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Determination of the appropriate doses of promising botanical powders against maize weevil, *Sitophilus zeamais* Mots (Coleoptera: Curculionidae) on maize grain

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The present laboratory study was carried out in the entomological laboratory the Department of plant science, Ambo University. The experiment was carried out using randomized complete block design with three replications to evaluate the efficacy of four locally available botanicals. The botanicals evaluated were: Neem (*Azadirachta indica*) leaf and seed, hop bush (*Dodonae angustifolia*) fresh leaf, Pyrethrum (*Chrysanthemum cinerariaefolium*) flower and Lomen grass (*Cymbopogon citratus*) leaf powders at three different doses (3, 4 and 5 g)/100 g of grain maize against maize weevil, *Sitophilus zeamais* Motsch. Their effectiveness was determined using different parameter such as grain damage and weight losses. The results revealed that all test materials at 5 g doses exhibited mortality action against maize weevil while at 3 g doses it gave the lowest percentage efficacy. Powdered leaves and seeds of neem and pyrethrum flower at 4 and 5 g were showed statistical significant (P<0.01) differences while powdered leaves of lemon grass at the similar rates were observed with moderately effectiveness and fresh leaves of hop bush gave the lowest mortality rate within 28 days of exposure in all tested doses. The result showed that the lower number of grains damaged in maize grains treated with botanical powders and the grain weight loss was also found low as compared to the untreated control. These findings suggest that botanical powders exert better mortality effect and hence reduced maize grain damage. It was also revealed that despite the high seed damage recorded in all botanical products, the *S. zeamays* numbers were relatively higher in untreated control while no grain seed damage was observed in standard check which was treated with Actellic dust. Maize grains treated with botanicals, indicated that insect reproduction and development were impaired in all botanical pesticides. However, all the doses tested for their insecticidal efficacy had an effect on the percentage weevil mortality and was found to be directly proportional to the amount of powder used. Therefore, The present study was suggested that Pyrethrum flower, neem leaf and seed powder can be used as good alternatives to chemical insecticides against *S. zeamays* due to their higher high mortality, lower grain damage and lower maize weight losses recorded as compared to untreated and synthetic insecticides.

Key words: Botanicals, powder, mortality, maize weevil, *Sitophilus zeamais*, grain damage, actellic dust.

INTRODUCTION

Maize is the third most important cereal crop following wheat and rice. It is also, one of the most popular crop plants all over the world, grown in over 140 million hectares (Zaidi and Singh, 2005). In Ethiopia, Maize is one of the major staples consumed food second place in contribution which 17% of land and production, 205,472.37 ton in year of 2011/2012 (CSA, 2012).

Dankyi et al. (1995) reported maize is an important source of carbohydrate and forms about 90 to 95% of the total calories intake of the coastal Savanna people. Insect pest damage to stored grains results in major economic losses in Ethiopia where subsistence grain production supports the livelihood of majority of the population; grain loss caused by storage pests such as the maize weevil, *Sitophilus zeamais* (Mots.) threatens food security. Reduction of insect damage in stored grains is a serious problem in developing countries in the tropics due to favorable climatic conditions and poor storage structures (Bekele et al., 1997).

Damage of maize grain begins from the field just before harvest and the insects are carried into the store where the population builds up rapidly (Adedire and Lajide, 2003). However, during storage, maize seeds are very susceptible to attack by maize weevils among of these *S. zeamais* is very serious. Grain damaged by insect pests in storage often result in significant losses including loss of viability (ISTA, 1995). Post harvest storage of maize is highly constrained by insect pest of maize weevil. Yield losses due to *S. zeamais* reported from farmers interviews, storage loss of maize due to weevil was estimated to be about 25 to 30% in the western part of Ethiopia (Emana, 1998). There are however, major problem to the use of chemical insecticides including human risk, cost of procurement, availability of insecticides on the market, development of resistant strains and residue in the food crops which has led scientists to investigating plant products as alternatives (Lale, 2002). Moreover, there is a need to determine an appropriate dose of some botanicals to effectively control storage insect pests. Therefore, this study was carried out to determine the potential efficacy of different plant products at different doses in powder form to use in the management of *S. zeamais*, under storage conditions.

MATERIALS AND METHODS

Rearing of maize weevils

The study was carried out at Ambo University plant science Department under the laboratory of Entomology, having an altitude of 2287 m above sea level, latitude of08°7`0`` North and longitude of 38°7`0``East. The mean maximum and minimum temperature of the laboratory was 24.2±2°C and 16.8±2°C, respectively, during the study period.

The insects were reared on whole maize in 5 L plastic jars after being treated for mites (Udo, 2000). Whole grains of local variety bought from local market were disinfested in an oven at 60°C for 1 h (Asmanizar and Idris, 2008) before using them as a substrate for insect rearing. The moisture content of maize grain was adjusted to 12 to 13%. After three weeks of oviposition, the parent weevils were sieved out after oviposition. Later the grain were kept in the incubator for adult emergence while the emerging generation of same age insects re-cultured at 24±2°C, 65±5% relative humidity (R.H.). The F1 generation was used for the experiment.

Collection and preparation of materials

Leaves and seeds of neem, *Azadirachta indica* were collected from Melka Werer Agricultural Research center, flower of Pyrethrum, *Chrysanthemum cinerariaefolium* was collected from Kulumsa Agricultural research center, leaves of hop bush, *Dodonae angustifolia* and lomen grass, *Cymbopogon citrates* were collected from Ambo areas. All the plant materials were dried under shade, in a well-ventilated area in the Entomological Laboratory of Plant Science Department, before grinding into fine powders using hand machine blender and sieved using 80 µm Laboratory sieve. The Actellic dust 2% insecticide was purchased from private limited chemical company. The powders were tested individually for their potential in protecting maize grains during storage.

Treatment application

The experiment was laid out in Randomized Compete Block Design (RCBD) with three replications. Twenty pairs of *S. zeamais* were introduced into the plastic jar containing 100 g grain maize in 0.5 L plastic jars at 3, 4, and 5 g% (w/w), while in control treatment there was no any botanicals added and in the standard check Actellic 2% dust was added in 0.1 g/100 g of maize grain. Each botanical was weighed and added to the maize grain in each jar and shaken well for uniform coating. The jars were covered with muslin cloth and secured with rubber bands as a ventilated lid. The treated grains in the jar were kept for about 28 days and mortality rate assessments were performed regularly every 1, 7, 14, 21 and 28 days after exposure of botanical powders.

Seed germination

The effect of treatments and their interactions on seed germination and viability was examined after 28 days of grain storage period. Seed germination was tested using 50 randomly picked seeds from undamaged grains after separation of damaged and undamaged grains in each jar according to the methods described in Haines (1991). The 50 grain sub-samples were germinated on moistene filter paper (Whatman No. 1) in Petri dishes arranged in a RCBD with four replicates. The experiment was maintained under laboratory conditions. The number of germinated seedlings from each Petri dish was counted and recorded after 7 days. The percent germination was computed according to the methods of Zibokere (1994) as follows:

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$$\text{Viability index (\%)} = \frac{NG \times 100}{TG}$$

Where NG = number of seeds that germinated, TG = total number of test seeds.

Data collection

Mortality rate were assessed for damage arising from natural insect infestations after 1, 7, 14, 21 and 28 days of treatment application. The assessment periods selected based on an earlier report by Dobie (1974) and Girma et al. (2008). Dead weevils were removed and counted during each assessment. Damage assessment was carried out on treated and untreated grains by taking samples of 50 grains from each jar. Each treatment was separated into undamaged and insect-damaged grains. The number of grains in each treatment was counted, weighed and the percent weight loss (percent insect damage) of maize grains in storage was computed according to the methods described in Haines (1991) as follows:

$$\text{Percent of weight loss} = \frac{UNd - DNu}{U(Nd + Nu)} \text{ X } 100$$

Where U = weight of undamaged grains, D = weight of insect-damaged grains, Nu = number of undamaged grains, Nd = number of insect-damaged grains.

Data analysis

The Analysis of Variance (ANOVA) was performed using Statistical Analysis Software (SAS, 2003), Data on % cumulative mortality as least significant difference (LSD) test was used to determine the differences among the means for different treatments, grain damage and yield loss parameters.

RESULTS AND DISCUSSION

The results revealed that significant (P<0.05) differences among the treatments at all the doses tested for their insecticidal efficacy and showed an effect on the percentage weevil mortality and was found to be directly proportional to the amount of powder used. However, lower mortality was observed within one day after the exposure of weevils to botanical powders at all treatments. A very lower amount of mortality resulted within 28 days when the weevils were exposed to the lowest dose (3 g) of the botanical powders. Both leaf and seed powder of *A. indica* gave the efficacy of 86.33 and 83.33% at the dose of (5 g) against maize weevils after 7^{th} days of exposure, respectively. Similarly, after 14^{th} days of application the efficacy of the neem seed was showed similar results, while neem leaves gave 100% mortality. The other botanicals indicated moderate results at the highest dose after 14^{th} day exposure except *C. cinerariaefolium* was showed 92.33% mortality rate and it gave 100% mortality rate within 21 days of exposure. Whereas *Cymbopogon citrates* gave a moderate percent at 5 g dose 62.22% mortality when compared with other botanical treatments and it was showed significantly (P<0.01) different results from that of untreated check. *Dodonae angustifolia* leaf powder gave less mortality rate even at 5 g dose application within 28 days of exposure.

Results confirm that botanicals can be used to protect stored maize grains against *S. zeamays* infestations. The use of botanical products and other available materials to protect stored maize grains have been reported by other workers (Lale, 1995; Keita et al., 2000). Lale (2000) had advanced that oil products from the neem plant are particularly more effective against insects. *Sitophilus zeamays* lays eggs inside the maize grains therefore the present study revealed that the use of different botanical powders could be applied in the control of *S. zeamays*. In this study the live maize weevils *S. zeamays* showed least in maize grains that were treated with pyrethrum flower and neem leaf powder as compared with other plant materials. Marilei et al. (2010), also reported that 40 g of corn treated with 6g of the extracts from leaves and seeds extracts from neem can be considered as a viable alternative for controlling the *S. zeamais* in stored corn. The results of the current study was confirmed by the previous work of Wanyika et al. (2009), that they have reported *C. cinerariaefolium*, affected the survival rate of the adult weevils in treatments (5.0 and 7.5 g) with a mortality rate range from 76.66 to 100%. It is also supported by the findings of Maribet and Aurea (2008), who found that lower mortality of adult maize weevils from corn grains treated with *C. citrates* within 24 days after insect introduction.

Endersby and Morgan (1991) observed that *A. indica* derivations are most effective as feeding poisons for nymphs or larvae of phytophagous insects. Hence, mortality rate of maize storage weevils, *S*. *zeamays* that caused by some botanicals as reported in the present study is most likely due to these inherent properties. Moreover, the results indicated that all doses gave more than 30% deaths of weevils were dead after 28 days of exposure to the botanicals powder (Table 1). All tested botanicals performed well in the reduction of maize weevil during maize storage as compared to the untreated control.

Grain damage and weight losses

The grain damaged and weight losses concerned from the maize grains treated with neem seed and pyrethrum flower powders, the lowest values were recorded at the dose of 5 g. Similar numbers of weigh losses of maize grains were relatively recorded in all the treatments. This study suggests that neem leaf, neem seed and pyrethrum flower powder can be used as good alternatives to manage maize weevil *S. zeamays* from maize storage (Table 2).

Table 1. Effects of different botanicals at different doses on the survival of maize weevils, *S. zeamais*.

Treatments	Rate/100 g	Mortality percent after treatment application				
		1st day	7 days	14 days	21 days	28 days
*Azadirachta indica (*seed)	3	10.00^{c}	25.67^{d}	40.00^{d}	40.0^{c}	46.67^{d}
	4	11.11^{c}	36.67^{c}	53.33^{c}	92.33^{a}	93.33^{a}
	5	13.33^{c}	83.33^{b}	83.33^{a}	95.55^{a}	95.55^{a}
Azadirachta indica (Leaf)	3	0.00^{d}	23.33^{d}	55.55^{c}	63.33^{b}	63.33^{c}
	4	10.00^{c}	36.67^{c}	62.22^{c}	100.0^{a}	100.0^{a}
	5	11.11^{c}	86.33^{b}	100.0^{a}	100.0^{a}	100.0^{a}
Dodonae angustifolia (fresh leaf)	3	0.00^{d}	10.00^{fg}	13.33^{fg}	16.67^{ef}	16.67^{f}
	4	0.00^{d}	13.33^{ef}	20.0^{efg}	20.00^{e}	20.00^{f}
	5	0.00^{d}	20.00^{de}	30.0^{de}	30.77^{d}	31.78^{e}
Chrysanthemum cinerariaefolium (flower)	3	8.89^{c}	10.00^{fg}	60.00^{c}	60.00^{b}	86.67^{b}
	4	32.33^{b}	13.33^{ef}	76.67^{b}	100.0^{a}	100.0^{a}
	5	25.56^{b}	20.00^{de}	92.33^{a}	100.0^{a}	100.0^{a}
Cymbopogon citrates	3	0.00^{d}	10.00^{fg}	10.0^{gh}	10.00^{fg}	34.44^{e}
	4	0.00^{d}	10.00^{fg}	10.0^{gh}	10.00^{fg}	47.78^{d}
	5	0.00^{d}	10.00^{fg}	21.11^{ef}	40.00^{c}	62.22^{c}
Actellic dust 2%		100^{a}	100.0^{a}	100.0^{a}	100.0^{a}	100.0^{a}
Untreated check		0.00^{d}	1.11^{g}	1.11^{h}	3.33^{g}	5.56^{g}
MSE		2.45	4.11	4.96	3.74	4.29
LSD		5.50	9.17	11.08	8.37	9.60
CV (%)		17.00	13.75	10.03	6.50	6.61

Means with the same letter are not significantly different.

Table 2. Effects of botanicals and *S. zeamais* on grain weight loss and germination.

Treatments	Rate/100 g	Grain damage (%)	Weight losses (%)
*Azadirachta indica (*seed)	3	3.67^{cbd}	0.27^{bcde}
	4	2.00^{ed}	0.27^{bcde}
	5	1.67^{e}	0.17^{bcde}
Azadirachta indica (Leaf)	3	3.33^{cde}	0.70^{bcde}
	4	3.00^{cde}	0.70^{bcde}
	5	3.33^{cde}	0.20^{bcde}
Dodonae angustifolia (leaf)	3	3.00^{cde}	0.67^{bcde}
	4	2.00^{e}	0.63^{bcde}
	5	2.67^{cde}	0.47^{bcde}
Chrysanthemum cinerariaefolium (flower)	3	4.33^{bc}	0.10^{bcde}
	4	5.33^{b}	0.03^{de}
	5	2.33^{de}	0.07^{cde}
Cymbopogon citrates	3	4.33^{bc}	0.80^{b}
	4	2.50^{de}	0.60^{bcde}
	5	2.17^{de}	0.73^{bc}
Actellic dust 2%		0.00^{f}	0.00^{e}
Untreated check		12.67^{a}	5.33^{a}
MSE		0.76	0.31
LSD		1.67	0.7
CV (%)		22.09	20.19

Means with the same letter are not significantly different.

Conclusion

In general, this study has revealed the plant powders at 5 g dosage had significant effects on mortality rate against *S. zeamais* within 28 days of exposure on maize grains. In particular, *A. indica (*seed), *A. indica (*leaf) and *Chrysanthemum cinerariaefolium* (flower) were observed at the dosage of 5 g with good performance after 7 to 21 days of applications and gave of 83.33 to 100% of mortality and maize grain damage and weight losses. Finally, it is recommended that neem seed and leaf, and pyrethrum flowers were effective when used as at 4 g powder/100 g of maize grain against maize weevil. It is also economically important and environmentally safe.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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