plants were counted in the two central rows of each plot and then pulled from the soil for recording plant height and number of leaves. Petiole length and leaf area were calculated using the Image Tools Software3 (Ver. 3) from digital images of the leaves. To determine fresh and dry yields, spinach plants were weighed immediately after harvesting and then oven-dried at 70 °C for 60h. Because spinach emergence at Gharakhil was considerably reduced by excessive rainfall and flooding (Figure 1), those data are not included in this article.

Lettuce

Lettuce was harvested on April 14 and 15, 2009, at Dashtnaz and Gharakhil, respectively. Plants within randomly placed 1-m^2 quadrates were selected and the number of leaves, plant height, and fresh weight were recorded as with spinach. Lettuce was then oven-dried at 70 ºC for 72 hours and weighted.

RESULTS AND DISCUSSION

Rice

Rice grain yields were not significantly different among herbicide treatments at Dashtnaz (Table 2). The difference in grain yields of herbicide treated plots could mainly be due to the difference in density of rice seeds (no m^{-2}) in these treatments (Table 2). The observed effect implies that the density of seeds(no m^{-2}) is more important than the 1000-seed weight in total rice yield (Murayama, 1979). Visual rating indicated the negative effect of oxadiargyl at 0.3 kg

Table 2. Effect of experimental treatments on rice injury, grain yield, 1000-seed weight, and seed number m^{-2} at Dashtnaz and Gharakhil.

Treatments	Rate (kg a.i. ha^{-1})	Dashtnaz				Gharakhil			
		Rice injury (%)	Grain yield (kg ha^{-1})	1000-seed weight (g)	Seed density (no m^{-2})	Rice injury (%)	Grain yield (kg ha^{-1})	1000-seed weight (g)	Seed density (no m^{-2})
Control	0	0 b	4,666 a*	23.53 a	19,811 a	0 a	2,717 a	23.04 a	11,771 a
Thiobencarb	3.16	0.5 b	4,792 a	23.93 a	20,042 a	1 a	3,251 a	22.19 a	14,651 a
Thiobencarb	6.33	1 b	5,085 a	23.29 a	21,821 a	1 a	3,023 a	22.40 a	13,496 a
Oxadiargyl	0.15	5 b	4,872 a	23.46 a	20,779 a	1 a	2,943 a	22.05 a	12,674 a
Oxadiargyl	0.3	31 a	4,646 a	23.40 a	19,887 a	1 a	3,201 a	22.32 a	14,426 a

*The same letter means no significant different at $P\leq$ 0.05.

a.i. ha^{-1} on rice growth (Table 2) with 31% injury, which was significantly higher than the other treatments. Severe leaf chlorosis and general stunting were obvious on rice treated with oxadiargyl at 0.3 kg a.i. ha^{-1}. However, the injury was transient and no significant difference was observed in the grain yield of this treatment compared to the control.

At Gharakhil, grain yields of the herbicide treated plots were insignificantly higher than the control, which could mainly be attributed to their higher density of rice seeds (no m^{-2}) (Table 2). The highest density of rice seeds (no m^{-2}) belonged to the thiobencarb treatment at low dose. At Gharakhil, visual rice injury from oxadiargyl was not as severe as at Dashtnaz. The difference in rice response to oxadiargyl was probably due to the differences in the soil properties. Higher soil OM at Gharakhil had probably caused higher adsorption of oxadiargyl (Wehtje *et al*., 1993; Ying and Williams, 2000b). At a lower soil solution equilibrium concentration (due to the higher adsorption), rice injury by oxadiargyl and its controlling effect on weeds are reduced. Field observations and rice yield at Gharakhil confirm this hypothesis.

Thiobencarb application did not significantly result in visible injury on rice plants at both sites (Table 2). Hill *et al*. (1990) did not also observe any visible injury on rice due to the application of thiobencarb at 4.5 kg a.i. ha^{-1}. Similar to oxadiargyl, thiobencarb could strongly be adsorbed by soil organic matter (Braverman *et al*., 1990), however, its persistence in soil had no considerable negative effect on the growth and yield of rice.

Some increase in yield may be related to the control of weeds by the herbicides. In the control plots, no physical/chemical treatment was applied against various weeds, where especially sedge (*Cyperus* spp.), at Dashtnaz, and barnyardgrass (*Echinochloa* spp.), at Gharakhil, grew. By comparing the efficacy of the two herbicides, one may conclude that the effect of these chemicals on rice yield and weed control depends mainly on the soil properties. Higher yield was achieved in thiobencarb treated plots at both sites, indicating higher efficacy of thiobencarb than oxadiargyl in rice fields. However, decision making on which chemical to use also depends on other environmental impacts and cost effectiveness of the herbicide.

Spinach

Fresh yield of spinach was significantly affected by the herbicide residues in the soil (Table 3). Among herbicide treated plots, greatest fresh spinach yields were with the high rates of thiobencarb and oxadiargyl. Carryover of low doses of thiobencarb and oxadiargyl reduced spinach fresh yield by 15% and 36%, respectively, in comparison with the control. Herbicides insignificantly reduced dry matter yield, the number of leaves per plant, and plant height (Table 3). Brandenberger *et al*. (2007) reported that emergence, growth, and yield of spinach was reduced due to the soil residues of sulfentrazone (Brandenberger *et al*., 2007). Moreover, it has been shown that spinach is very sensitive to imazamox soil residues (Pannacci *et al*., 2006). Decrease in spinach

Table 3. Effect of experimental treatments on yield and some agronomic characteristics of spinach at Dashtnaz.

Treatments	Rate (kg a.i. ha^{-1})	Fresh yield (kg ha^{-1})	Fresh yield reduction (%)	Dry matter yield (kg ha^{-1})	No of leaves $plant^{-1}$	Plant height (cm)	Petiole length (cm)	Leaf area index
Control	0	16,375 a	0	1,378 a	12.08 a	26.3 a	12.2 a	0.31 a
Thiobencarb	3.16	14,000 ab	14.5	1,190 a	11.78 a	25.7 a	14.1 a	0.35 a
Thiobencarb	6.33	14,688 ab	10.3	1,037 a	11.53 a	24.2 a	12.3 a	0.37 a
Oxadiargyl	0.15	10,500 b	35.9	1,062 a	11.38 a	23.8 a	12.5 a	0.26 a
Oxadiargyl	0.3	12,688 ab	22.5	1,051 a	11.08 a	25.8 a	14.3 a	0.32 a

yield is consistent with reductions in the number of leaves per plant and plant height. These results are supported by significant and positive correlations that exist between the number of leaves per plant and plant height and fresh yield (Table 4). As shown in Table 4, there is a negative correlation between fresh yield and petiole length. Leaf area index (LAI) responded differently to the herbicide residues in soil (Table 3). A significant and positive correlation exists between fresh yield and LAI. Greater LAI, however, did not result in more dry matter yield in the herbicide treated plots. This would be explained through shorter height of spinach under these treatments that may mean more shading of leaves on one another and, thus, less efficient canopy photosynthesis compared to the control.

Thiobencarb half-lives are approximately 100-200 and 12-77 days in flooded and non-flooded soils, respectively (Nakamura *et al*., 1977; Kawamoto and Urano, 1990; Doran *et al*., 2006). The change from reductive to oxidative state facilitates degradation of thiobencarb due to increase in microbial activities (Doran *et al*., 2006). This condition was fulfilled in the studied fields. Therefore, no significant effect was observed in spinach yield, which was seeded four months after thiobencarb application (Table 3).

No data were found in the literature for oxadiargyl half-life and its adsorption affinity. However, the half-life of oxadiazon, which belongs to the same chemical family as oxadiargyl, is between 48 and 108 days (Sudo *et al*., 2002). Oxadiazon is strongly adsorbed on clays and organic matter (Wehtje *et al*., 1993; Ying and Williams, 2000a). Hence, slow release of oxadiargyl from soil particles into bulk solution, may have a negative and significant effect on spinach growth and yield.

Lettuce

Soil residues of thiobencarb and oxadiargyl reduced significantly lettuce fresh yield at Dashtnaz (Table 5). The lowest fresh yield was obtained from the high dose of oxadiargyl. At Gharakhil, a non-significant trend in fresh yield was observed.

Dry matter yield of lettuce at Dashtnaz was not affected significantly by the herbicides (Table 5). At Gharakhil, soil residues of thiobencarb had no noticeable effect on lettuce fresh and dry matter yields compared with the control, but carryover of oxadiargyl at low dose caused 25% reduction in lettuce dry matter yield. A positive and significant correlation was found between the fresh yield with dry matter and with plant height (Table 6).

Half-lives suggested by researchers for oxadiazon, which belong to the same

Table 4. Correlation coefficients of fresh yield, dry matter yield, plant height, petiole length, and leaf area index in spinach at Dashtnaz.

	Fresh yield	Dry matter yield	No of leaves plant^{-1}	Plant height	Petiole length	leaf area index
Fresh yield	1	0.91**	0.53*	0.52*	-0.42^{ns}	0.56*
Dry matter yield	0.91**	1	0.37^{ns}	0.42^{ns}	-0.25^{ns}	0.40^{ns}
No of leaves plant^{-1}	0.53*	0.37^{ns}	1	0.29^{ns}	-0.11^{ns}	0.17^{ns}
Plant height	0.52*	0.42^{ns}	0.29^{ns}	1	0.11^{ns}	0.38^{ns}
Petiole length	-0.42^{ns}	-0.25^{ns}	-0.11^{ns}	0.11^{ns}	1	0.18^{ns}
Leaf area index	0.56*	0.40^{ns}	0.17^{ns}	0.38^{ns}	0.18^{ns}	1

NS: Not significant.
* and **; Designate significance at the 0.05 and 0.01 probability levels, respectively.

Table 5. Effect of experimental treatments on yield and some agronomic characteristics of lettuce at Dashtnaz and Gharakhil.

	Dashtnaz						Gharakhil				
Treatments	Rate (kg a.i.ha^{-1})	Fresh yield (kg ha^{-1})	Dry matter yield (Kg ha^{-1})	Dry matter yield reduction%	No of leaves plant^{-1}	Plant height (cm)	Fresh yield (Kg ha^{-1})	Dry matter yield (Kg ha^{-1})	Dry matter yield reduction (%)	No of leaves plant^{-1}	Plant Height (cm)
Control	0	47,875 a	4,000 a	0	20.8 a	34.6 a	37,033 a	4,100 a	0	18.9 a	34.5 a
Thiobencarb	3.16	31,250 b	2,917 a	27	20.7 a	34.8 a	35,350 a	4,100 a	0	16.8 a	33.7 a
Thiobencarb	6.33	31,625 ab	4,167 a	-4	17.3 a	34.7 a	30,973 a	4,100 a	0	19.6 a	29.7 a
Oxadiargyl	0.15	33,334 ab	3,292 a	18	20.5 a	35.4 a	33,667 a	3,075 a	25	18.2 a	29.8 a
Oxadiargyl	0.3	30,125 b	3,375 a	16	17.3 a	35.2 a	29,290 a	3,860 a	5.9	18.4 a	31.9 a

Table 6. Correlation coefficients of fresh yield, dry matter yield, number of leaves plant^{-1}, and plant height in lettuce at Dashtnaz and Gharakhil.

	Dashtnaz				Gharakhil			
	Fresh yield	Dry matter yield	No of leaves plant^{-1}	Plant height	Fresh yield	Dry matter yield	No of leaves plant^{-1}	Plant height
Fresh yield	1	0.71^{*}	-14^{ns}	0.53^{ns}	1	0.87^{**}	0.37^{ns}	0.75^{**}
Dry matter yield	0.71^{*}	1	-0.32^{ns}	0.19^{ns}	0.87^{**}	1	0.25^{ns}	0.67^{*}
No of leaves plant^{-1}	-14^{ns}	-0.32^{ns}	1	-0.03^{ns}	0.37^{ns}	0.25^{ns}	1	0.14^{ns}
Plant height	0.53^{ns}	0.19^{ns}	-0.03^{ns}	1	0.75^{**}	0.67^{*}	0.14^{ns}	1

chemical family as oxadiargyl (Sudo *et al*., 2002), are long enough to maintain a concentration in soil solution and affect soil fauna population or diversity or be absorbed directly by lettuce and make disorders in physiological processes that, consequently, reduce lettuce yield. Additionally, it is noted that some market value properties of the plants were undoubtedly influenced by the herbicide residues, for instance rice 1000-seed weight and spinach petiole length. Ability or inability of rice, spinach, and lettuce for herbicide absorption is not clearly known. As observed, the high dose of oxadiargyl led to chlorosis and growth reduction in rice. This may imply the absorption of oxadiargyl by rice and, consequently, its negative effect on the physiology of the plant. On the other hand, oxadiargyl is a broad-leaf herbicide and acts by blocking the porphyrinogen oxidase biosynthesis (Hwang *et al*., 2004). Hence, it may be expectable that this herbicide adversely affects growth of broad-leaf vegetables such as spinach and lettuce.

During the experimental period, the mean annual precipitation at Dashtnaz and Gharakhil were 563 and 622 mm, which were about 15% below the long term averages. On the other hand, the air temperature was, respectively, 2.3% and 5% above the annual mean (Figure 1). Under wet soil condition, higher temperature favors microbial degradation of the herbicides. However, higher temperature and lower precipitation than the long-term average means that, during the present experiment, herbicides carryover from rice to the aftercrops was probably more than an average season.

CONCLUSIONS

Based on the statistical analysis and discussion of the experimental data, the followings can be concluded:

Oxadiargyl affects rice and spinach fresh yield more than thiobencarb.

Assuming the same environmental risk for both herbicides, application of thiobencarb is to be preferred over using oxadiargyl.

No statistically significant differences were found in rice, spinach, and lettuce yield between the two applied doses of thiobencarb. Therefore, from economical and environmental point of view, the lower thiobencarb dose i.e.3.16 kg a.i. ha^{-1}, is recommended to be used in Iranian paddy fields.

The observed visual symptoms on rice plants and yield reduction in the rotational crops imply the possible presence of these chemicals in the plant tissues.

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اثر باقیمانده علف‌کش‌های تیوبنکارب و اگزادیارژیل روی اسفناج و کاهو در تناوب با برنج

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چکیده

به منظور ارزیابی اثر علف‌کش‌های تیوبنکارب و اگزادیارژیل روی برنج (*Oryza sativa* L.) و اثر باقیمانده آنها روی اسفناج (*Spinacea oleracea* L.) و کاهو (*Lactuca sativa* L.)، آزمایش‌های مزرعه‌ای در ایستگاههای تحقیقات کشاورزی دشت‌ناز و قراخیل-شمال ایران انجام شد. علاوه بر شاهد، تیمارها شامل تیوبنکارب با غلظت‌های ۳/۱۶ و ۶/۳۳ و اگزادیارژیل با غلظت‌های ۰/۱۵ و ۰/۳ کیلوگرم ماده موثر در هکتار بود. بعد از برداشت برنج، کرت‌های آزمایشی دست نخورده نگاه داشته شد تا اوایل مهر که در نیمی از سطح آنها اسفناج کشت گردید. در آذرماه در نیم دیگر از کرت‌ها کاهو نشاء گردید. اگزادیارژیل بیشتر از تیوبنکارب باعث اختلال در رشد و ایجاد کلروز در برنج گردید. اثرات منفی اگزادیارژیل در ایستگاه قراخیل کمتر بود که علت آن احتمالاً جذب سطحی بیشتر این علف‌کش توسط مواد آلی خاک بود. عملکرد تر اسفناج بطور معنی‌داری تحت تاثیر بقایای خاکی اگزادیارژیل در خاک دشت‌ناز قرار گرفت. در حالیکه اثر هر دو علف‌کش در کاهش عملکردتر کاهو در ایستگاه دشت ناز معنی‌دار بود. در قراخیل عملکرد تر کاهو کاهش معنی‌داری نشان نداد. نتایج آزمایش‌ها نشان دادند که خصوصیات خاکی بویژه مقدار ماده آلی، از عوامل اصلی کنترل کننده بقایای تیوبنکارب و اگزادیارژیل هستند. بعلاوه می توان نتیجه گرفت که اگزادیارژیل رشد رویشی و عملکرد برنج و عملکرد تر اسفناج را بیشتر از تیوبنکارب تحت تأثیر قرار می دهد. از آنجا که هیچگونه تفاوت معنی داری در عملکرد برنج، اسفناج و کاهو در دو غلظت بکار-رفته تیوبنکارب مشاهده نشد، با توجه به مسائل اقتصادی و ملاحظات زیست محیطی، غلظت پایین تیوبنکارب برای استفاده در اراضی شالیزاری شمال ایران توصیه می‌شود.