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Grain protectant efficacy of some plant extracts against granary weevil *Sitophilus granarius* L. (Coleoptera: Curculionidae)

Mehmet Karakas
Ankara University, Science Faculty, Department of Biology, Tandogan, Ankara, Turkey

Abstract
In this study, ethanol extract of *Pelargonium zonale* (L.) L'Hér. ex Aiton (Geranium), *Cymbopogon citratus* L. (DC. ex Nees) Stapf (Lemon grass), *Melissa officinalis* L. (Lemon balm), *Origanum majorana* L. (Marjoram) and *Coriandrum sativum* L. (Coriander) were evaluated for their efficacy on mortality and progeny production of wheat weevil, *Sitophilus granarius* L. (Coleoptera: Curculionidae). Adult insects were exposed to the 5 and 10% extracts treated wheat and mortality was assessed after 1, 2, 7, 14 and 21 days. Subsequently, all adults were removed and the treated grains remained at the same conditions for an additional 45 days. After this interval, the commodity was checked for progeny production. All extracts, the beetles mortality was increased in dose dependent manner. Results indicated that *C. citratus* and *P. zonale* extracts were more effective than *M. officinalis*, *O. majorana* and *C. sativum* against adult insects. Interestingly, the progeny production (F1) was complete by suppressed even in lowest dose. It was concluded that both *C. citratus* and *P. zonale* can be used for the protection of stored wheat from infestations of *S. granarius*.

Keywords: plant extract, mortality, progeny production, *Sitophilus granarius*

1. Introduction
The wheat weevil, *Sitophilus granarius* (also known as the grain weevil or granary weevil) occurs all over the world and is a common pest in many places [1]. It can cause significant damage to harvested grains that are being stored and many drastically decrease yields [2]. The females lay many eggs and the larvae eat the inside of the grain kernels.

Control of this pest population around the world primarily depends upon continued applications of organophosphorus and pyrethroid insecticides and fumigants, e.g., methyl bromide and phosphine, which are still the most effective means for the protection of stored food, feedstuffs and other agricultural commodities from insect infestation [3, 4]. But synthetic insecticide causes several problems like, environmental pollutions, health hazards, pest and pesticide resistance, disrupt biological control and ecosystem. Not only that the insecticides have been detected in excessive amounts in almost all the food materials including food grains, vegetables, fruits, meat, fish, eggs, milk and milk products, and even in human milk [5]. Thus, to combat these problems, there is an urgent need for safe but effective, biodegradable pesticides with no toxic effects on non-target organisms. This has created a world-wide interest in research particularly the use of plant extracts as alternative to synthetic chemicals [6]. Many plant extracts may be used for protection of stored product pests as they constitute a rich source of bioactive chemicals. Many of them are free from undesirable effect on non-target organisms, often active against specific target insects, biodegradable, and are potentially sound for use in integrated pest management [7]. Therefore, the present study was conducted to investigate the efficacy of aromatic plants leaf ethanol extracts on the impact on progeny production (F1 adult deterrence) of wheat granary weevil.

2. Materials and Methods
2.1 Insect culture
The granary weevil adults were obtained from the stock culture of the laboratory of the Plant Protection Department, Faculty of Agriculture, Ankara. The insects were reared on clean and uninfested and sterilized wheat grains (*Triticum aestivum* L. var. Bezostaya-1). Two hundred adult insects were released in 300 g wheat seeds in 1000 ml glass jar capped with muslin cloth to ensure ventilation. The jar was maintained at 27 ± 1 ºC and relative humidity at 65 ± 5%. After 7 days, the adults were removed and the jar was left for 45 days to obtain adult beetles and subsequently these beetles were used for the experiments.

2.2 Preparation of plant ethanol extracts
The leaves of geranium [*Pelargonium zonale* (L.) L' Hér. ex Aiton], lemon grass [*Cymbopogon citratus* L. (DC. ex Nees) Stapf], lemon balm (*Melissa officinalis* L.), marjoram (*Origanum majorana* L.) and coriander (*Coriandrum sativum* L.) were collected in and around Kızılcahamam city (N 40º 28′13. 252″; E 32º 39′00. 730″), Ankara. Collected leaves were washed with distilled water and air dried for ten days and macerated using home grinder. The powdered materials were separately subjected to ethanol extraction with Soxhlet apparatus for 24 hours. Crude extracts were passed through Whatman No.1 filter paper and concentrated by a rotatory

evaporator under low pressure. Dark-green residue obtained were stored in glass vials and maintained in a refrigerator at 4 ºC until further use.

2.3 Application procedure

Two concentrations (5% and 10%) were made in analytical grade acetone for assay. The extracts were mixed for about five minutes with wheat grains separately (1 ml/50 g wheat) and air dried for 15 minutes. Twenty four hour old about *S. granarius* (25 number) were released into plant extracts treated wheat containing beetles (20 x 10 cm) covered with perforated lid. Three replications were maintained for each concentration of the individual plant extract. Same volume of acetone treated grains was served as control. Observations were recorded on 1, 2, 7, 14 and 21 days after the treatment. After 21-day mortality observation, dead and live adults were removed from bottles and commodity was left at same conditions for an additional period of 45 days for progeny emergence observed. The percentage of reduction in progeny production was determined using Aldryhim [8] formula:

> [(Number of progeny in control – Number of progeny in treatment) / Number of progeny in control X 100]

All observations were corrected by using the Abbott's [9] formula:

> [1- (Number in Treated after treatment / Number in Control after treatment) X 100]

Corrected observations were subjected to statistical analysis, the one-way ANOVA and T-test.

3. Results and Discussion

Most of the treatment revealed significantly ($p < 0.05$) higher mortality at 21-day of exposure when compared to the control. Maximum mortality caused by 10% *C. citratus* treatment followed by *P. zonale* extract. In general, mortality rate was increased with increasing the concentration of plant extracts and exposure time. Among different plant extracts, the grains treated with 5% *C. sativum* extract produced low mortality followed by *O. majorana* extract (Table 1). Furthermore, both in *C. citratus* and *P. zonale* extracts (10%) caused high mortality of 54.11 and 45.33% respectively compared to other plant extracts after 7 days. Minimum mortality 22.00% recorded in grains treated with 10% *M. officinalis* extracts after 7 days. Observations showed that progeny production (F1) was complete suppressed in all the treated plant extracts at both doses.

Table 1: Effect of chosen plant extracts on adult mortality (%) of *Sitophilus granarius*

Aromatic plants	Treatments (%)	Exposure time				
		1 day	2 days	7 days	14 days	21 days
P. zonale	5	17.77 ± 1.66	24.33 ± 2.41	27.11 ± 1.76	45.00 ± 3.64	60.11 ± 4.12
	10	28.77 ± 3.33	39.00 ± 1.76	45.33 ± 3.77	59.11 ± 1.76	71.00 ± 4.26
C. citratus	5	24.11 ± 2.64	33.33 ± 3.77	42.66 ± 4.26	52.33 ± 3.76	66.33 ± 3.74
	10	34.00 ± 3.11	40.66 ± 1.76	54.11 ± 2.08	70.00 ± 1.76	85.11 ± 3.10
M. officinalis	5	14.00 ± 2.64	18.11 ± 3.74	25.00 ± 1.76	32.33 ± 1.41	33.33 ± 3.46
	10	12.33 ± 3.17	16.33 ± 1.76	22.00 ± 3.77	34.11 ± 1.64	40.11 ± 1.76
O. majorana	5	12.11 ± 1.76	19.00 ± 1.46	21.33 ± 1.76	28.66 ± 0.86	32.00 ± 2.46
	10	10.33 ± 2.64	16.11 ± 3.12	25.33 ± 3.74	35.00 ± 3.10	42.11 ± 2.08
C. sativum	5	11.11 ± 1.76	17.00 ± 1.68	18.11 ± 1.76	24.11 ± 2.21	28.00 ± 2.57
	10	10.66 ± 3.46	20.11 ± 2.57	31.33 ± 1.65	50.33 ± 2.72	60.33 ± 1.25

Results showed that higher dose of extracts for relatively short periods are more effective than the lower dose for a long period. The decrease in grain damage caused to stored wheat using *C. citratus, P. zonale* and *C. sativum* indicates the presence of toxic bioactive principles in these plants which was already reported. For instance, *C. citratus* leaf extract showed maximum insecticidal activity might be due to the presence of biological active agents such as segonder metabolits (5, 6, 7, 8, 3', 4', 5' – heptamethoxy flavone; 5, 6, 7, 8, 3' – penta methoxy – 4', 5' – methylene edioxyflavone and coumarin). The flavonoids possess a catecholic B-ring that seems to be responsible for the toxicant activity to insects [10], and this activity vary in agreement with the chemical structure of these compounds [11].

A slowly developing paralysis is a major feature of insect poisoning by coumarin [12]. In this context, there are close parallels with the botanical insecticide rotenone, antimycin A, and hydramethylnon, all of which block the electron transport in the respiratory process [12]. As surangin B is a potent inhibitor of mitochondrial electron transport in vitro, and as it produces a significant reduction in ATP in vivo, the bioenergetics muscle disruption is a prominent mechanism underlying the insecticidal action of this coumarin. The surangin B has the potential to release the neurotransmitter centrally in insects [12].

From the progeny production of *S. granarius*, emergence of adult insects from all controls indicated that tested insects were capable of effective oviposition. The progeny production was arrested by plant extracts. Thus, the extracts of *P. zonale, C. citratus, M. officinalis, O. majorana* and *C. sativum* either inhibit oviposition and / or killed the larvae at developmental stages after eggs laid in culture.

The results suggest that there may be different bioactive compounds in these extracts. The present findings suggest that the leaves of these plant possess certain bioactive components which require further investigation to determine the exact mode of action of these active components and their effect on non-target organisms.

4. References

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