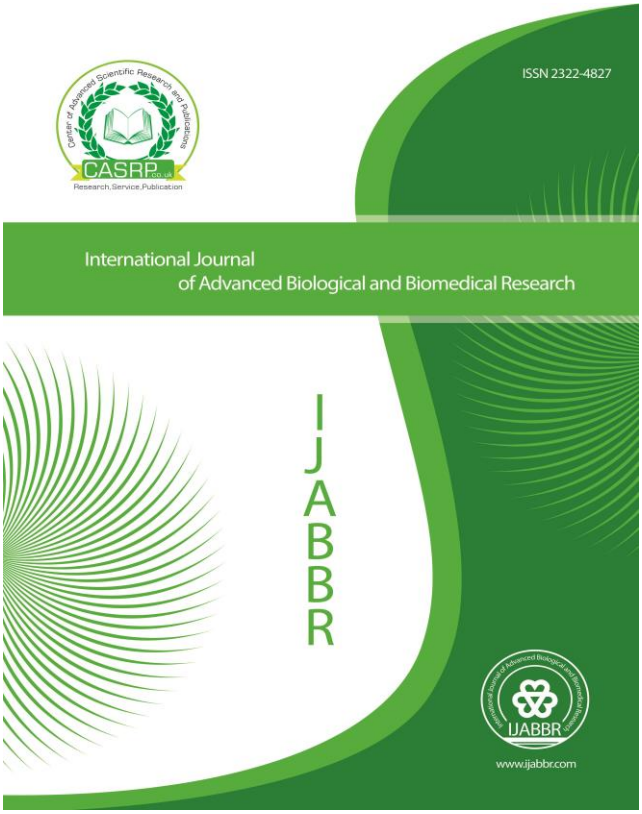

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Effects of applying different herbicides dosages Oxyfluorfen and Trifluralin on morphological, economical and biological yield of garlic (*Allium Sativum* L.)

Mohammad Raoofi[1,*], Sobhan Mahzari[2], Mohammad Ali Baghestani[3], Somayeh Giti[4]

[1]*Department of Agronomy and Plant breeding, University of Mohaghegh Ardabili, Ardabil, Iran.*

[2]*M.Sc Graduated of Identification and weed control, Iran.*

[3]*Iranian Research Institute of Plant Protection, Weed Research Department, Tehran, Iran.*

[4]*Research Lecturer of Toxicity & Weed Science, Deilik Company, Hamedan, Iran.*

Abstract

The present study evaluated the effects of different dosages herbicides Oxyfluorfen and Trifluralin on crop properties of garlic, including plant height, number of cloves per bulbs as well as economical and biological yield of garlic. In this research, a randomized complete block design, with seven treatments and three replications, along with a control sample (weeding and no weed control), was conducted in 2012 – 2013. The treatments were included the use of 1.5, 2 and 2.5 liters of Trifluralin per hectare, 1.5, 2 and 2.5 liters of Oxyfluorfen per hectare in one step, 1.5 liters Oxyfluorfen per hectare in two steps, a control with weed interference (two replications in each block) and a weeding and no weed control. Results showed that using different doses of herbicides significantly affected plant height, number of cloves per bulb, 100 seed weight, economical and biological yield and harvest index of garlic. The lowest economic yield was due to control treatment without controlling of weeds (540 $g.m^{-2}$) and the highest was obtained under 3 treatments of 1.5 liter of oxyfluorfen herbicide (1661.67 $g.m^{-2}$), hand weeding (1686.67 $g.m^{-2}$) and split oxyfluorfen application (1670 $g.m^{-2}$). Finally, oxyfluorfen treatment (1.5 liter) on 3 to 4 weeds leaf, were identified as the most appropriate treatments.

Keywords: Oxyfluorfen, Trifluralin, Garlic, Economical yield, Biological yield.

*** Corresponding author:** Department of Agronomy and Plant breeding, University of Mohaghegh Ardabili, Ardabil, Iran.

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1. Introduction

Garlic (Allium sativum L.) is an important winter crop in northern of Iran with a total of 9580 ha and yielding approximately 90, 197 tons per year (FAO, 2011). Garlic (Allium sativum L.) is the second most widely cultivated species of the genus, Allium after onion (Allium cepa) (Henry and Mann, 1963). Also, Garlic along with onions and leeks are three major cultivated species in Alliaceae family (Gilreath, 2008). This plant because of high economic and medicinal values is cultivated in 2610 hectares of agricultural lands of Mazandaran Province, Iran (Anonymous, 2012). Slow growth rate, low height, and a thin canopy that does not cover the soil enough to sup-press weeds make garlic a poor competitor against the latter until the beginning of spring (Yousefi et al., 2014). Adekpe et al. (2007) reported 71% yield losses in garlic crop if weeds are allowed to grow during the crop season. Weed interference is affected by the time of weed emergence relative to the crop's phonological development (Conley et al., 2003). The weeds, which emerge early or simultaneously with the crop, are highly competitive and they have to be managed by farmers (Grundy, 2003). Most weed management strategies in cereals target seedlings, as they are the most sensitive stage of the weed. However, emergence of weed seedlings varies every year in timing, extent and intensity. Weeds produces severe yield losses in garlic fields. Prediction of weed emergence timing will allow farmers to determine the time at which most of the weeds have already emerged and, consequently, the best time to apply a control measure (Buhler et al., 2000). This could therefore be an important component of an integrated weed management strategy (Roman et al., 2000). Since garlic is cultivated in mid-autumn and is harvested in mid-spring, so it is remained vulnerable almost 9 months in the farm land exposure to the weed species. The losses of weeds vary depending on the weather conditions; however, increasing in density of weeds per unit area will be resulted in more yield loss (Patrick, 2003). Some studies concluded that the density of weed species per unit area is not the only factor of damageability of the weeds, but also the time of the growth of weeds during the growing season would be more important (Kropff, 1987). Rashed Mohasel and Mousavi (2006) stated that the biomass of weeds reflects the growth factors of weeds. In a study, it has been concluded that the lack of weed control in onion fields would damage up to 94.63 percent on onions products (Moradi et al., 2009). The plants in Alliaceae family and especially garlic due to the low height, shallow depth roots, elongated, narrowed and vertical leaves, and the low density of canopy, has low competitive performance against weeds (Boydston and Seymour, 2002; Ghoshesh and Shannag, 2000; Ghoshesh, 2004). In the field of weed control in garlic farms, hand weeding is the most prevalent method among the native farmers of garlic farms. According to the reports, this method of management reduces the economic efficiency in reducing of this product (Hoseini et al., 2011). Therefore, other methods of weeds management in garlic farms should be examined. Chemical control of weeds is one of those methods that could be a priority in order to control of weeds if garlic not be used fresh. In a study, Hosseini et al (Hoseini et al., 2011) showed that among the use of different doses of different herbicides, the most suppression of weeds in garlic farms was obtained under 3 liters of Oxyfluorfen, that resulted in higher shoot dry matter weight, higher weight of cloves, higher number of cloves per bulb and higher bulb weight than other treatments. Qasem (1996) concluded that under rainfed conditions and high density of wild oats (*Avena sterilis* L.) only the application of Oxyfluorfen herbicide resulted in increasing of garlic yield. The research of Ebadipour et al (Ebadi Pour et al., 2011) showed that the use of Oxyfluorfen after hand weeding had the highest percentage of frequency of control and biomass of weed species in the onion farms. 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. The results of Sanjeev et al (2003) showed that the maximum economical yield of cabbage-onion rotation was obtained under the application of 0.16 kg of Oxyfluorfen. In another similar study, it was reported that an optimal control on weeds was achieved under the application of Oxyfluorfen in onion farms (Aegerter, 2006). In the study of Maknali et al (Makani and Shimi, 2009) the application of Oxyfluorfen twice with three weeks intervals was introduced as the best treatment to reduce the population and biomass of weeds in onion farms. The results of Shimi et al (2009) showed that in tobacco farms in the absence of nut sedge (*Cyperus diformis* L.), Trifluralin herbicide treatment was the best treatment to reduce the density and the biomass of weeds in these farms.

Ghanbari et al. (2009) study showed that the weed population in tomato farms was reduced to 74% by the usage of 48% Oxyfluorfen effective material. Moradi et al. (2009) evaluated the consumption of Trifluralin pre-emergently and Oxyfluorfen through post-emergently positive, in order to reduction 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.

Ghanbari Birgani and Sekhavat (2011) showed in a research that on average, ranking of herbicides in terms of the impact on weeds population control of mung bean farms was as follows: by Oxyfluorfen > Trifluralin > Prometrin> Pandimrtalin > Oxadiazon. The effect of Oxyfluorfen and Trifluralin herbicides on reducing the wet weight of weeds were more than other herbicides. They were also ranked herbicides in terms of impact on increasing grain yield that it was as follows: Oxyfluorfen > Trifluralin > Oxadiazon > Prometrin > Pandimrtalin. Therefore in this study, the effect of chemical management on reducing the density and biomass of weeds, yield and agronomic characteristics of garlic were studied in Mazandaran Province, Iran.

2. Materials and methods

To evaluate the effects of chemical management on agronomic characteristics of garlic, an experiment was conducted in a randomized complete block design with three replications in 2012 – 2013 years in a farm located in Babol next to Babol Province, Iran, with the geographic location with a longitude of 52' 47'' 40° East and latitude of 36' 22'' 33.6° North, average annual precipitation of 650 mm and relative humidity of 70%, with a distance of 70 km from Sari in Mazandaran Province. After the selection of location test, in order to determine the physical and chemical properties before the preparation of soil for planting, sampling from the soil was carried out from the depth of 0 to 30 cm at some point. The farm was plowed using a moldboard plow, then the used fertilizers in this study were added to the soil twice before planting and then the fertilizers were incorporated with the soil using a Disc. The amount of used fertilizers in this study according to soil test were including: 200 kg Urea per hectare that 100 kg as the base and 50 kg in two foliage stage and 50 kg in 4 foliage stage of garlic, 200 kg superphosphate triple per hectare, and 100 kg potassium sulfate. The research was performed in a land with area of 300 m^2 containing 30 plots with dimensions of 3×3 m^2. The planting process was done after disinfection of garlic seed varieties of Mazand for 24 hours in a solution of 2% carboxin thiram with the distance of 30×15 cm and the density of 23 plants per m^2 on 23/10/2012. After about two weeks from planting of garlic, germination was fully performed. The studied factors in 10 dosages of herbicide are including: 1.5, 2 and 2.5 liters per hectare of Trifluralin (Terflan) via formulations (EC 48%), 1.5, 2 and 2.5 liters per hectare of Oxyfluorfen, 1.5 liters per hectare of Oxyfluorfen in two stages (the half in first stage and the rest 18 days later) via formulations (EC 24%), hand weeding control and lack of weeding control (the number of replications of these two treatments were two folds of others (2 replications in each block and 6 replications in total)). Two weeks before planting Trifluralin herbicides were incorporated with the soil and Oxyfluorfen herbicides as post-emergently were applied in the 3 to 4 foliage stages of weeds using a backpack sprayer pump from the side of the nozzle sag (T-Jet). After 145 days from planting, 10 plants per plot were selected and plant heights measured. After maturity of garlics, 10 plants of garlic were eradicated and the number of cloves per bulb was counted and weight of 100 cloves of garlic was weighed. After full maturity of garlic, a square meter of each plot was harvested on 7.5.2013 and the harvested plants was placed for 48 hours in the farm and then bulb yield and biological yield were weighed and harvest index was also calculated. Statistical analysis software SAS (version 9.1) was used for analysis and the obtained averages were compared by means of the Duncan least significant difference test.

3. Results and discussion

3.1. Scoring garlic

Results of Table 2 show the different reactions of garlic plants under different applications of herbicides with different dosages. The lack of weed control in experimental plots resulted in heavy losses on the garlic. The use of 2 and 2.5 liters of Oxyfluorfen caused a little sustained medium loss, but this loss was gradually decreased over time and the plant returned to normal situation. The plant did not show a similar response to the application of 1.5 liter of Oxyfluorfen in one stage and splitting in two stages, but a significant difference was observed between the usages of 1.5 liter of Oxyfluorfen and its splitting in two stages although the adverse effect was negligible. This adverse effect on garlic was not observed in the use of Trifluralin with dosages of 1.5, 2 and 2.5 liters and hand weeding.

3.2. Agronomic characteristics of garlic

3.2.1. Plant height

Results of Table 1 show that the usage of different doses of different herbicides had a significant difference on the plant height of garlic, so that the shortest plants in the plots of without weed control treatments were measured and a significant difference was not observed between the mentioned treatments with the treatment of using 1.5 liter of Trifluralin (Table 2). Intense competition of garlic with the other species of weeds caused a decrease in the competitive performance of garlic. To this reason, shorter plants were produced. In contrast, under treatments of the usage of 1.5 liter of Oxyfluorfen in two stages and hand weeding treatment, plant height of garlic was increased due to lack of competition with weed species and no significant difference was observed between the above treatments with the usage of 1.5, 2 and 2.5 liters of Oxyfluorfen (table 2). The above results were matched with the results of reduced frequency and the biomass of weeds (weed results are not included in this paper).

Table 1
The analysis of variance table for the effect of herbicides on agronomic characteristics and economical yield of garlic.

Source of variation	DF	MS					
		Plant height	Number of cloves per bulb	Weight of 100 cloves	Economical yield	Biological yield	Harvest index
Replication	2	5.81 ns	1.57 ns	259.84 ns	2115.9 ns	6839.39 ns	7.02 ns
Treatments	9	166.78 **	61.21 **	3400.45 **	661122.12 **	477835.45 **	552.4 **
error	18	18.65	0.6	60.68	1527.57	10165.22	4.42
Coefficient of variation (CV%)		4.78	4.84	2.72	3.26	4.46	3.94

ns,* and ** are insignificant and significant at confidence level of 1% and 5%, respectively.

Table 2
The comparison between the effect of herbicides on agronomic characteristics and economical yield of garlic.

Doses of herbicides	Garlic ranking	Plant height (cm)	The number of cloves per bulb	Weight of 100 cloves (g)	Economical yield ($g.m^{-2}$)	Biological yield ($g.m^{-2}$)	Harvest index (%)
2 lit of Trifluralin	1 e	93 abc	14.66 d	276 c	996.67 d	2418.33 a	41.25 c
Control (Weedy)	7 a	81 d	9 e	233.33 e	540 f	1451.67 c	37.13 d
1.5 lit Oxyfluorfen in two stages	2 d	99.66 a	20.33 ab	316.66 ab	1670 a	2460 a	67.88 a
1.5 lit of Trifluralin	1 e	86.33 cd	15 d	254 d	793.33 e	1873.33 b	42.44 c
2 lit Oxyfluorfen	4 b	92 abc	19.33 b	308.33 b	1580 b	2450 a	64.51 a
1.5 lit Oxyfluorfen	3 c	97.66 ab	20.33 ab	325 a	1661.67 a	2456.67 a	67.62 a
Control (Weed Free)	1 e	99.66 a	21.33 a	330 a	1686.67 a	2476.67 a	68.13 a
2.5 lit Oxyfluorfen	4 b	92 abc	19.66 b	305 b	15.55 b	2408.33 a	64.51 a
2.5 lit of Trifluralin	1 e	90.66 bc	17 c	285 c	1371.67 c	2466.67 a	55.60 b

In each column, the average that at least one common letter are not significantly different.

3.3. The number of cloves per bulb

Results of Table 3 showed that the usage of different doses of various herbicides caused a significant difference in the number of cloves per bulb in garlic. The results of mean comparisons (Table 2) showed that the number of cloves per bulb produced in the treatment of without weed control was the lowest level. The presence of weeds with high biomass and density caused increase in extra-species competition and garlic plant used

photosynthetic products for competition with weeds under stress conditions, and on the another hand it decreased the number of cloves per bulb. The usage of 1.5 and 2 liters doses of Trifluralin did not affect the number of produced cloves per bulb and these two treatments were located in a statistical group, but increasing the dose of Trifluralin to 2.5 liters per hectare caused increasing in the number produced cloves per bulb (Table 2). The usage of 2 and 2.5 liters of Oxyfluorfen had also the same effect on this trait of garlic plant and significant differences were not observed between the two treatments, and these two treatments were in a lower level compared to hand weeding, the use of 1.5 liter of Oxyfluorfen and its splitting in two stages. The adverse effect and phytotoxicity of garlic under the use of different doses of 2 and 2.5 liters of Oxyfluorfen caused disturbances in the production of cloves per bulb of garlic and the plant spent their photosynthetic products in the reclamation of its shoots. In contrast, the highest numbers of cloves per bulb were counted under the treatments of using 1.5 liter of Oxyfluorfen, hand weeding and 1.5 liter of Oxyfluorfen in two stages. The ideal conditions under appropriate controlling of weeds besides using the above treatments resulted in the best usage of the plant from the ecological niche and increasing of the number of cloves per bulb.

3.4. 100 cloves weight of garlic

Analysis of variance of data from the weight of 100 cloves of garlic (Table 1) indicted that the application of different doses of various herbicides caused significant difference on this trait of garlic plant. The results of mean comparison showed that the lowest 100 weight of garlic cloves was weighed in the treatment of without weed control (Table 2). Intense competition of garlic plants with weeds resulted in a decrease in the weight of produced cloves of garlic. There was no significant difference between the use of Trifluralin with the doses of 2 and 2.5 liters per hectare on the weight of 100 cloves of garlic, but there was a significant differences between the above two treatments with the application of 1.5 liter Trifluralin on this trait. Also, a significant difference between the use of 2 and 2.5 liters of Oxyfluorfen was not observed on the weight of 100 cloves of garlic, and these two treatments were in a lower level than hand weeding control treatment. The reason for this was the adverse effect of using different doses of mentioned herbicides. The heaviest produced cloves obtained under the treatments of hand weeding, the use of 1.5 liter of Oxyfluorfen and the split of 1.5 liter of Oxyfluorfen in two stages.

3.5. Economic yield of garlic (bulb)

The results of Table 1 showed that the use of different doses of various herbicides caused a significant effect on economic yield of garlic (bulb). Comparing the mean data from the yield of bulb (Table 2) showed that the lowest yield of bulb was obtained in the treatment of no weed control. Using different doses of Trifluralin herbicide caused a significant effect on the yield of bulb so that the three doses of using this herbicide were placed in separate groups. Among these three treatments, the most appropriate treatment in the yield of bulb was related to the use of 2.5 liter of Trifluralin. The obtained results were matched with the obtained findings from the frequency and the biomass of weeds (Table 2), plant height, the number of cloves per bulb and weight of 100 cloves. The matching of the results of using 2 and 2.5 liters of Oxyfluorfen in the production of economical yield of garlic with the trait of garlic ranking, plant height, the number of cloves per bulb and the weight of 100 cloves is evident, so that these two doses of application showed no significant differences on bulb yield and were placed in a lower level than hand weeding control due to the adverse effect and phytotoxicity (Table 4), which forced the garlic plant to consume the photosynthetic products in producing young leaves and results in a decrease in economical yield of garlic. The results showed that the highest economical yield of garlic was obtained in the treatment of using 1.5 liter of Oxyfluorfen, hand weeding treatment and splitting of 1.5 liter of Oxyfluorfen in two stages, and there were no significant differences between the above treatments. The plant used the best from the resulted ecological niche in normal conditions, and it could transfer more photosynthetic materials to the reproductive organs and it could increase the bulb yield with more producing of cloves per bulb with higher weight. Similar results have been reported by other researchers (Hoseini et al., 2001; Makani and Shimi, 2009; Qasem, 1996).

3.6. Biological yield

The results showed a significant difference in the use of different doses of various herbicides on biological yield of garlic (Table 1). The results of the mean comparison of the obtained data from biological yield of garlic (Table 2) showed that the lowest biological yield of garlic was weighed in the treatment of without weed control.

Followed by the above treatment, the lowest biological yield of garlic was produced under the use of 1.5 liter of Oxyfluorfen. In contrast, the highest biological yield of garlic was obtained under the treatments of using 2 and 2.5 liters of Trifluralin, hand weeding, the use of 1.5, 2 and 2.5 liters of Oxyfluorfen and splitting of 1.5 liter of Oxyfluorfen in two stages, and there was no significant difference between the above treatments.

3.7. Harvest Index

The results of analysis of variance table (Table 1) showed that the harvest index of garlic showed different responses under the effect of different doses of various herbicides so that caused a significant effect on this index. The results of mean comparisons (Table 2) domonstrated that the lowest harvest index was achieved in the treatment of no weed control (Table 2). There were no significant differences between the use of 1.5 and 2 liters of Trifluralin on harvest index, but increasing the dose of Trifluralin to 2.5 liters per hectare increased harvest index of garlic. The above findings were matched with the results from the density and biomass of weeds (Table 2), economical and biologic yield of garlic. In contrast, the highest harvest index was obtained in the treatments of hand weeding; the use of different doses of Oxyfluorfen (1.5, 2 and 2.5 liters per hectare) and splitting of 1.5 liters of Oxyfluorfen in two stages. The matching of above results with the results of decreasing frequency and the biomass of weeds (Table 2), economical and biological yield of garlic is evident. According to the results, it could be stated that under proper controlling of weeds of garlic farms, a balance in transferring of photosynthetic products occurred between aerial and underground organs (bulb) and thus the harvest index of garlic was increased. Similar results have been reported by other researchers (Hoseini et al., 2011).

4. Conclusion

The results obtained from experimental trials on plant height, cloves number in the bulb, cloves weight and ultimately economic yield of garlic (bulb) showed that the treatment of using 1.5 liters of Oxyfluorfen in 3 to 4 foliage stages of weed species was as the best treatment.

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