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IPM STRATEGY FOR RODENT CONTROL IN ALFALFA CROPS

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Abstract: Integral pest management (IPM) emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. Support to IPM development in agricultural fields is the use of natural compounds to control rodent pests *(Kogan, 1998; Cumming 2006)*. Over the past several years we have witnessed increasing occurrences of resistance. This is why attention was focused in the 1990s on products based on vitamin D3 (cholecalciferol). For the first time we have introduced a rodenticide based on Se (0.1% sodium selenite) and for the first time we tried to control common voles and field mouse in alfalfa crops with another such compound, cellulose, i.e. a naturally-occurring substance with a mode of action different from other rodenticide active ingredients. The efficacy of vitamin D3, Se and cellulose in controlling voles (*Microtus arvalis*) and field mouse (*Apodemus agrarius*) in alfalfa fields was compared to the efficacy of products based on bromadiolone and brodifacoum. The trial complied with the PP 1/114(2) method *(OEPP/EPPO, 1999)*. The new Se-based products, cellulose based products and vitamin D3 based products achieved good efficacy against voles, *M. arvalis*, and field mouse, *A. agrarius*, compared to products based on bromadiolone and brodifacoum. These products have good toxicological and ecological properties and the fact that there have been no known cases of resistance make them recommendable for use against rodents in agricultural fields, especially alfalfa crops.

Key words: vitamin D3, cellulose, selenium, alfalfa crop, biological efficacy

Introduction

Rodent pests of agricultural fields and forest nursery greenhouses include at least 40 species and approximately as many subspecies, all of them members of the genus *Rattus*. Harmful field rodents belong to a group of pests causing occasionally significant to highly significant economic losses. Over the past several years, they have overpopulated large areas and caused considerable damage *(Davis,* *2004)*. Growth of rodent populations is caused by a number of factors: physiological condition of a population, climatic conditions, habitat and food resources. Data on the physiological condition are scarce, while the other conditions have been found highly conducive to their reproduction *(Đukić et al.2005)*.

The most important of field rodent pests of the family of short-tailed mice (*Cricetidae*) are common vole (*Microtus arvalis*) and hamster (*Cricetus cricetus*). Field mice (*Apodemus agrarius*) of the family of long-tailed mice (*Muridae*) can also become widespread in alfalfa crops *(Vukša, 2005)*.

Preventive or direct control measures can be applied to reduce losses caused by rodent pests. Preventive protection is based on intensive cropping practices, timely sowing and harvesting, ploughing in of crop residues, plowing up of boundaries, pastures and idle land, spatial isolation of the existing foci in alfalfa and other crops, and continuing monitoring of the pests' natural enemies.

Direct measures primarily include chemical control of rodents, but the scope of such treatments has been inadequate over the past several years. Chemical control of field and underground voles in small grain crops and in different foci in alfalfa crops is conducted from early spring to late autumn. Field mice are controlled immediately after their presence has been spotted for the first time, and especially in plots sown with seed crops. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. Support to IPM development in agricultural fields is the use of natural compounds to control rodent pests *(Kogan, 1998; Cumming, 2006)*. Over the past several years we have witnessed increasing occurrences of resistance. Rodents are known to be able also to develop resistance to some newly-designed anticoagualants, as well as cross-resistance to old and new compounds *(Lund, 1984; Greaves, 1995; Myllymaki, 1995; Thijssen, 1995)*.

Because of that the objectives of the present study were (i) to investigate products that contain active ingredients to which no resistance has been observed so far and which can be applied in cases of altered susceptibility to other rodenticides currently in use, while being environmentaly safe and not causing secondary poisoning, (ii) to estimate rodenticide based on vitamin D3 (cholecalciferol) whose mode of action is based on the mobilization of calcium from bones and tissues and calcification in blood vessels, kidneys, liver and heart, which ultimately results in heart arrest (a rodenticide based on Se (0.1 % sodium selenite), with the mode of action based on replacement of the SH group of functional enzymes with the S-S groups, was tested), (iii) to control common voles and field mouse in alfalfa crops with another such compound, cellulose, i.e. a naturally-occurring substance with a mode of action different from other rodenticide active ingredients, and (iv) to establish the most convenient IPM protection of alfalfa crop against field rodents.

Materials and Methods

The products EKOSEL-A granules (0.1% Na selenite) and EKOSTOP-D3 granules (0.075% cholecalciferol), manufactured by the company A.D. “CIKLONIZACIJA”, Novi Sad, Serbia, and the NATROMOUSE natural product composed of powdered maize cobs (40-45% cellulose), manufactured by the company PINUS TKI d.d., Rače, Slovenia, were tested against common vole (*M. arvalis*) and field mouse (*A. agrarius*) for biological efficacy. The products MAMAK B granules (0.005% bromadiolone), manufactured by the company A.D. “CIKLONIZACIJA”, Novi Sad, Serbia, and BRODY Fresh Bait (0.005% brodifacoum), manufactured by KOLLANT s.p.a. Milano, Italy, were used as standards. The trial complied with the PP 1/114(2) method *(OEPP/EPPO, 1999)*.

Product efficacy was tested in an alfalfa field of the Institute of Animal Husbandry in Belgrade in early spring (28.02. – 28.03.) of 2008 and 2009. Stage of development: two-to-five leaves, i.e. stage 12-17 on the BBCH scale *(Mitić, 2004)*. Soil type: Black meadow soil. Pest species: common vole (*M. arvalis*), frequency 89%, over striped field mouse (*A. agrarius*), frequency 11%. Type of experiment: Random block design. Number of replicates: 4. Plot size: 4 acres. Two days prior to rodenticide application all rodent holes were counted and closed. The next day active holes were counted (those that were reopened in the mean time). Rate of application: 15-20 g per active hole.

Application method: Holes were counted one day prior to rodenticide application and covered with earth. The next day baits were applied by plastic spoon into the active holes (open ones) and the holes were again covered with earth. Times of evaluation were: 3, 7, 14 and 28 days after application.

Rodent numbers were computed from the number of active holes and data were statistically processed using the analysis of variance and Duncan´s multiple range test.

Data on palatability and biological effectiveness of products and rodenticide efficacy against rodents in alfalfa crop were calculated using Abbott's formula *(Abbott, 1925)*.

Results and Discusion

Table 1 shows the efficacy of the cellulose-based product NATROMOUSE, cholecalciferol-based (vitamin D3) product EKOSTOP D3 granules, Se-based product EKOSEL A granules, and bromadiolone-based product MAMAK B granules and brodifacoum-based product BRODY Fresh Bait, as standards, all applied against common vole, *M. arvalis* and over striped field mouse, *A. agrarius,* in alfalfa crops during the early spring of 2008. The results of rodenticide testing in alfalfa crop three, seven, 14 and 28 days after the beginning of the experiment are presented.

Table 1. Average number of active holes before treatment (BT), three, seven, 14 and 28 days after treatment (DAT) and rodenticide efficacy in controlling *M. arvalis* and *A. agrarius* in alfalfa crop (2008)

	Average number of active holes (±SD)				
	BT	3 DAT	7 DAT	14 DAT	28 DAT
NATROMOUSE	32.50 ± 3.32	29.25 ± 2.75	16.00 ± 5.10	6.50 ± 2.65	6.25 ± 2.65
Ef (%)		11.36	51.87	80.86	81.99
EKOSTOP D3	28.25 ± 2.22	25.50 ± 1.91	24.25 ± 2.36	11.50 ± 1.29	6.50 ± 1.73
Ef (%)		9.73	14.79	58.74	78.12
EKOSEL A	18.75 ± 1.89	18.00 ± 1.63	11.00 ± 1.41	5.50 ± 2.06	4.25 ± 1.26
Ef (%)		15.70	49.11	74.55	81.02
MAMAK B	35.25 ± 4.50	31.50 ± 4.36	27.25 ± 6.70	16.25 ± 1.71	8.50 ± 4.04
Ef (%)		10.64	22.69	55.22	77.06
BRODYFr.B.	30.25 ± 4.19	22.75 ± 6.65	17.25 ± 3.30	3.00 ± 0.82	2.00 ± 0.82
Ef (%)		24.79	43.39	89.68	93.71
CONTROL	34.00 ± 5.72	34.00 ± 5.72	34.25 ± 5.25	35.25 ± 4.57	35.75 ± 3.59

Field vole numbers were found to drop significantly as early as 3 and 7 days after treatment with BRODY Fresh Bait (24.79 and 43.39%) and MAMAK B (10.64 and 22.69%), while the decrease is considerably lower for EKOSTOP D3 (9.73 and 14.79%). Unexpectedly, EKOSEL A (15.70 and 49.1%) and NATROMOUSE (11.36 and 51.87%) showed high efficacy 7 days after treatment. Fourteen and 28 days after treatment, the decrease in field vole numbers, i.e. the efficacy, became leveled for all three tested and two reference products, and it was high.

Table 2 shows the efficacy of three tested and two standard rodenticide products against common vole, *M. arvalis*, and over striped field mouse, *A. agrarius*, in alfalfa crops during the early spring of 2009. The results of rodenticide testing in alfalfa crop three, seven, 14 and 28 days after the beginning of the experiment are presented.

In the early spring of 2009, field vole numbers were found to drop significantly as early as 3 and 7 days after treatment with BRODY Fresh Bait (46.67 and 70.12%) and MAMAK B (15.75 and 63.60%), while the decrease was considerably lower for EKOSTOP D3 (15.70 and 49.10%), EKOSEL A (15.70 and 49.1%) and NATROMOUSE (11.20 and 22.10%). Fourteen and 28 days after treatment, the decrease in field vole numbers, i.e. the efficacy, became leveled for all three tested and two reference products, and the efficacy was high.

Table 2. Average number of active holes before treatment (BT), three, seven, 14 and 28 days after treatment (DAT) and rodenticide efficacy in controlling *M. arvalis* and *A. agrarius* in alfalfa crop (2009)

	Average number of active holes (±SD)				
	BT	3 DAT	7 DAT	14 DAT	28 DAT
NATROMOUSE	106.50 ± 7.12	105.25 ± 9.75	83.00 ± 5.10	56.50 ± 2.65	42.25 ± 2.65
Ef (%)		1.20	22.10	47.20	60.33
EKOSTOP D3	17.00± 2.16	16.75 ± 2.50	7.25 ± 2.22	4.50 ± 2.88	4.25 ± 2.50
Ef (%)		13.48	63.00	77.03	79.07
EKOSEL A	18.00 ± 1.41	17.00 ± 1.73	10.50 ± 2.38	5.00 ± 1.82	3.50 ± 1.73
Ef (%)		2.77	41.66	72.59	81.06
MAMAK B	18.50 ± 1.00	17.75 ± 1.26	7.75 ± 2.22	5.75 ± 1.50	5.00 ± 0.82
Ef (%)		15.75	63.60	73.03	77.37
BRODYFr.B.	22.50 ± 0.57	12.00 ± 2.94	7.75 ± 1.26	4.75 ± 1.50	3.50 ± 0.57
Ef (%)		46.67	70.12	81.68	86.97
CONTROL	18.00 ± 2.94	20.05 ± 3.65	20.75 ± 3.86	20.75 ± 3.86	21.50 ± 3.69

No data are available in literature on Se being used as a rodenticide in agricultural fields, alfalfa crops, except work of *Jokić et al. (2007)*. This investigation shows that very good efficacy of such products can be achieved.

Ingestion of cellulose baits by mice leads to immediate dehydration, decrease in blood volume and blood pressure, tissue decay and circulation arrest, and the ultimate result is death *(Anonymous, 2005)*. For that reason, humidity of the environment is one of the crucial factors for product efficacy. Based on the results of this experiment *(Jokić et al., 2007)*, soil moisture is a limiting factor and cellulose-based rodenticides can be applied only in soils that have low percentage of moisture. We found no other reported data on the efficacy of cellulose-based products in controlling field rodents. The efficacy of a cellulose product (NATROMOUSE) tested in our previous experiments *(Jokić et al., 2006)* against house mouse, *Mus musculus* in agricultural stored products was 91.66%.

There are many data on the efficacy of products based on vitamin D3 against various rodent species in alfalfa. *Vukša and Đedović (2004)* found vitamin D3 products to have a 89-95% efficacy range when applied against common vole and field mouse in alfalfa and wheat crops. *Witmer et al. (1995)* achieved good efficacy of tested baits containing different amounts of vitamin D3 a.i. against *Thomomys* spp. in the laboratory and in the field. A similar efficacy under field conditions against the same experimental animal was demonstrated by baits containing 0.150% vitamin D3. *Moran (1996, 2003)* investigated the efficacy of different product formulations (pelleted baits and wheat grains) based on vitamin D3 in controlling herbivorous and insectivorous rodents (*Meriones tristrami* and *Microtus guentheri*). The efficacy of pelleted baits was found to range between 30 and 80%, while efficacy achieved by applying vitamin D3 on wheat grains was within a 46-100% range. *Rowe et al. (1981)* reported 60-100% efficacy of bromadiolone products under field conditions. According toby *Brooks and Rowe (1987)*, the efficacy of products based on bromadiolone in the field ranges from 70% to 100%. Brodifacoum products were shown to have efficacy ranging from 98.4% to 100% *(Rowe et al. 1978)*. Products based on bromadiolone and brodifacoum have been found to demonstrate 80.8-97% efficacy against house mouse on poultry farms *(Parshad et al., 1987; Shafi et al., 1992)*. Our results in efficacy testing of cholecalciferol (vitamin D3), bromadiolone and brodifacoum products against *M. arvalis* and *A. agrarius* are consistent with reports by other authors *Brooks and Rowe (1987), Vukša et al. (2002)* and *Jokić at al. (2007).*

Conclusion

Compared to brodifacoum and bromadiolone efficacy, rodent product on the basis of vitamin D3, Se and cellulose, as a natural active ingredients, was found to have satisfactory efficacy in controlling agricultural fields.

Good efficacy, favourable ecological properties and the fact that there have been no known cases of resistance make these products recommendable for use to control rodents in alfalfa crops.

IPM strategija zaštite lucerke od glodara

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Rezime

Integralna zaštita bilja (IZB) podrazumeva uzgajanje zdravih biljaka sa što manjim narušavanjem ravnoteže agroekosistema i uvođenjem prirodnih mehanizama za kontrolu štetočina. Podršku razvoju IZB u poljoprivredi predstavlja uvođenje preparata na bazi prirodnih aktivnih materija za kontrolu glodara u polju. Poslednjih godina smo svedoci pojave rezistentnosti. Zbog toga je 90-tih godina razvijen rodenticid na bazi vitamina D3 (holekalciferol). Po prvi put, mi smo uveli rodenticide na bazi Se (0,1% Na selenita) i po prvi put smo pokušali da ih primenimo za suzbijanje voluharica i poljskih miševa u lucerki, kao i preparat na bazi prirodne supstance celuloze, čiji se mehanizam delovanja razlikuje od drugih aktivnih materija.

Efikasnost preparata na bazi vitamina D3, Se i celuloze u suzbijanju poljske voluharice (*Microtus arvalis*) i poljskog miša *(Apodemus agrarius*) u lucerki poredili smo sa efikasnošću preparata na bazi bromadiolona i brodifakuma. Testovi su rađeni po metodi PP 1/114(2) *(OEPP/EPPO,1999)*.

Novi preparati na bazi Se, celuloze i preparati na bazi vitamina D3 postigli su dobru efikasnost u kontroli brojnosti poljske voluharice (*M. arvalis*) i poljskog miša (*A. agrarius*) u poređenju sa preparatima na bazi bromadiolona i brodifakuma. Ovi preparati imaju dobra toksikološka i ekološka svojstva, a činjenica da se na njih ne može razviti rezistentnost doprinosi da ih preporučujemo za primenu u suzbijanju glodara u polju, naročito u lucerištima.

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