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EVALUATION OF THE INSECTICIDAL ACTIVITIES OF COTYLEDON POWDER OF MELON, *Citrullus vulgaris* Schrad AGAINST THE MAIZE WEEVIL, *Sitophilus zeamais* Motsculsky

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ABSTRACT

The insecticidal activity of cotyledon powder of melon (Citrullus vulgaris Schrad) against the maize weevil (Sitophilus zeamais, Motschulsky) was evaluated. The objectives of this study were to identify the potency of cotyledon powder of melon for the treatment of stored maize infested with *S. zeamais*. Cotyledon powder of melon, *C. vulgaris*, was mixed with 50g maize grains as direct admixtures at seven different rates: 0g, 0.5g, 1.0g 1.5g, 2.0g, 2.5g and 3.0g, and infested with five males and five females of *S. zeamais* respectively. These were observed for twenty-eight days for natality, mortality and oviposition of *S. zeamais*. Melon cotyledon powder significantly reduced the natality and oviposition of *S. zeamais* while significantly increasing the mortality ($P < 0.05$). Cotyledon powder of melon seed could therefore be used as a grain protectant at the rate of 3.0g per 50g of maize to achieve complete mortality of *S. zeamais*, while effectively decreasing natality and oviposition of *S. zeamais* in storage pest management systems. This will reduce the usage of chemical pesticides, thereby reducing their adverse effects on stored products.

Keywords: *Citrullus vulgaris, Sitophilus zeamais*, insecticidal activities, natality, oviposition, mortality

1. INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops cultivated in the world and it constitutes one of the major diets of millions of people. In Africa, maize is mainly grown by small-scale farmers for utilization as both human food and animal feed. Maize could be grilled, boiled, roasted or made into various products (Polaszek & Khan, 1998). However, the availability of maize is often hindered by infestation of insect pests which constitutes a major setback in the production and storage of maize. The most important storage pest of maize is *Sitophilus zeamais* Motschulsky (Coleoptera: Curculionidae). According to Obeng-Ofori and Amiteye (2005), *S. zeamais* is a serious cosmopolitan field-to-store pest of maize in tropical and subtropical regions. Damage caused by this insect becomes noticeable when the adult insect makes holes that reach approximately 1mm in size in the grain and deposits its eggs within the hole.

The insect then closes up the hole with a gelatinous waxy secretion. The developmental stage of the insect takes place within the grain after which the adult weevil bores its way out, leaving a characteristic emergence hole on the grain (Hill, 1983; Rees, 2004). Weevil damage reduces the availability of maize and may also reduce future maize production for farmers who use stored grains as seeds. In developing countries, maize production and consumption often falls below demand as a result of post-harvest losses due to storage pests and other spoilage agents (Udo, 2005). This results in major economic losses and threatens food security (Ivbijaro *et al.*, 1979). The problem is mostly severe in developing countries in the tropics due to unfavourable climatic conditions and poor storage structures (Bekele *et al.*, 1997). Insect infestation of maize grains leads to a reduction in both quality and quantity of harvested crops and in most cases pre-disposes the stored grains to secondary attack by disease causing pathogens (Evans, 1987). Post-harvest losses due to *S. zeamais* have been recognized as an important constraint to grain storage in Africa (Markham *et al.*, 1994; Oduor *et al.*, 2000).

Various measures have been adopted to significantly reduce the level of infestation by this pest to the barest minimum. These measures include physical, biological and chemical control among others. Under chemical control, the use of pesticide has been adopted. However, several problems are associated with the use of pesticides. These include development of resistant pests, destruction of natural enemies, destruction of non-target species and contamination of food and the environment among others (Marini-Bettolo, 1977; Parmar & Devkunar, 1993; Obeng-ofori *et al*., 1997).

Because of these problems, the search for possible alternatives to insecticides has been intensified. To this end, research efforts are currently being focused on the use of plant products such as plant powder, extracts and oils which are cheaper, safer and eco-friendly (Adedire & Ajayi, 1996). The use of plants in the protection of grains against insect infestation has been an age-long practice among small-scale farmers in Africa (Jacobson, 1983; Hassanali *et al*., 1990; Poswal & Akpan, 1991). Plant-derived insecticides are short-lived in the environment, thus posing less risk to non-target organisms and are accepted by organic certification programs and certain consumer groups because they are naturally occurring (Isman, 2000; Weinzierl, 2000). However, most farmers are ignorant of the correct rate and amount of botanical agents that could be toxic to storage pests resulting in ineffective control of these pests. This has led researchers to investigate the insecticidal activities of various botanical agents, the rate and also the amount at which they could be applied to stored grains in order to effectively control the pests. The toxicity of *Piper guineense,* a black pepper variety, has been reported to be very high on the cowpea beetle, *Callosobruchus maculatus* (Ivbijaro & Agbaje, 1986). The toxicity of *P. guineense* to the nymphs and adults of the grasshopper, *Zonocercus variegates* has also been reported (Ogobegwu, 1973, unpublished data). Ivbijaro (1983) reported that the application of neem seed powder, *Azadirachta indica* to weevil-infested maize grains prevented oviposition at the high dose, reduced oviposition markedly at the low dose, and completely halted post-embryonic development at all doses. Ivbijaro (1984) reported that at all doses, groundnut oil significantly reduced the natality and oviposition of the rice weevil, *Sitophilus oryzae* while increasing the mortality of same. Testa powder of melon, *Citrullus vulgaris*, has been reported to significantly reduce oviposition and natality of *S. zeamais* in maize (Edelduok *et al*., 2012). Rajapakse and Emden (1997) reported that corn oil, groundnut oil, sunflower oil and sesame oil significantly reduced the oviposition of *Callosobruchus maculatus*, *C. chinensis* and *C. rhodesianus*, and also significantly reduced the longevity of adults of *C. maculates* and *C. chinensis*. Effective treatment has been observed with leaves from *Eucalyptus globules*, *Schinese molle, Datura stramonium*, *Phytolacca dodecandra* and *Lycopersicum esculentum* causing high adult weevil mortality for *S. zeamais* (Firdissa & Abraham, 1999).

All these reports are an indication that natural plant products can be used in controlling pest infestation of stored grains. However, much still remains to be known about several other natural plant products that can be used in controlling pest infestation of stored products. According to Ukeh *et al.* (2008), plant powders are cheap, easily biodegradable and readily available and will not contaminate food products in acting as protectants in small-scale storage systems. Thus, this study was aimed at evaluating the insecticidal activities of cotyledon powder of melon, *Citrullus vulgaris* on the mortality, natality and oviposition of the maize weevil, *Sitophilus zeamais*, and to determine the amount at which they could be applied.

2. MATERIALS AND METHODS

2.1 Collection and culturing of the maize weevil, Sitophilus zeamais

20g of weevil-infested *Zea mays* grains was purchased from Uyo main market. Adult male and female weevils were culled out and introduced into jars containing un-infested maize grains. After two weeks, the adult insects were removed. The emerging weevils (0-1 week old) were used for the experiment.

The sexes of *S. zeamais* were determined by examining the snout a hand lens. The snouts of females are longer and thinner while that of males are shorter and fatter. Also, the females have smooth textured bodies while that of the males are rough (Kranz *et al*., 1978).

2.2 Collection and preparation of bio-pesticidal materials

20g of unshelled seeds of melon, *Citrullus vulgaris* was purchased and hand-shelled. The cotyledon was separated from the testa, dried and ground into powder using an electric blender.

2.3 Preparation of maize grains

2.5kg of maize grains was used for the experiment. The maize grains were purchased and fumigated with half a tablet of phostoxin for forty-eight hours in an air-tight container. This was done to kill any weevils or eggs that might have been laid in the maize grains (Price & Mills, 1988). After 48 hours, the phostoxin was removed. The maize grains were then aerated for five days to remove any toxic residue of phostoxin.

2.4 Treatment of weevils-infested maize grains with cotyledon powder of *C. vulgaris*: Effect on mortality of *S. zeamais*

Cotyledon powder of *C. vulgaris* was applied to different containers, each containing 50g of maize grains at the rate of 0.5g, 1.0g, 1.5g, 2.0g, 2.5g and 3.0g respectively. The containers were then shaken vigorously for optimum coverage of the grain surfaces. Cotyledon powder of *C. vulgaris* was not applied to the control.

Five males and five females of *S. zeamais* (0-1 week old) were introduced into each 0.5g, 1.0g, 1.5g, 2.0g, 2.5g and 3.0g of ground melon cotyledon and also to the control. Each treatment and control was replicated four times. A completely randomized experimental design was adapted for the experiment. The containers were then covered with thin white netting which was kept in place by rubber bands. The containers were labeled to avoid mixing them up.

After every forty-eight hours, the mortality of *S. zeamais* in treated and untreated maize grains was observed and recorded. This was done by gently touching the insects with a pair of forceps after they had been emptied unto a white surface. Insects that did not move when touched were considered dead. This continued for twenty-eight days when all survivors in the treated and untreated grains were removed to avoid mixing with the emerging F_1 generation.

2.5 Treatment of weevils-infested maize grains with cotyledon powder of C. vulgaris: Effect on oviposition of S. zeamais

Twenty-eight days after initial infestation, the weevils were removed and twenty grains were taken at random from each of the jars containing the cotyledon powder of *C. vulgaris*, and also, from each of the control jars. The grains were stained in gentian violet (Goosens, 1949) to reveal the egg plugs.

2.6 Treatment of weevils – infested maize grains with cotyledon powder of *C. vulgaris*: Effect on natality of S. zeamais

Seven days after the removal of the adult *S. zeamais*, emergence of F_1 progeny was observed in both control and treated grains. The number of F_1 progeny was recorded.

2.7 Data analysis

From the experiments conducted, data was collected and tabulated. The data was subjected to a one-way analysis of variance (ANOVA) at 5 % level of significance ($P < 0.05$). This was to help in determining whether there were significant differences in the treatments or not. Significant differences between treatment means were assessed using the Fisher's Least Significant Difference (LSD) test.

3. RESULTS

3.1 Treatment of weevils-infested maize grains with cotyledon powder of C. vulgaris: Effect on mortality of S. zeamais

The mortality of *S. zeamais* increased with increased dosage application. Complete mortality of weevils was recorded at 2.5g and 3.0g of melon cotyledon powder per 50g of maize grains respectively. At 0.0g (control), only one insect died in each replicate. The mortality of *S. zeamais* in maize grains treated with cotyledon powder of melon after twenty-eight days is as shown in Table I.

From the analysis of variance test, there was a significant difference ($P < 0.05$) in the total mortality of *S. zeamais* in maize grains treated with melon cotyledon powder after twenty-eight days. The LSD test indicated a significant difference ($P < 0.05$) between treatment at 0.5g and 1.0g dosages of melon cotyledon powder. Also, the LSD test indicated significant differences between all the treatments dosages and the control.

3.2 Treatment of weevils-infested maize grains with cotyledon powder of C. vulgaris: Effect on natality of *S. zeamais*

The natality of *S. zeamais* decreased with increased dosage application. The untreated grains had the highest rate of natality while 3.0g treatments had the lowest rate. Table II shows the natality of *S. zeamais* in maize grains treated with cotyledon powder of melon.

The analysis of variance test showed that there was a significant difference ($P < 0.05$) in the natality of *S. zeamais*. The LSD test indicated no significant difference (P > 0.05) between the treatment dosages. However, there were significant differences (P < 0.05) between the treatments and the control.

3.3 Treatment of weevils-infested maize grains with melon cotyledon powder: Effect on oviposition of *S. zeamais*

S. zeamais were able to lay eggs at all the treatment dosages. However, the oviposition of insects decreased with increase in dosage application. The oviposition of *S. zeamais* in maize grains treated with melon cotyledon powder after one month is as shown in Table III.

The analysis of variance test indicated a significant difference (P < 0.05) in the total oviposition of *S. zeamais* in maize grains treated with melon cotyledon powder. The LSD test showed significant differences between the treatment dosages and the control. The LSD test also showed a significant difference between 1.5g treatment and 2.0g treatment.

4. DISCUSSION

The study revealed that maize grains with cotyledon powder of melon, *Citrullus vulgaris* at the dosage rates of 0.5g, 1.0g, 1.5g, 2.0g, 2.5g and 3.0g per 50g of maize gave promising levels of control of *Sitophilus zeamais* in terms of reduction in oviposition and natality, and increase in mortality of weevils. Even though the natality and oviposition of *S. zeamais* were not completely halted at any of the treatment dosage rates, they were lower than the no pesticide treatment (control) (Table II and Table III). Cotyledon powder of *C. vulgaris* therefore might have exhibited low levels of insecticidal activities resulting in low natality and oviposition of *S. zeamais*. The insecticidal activities of cotyledon powder of melon on the natality and oviposition of *S.* zeamais might have been due to the presence of oil. The mode of action of plant oils has been suggested to include physical barrier to respiration of insects, eggs and young larvae (Don-Pedro, 1989; Credland, 1992). Moreover, Rajapakse (2006) suggested that the mechanical effect of large quantities of powders themselves could have an effect on oviposition. This can be seen in Table II and Table III where natality and oviposition were lowest at higher doses (larger quantities) of cotyledon powder of melon. The insecticidal activity of the plant powder corroborates earlier observations that another plant powder, that of *P. guineense* caused early mortality of weevils thus interfering with their ability to commence a fresh cycle of oviposition (Ivbijaro, 1990; Udo, 2005). Statistically however, cotyledon powder of melon significantly reduced (P < 0.05) the natality and oviposition of *S. zeamais* in the present study.

Cotyledon powder of melon exhibited a very high level of insecticidal activity on the mortality of *S. zeamais*, resulting in a very high mortality rate of *S. zeamais*. In fact, total mortality (100 %) was observed at 2.5g and 3.0g treatment dosage. This mode of action could be attributed to stomach poison since the weevils feed directly on the grains (Adedire & Ajayi, 1996). It could also be attributed to some active constituents of plants which may possess contact, stomach and respiratory poisoning properties (Stoll, 1988). Also, the presence of curcin which is toxic to animals' body (Duke, 1985) might have contributed to this high mortality rate. The presence of oil in the melon cotyledon powder could have been yet another factor contributing to the high mortality rate. Oil is known to reduce the respiratory activity of insects and is also toxic to the eggs (Don-Pedro, 1989; Credland, 1992). The increase in mortality of *S. zeamais* treated with cotyledon powder of *C. vulgaris* suggests that the effect is directly proportional to the amount used. This result is in agreement with reports of Niber (1994) and Adedire and Lajide (2003) who reported that some tropical plants could be admixed with grains in storage in order to protect them from storage pests.

Other reports with similar trends to this study have shown that the insecticidal activities of various plants parts and plant products on *S. zeamais* showed varying degrees of success (Cobbinah & Appiah-Kwarteng, 1989; Obeng-ofori *et. al.*, 1997; Arannilewa *et al.*, 2006; Edelduok *et al.*, 2012). Adedire and Ajayi (1996) recorded 100% mortality of *S. zeamais* treated with *C. frutescens* 28 days after treatment on maize grains. The findings of this work is also similar to that of Ivbijaro (1983) who studied another botanical, the neem seed, *Azadirachta indica* and found out that the neem seed severely reduced egg-laying in female *S. oryzae*, while increasing the mortality of same. Ivbijaro (1984) also found out that groundnut oil reduced the oviposition and natality of *S. oryzae*, while increasing the mortality of same.

5. CONCLUSION

The findings of this work indicate that the cotyledon powder of melon could be used in controlling the maize weevil (*Sitophilus zeamais)* in stored maize grains. This will reduce chemical pesticide usage, remove the risks of toxic residues in foods and ensure the continued availability of insect-free maize for food, planting, trading and storage.

It is recommended that the application of 3.0g of melon cotyledon powder per 50g of maize be used for complete mortality of *S. zeamais* to be achieved. Also, application of 3.0g of melon cotyledon powder to 50g of stored maize will significantly reduce the natality and oviposition of *S. zeamais.* Further studies aimed at determining the active ingredients of melon cotyledon are recommended. Furthermore, the active ingredient should be formulated into bio-insecticide for the management of maize storage weevil.

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Table 1: Mortality of *S. zeamais* in maize grains treated with cotyledon powder of *C. vulgaris* after twenty-eight days

Replicates	Dosages of melon cotyledon powder per 50g of maize grains (g)						
	0.0	0.5	1.0	1.5	2.0	2.5	3.0
1	1	3	7	5	8	10	10
2	1	2	7	10	6	10	10
3	1	5	6	6	10	10	10
4	1	4	9	9	10	10	10
Total	4	14	29	30	34	40	40
Mean	1.00	3.50	7.25	7.50	8.50	10.00	10.00

LSD = 1.97

Table 2: Natality of *S. zeamais* in maize grains treated with cotyledon powder of *C. vulgaris* seven days after removal of adult weevils

Replicates	Dosages of melon cotyledon powder (g) per 50g of maize grains						
	0.0	0.5	1.0	1.5	2.0	2.5	3.0
1	20	10	2	3	3	0	0
2	32	4	6	3	3	0	1
3	34	6	5	3	1	2	1
4	32	7	5	2	0	2	0
Total	118	27	18	11	7	4	2
Mean	29.50	6.75	4.50	2.75	1.75	1.00	0.50

LSD = 4.10

Table 3: Oviposition of *S. zeamais* in maize grains treated with melon cotyledon powder after one month

Replicates	Dosages of melon cotyledon powder (g) per 50g of maize grains						
	0.0	0.5	1.0	1.5	2.0	2.5	3.0
1	27	11	8	6	3	2	1
2	25	9	5	7	4	1	1
3	28	12	6	5	3	2	2
4	23	10	7	6	2	1	1
Total	103	42	26	24	12	6	5
Mean	25.75	10.75	6.50	6.00	3.00	1.50	1.25

LSD = 1.77

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