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Efficacy of Rodent Control in Alfalfa and Wheat Crops Using Chemical and Natural Rodenticides

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SUMMARY

Biological efficacy of chemical and natural rodenticides in controlling rodents in alfalfa and wheat crops was investigated. The experiment was set up using a randomized block design with four replicates and 400 m^2 plots in compliace with a standard OEPP/EPPO method. Examination was based on the average number of active holes and rodenticide efficacy was measured three, seven, 14 and 28 days after treatment. Rodent numbers were computed from the number of active holes, and rodenticide efficacy using Abbott's formula. The appearance and arrangement of active holes indicated the presence of common vole (*Microtus arvalis* Pall) and striped field mouse (*Apodemus agrarius*) in the plots. The products tested demonstrated satisfactory efficacy in controlling rodents in alfalfa and wheat crops. Products based on vitamin D3 achieved 87-90% efficacy in both crops. The efficacy of a bromadiolone-based product ranged from 84% to 90%, while a cellulose product displayed the highest variation in efficacy, ranging from 86% to 98%.

Keywords: Cellulose; Vitamin D3; Bromadiolone; Alfalfa; Wheat; Efficacy

INTRODUCTION

Several rodent species cause yield losses in alfalfa and wheat crops simultaneously, primarily common vole (*Microtus arvalis* Pall) and striped field mouse (*Apodemus agrarius*). Overpopulation of hamsters (with more than two burrows per ha) also occurs in some areas and seasons, mostly due to migration caused by various factors, and it may cause considerable economic losses by reducing total and grain yields, especially of wheat and alfalfa (Čamprag, 1980; Davis et al., 2004; Đukić et al., 2005).

Rodents find suitable environments for development and reproduction in some plant crops, due to their densities and general conditions of cultivation, and they spread from such environments into surrounding areas, causing additional damage (Čamprag, 1980; Stenseth et al., 2003; Heroldova et al., 2007).

Although various agricultural practices are able to reduce their numbers and reproductive potential, chemicals are still the main method of controlling rodent numbers (by eradicating them or maintaining their numbers at acceptible level) (Endepols, 2002; Sayed and Lynwood, 2002). A wide selection of roden-

ticide products with different chemical compositions, modes of action and toxicity levels have been used for the purpose in Serbia, as well as worldwide (Mitić, 2004; Tomlin, 2006). Rodenticide treatments, primarily with chemicals, improve plant production both in terms of quality and quantity. However, those compounds are generally highly toxic and cancerogenous to humans and animals. Pesticide residues in foodstuffs are hard to detect, while residues in soil are environmental pollutants. Many of such compounds also affect beneficial organisms (Vitorović and Milošević, 2002).

In this study, we aimed to determine the abundance of rodent pest species in alfalfa and wheat crops and to compare the effectiveness of control methods involving different formulations of natural and chemical products.

MATERIAL AND METHODS

The experiments were conducted in an alfalfa field of the Institute of Animal Husbandry in Zemun and a winter wheat field at Putinci in the spring of 2005.

The general appearance of active holes in alfalfa indicated a predominance of common voles (820 a.h.[1] or 82%) over striped field mouse (180 a.h. or 18%). Alfalfa was at a two-to-five-leaf stage, i.e. stage 12-17 on the BBCH scale (Mitić, 2004). In wheat, there was a roughly equal proportion of common vole (225 a.h. or 47%) and field mouse (254 a.h. or 53%) and the crop was at the beginning of tillering, i.e. at stage 21 of the BBCH scale (Mitić, 2004).

Trials were set up using a randomized block design with four replicates and 400 m^2 experimental plots. The following rodenticides were tested: Natromouse (a.i. cellulose 45%), manufactured by PINUS TKI d.d. Rače, Slovenia; Ekostop D3 paraffinized block and Ekostop D3 paraffinized pellets (i.e. vitamin D3 0.0075%), manufactured by AD Ciklonizacija, Serbia; and Hemus AB (i.e. bromadiolone 0.005%), manufactured by Hemovet d.o.o., Novi Sad, Serbia.

[1] a.h. (active hole)

The main meteorological parameters, measured during experiment set-up, are shown in Table 1. Air temperature and humidity, and wind speed at the time of bait laying were measured by a mini meteorological station. Soil moisture was measured by a standard method for soil hygroscopic water (Korunović and Stojanović, 1977).

Meteorological conditions were appropriate for setting up the experiments in alfalfa and wheat crops.

Table 1. Meteorological data during treatment in alfalfa and wheat crops
Tabela 1. Meteorološki podaci zabeleženi za vreme tretmana u usevima lucerke i pšenice

Crop Usev	Air temperature (°C) Temperatura vazduha (°C)	Air humidity (%) Vlažnost vazduha"(%)	Soil moisture (%) Vlažnost zemljišta (%)	Wind speed (m/s) Brzina vetra (m/s)
Alfalfa – Lucerka	17.3-17.9	37-40	20.31-20.95	1.2-2.7
Wheat – Pšenica	21.0-21.8	29-31	15.22-15.73	1.8-2.2

The experiments were conducted in compliance with the standard OEPP method PP 1/114(2) (OEPP/EPPO, 1999). Two days prior to rodenticide application, holes were counted and closed. The next day, baits were laid into active holes (those that were reopened in the meantime) by plastic spoon, and all holes, including untreated ones, were closed again. Bait portions were 15-20 g per active hole. The features recorded included the average number of active holes and efficacy of rodenticides at time intervals of three, seven, 14 and 28 days. Rodent numbers were computed from on the number of active holes and data were statistically processed using the analysis of variance and Duncan's multiple range test. As infestation was uniform in the experimental plots, Abbot's formula (1925) was used to calculate the percentage of rodenticide efficacy.

RESULTS

Experiment in alfalfa crop

Table 2 presents the results of rodenticide testing in alfalfa crop three, seven, 14 and 28 days after the beginning of the experiment.

Figure 1 shows the calculated rodenticides efficacies against rodents in alfalfa crop.

Three days after treatment in alfalfa, initial efficacy of Ekostop D3 paraffinized pellets and Hemus AB was 37.91% and 40.11%, respectively, and lower than that of Ekostop D3 paraffinized block (64.28%) and Natromouse (66.48%). From the third to 14th day, efficacy became more uniform and there was

Table 2. Average number of active holes of *M. arvalis* and *A. agrarius* before treatment (BT), three, seven, 14 and 28 days after treatment (DAT) in alfalfa crop
Tabela 2. Prosečan broj aktivnih rupa *M. arvalis* i *A. agrarius* pre tretmana (BT), tri, sedam, 14 i 28 dana posle tretmana (DAT) u usevu lucerke

Product – a.i. content Preparat – Sadržaj a.m.	Average No. of active holes of *M. arvalis* and *A. agrarius* Prosečan broj aktivnih rupa *M. arvalis* i *A. agrarius*				
	BT	3 DAT	7 DAT	14 DAT	28 DAT
Natromouse (cellulose 45%)	51.25a	15.25a	8.25a	7.25a	7.00b
Ekostop D3 paraffin pellets (vitamin D3 0.0075%)	55.00a	28.25b	13.00b	6.00a	5.50ab
Ekostop D3 paraffin block (vitamin D3 0.0075%)	48.50a	16.25a	8.75a	6.25a	6.00ab
Hemus AB (bromadiolone 0.005%)	47.75a	27.25b	15.75b	5.00a	5.00a
Untreated – Kontrola	47.50a	45.50c	47.75c	48.25b	49.25c

Values marked with the same letter have no significant statistical difference (P≤ 0.005; Duncan's test)
Vrednosti obeležene istim slovima se ne razlikuju statistički značajno (P≤ 0.005; Dankanov test)

no significant statistical difference between the products tested. Twenty-eight days after the beginning of experiment, no significant statistical difference was found for the efficacy of any of the products except Natromouse (85.78%), which had lower efficacy. Ekostop D3 paraffinized block had 87.82% and Ekostop D3 paraffinized pellets 88.83% efficacy, while Hemus AB achieved the highest efficacy of 89.85%.

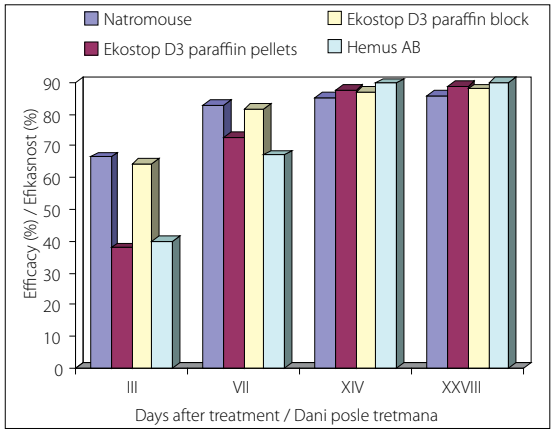

Figure 1. Rodenticide efficacy in alfalfa crop
Slika 1. Efikasnost rodenticida u usevu lucerke

Experiment in wheat crop

Table 3 shows the results of rodenticide testing in wheat three, seven, 14 and 28 days after the beginning of the experiment.

Figure 2 presents data on the calculated rodenticides efficacy in controlling rodents in wheat.

Three days after treatment in wheat, there was no significant statistical difference among the products tested. The lowest initial efficacy was found for Hemus AB (16.24%), while the efficacies of all other products did not differ significantly, staying within a range of 29.06-36.75%. Seven days after treatment, Natromouse efficacy reached 87.29%. Ekostop D3 paraffinized pellets had 66.95%, Ekostop D3 paraffinized block 69.49%, while the efficacy of Hemus AB was lowest, 44.91%. Over the period, a significant

Table 3. Average number of active holes of *M. arvalis* and *A. agrarius* before treatment (BT), three, seven, 14 and 28 days after treatment (DAT) in wheat crop
Tabela 3. Prosečan broj aktivnih rupa *M. arvalis* i *A. agrarius* pre tretmana (BT), tri, sedam, 14 i 28 dana posle tretmana (DAT) u usevu pšenice

Product – a.i. content Preparat – Sadržaj a.m.	Average No. of active holes of *M. arvalis* and *A. agrarius* Prosečan broj aktivnih rupa *M. arvalis* i *A. agrarius*				
	BT	3 DAT	7 DAT	14 DAT	28 DAT
Natromouse (cellulose 45%)	22.25a	19.25a	3.75a	1.00a	0.50a
Ekostop D3 paraffin pellets (vitamin D3 0.0075%)	24.50a	20.75a	9.75b	4.00ab	4.00b
Ekostop D3 paraffin block (vitamin D3 0.0075%)	22.25a	18.50a	9.00ab	3.75ab	3.25b
Hemus AB (bromadiolone 0.005%)	27.00a	24.50ab	16.25c	5.00b	4.75b
Untreated – Kontrola	27.50a	29.25b	29.50d	29.75c	30.50c

Values marked with the same letter have no significant statistical difference (P≤ 0.005; Duncan's test)
Vrednosti obeležene istim slovima se ne razlikuju statistički značajno (P≤ 0.005; Dankanov test)

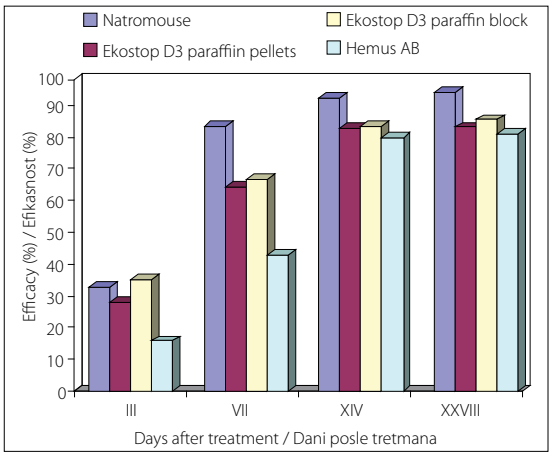

Figure 2. Rodenticide efficacy in wheat crop
Slika 2. Efikasnost rodenticida u usevu pšenice

statistical difference was found between the efficacies of Natromouse, the most effective product, and all other products tested. Fourteen days after treatment, there were no significant statistical differences among the products tested, the only exception being Hemus AB (83.19%), which achieved lower efficacy. Twenty-eight days after the beginning of experiment, a significant statistical differences was detected between Natromouse as the most effective (98.36%) and all other products tested.

DISCUSSION

Unlike the other active ingredients tested, cellulose causes dehydration in rodents that leads to reduced blood volume and blood pressure, dehydration of tissues, circulation arrest and, finally 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, we concluded that soil moisture is a limiting factor and that cellulose-based rodenticides can be applied only in soils that have low percentage of moisture. In our further research, we therefore plan to determine the maximum limit of soil moisture that allows successful rodent control with cellulose-based products.

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 in agricultural stored products was 91.66%.

There are very scarce data on the efficacy of products based on vitamin D3 against various rodent species in alfalfa and wheat. 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. According to World Health Organization data cited by Brooks and Rowe (1987), the efficacy of products based on bromadiolone in the field ranges from 70% to 100%. The authors reported 97-100% efficacy of vitamin D3 based products against house mouse (*Mus musculus*) in the field. Rowe et al. (1981) reported 60-100% efficacy of bromadiolone products under field conditions. Witmer et al. (1995) tested the efficacy of baits containing different amounts of vitamin D3 a.i. against *Thomomys* spp. in the laboratory and in the field. Baits containing 0.003% vitamin D3 were found to cause mortality in 70% of the laboratory animals tested. A similar efficacy under field conditions against the same experimental animal was demonstrated by baits containing 0.150% vitamin D3. Such a considerable difference points at the fact that rodents in the field have untreated food available to them along with the food containing baits. 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.

Summing up the results, we conclude that the products based on vitamin D3 and bromadiolone achieved approximately equal efficacy in controlling rodents in alfalfa and wheat crops. The cellulose-based product, Natromouse, demonstrated the most oscillating efficacy in both crops. The mechanism of activity of that active ingredient (cellulose) suggests that moistness of the environment played an important factor in the activation of characteristics of that rodenticide.

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Efekti suzbijanja glodara u usevima lucerke i pšenice primenom rodenticida hemijskog i prirodnog porekla

REZIME

Ispitivana je biološka efikasnost rodenticida prirodnog i hemijskog porekla za suzbijanje glodara u usevima lucerke i pšenice.

Eksperimenti su izvedeni prema standardnoj metodi OEPP/EPPO. Ogled je postavljen po potpuno slučajnom blok sistemu, sa četiri ponavljanja i veličinom osnovne parcele od 400 m^2. Obeležja koja su praćena tokom ovog ispitivanja su prosečna brojnost aktivnih rupa i efikasnost rodenticida u vremenu od tri, sedam, 14 i 28 dana. Brojnost glodara je izračunata na osnovu broja aktivnih rupa, a efikasnost rodenticida prema Abbott-ovoj formuli.

Na osnovu izgleda i prostornog rasporeda aktivnih rupa utvrđeno je prisustvo poljske voluharice (*Microtus arvalis* Pall) i poljskog miša (*Apodemus agrarius*) na eksperimentalnim parcelama. Testirani preparati pokazali su zadovoljavajuću efikasnost u suzbijanju glodara u usevima lucerke i pšenice. Preparati na bazi vitamina D3, u oba useva, pokazali su efikasnost 87-90%. Efikasnost preparata na bazi bromadiolona bila je u intervalu 84-90%, dok je preparat na bazi celuloze pokazao najveće oscilacije i njegova efikasnost je bila u intervalu 86-98%.

Ključne reči: Celuloza; vitamin D3; bromadiolon; lucerka; pšenica; efikasnost