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The effect of herbicides application with different doses to chemical control of weeds in garlic farms (*Aliium sativum* L.) and its impact on soil fauna

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ABSTRACT: In order to investigate the effect of different herbicides application with recommended doses and 25 % lower than that on weeds in garlic farms and its impact on soil fauna, an experiment through the completely randomized block design with three repetitions during cropping season 2012-2013 in the Maryanj village, the city of Hamadan was performed. The examined treatments included the use of herbicides Sethoxydim, Oxyfluorfen, Trifluralin, *haloxyfop-R methyl* ester, and Chlorthal-Dimethyl; all with recommended dosage respectively, 3, 1.5, 2.5, 1 liter and 8 kg per hectare and 25 % less than the recommended dose, respectively include 2.25, 1.12, 1.87, 0.75 liter and 6 kg/hectare, lack of control model (lack of weeding) and weed control model (weeding). The results showed that Oxyfluorfen herbicide with reduced dose caused remarkably reduction in a wide range of farm weeds. The only herbicide, which caused leaf scorch of garlic, was Sethoxydim which is not recommended in garlic agriculture. Oxyfluorfen devoted the most edaphic mites to itself and in terms of environmental preservation was considered the best treatment and had the less negative effects on soil fauna.

***Keywords*:** Garlic, Weeds, Herbicide, Reduced Dosage, Soil Fauna

INTRODUCTION

Garlic (Aliium sativum L.), one of the three major cultivated species in the Alliaceae family (Gilereath, 2008) and its origin is Central Europe or Western Asia (Vaziri Elahi, 1999). Garlic is among fragrant vegetables and it is used in the preparation of various kinds of foods (Appendage, 2005). Garlic, like onions, requires nutritious substances such as phosphorus and potassium (Vaziri Elahi, 2008). The plant grows in the thermal range of 7 to 30 °C and at 20 °C will grow at the best pace (Appendage, 2005).

Considering the wide range of weeds in garlic farms, and the issue that the period between planting and harvesting of this plant lasts for 270 days, management and weed control in garlic farms will be necessary. Long-term effects of simultaneous presence of both cultivated plants and weeds will cause reduction in economic benefits (Apland 1993 and Seeley 1995). Existence of weeds can also be a proper place for plant pests in farms (Raoofi, 2011). Presence of weeds with high ability of seed production cause yearly growth of weeds in the farms (Montazeri, 2005). In the field of weed control in garlic farms, manual weeding is the most prevalent method among the native farmers of garlic farms. High expenses of the above mentioned method, reduces the economic efficiency of the production, so in this case, the chemical control of weeds has become noteworthy. In a research, two times consumption of Oxyfluorfen post-emergence with three weeks interval was introduced as the best treatment to reduce the population and biomass of weeds in onion farms (Malkani & Shimi, 2010). In another investigation in Tobacco farms, it was found that in the absence of *Cyperus rotundus*, Trifluralin is the most appropriate treatment to reduce

the density and biomass of weeds is the so-called farms (Shimi et al., 2010). Moradi et al. evaluated the consumption of Trifluralin pre-emergently and Oxyfluorfen through post-emergently positive, in order to reduction the abundance of weeds in pea farms. In their study, they mentioned the reduction of 83.27 percentages in weed biomass under use of Oxyfluorfen. They also stated that by application of Trifluralin, 78.03% of weed biomass in pea crops was reduced (Moradi et al, 2010). Ghanbari et al. (2010) study showed that the weed population in tomato farms was reduced to 74% by the usage of 48% Oxyfluorfen effective material. In another similar study, it was expressed that the use of Oxyfluorfen after manual weeding treatment, yielded the highest percentage of weed control and reduction in dry weight of weed species. It also caused increase in average weight and diameter in onion bulb; while no adverse effect was observed on onion qualitative traits under usage of Oxyfluorfen (Ebadi Pour et al., 2011). Nowadays, due to the high level of herbicide usage, we encounter the phenomenon weed resistance to herbicides, so that many of weed species show resistance against commonly used herbicides with various or even different modes of action (Powels et al., 1997). Thus, decreasing in dosage of the used herbicide can be important to delay occurrence of the resistance phenomenon (Baghestani, 2008). Accordingly in this study, the effect of several herbicides with recommended doses and 25% lower than that on the weeds in Hamadan garlic farms were evaluated. One of the most significant problems associated with herbicide usage is excessive amounts of their residues in soil and pollution of soil, water and it's transmittance to groundwater and for this reason application of herbicides has become a concern worldwide; therefore determining the side effects of pest control methods on environment and its effect on soil micro fauna is a necessity (Campagna, 1995). Nowadays, while applying the weed control methods, their compatibility with environment is also considered.

However existence of edaphic mites especially within 15 to 20 cm of soil will cause chemical pesticides to be non-toxic; these edaphic mites make up seven percent of soil micro fauna weight (Raoofi, 2011), irregular application of pesticides will have adverse impacts on these factors and will lead to their destruction. Considering the importance of soil micro fauna agents and harmful effects of irregular usage of herbicides on them, study on these factors will be of great importance.

MATERIALS AND METHODS

To evaluate the effect of different herbicides application with recommended doses and 25 % lower than that on the population of weeds, Chenopodium album, Convolvulus, Descurainia sophia, Rapistrum rugosum, Gallium verum, Liquorice, Lathyrus, Lawn and total abundance of weeds in garlic farms, an experiment through the completely randomized block design with four repetitions during crop year 2011-2012 in a farm, in the Maryanj village, the city of Hamadan was carried out.

The planting process was done after disinfection of garlic seed varieties of Hamadan for 24 hours in a solution of 2% carboxin thiram with the distance of 30×15 cm. Investigated treatments included usage of herbicides, Sethoxydim in the stage containing 2 to 5 weed leaves via formulations (EC 12/5%), Oxyfluorfen through pre-emergence via formulations (EC 24%), Trifluralin through pre planting and mixed with soil via formulations (EC 48%), haloxyfop-R methyl ester in the stage including 2 to 5 weed leaves via formulations (EC 10/8%) and Chlorthal-Dimethyl through pre planting and mixed with soil via formulations (WP 75 %), all with the recommended doses which respectively include, 3, 1.5, 2.5, 1 liter and 8 kg/hectare and 25% less than the recommended doses which respectively include 2.25 ,1.12 ,1.87 ,0.75 liters and 6 kg/hectare, lack of control model (lack of weeding) and weed control model (weeding). The research was performed in a land with area of 600 m2 containing 48 plots with dimensions of 3×4 m2. Thirty days after the last spraying, quadrat sampling was done from each plot in a size of 50cm×50cm and the density of weed species was recorded separately in terms of the counted type and total abundance. Three soil samples to a depth of 25 cm were taken randomly from each plot and in order to determine the number and family of edaphic mites were transferred to the laboratory. After exit of edaphic mites via Berlease Funnel, their family was recognized using mite's key identification and their abundance were counted. The obtained data was evaluated by the use of SAS ver.9 software and comparing the averages using LSD test.

RESULTS AND DISCUSSION

Lawn density: The use of different herbicides with recommended and reduced doses, showed significant differences in density of the grass weed found in garlic farms (Table 1). The comparison of results which were obtained from data averages of grass abundance in garlic farms (Table 2) showed that the most abundant counted lawn weed after the case lack of control model, was related to Trifluralin treatment with the reduced dosage. However, the recommended treatment doses and reduced ones were in a same statistical group. Oxyfluorfen herbicide with

the recommended and reduced doses, manual weeding, Sethoxydim with the recommended and decreased doses, haloxyfop-R methyl ester with recommended and reduced doses, weren't significantly different from each other. Although, Sethoxydim controlled the one year grass weed, this herbicide is not recommended due to the creation of leaf scorch in garlic plant. Application of Oxyfluorfen with 25% reduced doses is recommended to control annual grass in garlic farm.

Chenopodium album density: Results of Table 1 showed that significant statistical difference was observed between usages of different herbicides with different doses on *Chenopodium album* weed density. Haloxyfop-R methyl ester with recommended and reduced doses and lack of weed model were in a same statistical group, so that most abundant case of *Chenopodium album* weed density were counted in treatment of the lack of control model. No significant difference was observed between the lack of control model and treatment of Haloxyfop-R methyl ester consumption in weed control (Table 2). Manual weeding and Oxyfluorfen in two applied doses, showed no significant difference, so Oxyfluorfen with reduced dose is recommended for weed control.

Convolvulus weed density: application of different herbicides with recommended and reduced doses caused significant difference in density of *Convolvulus* weed (Table 1), So that the most abundant case of *Convolvulus* weed was counted in lack of control model treatment and no significant differences were observed between the above mentioned treatment with the group containing Haloxyfop-R methyl ester with recommended and decreased doses (Table 2). Manual weeding and Oxyfluorfen with recommended and reduced doses, were not significantly different and therefore for *Convolvulus* weed control, treatment of Oxyfluorfen with reduced doses is recommended (Table 2).

Descurainia sophia density: Usage of different herbicides with recommended and reduced doses, were significantly different in *Descurainia sophia* density in garlic farms, (Table 1). The comparison results between the obtained data averages from *Descurainia sophia* abundance in garlic farms (Table 2) showed that the most abundant counted case of *Descurainia sophia* was related to the lack of control model treatment, however the Haloxyfop-R methyl ester treatment with recommended and decreased doses and the lack of control model, showed no significant difference. Treatments of Oxyfluorfen with recommended and decreased doses and manual weeding were not significantly different and placed in a same statistical group, so Oxyfluorfen with reduced doses is recommended to control *Descurainia sophia* in garlic plant.

Rapistrum rugosum density: Results from Table 1 shows that significant statistical differences were observed between the usage of different herbicides with recommended and reduced doses on *Rapistrum rugosum* density. Haloxyfop-R methyl ester with recommended and decreased doses and lack of control model were placed in a same statistical group, so that the most abundant case of *Rapistrum rugosum* was counted with the number of 7.7 plants/m^2 in lack of control model treatment and no significant differences was observed between the lack of control model treatment and Haloxyfop-R methyl ester consumption with the recommended and decreased doses on *Rapistrum rugosum* control (Table 2). Manual weeding and Oxyfluorfen through two used doses, were not significantly different. Therefore, Oxyfluorfen with reduced doses is recommended for controlling *Rapistrum rugosum*.

Gallium verum density: Usage of different herbicides with recommended and reduced doses was significantly different in *Gallium verum* density in garlic farms (Table 1). Results from comparison between the obtained data averages from *Gallium verum* abundance in garlic farms (Table 2) show that the most abundant counted case of *Gallium verum* was related to the lack of control model treatment with density of 13.6 plants/m^2. Manual weeding was significantly different from other treatments. Trifluralin treatment with recommended and reduced doses and also Oxyfluorfen with recommended and reduced doses showed no significant difference but Oxyfluorfen with reduced dosage contained the lowest density of *Gallium verum*. Therefore, this treatment is recommended to control *Gallium verum*.

Liquorice density: Results from Table 1 showed that significant statistical differences were observed between usages of different herbicides on Liquorice density. The most abundant case of Liquorice was counted in lack of control model with the number of 6.1 plants/m^2 and significant differences were seen between the lack of control model and other treatments (Table 2). Manual weeding and Oxyfluorfen with the two used doses showed no significant difference, so Oxyfluorfen with reduced doses is recommended for the control of Liquorice.

Lathyrus density: application of different herbicides with recommended and reduced doses caused significant difference in density of *Lathyrus* weed in garlic farms (Table 1), Results from the obtained data averages from *Lathyrus* abundance in garlic farms (Table 2) show that the most abundant counted *Lathyrus* weed was related to the lack of control treatment. Manual weeding, Oxyfluorfen and Sethoxydim treatments with the recommended and decreased doses were not significantly different and were placed in a same statistical group. Sethoxydim treatment caused phytotoxicity in garlic plant and for this reason is not a suitable treatment for weed control. Therefore Oxyfluorfen with reduced doses is suggested to control *Lathyrus* weed in garlic plant.

Total abundance of weeds: Results from variance analysis of usage of various herbicides with different doses, Show statistically significant differences in controlling weed population in garlic farms (Table 1). Results of Table 2 show that the highest population of weed species in garlic farms were counted in lack of control model treatment. The best treatment to control a broad range of weeds in garlic farms was Oxyfluorfen. These results confirmed the gained results from the weed abundance with type separation in garlic farms (Table 2). The above results were matched with the results of performed studies by Ghanbari et al. (2010), Moradi et al. (2010) and Malkani and shimi (2010).

Table 1. Variance analysis of different herbicides application effects on observed weeds traits in garlic fields

Total abundance	*Lathyrus*	Liquorice	*Gallium verum*	*Rapistrum rugosum*	*Descurainia sophia*	*Convolvulus*	Chenopodium album	Lawn	df	SOV
6.71 ^{ns}	0.69 ^{ns}	1.04 ^{ns}	0.51 ^{ns}	0.61 ^{ns}	1.01 ^{ns}	1.09 ^{ns}	1.12 ^{ns}	0.33 ^{ns}	2	block
229.79**	72.13**	29.66**	22.53**	19.13**	26.91**	23.29**	25.13**	15.19**	12	treatment
12.87	2.62	0.03	4.18	3.25	1.06	0.02	0.01	0.1	24	error
18.12	21.83	25.61	31.19	34.86	20.74	27.17	32.37	29.37		cv

ns, * and **, respectively are lack of significant difference and significant difference at the probability level of 5 and 1%

Effect of experimental treatments on soil fauna factors: After separation of edaphic mites from taken soil samples from the farm, as a remarkable portion of the soil fauna agents, they belong to 11 families that included: *Notrida, Oribatulidae*, *Epilohmanidae*, *Caligonellidae*, *Erythraeidae*, *Pygmephoridae*, *Stigmaedae*, *Phytoseidae*, *Uropodidae*, *Parasitidae* and *Phyzotritidae*.

Manual weeding, lack of weeding and Oxyfluorfen with 25% reduced doses, had no significant differences with each other and were placed in a same statistical group.

The lowest and most unfavorable treatment in terms of the number and abundance percent of edaphic mites were related to Chlorthal-Dimethyl with recommended and reduced doses. Oxyfluorfen herbicide had the least adverse effect on the terricolous microfauna agents and therefore was considered the most appropriate treatment for environmental preservation (Chart 1).

Since Nabu S (Sethoxydim) caused leaf scorch in garlic plant, its application is not recommended for garlic. Sethoxydim herbicide can be recommended for perennial plants which have deep roots, because such plants like alfalfa forage plant will have the ability of restoration and re-growth.

Garlic is an annual plant and as the result of using Sethoxydim will develop leaf scorch and is not capable of regeneration. Consumption of Oxyfluorfen with 25% reduced doses is recommended to control annual grass in garlic farm, because Oxyfluorfen herbicide was consumed pre-emergently and could control the grass density well at the beginning of grass growth . By the control of grass weed growth, Garlic plant growth was transcended over grass growth and through growth and overcasting on the grass in continuation of growth inhibits the grass growth.

Chenopodium album is considered troublesome and persistent weeds in garlic farms of Hamadan locale and farmers generally use herbicides such as Trifluralin and Haloxyfop-R methyl ester; as a result, it is likely that weeds in general, and in particular *Chenopodium album* become resistant to herbicide usage and for this reason none of the locale weeds controlled by applying these herbicides.

Haloxyfop-R methyl ester was unable to control *Convolvulus. Convolvulus* is a broadleaved plant and since the above herbicide was an herbicide effective on narrow leaved plants, the desired result was not achieved via using this herbicide. Also, the Haloxyfop-R methyl ester herbicide, due to constant application over years and weed resistance, could not be successful to control of *Descurainia sophia* and *Rapistrum rugosum* density. Trifluralin treatment through inhibiting cell division and Oxyfluorfenbe pre-emergently were able to control *Gallium verum* weed. But Oxyfluorfen resulted in better control by quick and timely control of *Gallium verum*, which in continuation, growth of garlic plant transcended *Gallium verum* weed.

In the course of continued growth, Garlic inhibited the weed from using possible resources and conditions. Oxyfluorfen with reduced dosage may have the ability to play the role of sustainable management in herbicides consumption.

This herbicide as inhibitor of PPO, at the beginning stage of Liquorice and *Lathyrus* growth, could control the two weeds well. Although Chlorthal-Dimethyldual is a dual purpose herbicide (narrow leaved and broad leaved herbicide), but did not have favorable effect on a broad spectrum of weeds in order to control them, and it may be happened due to granule formula and the consumed soil. It's low toxicity and repetition of its application in farms and also out of reach amounts of herbicide due to irrigation can be considered as other responsible reasons for the low performance of the herbicides to control weeds in garlic farms.

In general, lack of weeding model was undesirable to control a wide variety of weeds, but the best treatment for weed control was Oxyfluorfen with 25% reduced doses.

Not using of the herbicide by locale farmers caused its application to be effective in weed control and no resistance problem was observed. It is hoped that through reduction in consumption of the herbicide dose, the same results as the standard dose can be achieved which help us for at least several years no to having the problem of weed resistance so that an herbicide with a different mode of action to control garlic weeds, would be noticed on the related experts' agenda.

From recognizing the 11 edaphic mites' families, it can be seen that the consumed soil granula herbicides, such as dacthal, due to direct contact with soil living micro-organisms, will have the most negative impacts on soil fauna.

Table 2. Comparison between average of different consumption levels of different herbicide, on weeds in Garlic farms of Hamadan locale

Weed:	Grass	Chenopodium album	*Convolvulus*	*Descurainia sophia*	*Rapistrum rugosum*	*Gallium verum*	Liquorice	*Lathyrus*
Treatments :				*Plant.m^{-2}*				
Nabu S 3 liters	0 d	3/1 c	1/9 c	2/8 d	1/1 de	1/1 d	2/61 bc	0/12 e
Goal (Oxyfluorfen) 1.5 liters	0 d	0/7 d	0/47 d	0/1 e	0/09 e	0/9 d	0 e	0 e
Treflan 2.5 liters	6/7 b	9/2 b	5/4 b	6/8 c	2/97 c	1/8 d	1/2 cd	1/5 d
Dacthal 8 kg	2/9 c	9/6 b	5/73 b	14/1 ab	5/58 ab	3/9 c	2/73 bc	3/3 c
Gallant super 1 liter	0/21 cd	22/9 a	14/1 a	16/9 a	6/6 a	7/1 b	2/3 bc	5/5 b
Nabu S 2.25 liter	0/1 d	2/9 c	2/9 c	2/8 d	1/6 de	1/3 d	3 b	0/1 e
Goal (Oxyfluorfen) 1.12 liters	0 d	0/9 d	0/51 d	0/14 e	0/07 e	1/1 d	0/1 e	0 e
Treflan 1.87 liters	7/2 b	8/8 b	5/13 b	7/1 c	2/82 c	1/9 d	1/6 cd	1/5 d
Gallant super 0.75 liter	0/18 d	21/7 a	12/98 a	18/6 a	6/5 a	7/6 b	2/7 bc	6/1 b
Dacthal 6 kg	3/1 c	9/1 b	5/71 b	12/9 b	5/3 ab	4/1 c	2/92 bc	3/7 c
Lack of weeding model	11/3 a	23/6 a	14/18 a	19/7 a	7/7 a	13/6 a	6/1 a	8/4 a
Manual weeding	0 d	1/2 cd	0/17 d	0 e	0 e	0/1 e	0/2 e	0 e

In each column, means that at least have one common character, do not have significant difference. LSD 5%

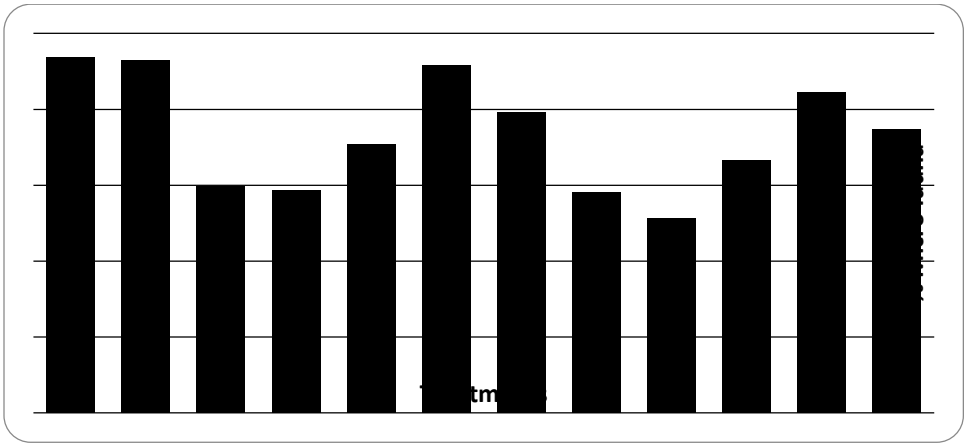

Chart 1 shows the effect of treatments on soil fauna

N: Nabu S, Go: Goal (Oxyfluorfen), T: Treflan, D **:**Dacthal, Ga **:**Gallant super, C1: lack of weeding model, C2: manual weeding model

: Standard dose, (b): Reduced dose

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