African Journal of Biotechnology Vol. 8 (20), pp. 5337-5342, 19 October, 2009
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2009 Academic Journals

Full Length Research Paper

Toxicity appraisement of methaldehyde, ferricol®, snail repellent tape® and sabzarang® (snail repellent paint) on land snails (*Xeropicta derbentina*), (*Xeropicta krynickii*)

Behnam Amiri-Besheli

College of Agricultural science, Sari Agricultural Science and Natural Resources University, P. O. Box 578 Sari Iran.
E-mail: amirib689@yahoo.com.

Accepted 8 September, 2009

Different control methods have been applied to control the land snail (*Xeropicta derbentina* and *Xeropicta krynickii*) but the chemical method is realized to be the most effective method to control this pest. The main goal of this work was to determine the efficacy of methaldehyde, Ferricol, Snail repellent tape and Snail repellent paint (Sabzrang) on this pest. Methaldehyde, Ferricol were used as bait around citrus trees and Snail repellent tape and Snail repellent paint rolled up around main stem of the citrus trees. The life snails on citrus trees were monitored at 2, 15, 29, 36, 68 and 98 days after treatments. Analysis of variance showed that there were significant differences between treatments and control, and also significant differences were found among treatments ($p < 0.01$). LSD and Tukay-Test among the above treatments has shown that repellent band and methaldehyde with 5 ± 1.3 and 10.6 ± 0.9 percentage of the alive snail on trees, respectively, were more effective than repellent color and biological toxin with 14.2 ± 2.6 and 31.3 ± 3.9 percentage alive snail on citrus trees and significant differences with control, respectively. The control efficacies of the methaldehyde and Ferricol were 91.87 and 82.63%, respectively; also the total control efficacies of the Snail repellent tape and Snail repellent paint were 95.22 and 82.26%, respectively, after 2, 15, 29, 36, 68 and 98 days of post treatment. Therefore the Snail repellent tape and methaldehyde were better than the other treatments for the management of land snail population.

Key words: Methaldehyde, ferricol, snail repellent tape, snail repellent paint, (*Xeropicta derbentina*), (*Xeropicta krynickii*).

INTRODUCTION

Slugs and snails are significant agricultural pests in humid area worldwide. Among them *Xeropicta derbentina*, a native of Eastern Mediterranean Europe, was introduced to south-eastern France during the 1940s and is now widely spread across the world (Kiss et al., 2005). In summer it aggregates on plants, making its populations clearly visible. *X. derbentina* and *Xeropicta krynickii* are among the most frequently encountered land snails in Mediterranean countries. Due to their good adaptation to warm countries and their summer activity, these snails could potentially represent a sentinel species to evaluate environmental pollution during summer when pesticide application rates increase in orchards. *X. derbentina* and *X. krynickii* are thus able to have various growth speeds and life spans and appears to switch from an annual life cycle to a biennial cycle in response to population density or climatic conditions.

The high cost of developing new chemical controls and the relatively small market for slug and snail controls compared to other pesticides, such as insecticides, seem to overshadow research into their development. Research involving pre-existing pesticides is economical and can involve relatively little time compared to the development of new chemicals. According to Gimingham (1940), methaldehyde has been the most effective chemical control for slugs and snails since introduction as molluscicidal bait in 1934. Mesurol® (methiocarb), a restricted use pesticide is another popular molluscicide often

Table 1. The pesticides used in this experiment.,

Common name	Trade name	Active ingredient	Manufacturer	LD_{50} for rats (mg/kg)	Recommended dosage (g/m^2)
Methaldehyde	Metazon®	Methaldehyde 6%	Giyah co.	650	1 - 6
Iron phosphate	Ferricol®	iron phosphate 1%	Kimiasabzavar Co.	> 5000	2 - 5
Activated copper	Snail repellent tape®	Copper metal and iron salts	Kimiasabzavar Co.	> 5000	--
Repellent paint	Sabzarang®	Copper salts	Kimiasabzavar Co.	> 5000	--

considered more effective and longer lasting under field conditions than methaldehyde (Mutze and Hubbard, 2000). However, because carbamates such as Sevin are broad-spectrum pesticides, they can negatively affect non-target beneficial arthropods such as predaceous beetles (Singh and Agarwal, 2007). Home gardeners have used other methods of slug and snail control including table salt (NaCl), ammonia (NH_3), beer, ashes and diatomaceous earth. Additionally, iron phosphate bait has become popular over the past several years as a molluscicide. There is ongoing research into the use of naturally occurring botanical chemicals (e.g., caffeine, garlic, cinnamamide and chemicals from mushrooms) as molluscicides, repellents and antifeedants (Hollingsworth et al., 2002; Schüder et al., 2003).

Biopesticide are safe to use around pets, humans, fish, birds, beneficial insects and mammals. It is applied to the soil as a pellet that also contains bait to attract snails and slugs. Snails and slugs cannot tolerate copper on Repellent band; it gives them a slight electrical shock on contact. Knowing this is great, but keep in mind that it creates a barrier only. And also repellent color will not kill them; they will only keep them out of an area that does not already have a problem.

The objective of this study was to investigate the toxicity of methaldehyde, Ferricol (non-toxic snail and slug bait), Snail repellent tape (copper barrier) and Snail repellent paint on land snail (*Xeropicta derbentina*), (*Xeropicta krynickii*) (Stylommatophora:Hygromiidae).

MATERIALS AND METHODS

Chemical preparation

The pesticides used in this experiment have shown in Table 1.

Laboratory bioassay and experimental design

This experiment took place at 1 ha of citrus orchard of the faculty of agricultural science Sari Agricultural Science and Natural Resources University. The ornamentals were heavily infested with a large population of land snail (*X. derbentina* and *X. krynickii*), which caused a heavy infestation. Dense populations of this species were present on the weeds around the citrus tree. This experiment was performed at completely random design. Five treatments were assigned along the citrus orchard. Each treatment was repeated four times randomly and in each replicate 4 trees were used. The experiment was repeated for two consecutive years, 2007 and 2008. The first plot was treated with methaldehyde bait and the second with Ferricol® bait. In the third plots, the trunks of young citrus trees were painted with Sabzarang*®*, as a 10 cm wide band, to prevent the snails from climbing the trees.

The tree trunks in the last plots were wrapped with 5 cm wide Snail repellent tape®, which is claimed by the manufacturer to repell snails for several seasons. The number of live snails was counted before each treatment, on 29th April 2008 and again 2, 15, 29, 36, 68 and 98 days after treatments. All countings were performed in the morning. On 4th June 2007, all the land snails (*Xeropicta derbentina* and *Xeropicta krynickii*) subject to the experiments were terminated.

Statistical analysis

The means of the snail counts were square-root transformed and the treatment differences were subjected to ANOVA. Means were evaluated by Tukey multiple range and LSD test at the 0.01 significance level (SAS, 1995). The adjusted control efficacy was calculated with Henderson and Tilton's formula (Henderson, 1955).

RESULTS

Analysis of variance showed that there were significant differences among the numbers of live snails in the treated and untreated trees. These results showed that each factor has independent and separate effect on percentage of mortality and number of remaining live snails on trees (Table 2). The percentage of overall control efficacy with Methaldehyde, Ferricol®, Snail repellent tape® and Sabzarang® (Snail repellent paint) were 91.87, 82.63, 95.22 and 82.26, respectively, after 98 days post-treatment (Table 3). There were also significant differences in percentage of live snails between the control and the treatments ($p < 0.0001$).

The percentage of live snails decreased on day 2 in all treatments except control (Table 3). On subsequent days, the significance of the difference between the treatments and the control increased ($P < 0:001$), while the numbers of snails in the treated plots gradually declined; especially in those treated with Snail repellent tape® and Sabzarang® (Snail repellent paint) (Table 3). Tukey's multiple range test ($P < 0.01$) showed that among different treatments at the present study, the percentages of live snails on citrus trees with Snail repellent tape® with 5.07% and methaldehyde with 10.63% were less than the percentages of live snails with Sabzarang® (Snail

Table 2. The ANOVA of different biorational pesticide on citrus live snail on citrus trees.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
treat	0.380	4	0.095	123.679	**
day	0.050	24	0.002	2.727	**
treat * day	0.046	96	0.000	0.627	ns
Error	0.288	375	0.001		

**Significantly different (P<0.01)

Table 3. The comparison between molluscocide on citrus land snail alived in periods of experiment with control efficacies for these toxins consist of Tukay´s test.

Treatment day	Subset subset for alpha = 0.01						
	control	Methaldehyde	Ferricol®	Snail repellent tape®	Sabzaran ® (Snail repellent paint)	Total	F ratio (df = 4)
2	100 d	25.8 ab	100c	0	0	45.16 ±22.87	5.02,p < 0.05
15	100 d	12.9 ab	100c	0	0	42.58 ±23.55	4.38,p <0.1
29	100 d	12.9 ab	50c	5.88a	0	33.75 ±18.71	6.85,p < 0.05
36	100 d	12.9 ab	50c	5.88a	0	33.75 ±18.71	6.85,p < 0.05
68	76.47 d	3. 22 ab	0	0	0	15.93 ±15.14	1.54,p = Ns
98	41.17 d	9. 67 ab	83. 33c	5. 88a	8. 33b	29.67 ±14.88	13.68,p < 0.05
Total	86.27 ± 9.8	12.3 ± 3	63.88 ± 15.76	2.94 ± 1.31	1.38 ± 1.38	33.47 ±7. 37	
Control efficacies		91.87	82.63	95.22	82.26		

Means followed by the same letter are not significantly different.

Table 4. The comparison of the mean of different control agents on percentage of live snails of citrus land consist of Tukey's test during 98 days.

treatment	Subset subset for alpha = 0.01			
	1	2	3	4
Snail repellent tape®	5.07±1.34			
Methaldehyde	10.63 ± 0.91	10.63 ± 0.91		
Sabzarang® (Snail repellent paint)		14.23±2.62		
Ferricol®			31.33± 3.97	
control				86.20± 2.78

repellent paint) with 14.23%, Ferricol® with 31.33% and control with 86.20%. Overall, the total percentage of live snails decreased dramatically in all treatments compared to control (Table 4).

Multiple slope of LSD test (P < 0.01) showed that among different molluscocides at the present study, the percentage of live snails on citrus trees, with Snail repellent tape® with 5.07%, methaldehyde with 10.63% and Sabzarang® (Snail repellent paint) with 14.23% were less than Ferricol® with 31.33% and control with 86.20% (Table 5).

The first observation, 2 days after treatment, Snail repellent tape® and Sabzarang® (Snail repellent paint) showed high control efficacy with100% (Table 6). The next observation until 36 days after treatment, Snail repellent tape® and Sabzarang® (Snail repellent paint) still showed high control efficacy with100% (Table 6). After 68 days of treatment, Snail repellent tape® and Ferricol® showed high control efficacy with 100% (Table 6). At 98 days after treatment, Snail repellent tape® and Sabzarang® (Snail repellent paint) showed high control efficacy with 85.71 and 79.76%, respectively (Table 6).

Table 5. The comparison of the mean of different control agents on percentage of live land snails (mean ± sd).

treatment	Mean ± std
control	86.20± 2.78
Methaldehyde	10.63 ± .91**
Ferricol®	31.33± 3.97**
Snail repellent tape®	5.07±1.34**
Sabzarang® (Snail repellent paint)	14.23±2.62**
Tukay(0.05)	9.85
Tukay(0.01)	16.34

**Significantly different (P < 0.01).

Table 6. The comparison of the mean of different post application days of control agents on percentage of live snails and control efficacies during treatment period. consist of Tukay's test.

Treatment	After 2 days	Control efficacies
control	100	…..
Methaldehyde	25.8	83.31
Ferricol®	100	1.45
Snail repellent tape®	0	100
Sabzarang® (Snail repellent paint)	0	100
Total	45.16 ± 22.87	……
F ratio (df = 4)	5.02, p< 0.05	……
Treatment	After 15 days	Control efficacies
control	100	……
Methaldehyde	12.9	92.69
Ferricol®,	100	33.89
Snail repellent tape®	0	100
Sabzarang® (Snail repellent paint)	0	100
Total	42.58 ± 23.55	……
F ratio (df = 4)	4.38, p<0.1	……
Treatment	After 29 days	Control efficacies
control	100	……
Methaldehyde	12.9	90.46
Ferricol®,	50	63.04
Snail repellent tape®	5.88	95.65
Sabzarang® (Snail repellent paint)	0	100
Total	33.75 ± 18.71	……
F ratio (df = 4)	6.85, p< 0.05	……
Treatment	After 36 days	Control efficacies
control	100	……
Methaldehyde	12.9	90.46
Ferricol®,	50	63.04
Snail repellent tape®	5.88	95.65
Sabzarang® (Snail repellent paint)	0	100
Total	33.75 ± 18.71	……
F ratio (df = 4)	6.85, p< 0.05	……
Treatment	After 68 days	Control efficacies
control	76.47	……
Methaldehyde	3.22	95.78
Ferricol®	0	100

Table 6. contd.

Snail repellent tape®	0	100
Sabzarang® (Snail repellent paint)	0	89.10
Total	15.93 ± 15.14	……
F ratio (df = 4)	1.54, p= Ns	……
Treatment	After 98 days	Control efficacies
control	41.17	……
Methaldehyde	9.67	76.50
Ferricol®,	83.33	-102
Snail repellent tape®	5.88	85.71
Sabzarang® (Snail repellent paint)	8.33	79.76
Total	29.67 ± 14.88	……
F ratio (df = 4)	13.68, p< 0.05	……

DISCUSSION

This is the first time that new pest control agents such as Snail repellent tape® and Sabzarang® (Snail repellent paint), have been used against *X. derbentina* and *X. krynickii* in a citrus nursery for approximately 100 days.

The result of this research project demonstrated that the control efficacy of Snail repellent tape® and Sabzarang® (Snail repellent paint) were higher than others. However, the control efficacy of methaldehyde was 90% (Table 6). The mode of action of methaldehyde is destruction of the mucus production abilities of the slugs reducing mobility and digestion but, methaldehyde activity is reduced by sunlight, fungal growth and moisture and also methaldehyde must target periods of high slug and snail activity to be effective (Speiser and Hochstracer, 1998); this is the reason for employing alternative control agents, in this study.

One way to reduce the number of slugs and snails is to use copper strips on the glasshouse and orchards. Slugs and snails are repelled by copper as has been shown in this experiment, since their slimy bodies receive a small electrical shock. This approach is used by the citrus growing industry, where they wrap the strips around the trunks of citrus trees.

Snail barrier can be installed with tabs on either top or bottom. The bottom configuration is preferred on trees and bushes for easier removal of snails. The top configuration is preferred on pots and other containers for ease of installation. Snails will crawl over accumulated snails below the barrier. Slugs were observed producing large amounts of mucus when they came into contact with the copper surfaces. This irritation can cause significant dehydration. Both slugs and snails were observed to quickly withdraw their tentacles when encountering copper surfaces (Schuder et al., 2003).

Ferricol® is an environmentally safe bait containing 1% iron phosphate. Baits containing methaldehyde or carbaryl are most successful when distributed in infested areas just after rain or after irrigation, when the snails/slugs are most active. These baits are hazardous to non-target organisms such as dogs, cats, wildlife and children.

Baits containing iron phosphate are safe around pets and wildlife. The iron phosphate bait does not kill snails/slugs instantly, but it makes them stop feeding and eventually die. It is more effective against slugs than snails. It may be used around vegetables.

After eating iron phosphate bait, snails and slugs stop feeding and die within 3 to 6 days. They often crawl into secluded places, so you may not see dead bodies. Iron phosphate is considered by the U.S. Environmental Protection Agency to be generally regarded as safe for food use. No toxicity has been seen in mammals, birds, or fish and has the advantage of being safe for use around domestic animals, children, birds, fish and other wildlife and is a good choice for a garden IPM program. It is applied to soil as a pellet that also contains food grade attractants to lure snails and slugs. It is not volatile and does not readily dissolve in water, which minimizes its dispersal beyond where it is applied. This also means that it will remain effective after repeated rainfalls, unlike methaldehyde.

When snails and slugs eat the pellets, the iron phosphate interferes with calcium metabolism in their gut, causing the snails and slugs to stop eating almost immediately (Shmuel et al., 2004). Ingestion of the iron phosphate bait, even in small amounts, will cause snails and slugs to cease feeding, although it may take several days for the snails to die.

Sabzarang® (Snail repellent paint), especially used in this experiment for controlling snail, contains insoluble copper salts and special sticking and binding agents.

Copper used in repellent paints can act both as a micronutrient or a toxin for different groups of marine organisms. This dual role of copper can cause direct and indirect effects varying in direction and magnitude, which increases the potential for confounding the results with experimental artifacts. Nevertheless, most authors working with barriers of copper paint have reported no detrimental effects on algae recruitment and growth, except within a few centimeters of the barriers (Cubit, 1984; Johnson, 1992; Benedetti-Cecchi and Cinelli, 1997). Pulse exposure to copper has recently been found to reduce the tenacity of patellid limpets (Cartwright et al., 2006).

The possibility that barriers of copper containing paints might affect the intensity of grazing per limpet cannot, therefore, be totally discounted, even though that same study reported no effect on grazing. For future research, laboratory and field tests for different crops and trees are suggested.

REFERENCES

Benedetti-Cecchi L, Cinelli F (1997). Confounding in field experiments: direct and indirect effects of artifacts due to the manipulation of limpets and macroalgae, J. Exp. Mar. Biol. Ecol. 209: 171-184.

Cartwright SR, Coleman RA, Browne MA (2006). Ecologically relevant effects of pulse application of copper on the limpet *Patella vulgata*, Mar. Ecol. Prog. Ser. 326: 187-194.

Cubit JD (1984). Herbivory and the seasonal abundance of algae on a high intertidal rocky shore, Ecology, 65(1984): 1904-1917.

Henderson GF (1955). Test with acaricide against the brown wheat mite. J. Econ. Entomol. 48: 157-160.

Gimingham CT (1940). Some recent contribution by English workers to the methods of insect control. Appl. Biol. 27: 161-175.

Hollingsworth RG, Armstrong JW, Campbell E (2002). Caffeine as a repellent for slugs and snails. Nature, 417: 915-916.

Johnson LE (1992). Potential and peril of field experimentation: The use of copper to manipulate molluscan herbivores, J. Exp. Mar. Biol. Ecol. 160: 251-262.

Kiss L, Labaune C, Magnin F, Aubry S (2005). Plasticity of the life cycle of *Xeropicta derbentina* (KRYNICKI, 1836), a recently introduced snail in mediteranean France. J. Mollus Studies, 71(3): 221-231; doi:10.1093/mollus/eyi030

Mutze, GJ, Hubbard DJ (2000) Effects of molluscicide baits on field populations of house mice. Agric. Econ. Environ. 80(3): 205-211.

SAS (1995). Statistics and graphics guide version 3.1 SAS institute Inc., Cary, NC, USA, p. 593.

Schüder I, Port G, Bennison J (2003). Barriers, repellents, and anti feedants for slug and snail control. Crop Prot. 22: 1033-1038.

Shmuel M, Yaacov G, Benjamin Y (2004). Management of land snails in cut green ornamentals by copper hydroxide formulations. Crop Prot. 23: 647-650.

Singh DK, Agarwal RA (2007). Toxicity of Piperonyl Butoxide-Carbaryl Synergism on the Snail *Lymnaea acuminata* Internationale Revue der gesamten. Hydroe Hydro, 74(6): 89-699.

Speiser B, Hochstrasser M (1998). Slug damage in relation to watering regime. Agric. Ecosyst. Environ. 70: 273-275.