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Evaluation of the Different Irrigation Time on *Agriolimax agrestis* Damage in Lettuce Fields of Tehran Province

ELHAM AHMADI
Agricultural Zoology Research Department, Iranian Research Institute of Plant Protection, Tehran, Iran

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*Corresponding author: Email: *e1_ahmadi@yahoo.com*

ABSTRACT

One of the effective managing methods for slugs control is cultural method. A field study on the effect of different irrigation times on slug (*Agriolimax agrestis*)(Stylommatophora: Limacidae) damage in lettuce plants was carried out in the Varamin region in 2009. Treatments consisted of irrigation at various times: 1- irrigation in the morning, 2-irrigation after sunset 3-irrigation after sunset with Fericol bait (5gr/m²) and 4-irrigation after sunset with Methaldehyde bait (2.5gr/m²). The experiment conducted in a randomized complete block design with four replications. Each replicate consisted of three rows of 3 m length and 50 cm width and with in row plant spacing of 25 cm with a total of 36 plants /plot. The results indicated that maximum damages (based on the feeding of leaves) and minimum lettuce yield obtained for irrigation after sunset treatment with 52.82±3.4 percent of damaged plants with a lettuce yield 20.12 ton per hectare. Minimum damages with maximum yield found with treatment 4 with 10.53±2.8 percent damages with lettuce yield of 39.3 ton per hectare. Treatments 1 and 3 were with 10.92±2.7 and 10.71±2.3 percent damage and lettuce yield of 39.01 and 39.17 ton/ha respectively. There was no significant differences between the lettuce yields in the treatments 1, 3 and 4 at level of 5% ($p>0.05$) and were placed in group A. Also, it seems that changing irrigation times (treatment 1) is one of useful strategies in IPM method for controlling and reducing slug damage to lettuce plants which it has lettuce yield near to treatments 3 and 4.

Keywords: *Agriolimax agrestis*, Irrigation time, New method, Lettuce fields, Tehran province

INTRODUCTION

Slugs are important pests in agricultural and horticultural crops worldwide (Godan, 1983; Port and Port, 1986; South, 1992). They feed on seeds and seedlings and damage various parts of mature plants (Wiktor, 1989; Maillard, 1993; Byers and Calvin, 1994; Briner and Frank, 1998; Frank, 1998). Control of slugs on lettuce plants are important because they cause the loss of lettuce quantitatively and qualitatively. In recent years, the problems caused by slugs have increased dramatically, as illustrated by the 70-fold increase of molluscicide usage over the last 30 years as observed in the United Kingdom (Gartwatte and Thomas, 1996). In vegetable alone, molluscicide use, including its application, is calculated to cost some £20 million annually, yet the damage to seeds and seedlings is not reliably controlled (Barker, 2002). In Central Europe, vegetables (particularly lettuce and many Brassicaceae) are especially susceptible to slug damage

(Godan, 1983; South, 1992). Damage is caused by gastropods due to both feeding and contamination of the harvested plants, with their bodies, eggs, feces or slime, leading to deterioration in the quality of the harvest and lead to financial losses. They injure lettuce plants by chewing holes of various sizes in the leaves and stems. These holes may be in the middle of the leaf or on the edge. Also they are capable of feeding on roots and seeds. The early seedling is most susceptible to slugs; they sometimes consume the entire seedling. The slug causes damage below the soil surface to the seeds and roots, so that seeds cannot germinate. In the case of lettuce plants, the result will be a very poor and damaged crop. The pest slug *Agriolimax agrestis* is the most important pest species in lettuce crop in different parts of Iran. Most commonly, slugs are controlled with baits that are the most consistent and efficient method of slug control. Several pellets or baits (metaldehyde pellets and carbamates such as sevin baits) are available, which contain a molluscicide, a poison. Besides these methods of direct control, there are other alternatives to using bait. Cultural method include sowing depth, sowing date and watering time of lettuce plants. There are other alternatives to using either organic or traditional bait. (Glen *et al*., 1990; Hammond, 1996). The objective of this study was controlling and comparing slug damage with alternations of the watering time (watering in the morning, watering in the evening and using slug pellets) on this pest.

MATERIALS AND METHODS

This experiment was carried out at one hectar of lettuce plants of Varamin on Aridisols soils in 2009 to evaluate efficacy of different irrigation time, on control of slugs (*Agriolimax agrestis*). Soils family were fine, mixed active, thermic, typic haplocambids based on soil taxonomic system (USDA, 1999). The area was located between 25° 21É longitude and 51° 38Ń latitude in the north of Varamin city (42 km south-west of Tehran province, Iran) in the alluvial plain of Varamin. Lettuce sown in chamber on 27 March and harvest on 17 June. After soil was prepared by plowing and disking, plots were formed and seedlings of lettuce (four weeks after emergence) were planted in a field at the spacing of 50 cm between rows and 25 cm within plants. Irrigation was done every three days and its rate was 160 liters per square meter during the growing period. Treatments included 1-irrigation in the morning 2-irrigation after sunset 3-irrigation after sunset with Fericol bait 4-irrigation after sunset with Methaldehyde bait. The baits (Methaldehyde and Fericol) were broadcast evenly over the plots by hand at a rate of 2.5gr/m² and 5gr/m² respectively as recommended by the manufacture. Treatments were arranged in a randomized complete block design with four replications. Slugs were released at 160 individuals per each treatment (In total, treatments were applied with 640 Slugs). Each replicate consists of three rows of the three meters in length and in total 36 plants were considered. Interval treatments which spaced three meters from each other and separated by wire meshes. In different stages, all farming protections such as weeding were carried out similarly for all treatments.

On each sampling date five quadrates (1x1m²) per plot were taken. The total number of lettuce plant leaves and the numbers of damaged leaves were counted 2, 8, 14, 21, 28, 35, 42, 50 and 60 days after lettuce seedlings with 4 leaf stage transplantation and calculated into percentages for each plant separately. Plants which were completely eaten by slugs were considered as 100% leaf loss.

In all treatments, lettuce heads were harvested and fresh mass of marketable lettuce was recorded.

Statistical analysis

Statistical analysis of experimental data were conducted using the SAS software package and the means were separated following ANOVA by Duncan's multiple range test with at least 0.05 significance level.

RESULTS

In 2009, Comparison of the treatments (Table 1, 2 and 4) reveals that there were not significant ($p<0.05$) differences among treatments 1, 3 and 4 in leaf loss and lettuce yield per plot. Treatment one (irrigation in the morning) showed approximately the same level of control as treatments 3 and 4. The effect of sampling time on leaf loss was significant and slug damage decreased with change of irrigation time during the planting season (Table 4). Percentage of slug damage was higher in plots with irrigation after sunset (Evening watering created a very slug-friendly environment). Combining metaldehyde or fericol with irrigation after sunset had a significant effect on the reduce percentage of damage lettuce plants, although not better than treatment irrigation in the morning. On any given day, there were not statistically significant differences in slug damage between treatments 1, 3 and 4. However, differences between treatments of different days were evaluated at the trial period (Table 3). Analysis of variance showed that there were significant differences among the leaf loss in the treatment 2 and other treatments (Table 2). These results show that each factor has not separate and independent effect on percentage of damage and lettuce yield. Duncan's Multiple Range Test ($p<0.05$) showed that among different treatments at the present study, the percentages of slugs damage on lettuce plants in treatment two (irrigation after sunset) with 52.82% were more than other treatments. The first observation, 2 days after lettuce seedlings, treatments 1, 3 and 4 showed low leaf loss with 8.25%, 8% and 7% respectively. There were not significant differences between treatments 1 and 3 with 4 at 5% level. The percentages of lettuce plants damage decreased on this day in all treatments except treatment 2 (Table 2). The next observation, 8 days after lettuce seedlings, treatments 1, 3 and 4 showed leaf loss with 9.5, 9.6 and 9.5% respectively. The significance of the difference between the 1, 3 and 4 treatments and the treatment 2 increased ($P<0.05$). On subsequent days, After 14 days of lettuce seedlings, treatments 1, 3 and 4 showed leaf loss with 11.02%, 10.2 and 10.1% respectively. 21 days after treatments, treatments 1, 3 and 4 showed leaf loss with 11.45%, 10.5 and 10.5% respectively. At 28 days after treatments, the mean damage degree treatments were not significant with 11.5, 11 and 11.1% respectively. At 35 days after treatments, the average percentage damage of treatments 1, 3 and 4 for slugs gradually decreased with 11.6, 11.3 and 11.2% respectively. At 42 days after treatments, treatments 1, 3 and 4 showed low leaf loss with 11.65, 11.8 and 11.7% respectively. At 50 days after treatments, treatments 1, 3 and 4 showed low leaf loss with 11.67, 11.9 and 11.8% respectively. At 60 days after treatments, treatments 1, 3 and 4 showed low leaf loss with 11.7, 12 and 11.9% respectively (Table 2). Overall, the total percentage of slugs' damages in treatments 1, 3 and 4 were gradually increased. The results indicated that maximum damage (based on the feeding of leaves) and minimum lettuce yield obtained for treatment 2 (irrigation after sunset) with 52.82±3.4 percent performance loss with a lettuce yield

20.12 ton per hectare. Minimum damage with maximum yield found with treatment 4 with 10.53±2.8 percent damages with lettuce yield of 39.3 ton per hectare. Treatment 1 and treatment 3 were with 10.92±2.7 and 10.71±2.3 percent damages and lettuce yield of 39.01 and 39.17 ton per hectare respectively. Lettuce yield in treatments 1, 3 and 4 were insignificant at level of 5% (P>0.05) and were placed in group A and with other words, the treatment one was as effective as treatments 3 and 4 on slugs (Table 4).

The results indicated, there were significant differences in leaf loss between treatment 2 and treatments 1, 3, 4, respectively on all dates from day 2 to day 60 at 5% level, while there were no significant difference between treatments 1, 3 and 4. Also, it seems that changing irrigation times (treatment 1) is one of strategies useful in IPM method for controlling and reducing slug damage to lettuce plants which it has lettuce yield near to treatments 3 and 4.

Table 1. Analysis of variance for different treatments on *A. agrestis* population on lettuce during 2009 in Varamin fields

SOV	df	MS								
		2 days	8 days	14 days	21 days	28 days	35 days	42days	50 days	60 days
Treat	3	1041.22*	1492.64*	1568.26*	1696.86*	1814.94*	1921.4*	2059.6*	2219.2*	2336.1*
Block	3	0.89	4.09	6.24	3.68	3.30	3.16	1.29	1.18	0.97
Error	9	1.78	3.9	2.78	1.61	1.04	0.88	0.30	0.61	0.72
CV		10.44	12.25	10.21	8.06	6.7	6.22	4.57	5.3	5.57

* Significantly different (p<0.05)

Table 2. Mean percentage damage of different treatments and sampling intervals *A. agrestis* on lettuce during 2009 in Varamin fields

	Days after treatments									
Treatments	2 days	8 days	14 days	21 days	28 days	35 days	42 days	50 days	60 days	average
Irrigation in the morning	8.25[a]	9.5[a]	11.02[a]	11.45[a]	11.5[a]	11.6[a]	11.65[a]	11.67[a]	11.7[a]	10.92[a]
Irrigation after sunset	40[b]	48.25[b]	50[b]	52[b]	53.8[b]	55.2[b]	57.1[b]	58.9[b]	60.2[b]	52.82[b]
Irrigation after sunset with Fericol bait (5gr/m²)	8[a]	9.6[a]	10.2[a]	10.5[a]	11[a]	11.3[a]	11.8[a]	11.9[a]	12[a]	10.7[a]
Irrigation after sunset with Methaldehyde bait (2.5gr/m²)	7[a]	9.5[a]	10.1[a]	10.5[a]	11.1[a]	11.2[a]	11.7[a]	11.8[a]	11.9[a]	10.53[a]

* Average percentage damage, followed by different letters, are significantly at P<0.05 according to the Duncan's Multiple Range Test.

* Means followed by the same letter within a column do not differ significantly at P<0.05

Table 3. Mean damage percent of *A. agrestis* in different treatments during 2009 in Varamin fields

Treat/ sampling intervals	Effect of treatment	The effect of sampling times after the treatments time	
		2	15.81±1.4 [a]
irrigation in the morning	10.92±2.7 [a]	8	19.27±3.5 [b]
irrigation after sunset	52.82±3.4 [b]	14	20.30±2.6 [c]
irrigation after sunset with Fericol bait (5gr/m²)	10.71±2.3 [a]	21	21.11±2.2 [d]
irrigation after sunset with Methaldehyde bait (2.5gr/m²)	10.53±2.8 [a]	28	21.85±2.5 [e]
		35	22.32±2.9 [e]
		42	23.06±2 [f]
		50	23.56±2.15 [fg]
		60	23.95±3.1 [g]

* Effect of treatments and sampling times, followed by different letters, are significantly at P<0.05 according to the Duncan's multiple range test

Table 4. Mean leaf loss and lettuce yield of lettuce in field trials in 2009.

Treatments	Loss leaf (%)	Lettuce yield (ton/ha)
irrigation in the morning	10.92±2.7 [a]	39.01 [a]
irrigation after sunset	52.82±3.4 [b]	20.12 [b]
irrigation after sunset with Fericol bait (5gr/m²)	10.71±2.3 [a]	39.17 [a]
irrigation after sunset with Methaldehyde bait (2.5gr/m²)	10.53±2.8 [a]	39.30 [a]

* Average percentage damage and lettuce yield, followed by different letters, are significantly at P<0.05 according to the Duncan's Multiple Range Test

DISCUSSION

Lettuce appears to be an attractive food source to slugs due to its thin, soft leaves and low levels of secondary compounds (Hegnauer, 1964). It is the most popular amongst the salad vegetable crops (Squire *et al*., 1987). Investigations carried out by Stevens (1974) in USA, lettuce is ranked 26th among vegetables and fruits in terms of nutritive value and 4th in terms of consumption rate highlighting the ever-increasing importance of this crop. Slugs are major pests in lettuce fields, being capable of causing severe yield loss in different countries. They cause injury to seedling lettuce in numerous manners, ranging from complete destruction of the germinating seed or germinating seedling to heavy defoliation through growth stages (Barker, 2002). Little information is known about the effect of different irrigation time on slug's damage control. This study showed the effect of these treatments (irrigation in the morning, irrigation after sunset, irrigation after sunset with Fericol bait (5gr/m²) and irrigation after sunset with Methaldehyde bait (2.5gr/m²)) on slug injury to the crop. One of the most effective means of controlling slugs is to alter their environment. Slugs are not generalists when it comes to the type of environment; on the contrary, they require cool, moist, dark conditions making it easy to identify the areas of the field in which they will persist. We can make some simple adaptations to the plant community that will reduce the slug populations quickly. Lacking a shell, slugs require more contact with moist environments to avoid desiccation. Moisture is key to slug survival, so the first step in changing their environment is to reduce the level of moisture available. Avoid watering late in the day as the moisture persists after the sun sets, creating the perfect slug environment (Barker, 2002). Water early in morning to allow the water to evaporate, and use drip irrigation with water directed

toward individual plants (University of Illinois Extension, 1999). In the present experiments, the results indicate that there was not variation in the effectiveness of the treatments 1(irrigation in the morning), 3 (irrigation after sunset with Fericol bait) and 4(irrigation after sunset with Methaldehyde bait), which is possibly due to several factors. Treatment 1 (morning irrigation) gave a level of protection as good as treatments 3 (irrigation after sunset with Fericol bait (5gr/m²) and 4 (irrigation after sunset with Methaldehyde bait (2.5gr/m²). Because water content of slugs' body is very high, they are very susceptible to drying out. With changing of irrigation time without damaging our plants slugs' reduction can be achieved. It is recognized that prevailing environmental conditions can strongly influence both slug activity and molluscicide treatment efficacy. Slugs are most active in crops at night or following rain on overcast days (Bari, 2004). Changing watering times has neither environmental nor financial negative side effects. Thus morning irrigation seems to be a cultural method for reducing slug damage in watered crops.

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