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COMPARATIVE EFFICACY OF SWEET ORANGE, *CITRUS SINENSIS*(L) RIND POWDER AND OIL FOR THE CONTROL OF MAIZE WEEVIL, *SITOPHILUS ZEAMAIS* (MOTSCHULSKY).

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ABSTRACT

Sweet orange, Citrus sinensis (L.) rind powder and oil were evaluated for the control of maize weevil, Sitophilus zeamais (Mot.) under ambient laboratory conditions (28 ± 2° C and 75 ± 20% R.H.). Experiments consisted of exposing adult S. zeamais to both the powder and oil for 42 days. Mortality counts were taken from the first day after treatment (DAT) until 42 DAT. The result indicated that pulverized orange rind had no significant mortality effect on adult S. zeamais (P≥0.05) resulting in severe damage of the grains and weight loss. The Weevil Perforation Index (WPI) for all the dosages of the powder was greater than 50%, indicating reduced protectant effect; while the rind oil treatment resulted in significant mortality of adult S. zeamais (P≤ 0.05). There was significant reduction of grain damage when protected with oil extract. The WPI of all the dosages was below 50%, which confirmed the efficacy of the orange rind oil. The C. sinensis rind oil, not the powder can therefore be used for the storage of maize grains.

Key Words: Orange biopesticides, maize weevil, control.

INTRODUCTION

Maize, *Zea mays* (L.), a member of the family Poaceae is an important cereal in Nigeria. Among other important applications, maize is used as food for humans, major carbohydrate component of animal feeds, grains in brewing industry, starch for textile industries and for the formulation of baby-weaning foods. Maize production in Nigeria is constrained by the attack of a large number of insect pests during storage, of which *S. zeamais* is a serious one (Adedire and Ajayi, 1996, Gwinner *et al.*, 1996; Adedire, 2001). Various methods have been employed to control maize weevils both in the field and during storage. Storing of resistant varieties has been advocated as a way of controlling maize weevil infestation (Adesuyi, 1977; Morah and Mbata, 1982). The use of synthetic insecticides to control maize weevil and other stored product pests has a lot of attendant problems, notably, high mammalian toxicity, high level of persistence in the environment, insect resistance and health hazards to workers (Sighamony *et al.*, 1986; Adedire and Ajayi, 1996). Current research efforts on product development are being focused more on ecologically tolerable control measures including the use of inert materials, plant powders, oils and extracts. The tropical region is well endowed with a wide array of these floristic species with defensive chemicals and quite a good number of them have been used traditionally in protecting maize against weevil attack (van Huis, 1991; Lale, 1995). Seed powder and oil of black pepper, *Piper nigrum, P. guineense, P. umbellatum* and *Capsicum frutescens* are known to adversely affect the biology of the maize weevil and also cause high adult mortality (Su and Sondeyam 1980; Ivbijaro and Agbaje, 1986; Lale 1992; Adedire and Ajayi, 1996). Lajide *et al.*, 1998 reported that pulverized seeds of *Uvaria afzelli, P. umbellatum, Eugenia aromatica* and the bark of *Erythrophleum guineense* were highly toxic to maize weevils. Neem seed powder and oils are effective in repelling and killing maize weevil (Akou-Edi, 1984); the powder and oil extract of *Dennettia tripetala,* have been reported to be effective against *S. zeamais* (Agbakwuru *et al.*,

1978; Lale, 1992). This study was therefore undertaken to evaluate the use of sweet orange rind powder and oil for the control of maize weevil, *S. zeamais* and to assess the comparative effectiveness of *C sinensis* rind oil and the powder for the control of the pest.

MATERIALS AND METHODS

Location of study

The study was conducted at the Michael Okpara University of Agriculture, Umudike. Umudike lies on latitude 05° 29'N and Longitude 07° 33'E, at an altitude of 122m above sea level. It has an average rainfall of 2200mm per annum, distributed over an eight month period (March–November), with bimodal peaks in June–July and September, with a short dry spell in August. It lies within the tropical rainforest zone, where the mean daily temperature is above 29°C all through the year but rarely exceeds 35°C.

Insect Culture

The maize weevils used for this study were reared in maize grains of "Bende white", a highly susceptible local cultivars purchased from Umuahia main market and placed on plastic buckets covered with muslin cloth. These buckets were kept inside laboratory cupboards at ambient temperature and relative humidity (28 ± 2°C and 75 ± 20% R.H), under which the experiments were equally carried out.

Preparation of plant materials

The plant material used for insecticidal activities against *S. zeamais* (Mot.) was *C. sinensis* rind, and it was collected from orange sellers in the market. The rind was sun-dried for two weeks, with occasional turnings of the materials. The rind was later put into envelopes and oven-dried at a temperature of 60°C for easy grinding. The oven-dried plant materials were milled into fine powder using a macro-hammer mill. Mesh size of 500µm was used to screen the powder to produce very fine powder. The powder was divided into two; 520g was set apart for the powder experiment while 1,150g of the powder was used for the extraction of oil. The powder was put into 9 thimbles and the oil was extracted using 450ml of acetone for 2h. The resulting oil weighed 30g.

Application of Botanicals

Clean, healthy and uninfested maize grains used for this study were obtained from Umuahia main market ("Bende white"). Fifty grammes (50g) of maize were put into transparent laboratory vials for the oil and powder experiments. Six different concentrations, namely; 0.5g, 1.0g, 1.5g, 2.0g,2.5g and 3.0g of *C. sinensis* rind powder per 50g maize corresponding to 1%, 2%, 3%, 4%, 5% and 6% were added to the clean maize grains and thoroughly mixed using a stirring glass rod. A control treatment in which no powder was added was also set up. A treatment in which 1g of permethrin (2%), a synthetic insecticide was added to 50g maize was included for comparison. Three replicates of each treatment were made and laid out in a completely randomized design (CRD).

Also, four concentrations, namely; 25mg, 50mg, 75mg and 100mg of the *C. sinensis* rind oil were used. These concentrations were applied separately in 0.2ml of analytical grade of acetone to 50g seeds of maize, "Bende white", in 100ml beakers. Each concentration and seed lot were thoroughly mixed with a stirring rod so as to ensure uniform coating. The 50g coated maize grains were placed into the transparent vials. A control treatment in which 0.2ml of analytical grade of acetone was uniformly coated on 50g maize grains was set-up. A 0.2ml of Dichlorvos (DDVP), a synthetic insecticide was thoroughly mixed with 50g maize and put into the vials for comparison. Four replicates of each treatment were made. These treatments were left to dry for about 2 hours before maize weevils were introduced. Each vial was covered with muslin cloth held tightly in place with rubber bands. This ensured that the insects did not escape and adequate aeration was provided. The mortality counts of the weevils were recorded at 1day, 2days, 5days, 7days, 14days, 21days, 28days, 35days and 42days after treatment (DAT). Damage by the weevils to the maize grains was assessed at 60days after treatment using the method of Fatope *et al.* (1995), in which weevil perforation index (WPI) was determined. Percentage weight loss by the grains was also determined.

$$\text{Weevil Perforation Index} = \frac{\%\text{ treated maize grain perforated}}{\%\text{ control maize grain perforated}} \times \frac{100}{1}$$

The data were subjected to analysis of variance (ANOVA) after transformation using the arc sine (percentage) method. Significant means were separated by the Least Significant Difference (LSD) at 5% probability level.

RESULTS

Table 1 shows the effect of *C. sinensis* rind powder on the mortality of the maize weevil, *S. zeamais* at different periods of assessment. There was no significant difference between each treatment and the control within the first three weeks of the commencement of the experiment However, all the treatments were significantly different $p<0.05$ from the synthetic insecticide, permethrin, no matter the rate at which the orange rind powder was applied.

Longer exposure, such as 28 DAT, 35 DAT and 42 DAT interacted with higher dosages to give mortalities significantly higher than the control, but not comparable to the synthetic insecticide. At the highest rate of 3g/50g maize and at 42DAT, adult mortality was 51%, while that of the synthetic insecticide was 89%. Generally, orange rind powder was not efficient in the control of the weevil, *S. zeamais*

Table 2 shows the damage by *S. zeamais* to maize grains treated with sweet orange rind powder 60 days post treatment. The percentage seed damage was highest in the control with 59%. However, maize grains treated with orange rind powder had between 34.86% and 48% seed damage, which did not differ from the control ($P< 0.05$). The synthetic insecticide, permethrin, with 5.8% damage, significantly reduced damage caused by the weevil, when compared to all the treatments and control. With a weevil perforation index (WPI) of 9.86, permethrin also showed better protectant effect and significantly superior to the sweet orange rind powder tested at various concentrations. The WPI for the orange rind powder ranged from 59.2 to 81.46, all of which are greater than 50.

Table 1:Percentage mortality count of adult *S. zeamais* treated with *C. sinensis* Rind Powder and Permethrin grain dust.

Treatment dosages (g/50kg maize grain)	Days after Treatment DAT)								
	1	2	5	7	14	21	28	35	42
0.0	0.99	0.99	0.99	0.99	0.99	0.99	0.99	6.81	6.81
0.5	0.99	0.99	0.99	0.99	0.99	0.99	6.81	32.22	34.23
1.0	6.81	6.81	6.81	6.81	6.81	6.81	6.81	18.04	32.30
1.5	0.99	0.99	0.99	0.99	6.81	6.81	28.29	30.99	35.22
2.0	0.99	0.99	6.81	6.81	9.51	9.51	23.36	28.08	34.63
2.5	0.99	0.99	0.99	0.99	0.99	0.99	17.55	39.15	46.92
3.0	0.99	0.99	0.99	0.99	0.99	0.99	25.37	43.08	50.85
Permethrin	89.19	89.19	89.19	89.19	89.19	89.19	89.19	89.19	89.19
F-LSD$_{(0.05)}$	6.24	6.24	9.13	12.91	12.91	12.91	6.71	18.56	17.68

Table 2: Damage by *S. zeamais* (Motsch.) to maize treated with *C. sinensis* rind powder 60 days post – treatment

Dosage g/50g Maize	Total Number of seeds	Number of seeds damaged	Number of undamaged seed	Percentage seed damage (%)	Weevil Perforation Index (WPI)
0.0	189.00	111.33	77.67	58.90	-
0.5	192.66	83.33	109.33	43.25	73.43
1.0	196.00	68.33	127.67	34.86	59.19
1.5	196.67	75.67	121.00	38.48	65.33
2.0	197.66	79.33	118.33	40.13	68.13
2.5	198.34	94.67	103.67	47.73	81.04
3.0	196.67	88.67	108.00	45.09	76.55
Permethrin	195.33	11.33	184.00	5.09	9.86
LSD $_{(0.05)}$	12.33	24.05	23.74	11.06	

Table 3: Weight Loss due to S. zeamais attack 60 days post treatment.

Dosages g/50g maize	Wt. After infestation (g)	Wt. Loss (g)	%Wt. loss
	40.81	9.19	18.38
0.5	42.18	7.82	15.64
1.0	42.56	7.44	14.88
1.5	42.94	7.06	14.12
2.0	43.35	6.65	13.31
2.5	42.29	7.71	15.42
3.0	42.35	7.65	15.30
Permethrin	49.46	0.54	1.08
$LSD_{(0.05)}$	2.57	2.57	

Table 4: Percentage mortality of *S.zeamais* fed on maize treated with *C. sinensis* rind oil of different rates and Dichlorv os (DDVP)

Treatment (DAT) (Dosages) mg/50g maize	Days After Treatment								
	1	2	5	7	14	21	28	35	42
Acetone (Control)	13.41	13.41	21.46	22.97	24.41	24.41	31.05	36.92	39.2
25	0.99	0.99	5.35	5.35	18.14	29.36	45.0	46.44	47.89
50	5.35	5.35	20.47	32.89	34.36	47.95	58.98	65.05	70.25
75	5.35	9.72	27.33	41.84	46.44	57.05	65.47	67.50.	71.91
100	5.36	14.08	26.49	31.84	35.44	60.64	70.25	73.94	78.35
DDVP(0.2ml)	89.19	89.19	89.19	89.19	89.19	89.19	89.19	89.19	89.19
F-$LSD_{(0.05)}$	13.36	13.87	17.82	20.78	23.86	19.00	18.65	16.43	17.45

Table 5: Damage of maize grains treated with *C. sinensis* rind oil and Dichlorvos by *S.zeamais* 60 days post treatment

Dosage mg/50g maize	Total number of seeds	Number of seeds damaged	Number of Seeds undamaged	Percentage seed damage (%)	Weevil Perforation Index (WPI)
Acetone 0.0	202.00	159.25	42.76	78.84	_-
25	173.00	51.25	121.75	29.62	37.58
50	174.25	35.75	138.50	20.52	26.04
75	188.25	16.50	171.75	8.76	11.12
100	170.00	4.25	165.75	2.50	3.17
DDVP (0.2ml)	198.00	7.50	203.75	3.79	4.89
LSD (0.05)	11.92	14.98	24.12	8.76	

Weight loss suffered by the maize grains due to attack by *S.zeamais* 60 days post treatment is shown in Table 3. Weight loss was highest in the control, with 9.19g, equivalent of 18.38%. Seeds treated with permethrin (coopex grain dust) were not damaged having lost 0.54g weight, which is equivalent to 1% weight loss. All the orange rind powder treatments were not significantly different from the control. The percentage mortality of adult *S. zeamais* fed on maize grains treated with *C. sinensis* rind oil at different rates and Dichlorvos (DDVP) is shown in Table 4. Within the first 14 days after treatment various rates of the orange rind oil treatment were moderately effective but did not differ significantly from each other and from the control ($P \geq 0.05$). At 21, 28, 35 and 42 days after treatment, the rind oil rate of 25mg/50g maize was ineffective; hence the mortality it recorded was not significantly different from the control. However, mortalities of adult weevil recorded by 50mg, 75mg and 100mg/50g maize grains were significantly higher than the control ($P < 0.05$). Dichlorvos (DDVP), the synthetic insecticide was most effective in all the days of treatment, but the orange rind oil at the rates of 50mg, 75mg and 100mg/50g maize achieved levels of protection to the maize grains comparable to Dichlorvos, though the synthetic insecticide was superior to all the orange rind oil rates, having 89.19% adult mortality. Thus, the ranking of effectiveness of these treatments is as follows: DDVP > 100mg > 75mg > 50mg > 25mg > control.

Damage by *S. zeamais* to maize grains treated with *C. sinensis* rind oil 60 days after

treatment is shown in Table 5. The highest percentage seed damage was recorded on the control with 78% seed damage, while the least damage was done on maize grains treated with orange rind oil at 100mg/50g maize grain with 2.5% seed damage. The maize grains treated with the synthetic insecticide, Dichlorvos recorded 4% seed damage. Grains treated with the orange rind oil had between 2.5% and 29.62% seed damage.The Weevil Perforation Index (WPI) of all the rates of orange rind oil and Dichlorvos indicated positive protectant effect, ranging between 3.17 and 37.58, all being less than 50. The orange rind oil at 100mg/5g maize grains had the least weevil perforation index of 3.17, followed by Dichlorvos with 4.88. Although the percentage adult mortality of *S. zeamais* adults in maize grains protected with 25mg orange rind oil did not differ significantly from the control. The damage to grains protected by it was less than that of the control (Tables 4 and 5).

DISCUSSION

The study has shown that toxicity of *C. sinensis* rind powder was moderately effective against the maize weevil, *S. zeamais* at 35 and 42 days post treatment when 3g/50g maize caused 51% mortality. The observed mortality was very low when compared to 1g/50g maize of Coopex grain dust which recorded 89% mortality. Longer exposure with higher dosages to treated maize may be adopted since they contain high active ingredients. *C .sinensis* rind oil was found to be more effective against the maize weevil, *S. zeamais* than the rind powder. This is in consonance with the reports by Don-Pedro (1989), Kumar and Okonkwo (1991). *C. sinensis* rind oil dosages of 50, 75 and 100mg/50g maize caused total mortality of the weevils at 28, 35 and 42 days after treatment, which showed that the insecticidal strength increased with the length of storage. The mode of action of plant oils has been suggested to include physical barrier to respiration of insects, eggs and young larvae (Credland, 1992); toxicity and repellence by constituents. Insecticidal activity may reside in the oil contained in the rind (Emeasor and Emosairue 2002) and therefore *C.sinensis* rind oil had great potential for use as seed protectant against *S.zeamais* infestation. The result of the study also confirms that synthetic insecticides such as Dichlorvos and Permethrin are usually superior to the botanicals. There is an indication that orange rind oil dosages of 50, 75 and 100mg are similar in efficacy to Dichlorvos. The use of botanicals is more acceptable to the farmers and grain merchants because of general safety and ease of handling. Furthermore, heaps of orange peels are sources of environmental pollution, especially in municipal settlements where huge sums of money are expended to evacuate the refuse. The use of orange peels in agriculture and protection of grains in particular can be of immense value in keeping the environment clean.

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