Potential of common herbs as grain protectants: repellent effect of herb extracts on the granary weevil, *Sitophilus granarius* L.

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Abstract

Use of insect repellent compounds of plant origin seems to be an alternative method for chemical control of stored-product pests. Interest in botanicals has grown rapidly during recent years, because of high costs of pesticide usage to farmers, the danger of pesticide misuse, and fears of toxic residues in food. The objective of the present work was to test the possible repellent effect on the granary weevil, *Sitophilus granarius* L., of water extracts of five common medicinal herbs.

Water extracts of the following common herbs were studied: (1) *folium salviae*, leaves of the sage, *Salvia officinalis* L.; (2) *Flos chamomillae*, flowers of the chamomile, *Matricaria chamomilla* L.; (3) *fructus foeniculi*, seeds of the dill, *Anethum graveolens* L.; (4) *herba absinthii*, flowers, leaves and shoots of the wormwood, *Artemisia absinthium* L.; (5) *flos sambuci*, flowers of the European elder, *Sambucus nigra* L. Wheat grains were sprayed with the water extract, or grains were wetted in the extract, and then dried slowly.

Medicinal herbs contain biologically active substances that affect behaviour and reproduction of the granary weevil. The dill, chamomile, elder and wormwood extracts were found to exhibit a repellent effect on the granary weevil, while extracts of the sage were not active. The repellency degree of herb extracts increased with the increase of their concentration. The method of application of the water extracts of herbs on wheat grain (spraying or wetting wheat grains with the extract) had not any effect on their degree of repellency to the granary weevil.

Granary weevils oviposit in grains treated with herb extract, but the number of progeny is always lower in the treated grains than in the control (treated with distilled water only). However, water extracts of medicinal herbs at the concentrations tested have no insecticidal effects.

Introduction

Of more than 400000 ingredients of plants, only about 20000 chemical compounds have so far been identified (Swain 1977). Biologically active substances of plant origin may affect insects and mites, including pests of stored products. Some secondary metabolites of plants are toxic to the pests (pyrethrum, nicotine, rotenone), while the others are repellents, antifeedants (azadirachtin, rape seed extract), and sterilants (extracts of *Acorus calamus* L.).

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Use of insect repellent compounds of plant origin seems to be an alternative method for chemical control of stored-product pests. Interest in botanicals has grown rapidly during recent years, because of high costs of pesticide usage to farmers, the danger of pesticide misuse, and fears of toxic residues in food. Extracts of neem tree kernels (*Azadirachta indica* A. Juss), ak (*Calotropis procera* Ait.), gardinia (*Gardinia jasminoides* Ellis), rape seeds (*Brassica napus* L.), soapnut (*Sapindus trifoliatus* L.), and other plant products exhibit repellent effect on various species of stored-product pests (Jilany and Malik 1973; Quadri 1973; Ediz and Davis 1980; Khan 1982). These substances are relatively non-toxic to man, and they can be prepared easily from commercially available or inexpensive raw materials. The botanicals having efficient repellent effect on the insects may be practically applied in the control of storage infestation.

The objective of the present work was to test the possible repellent effect on the granary weevil, *Sitophilus granarius* L., of water extracts of five common medicinal herbs.

Material and Methods

Water extracts of the following common herbs were studied for repellent effect on the granary weevil, *Sitophilus granarius*: (1) *folium salviae*, leaves of the sage, *Salvia officinalis* L.; (2) *flos chamomillae*, flowers of the chamomile, *Matricaria chamomilla* L.; (3) *fructus foeniculi*, seeds of the dill, *Anethum graveolens* L.; (4) *herba absinthii*, flowers, leaves and shoots of the wormwood, *Artemisia absinthium* L.; (5) *flos sambuci*, flowers of the European elder, *Sambucus nigra* L. Dried herbs were purchased from a local supermarket. Herb portions of 5 g, 10 g, or 15 g in hot distilled water (200 mL) were stirred for 10 minutes and filtered. Wheat grains (300 g per treatment) were sprayed with the water extract, or grains were wetted in the extract for 30 minutes, and then dried slowly. Concentration of herb extracts is expressed hereafter in grams of dry herbs per 200 mL of water.

The water extracts of medicinal herbs were evaluated for their repellence to the granary weevil using the method described by Brzostek and Ignatowicz (1990). Petri dishes (5 cm diameter × 1.5 cm deep) were divided by folded filter paper into two equal cells, cell A and cell B (Figure 1). Wheat treated with the herb extract was placed into the cell A, while grains treated with distilled water only (control) were placed in the cell B. Twenty granary weevils were introduced into each choice test dish. After 3, 4, and 5 days, the number of beetles present in the cells A and B was recorded.

Effects of the water extracts of medicinal herbs on the reproduction of the granary weevil were studied using the 'no-choice test'. Wheat grains (about 200 g) treated with the herb extracts were placed in 0.375 L jars, and then 50 unsexed weevils were introduced into these jars for oviposition. In the control treatments, wheat grains sprayed with distilled water, or grains wetted in distilled water were used. The cultures were kept in temperature controlled cabinets, in darkness, at

25 ± 1ºC and 70% r.h. After 1 week, parental weevils were sieved out and discarded. After next 4 weeks, the number of progeny (F_1) was determined. The number of F_1 adults was used as a criterion for evaluation of the results. The F_1 adult emergence in the treated sample compared to the F_1 adult emergence in the control is an index of effectiveness of the treated material in reducing infestation (Su 1989).

Results and discussion

Results obtained indicate that the medicinal herbs contain biologically active substances that affect behaviour and reproduction of the granary weevil, *S. granarius* L. When the water extracts of various herbs were applied on wheat grains, the effects of the treatments on weevils were different.

Extracts of sage, *Salvia officinalis*, had little or no repellent effect on the granary weevil (Figure 2), but affect considerably the reproduction of the pest, with the number of F_1 weevils emerged from the treated grain significantly lower than from the control (Table 1). Some biologically active components of the sage may affect *S. granarius* oviposition and/or development. Dover (1985) found that alcohol extracts of sage reduce oviposition of the diamond-back moth, *Plutella xylostella* (L.) and the white butterfly, *Pieris brassicae* L., and feeding of their larvae. Activity of these extracts is caused by the volatile components produced and stored in the glandular hairs on plants surfaces.

The water extract of wormwood, *Artemisia absinthium* exhibited a strong repellent effect to weevils. Significantly fewer weevils were always noted in the grain sprayed with the water extract of wormwood than in the cell with control grain (Figure 3). Similar results were obtained in the tests, in which the granary weevil adults were offered control grains vs. grains wetted in the water extracts (Figure 4). The reproduction of weevils was reduced by the treatments with water extracts of wormwood, but not inhibited completely. The higher the concentration of the extract, the lower the number of F_1 generation (Table 2). Water extracts of the wormwood are toxic to lepidopterous larvae and therefore they are suggested for a practical use against the codling moth larvae of the diamond-back moth and other leaf-feeding caterpillars (Wasina 1978). Powdered leaves of the wormwood were also

Table 1. Effect of the water extract of sage on the reproduction of *S. granarius* in a no-choice test

Wheat grains wetted with the water extract of sage	Number of progeny[a] (means of 5 replicates)	% Red.[b]
0 g (control)	150 a	0.0
1 g	110 b	26.7
3 g	68 c	54.7
4 g	90 b	60.0

[a]Means followed by different letters in the column are significantly different ($p < 0.05$, by Duncan's multiple range test)

[b]% Red. = percent of reduction = 100 – (No. of F_1 adults from test sample/ No. of F_1 adults from control) × 100.

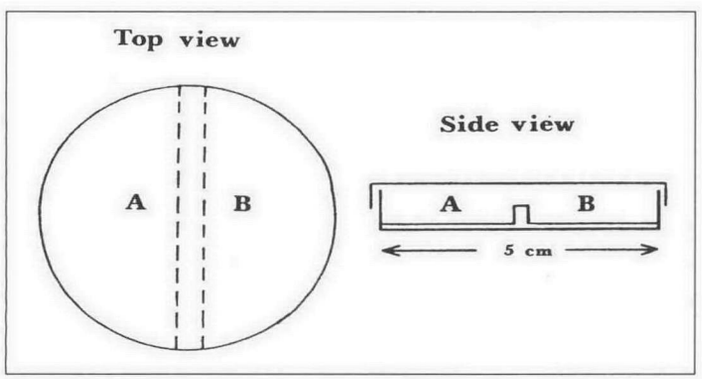

Fig. 1. Petri dishes used for the two-choice test: A,- cell A; B,- cell B.

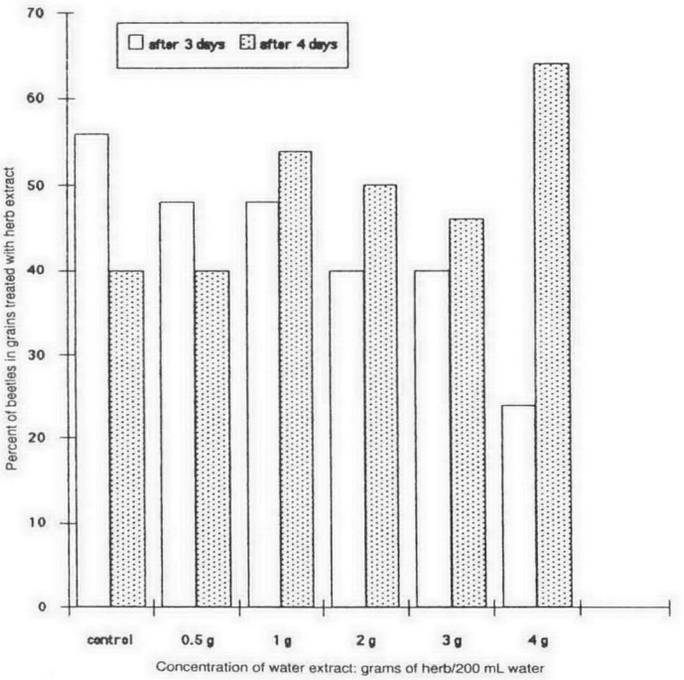

Fig. 2. Preference of the granary weevil adults offered control grain vs. grain wetted in the water extract of the sage at indicated concentration, in a two-choice test.

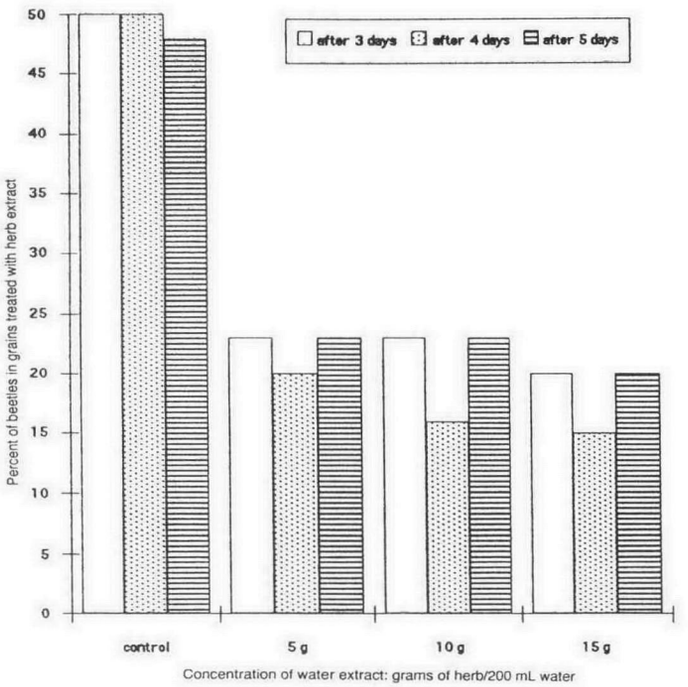

Fig. 3. Preference of the granary weevil adults offered control grain vs. grain sprayed with the water extract of the wormwood at indicated concentration, in a two-choice test.

insecticidal to larvae of ixodid ticks (Reznik and Imbs 1965), but leaf extracts were nontoxic to *Culex pipiens* larvae (Novak 1968). Alcohol extracts of the wormwood were found to inhibit feeding of the Colorado potato beetles more efficiently than the water extracts (Wyrostkiewicz 1992).

Water extracts of the elder flowers, *Sambucus nigra*, were found to repel the granary weevils. The repellency degree was similar for all concentrations tested (Figures 5, 6). Elder extracts reduced infestation of grain relatively to their concentration (Table 2). Leaves of the European elder contain alkaloids and glycosides which produce hydrogen cyanide (HCN). The emission of HCN provide the potential for an allelochemic 'umbrella' effect against various lepidopterous pests in the field, if the elder is grown in close proximity to their host plants (Wasina 1978).

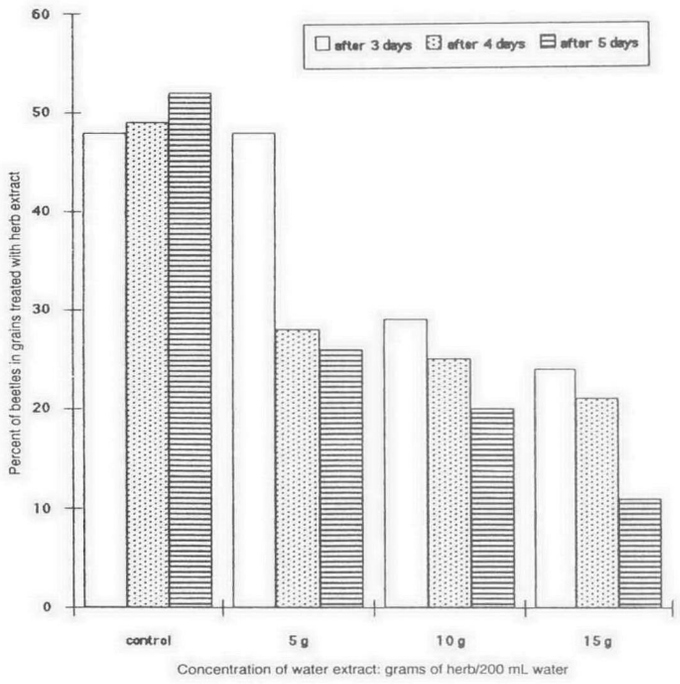

Fig. 4. Preference of the granary weevil adults offered control grain vs. grain wetted in the water extract of the wormwood at indicated concentration, in a two-choice test.

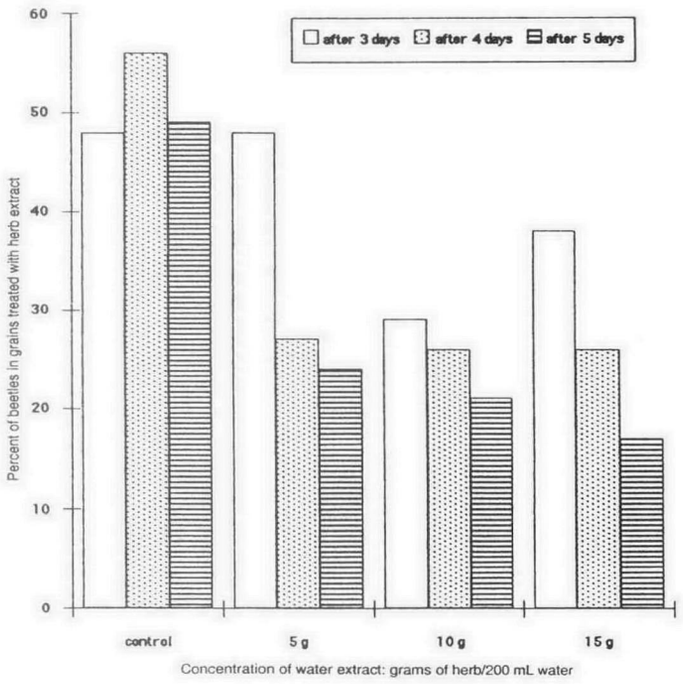

Fig. 5. Preference of the granary weevil adults offered control grain vs. grain sprayed with the water extract of the elder at indicated concentration, in a two-choice test.

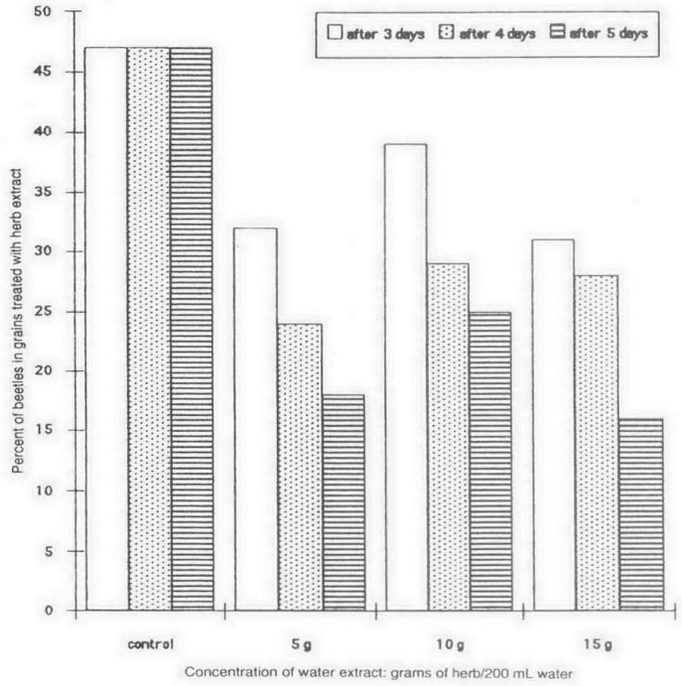

Fig. 6. Preference of the granary weevil adults offered control grain vs. grain wetted in the water extract of the elder at indicated concentration, in a two-choice test.

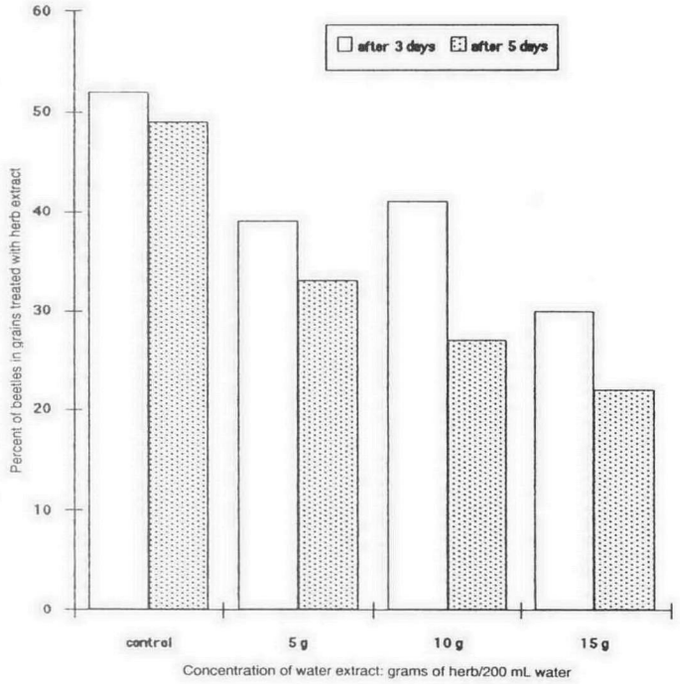

Fig. 7. Preference of the granary weevil adults offered control grain vs. grain sprayed with water extract of the chamomile at indicated concentration, in a two choice test.

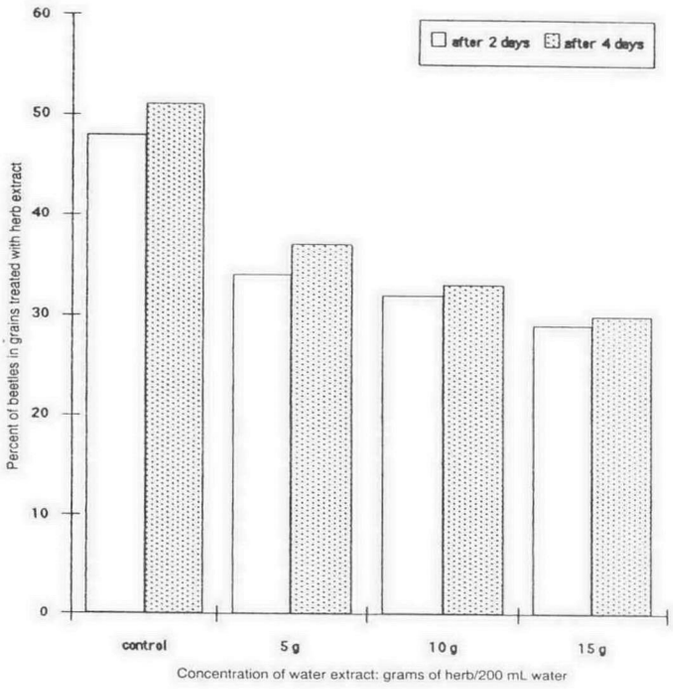

Fig. 8. Preference of the granary weevil adults offered control grain vs. grain wetted in the water extract of the chamomile at indicated concentration, in a two-choice

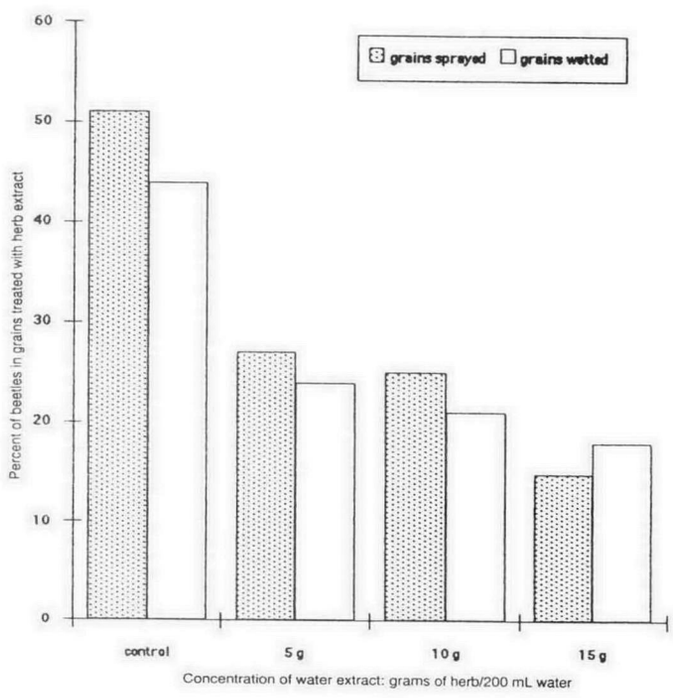

Fig. 9. Preference of the granary weevil adults offered control grain vs. grain treated with the water extract of the dill seeds at indicated concentration, in a two-choice test.

Table 2. Effects of the water extracts of medicinal herbs on the reproduction of *S. granarius* in a no-choice test

Medicinal herb	Concentration of water extract- grams of herbs per 200 mL of water[a]							
	Control		5 g		10 g		15 g	
	n	% red.	n	% red.	n	% red.	n	% red.
Flowers of elder	52 a	0	28 b	41.2	23 b	55.8	10 c	80.8
Flowers of camomile	63 a	0	42 ab	33.3	36 b	42.9	15 c	76.2
Dill seeds	62 a	0	50 b	80.6	33 bc	53.2	28 c	54.8
Herb of wormwood	63 a	0	42 ab	33.3	35 b	55.5	10 c	84.1

[a]Means followed by different letters in the rows are significantly different ($p < 0.05$, by Duncan's multiple range test); n = number of F_1 progeny (mean of 5 replicates); % Red.= percent of reduction = 100 – (No. of F_1 adults from test sample/No. of F_1 adults from control) × 100

Granary weevils were repelled also by the water extracts of chamomile, *Matricaria chamomilla*, applied to wheat grain by spraying or wetting. Repellency of the extracts increased with their concentration (Figures 7, 8). Larvae of ixodid ticks exposed to the powdered flowers were killed within a few hours (Reznik and Imbs 1965). Water extracts of camomile flowers and leaves are toxic to various pests (Wasina 1978), but not to the granary weevil at concentrations tested. However, chamomile extracts inhibit the reproduction of the granary weevil, as the number of F_1 progeny is always lower in the treated grains than in the control. Wasina (1978) reported that extracts of chamomile are successfully used in controlling insects with the piercing and sucking mouth-parts (Wasina 1978).

Water extracts of the dill seeds, *Anethum graveolens*, exhibited a strong repellent effect on weevils. The cell containing grains sprayed with the water extracts of dill seeds had fewer weevils than the cell with grains treated with distilled water only. Similar results were found in the experiments involving wheat grains wetted with the water extracts. The method of application of the water extracts of herbs on wheat grain had no effect on their degree of repellency to the granary weevil (Figure 9). Su (1985) reported that acetone extract of dill seeds at 2000 ppm provide complete protection of grain against the rice weevil, *Sitophilus oryzae* (L.) 1-day after treatment, and still provide 68% reduction of the F_1 generation after treated wheat was stored for 52 weeks. Extract of dill seeds also has been shown to give long-lasting repellency to confused flour beetles, *Tribolium confusum* (Jacquelin du Val). Two major components of dill seeds, dillapiol and *d*-carvone, were found to repel rice weevils. Powdered dill leaves were toxic to ixodid larvae (Reznik and Imbs 1965).

Chamomile, dill, elder and wormwood extracts were shown to exhibit a clear repellent effect on the granary weevil. The degree of their repellency increased with increasing concentration. Weevils oviposit in grains treated with herb extract, but the number of F_1 progeny is always lower in the treated grains than in the control (treated with distilled water only). Water extracts of medicinal herbs at the concentrations tested have no insecticidal effects on adults. However, Throne (1990) and Baker et al. (1991) have demonstrated that non-lethal inhibition of populations may result in prolonged significant reductions in stored-product populations.

The results suggest that herbs are good candidates to develop naturally occurring control agents for the granary weevil. Further studies of the repellent properties of plant products for stored-product insect control are warranted.

Acknowledgment

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