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Comparative Efficacy of Fennel Seed and Koseret Leaf Powders in Management of Adult Maize Weevil (*Sitophilus zeamais* motsch.) in Stored Maize Grains

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Abstract

The use of plant extracts as pest control is beneficial over synthetic pestidides because of their easily degradable, effective and ensure safety of the consumers and the environment. This study was aimed to examine the effect of ground funnel seed and koseret leaf in control of maize weevil and prolonged storage of the powders on their insecticidal activity in stored maize grains. A factorial experiment was laid in a complete randomized design replicated twice. The treatments have shown high repellence against maize weevil at all concentration of treatments. Mean separation for maize weevil mortality rate at different concentrations of fennel seed, koseret leaf and their combination powders resulted with no mortality. The highest mean mortality rate was recorded for fennel seed. Maize weevil progeny emergence rate during extended duration of maize storage as treated with fennel seed, koseret leaf, and their combination powders showed the highest progeny emergence rate in control group in all treatments. This study revealed insect repellents and pesticidal activity of fennel seed, koseret leaf powders and their combinations. Characterizing their effect in control of maize weevil and prolonged storage of the powders on their insecticidal action is crucial in protection of grains at a minimum cost.

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biopesticidal activity, botanical extracts, insect repellents, progeny emergence, weevil mortality rate, synthetic pesticides.

Introduction

Certain plants have capability of developing their own chemical defense against herbivores, subsequently synthesize secondary metabolites with insecticidal properties against insects. Pest control or repelling organic extracts of plant origin offer protection with minimal impacts on the ecosystem (Batish, *et al.*, 2006). Effective repellent causes the target pest to make an oriented movement away from the source of stimulus, and in cases where escape is not possible over stimulation of the receptors leads to death of the pest.

Plant extracts in powder or essential oil form from different bioactive plants are known to be effective repellents against different economic storage pests of grains, even for stored cereals Owusu (2001). Cereals such as wheat, maize and rice, together comprise at least 75% of the world grain production and they are among the world 's most important staple foods, Food and Agricultural Organization (2008). They constitute the major sources of food in the world and are usually seasonally cultivated with single harvesting per year in some regions. With the seasonality of cultivation, preservation is of high importance ensure sustenance of their economic value, continuous supply at stable price and maintain their nutritional value. Post- harvest losses are recognized as a major constraint in Africa, with storage damage sometimes as high as 40% (Dancewicz and Gabryś 2008). Temperate countries suffer much less from stored grain pests as compared to tropical countries especially areas with high humidity. More than half the cases of poisoning and about three-fourth of deaths documented took place in third world countries which together consume only 15 % of the total pesticide output in the world Anonymous (1992). The increasing public concern over chemical pesticide safety and possible damage to the environment has resulted in increasing attention being given to natural products of mostly plant origin for the control of storage pests worldwide.

Apart from the negative effects of synthetic insecticides, in most remote rural areas their availability is unreliable, and are frequently diluted to ineffective concentrations by unscrupulous traders, outdated, and ineffective owing to rapid evolution of pesticide resistance. Exploring the potential to utilize the pesticide properties of plants has become a key focus of research in pest control. Some plants are known to contain bioactive metabolites, which show antifeedant, repellent and toxic effects on a wide range of insect pests Khalequzzaman (2010).

Mixing of synthetic insecticides with grains may sometime prove disastrous. The destructive activities of insects and other storage pests have been adequately subdued by synthetic chemical control methods comprising fumigation of stored commodity with carbon disulphide, phosphine or dusting with malathion, carbaryl, pirimiphosmethyl or permethrin (Ileke and Oni, 2011). However, high persistence, poor knowledge of application, increasing costs of application, pest resurgence, genetic resistance by the insect and lethal effects on non-target organisms in addition to direct toxicity to users Khalequzzaman(2010).The present study was planned to investigate the effect of ground funnel seed and koseret leaf powders in control of maize weevil and prolonged storage of the powders on their insecticidal activity in stored maize grains.

Materials and Methods

4 kg maize grain of open pollinated variety were obtained from Haramaya University research station. Half of the grain was randomly sampled and stored in a refrigerator for about two weeks in order to kill any prior sources of the maize weevil inoculum and eggs that might be already pre-existing in the grain as by Parugrug and Roxas (2008). 200g grain was placed in bottles with perforated lids to prevent weevils from escaping and for aeration. The funnel seeds and koseret leaf samples was air-dried under shade at an ambient temperature to avoid photo degradation of active ingredient by ultra-violet ray as recommended by Salako (2004). The samples were ground to fine powder using grinding machine and sieved with a 10 mm sieve. The fine powder was kept in air-tight containers until required.

Experimental Design

A factorial experiment laid in a complete randomized design in two replications. 200 g of maize grain + 30 maize weevils + and 1g funnel seed, 5g koseret leaf, and 10g mixture of both funnel seed and koseret leaf powder were used.

Preparation of insect culture

The parent stock of maize weevils was obtained from infested maize grains. The insects were cultured under room temperature. 1 kilogram of maize grain food medium was weighed into two different glass jars. About four hundred adult insect pests were introduced into each culturing medium for around 45 days, hence at the end about 240 adult insect pests were randomly selected for this study.

Test for Repellence

Repellency test was conducted using the method employed by Garcia (1990) with some modifications. Transparent plastic tubings, 13cm long x 1.3 cm diameter as test cylinders were used in the experiment. Each test cylinder was plugged at one end with fine mesh tulle containing 1, 5 and 10 g of funnel seed, koseret leaf, and their mixture powder while the other end was plugged with clean cotton ball which served as control. About 30 maize weevils were introduced at the middle of each test cylinder through a hole at the middle portion of the cylinder.

The hole was covered with nylon tulle mesh to keep the insects inside the cylinder. The cylinders were grouped accordingly to represent the treatments and replications. Each treatment consisted of three cylinders and replicated twice. The cylinders were left undisturbed and the number of weevils that moved towards the untreated halves of the cylinders were counted and rated every hour for the first five hours and at 24, 48 and 96 hours. Repellency rating was calculated using the formula:

Repellency rating = $\frac{n(1)+n(3)+n(5)+n(7)}{N}$ Where: n = number of insects stayed at 0, 1-2, 3-4 and 5-6 cm from the center of the cylinder towards the untreated cotton plug, respectively. 1, 3, 5 and 7 = rating scale on the reaction of the insects on different test materials. N= Total number of insects introduced per cylinder. The degree of repellency of each test material was based on the following scale (Table 1).

Weevil mortality test

Three hundred grams of maize grain adjusted to 10% moisture content was treated with 1, 5, & 10g of each of the test treatment in 12cm high x 6.5 cm diameter glass jars. Funnel seed powder was used in the first treatment and koseret leaf powder in the second experimental unit while admixture of both funnel seed and koseret leaf powders were used in the third experimental unit. The admixtures were shaken manually for 5 minutes and then tumbled for 15 minutes in a mechanical tumbler. The treated grain jars were left undisturbed for an hour. Random population of 30 adult maize weevils were introduced per treatment. The glass jars were covered with filter paper and sealed with molten wax to keep the insects inside. Untreated maize grain was served as control. Each treatment was replicated twice. Maize weevil mortality rates was measured by physically counting dead weevils at 10 and 30 days after exposure to the treatment. The mortality counts were done during the day when the weevils are highly active due to high temperatures and relative humidity. Percent adult mortality was determined by counting the number of dead insects divided by the total number of insects introduced multiplied by 100.

Grain loss and germination test

Grain loss assessment was determined by using Hundred Grain Method (HGM) as follow:

$$\text{HGM} = \frac{\text{initial HGM} - \text{final HGM}}{\text{initial HGM}} \text{x } 100$$

Mass of 100 grain at the beginning of the storage period was compared with mass of 100 grain after 48 days' intervals during the experiment.

Results and Discussion

Repellence test of maize weevil against fennel seed and koseret leaf powders as indicated in Table 2. All the treatments have shown high repellence against maize weevil at all amounts of treatments (1, 5, and 10 grams) in the whole durations. However, there was no significance difference among treatments. Maize weevil mortality rate during 30 days of treatment of maize grain with different amounts of fennel seed, koseret leaf and combination of fennel seed and koseret leaf powders (Table 3) was revealed that there was no mortality of maize weevils recorded for control. However, significant mortality was recorded for each treatment. The highest maize weevil mortality was observed for 10 g than for 5 and 1g in all treatments. The highest mean mortality rate was resulted for fennel seed powder followed by the admixture of fennel seed and koseret leaf powders during 10 days of treatment. In a similar manner the highest maize weevil mortality rate during 30days storage was recorded for both fennel seed and admixture powders with non-significant differences. This specified insecticidal potential of all fennel seed and koseret leaf powders either separately applied or in combinations.

Maize weevil progeny emergence rate during extended duration of maize grain storage as treated by fennel seed, koseret leaf, and their combination powders as indicated in Table 4. It was observed that the highest progeny emergence rate was recorded for control group in all treatments. No progeny emergences were recorded for all treatments indicating biopesticidal activity of fennel seed and koseret leaf powders against storage maize weevil.

Grain loss and germination test due to damage by maize weevil (*Sitophilus zeamais*) on maize grains after 30 days of treatment with fennel seed and koseret leaf powders as indicated in Table 5. It was indicated significance difference between control and treated groups in both grain weight loss and germination test.

The highest grain loss and the least percent germination was recorded for control group indicating that fennel seed and koseret leaf powders can be used to reduce grain loss during postharvest storage. The predominant control of this pest is the use of synthetic residual pesticides, which have adverse effects on consumers and environment.

Table.1 Scale for the determination of the degree of repellency of the test materials

Rating	Distance (cm) from center of the cylinder towards the untreated plug	Description
1	0	Ineffective
3	1-2	Slightly repellant(SR)
5	3-4	Moderately repellant (MR)
7	5-6	Highly repellant(HR)

Table.2 Mean values for repellence test at diverse concentration.

Treatment	24hrs			48hrs		
	FS	KL	FS+KL	FS	KL	FS+KL
0gm	2.25±0.35b	2.25±0.35c	2.25±0.35b	2.25±0.35c	2.25±0.35b	2.25±0.35c
1gm	6.52±0.26a	3.45±0.02b	4.25±1.15ab	3.27±0.24bc	9.68±1.49a	5.07±0.75a
5gm	6.17±0.33a	5.85±0.40a	4.97±0.85a	4.80±1.32ab	11.47±1.13a	3.73±0.05b
10gm	6.30±0.14a	5.42±0.49a	5.45±0.31a	5.90±0.05a	10.7±2.24a	6.07±0.38a
	96hrs			144hrs		
0gm	2.25±0.35b	2.25±0.35a	2.25±0.35c	2.25±0.35b	2.25±0.35c	2.25±0.35b
1gm	4.45±1.16a	3.53±0.47a	3.32±0.16b	5.32±1.06a	3.67±0.19b	4.47±1.13a
5gm	4.80±0.85a	4.77±1.70a	4.28±0.45a	5.63±0.09a	5.72±0.54a	5.22±0.92a
10gm	5.85±0.02a	4.76±1.22a	4.30±0.28a	6.05±0.12a	5.20±0.14a	5.5±0.26a

 Mean of the same letter within a column were not significantly different at 0.05 probability level based on Tukey HSD (Honestly Significantly Different) test. FS: fennel seed powder; KL: koseret leaf powder; FS+KL: combinations of fennel seeds and koseret leaf powders.

Table.3 Weevil mortality rate after 10 and 30 days treated with different amounts of extract

Treatment	10 days		
	FS	KL	FK
0gm	0.00d	0.00b	0.00b
1gm	15.00±2.36cC	23.33±4.71aB	30.00±9.43aA
5gm	25.00±2.36bB	26.67±4.70aB	33.33±9.2aA
10gm	55.00±2.23aA	28.33±7.07aB	33.33±4.72aB
	30 days		
0gm	0.00b	0.00b	0.00c
1gm	21.67±2.36aA	20.00±4.72aA	18.33±2.36bA
5gm	23.33±4.71aB	21.67±2.35aB	26.67±4.71aB
10gm	30.00±4.75aA	26.67±4.70aB	31.67±2.30aA

Means followed by same letter within a column were not significantly different at 0.05 probability level based on Tukey HSD (Honestly Significantly Different) test. Small letters: significance within column; capital letters: significance within row. FS: fennel seed powder; KL: koseret leaf powder; FS+KL: combinations of fennel seeds and koseret leaf powders.

Table.4 Maize weevil progeny emergence rate during 60 days of storage period

Treatment	FS	KL	FK
0gm	2.33±0.28a	2.33±0.28a	2.33±0.28a
1gm	-0.53±0.09b	-0.33±0.09b	-0.52±0.07b
5gm	-0.30±0.05b	-0.55±0.07b	-0.67±0.05b
10gm	-0.43±0.05b	-0.68±0.02b	-0.70±0.04b

Means followed by same letter within a column were not significantly different at 0.05 probability level based on Tukey HSD (Honestly Significantly Different) test. FS: fennel seed powder; KL: koseret leaf powder; FS+KL: combinations of fennel seeds and koseret leaf powders.

Table.5 Grain loss and germination test due to damage by maize weevil after 30 days of treatment with fennel seed and koseret leaf powders

Treatment	Weight loss (%)		
	FS	KL	FK
0gm	38.81±0.67a	38.81±0.67a	38.81±0.67a
1gm	12.79±1.77b	28.21±7.25ab	20.85±7.73b
5gm	8.32±2.86bc	18.68±2.84ab	26.07±0.20b
10gm	4.60±1.07c	8.10±8.74b	15.41±5.48b
	Germination test (%)		
	FS	KL	FK
0gm	77.00±1.41c	77.00±1.41c	77.00±1.41c
1gm	88.50±2.12b	90.50±2.20b	94.50±0.71b
5gm	91.00±2.83ab	94.00±1.41ab	98.50±0.70a
10gm	95.50±2.10a	96.50±2.4a	96.50±0.47ab

Means followed by same letter within a column were not significantly different at 0.05 probability level based on Tukey HSD (Honestly Significantly Different) test.FS: fennel seed powder; KL: koseret leaf powder; FS+KL: combinations of fennel seeds and koseret leaf powders.

The use of phytochemicals for controlling storage pests constitutes an attractive alternative to synthetic products, since plant may be more biodegradable and safer. It was also reported that combinations of different rates of Malathion 5% dust and neem seed powder caused higher weevils mortality than the untreated control (Ibrahim; Sisay, 2012). In his preliminary study, Demissie (2006) also reported that the combined use of minimum rates of *Chenopodium* plant powder, botanical triplex, silicosec and filter cakes with weevil tolerant varieties has reduced grain damage. Related study was conducted by Bayih (2014) who reported that the unitary and binary botanical formulations at lower and higher rates were effective against *Zabrotes subfasciatus*. Besides, it was indicated that the powders of *Plectranthus glandulosus* and *Azadirachta indica* in isolation as well as at their different proportions of their binary combinations generally caused significant mortality to adult *Callosobruchus maculatus* and *S. zeamais* compared to the controls Katamssadan(2016). The rates of mortality of weevils in all of the combinations of Malathion dust and Mexican tea powder and their respective pure treatments were significantly higher than that of untreated check Ibrahim (2015). It was also shown that the combination of neem seed powder and Malathion at the proportions of 40+20% and 50+10% on maize were additive with respect to the mortality caused to *Sitotroga cerealella* Olivier Ibrahim(2014). The present study has also shown that the integration the different management tactics tested induced significantly higher protection of maize grains against weevils attack than unitary tactics tested for one month. This might be due the enhanced mortality effect in integrated treatments than unitary tactics tested, which in turn might be probably due to the presence of great possibility of synergism of morality factors in integration than those applied unitarily. Similarly, it was also reported that for the reason of their synergetic effects, integration of one management method with other sustainable method could provide long lasting solution to losses in storage Dobie(1977). Besides, it was also reported that integrating of different botanicals has enhanced their potency in controlling stored grain insect pests than those applied unitarily Bayih(2014). In his preliminary study, Demissie (2006) also reported that the combined use of minimum rates of *Chenopodium* plant powder, botanical triplex, silicosec and filter cakes with weevil tolerant varieties has reduced grain damage at Bako of Ethiopia. Katamssadan (2016) also indicated that the binary combinations of the powders reduced progeny emergency more than each botanical applied alone, with Neem Azal being more potent than *P. glandulosus*. According to him, all the binary combinations of the powders completely suppressed progeny production in *S.zeamais*. The integrating neem seed and Mexican tea powder provided significant protection to maize from the maize weevil Ibrahim (2017). It was also reported that combinations of different rates of Malathion 5% dust and neem seed powder caused higher weevils mortality than the untreated control (Ibrahim and Sisay, 2012). Among treatments the least percentage grain loss (4.60%) and the highest percentage germination with insignificant differences were recorded for fennel seed powder indicating that both fennel seed and koseret leaf powders were effective treatments for control of maize weevil. This finding was in accordance with Danga *et al.*, (2014) who demonstrated significant reduction in progeny emergence, percentage grain damage, grain weight losses, but did not affect maize grain germination, during 4 months of maize grain storage.

All the treatments have shown high repellence against maize weevil at all amounts of treatments in the whole durations. However, there was no significance difference have been seen for all the treatments including fennel seed, koseret leaf and their combination powders. Mean separation for maize weevil mortality rate during 30 days of treatment of maize grain with different concentrations of fennel seed, koseret leaf and their combination powders shown that there was no mortality of maize weevils recorded for control. However, significant mortality was recorded for each treatments during 30 days of storage. The highest mean mortality rate was recorded for fennel seed powder. Maize weevil progeny emergence rate during extended duration of maize grain storage as treated by fennel seed, koseret leaf, and their combination powders indicated the highest progeny emergence rate control group in all treatments. No progeny emergences were recorded for all treatments indicating biopesticidal activity of fennel seed and koseret leaf powders against storage maize weevil. The present study found that fennel seed, koseret leaf powders ant their combinations could be used as effective insect repellents and pesticidal activity.

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