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Insecticidal Effects of Ethanol Extracts of *Capsicum Frutescens* and *Dennettia Tripetala* against *Sitophilus Zeamais* Motschulsky on Stored Maize

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ABSTRACT

Efficacy of ethanol extracts of *Dennettia tripetala* and *Capsicum frutescens* fruits was investigated on *Sitophilus zeamais* at the Entomology Research Laboratory, Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria under an ambient temperature of 27 ± 2^0 C and 65 ± 5% relative humidity. The plant extracts at concentrations 10, 20 and 30 %v/v were applied against 50 g of maize grains. Experiment was arranged in a Completely Randomised Design in four replicates and parameters assessed, including adult mortality, number of F1 progeny and percentage seed viability, were subjected to analysis of variance and means separated using Duncan's Multiple Range Test. Results showed that the two plants had varying degree of insecticidal activities but were both effective against the weevils. Mortality of S. *zeamais* was highest (80%) at the highest concentration of 30% v/v of D. tripetala at 96 h. The mean number of eggs laid on grains treated with the extracts was reduced from 24.50 in the solvent-treated to 2.75 at 30% v/v D. tripetala extract concentration while adult emergence reduced from a mean of 23.00 in the solvent-treated grains to 3.00 at 30% extract treatment. C. frutescens at 30 %v/v possessed the highest repellent action to S. *zeamais* and no significant difference was observed in the germination of seeds treated with concentrations of the extracts as well as the control. The results obtained reveal that extracts from the two plants are effective in controlling S. *zeamais* and could serve as an alternative to synthetic insecticides.

Keywords: Capsicum frutescens, Dennettia tripetala, Sitophilus *zeamais*, mortality, oviposition

INTRODUCTION

The maize weevil, *Sitophilus zeamais* (Motsch.) (Coleoptera: Curculionidae) is a serious pest of stored maize grain in Africa, although it is capable of developing on all cereal grains and cereal products [23; 24; 5]. Declining food production, worsened by huge losses resulting from *S. zeamais* attack during maize storage expose farmers to different magnitudes of food shocks [16].

As a primary pest of stored maize, *S. zeamais* is capable of penetrating and infesting intact kernels of grain, in which immature stages develop [15] leaving the maize emptied of its nutritional and seed value culminating in outright rejection of the product at the local and international markets [17]. Both the larval and adult stages of this field-to-store insect devour the kernel, causing commodity weight losses [2; 12]. Efficient and effective control of *S. zeamais* has centered on the use of synthetic insecticides [14; 3].

However, the use of these chemicals is hampered by many attendant problems such as development of resistant insect strains, toxic residues in foods and humans, workers' safety and high cost of procurement [22; 1; 18]. Many plants that are eco-friendly and readily available in the environment can be used in the control of insects in stored products [20].

Previous studies have shown the use of plant extracts in the control of pest as important natural chemicals and as possible sources of non-phytotoxic insecticides [7; 9; 12]. These plants exert various physiological and behavioural activities on stored product insects and notable among these plants are

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various spices and medicinal plants used traditionally for protecting foodstuffs against insects [8; 10; 19]. The present study evaluated the efficacy of *Capsicum frutescens* and *Dennetia tripetala* against the maize weevil, *Sitophilus zeamais* on stored maize.

MATERIALS & METHODS

Rearing of *Sitophilus zeamais*

The parent stock of *S. zeamais* used for this study was obtained from the Entomology Research Laboratory of the Department of Crop Protection and Environmental Biology, University of Ibadan, Nigeria where the research was undertaken. The insects were cultured under laboratory conditions of 27 ± 2°C ambient temperature and 65 ± 5% relative humidity. This was done by weighing 300g of the maize grains into 4 kilner jars. Fifty unsexed adult of *S. zeamais* were then introduced into the kilner jars and kept in the laboratory for one month for the insects to lay eggs and multiply. New generations of the maize weevil were subsequently reared on cleaned disinfested TZPB maize variety in the laboratory and culture maintained for availability of insects needed throughout the experiment.

Collection and Preparation of Plant materials

Fresh fruits of two plant materials commonly used as food condiments in diets namely *D. tripetala* (pepper fruit) and *C. frutescens* were purchased from Oja Oba markets in Ondo, Ondo State, Nigeria. *D. tripetala* commonly known as pepper fruit belongs to the family Annoaceae while *C. frutescens* commonly called black pepper belongs to the family Solanaceae. Each of the plant samples was washed, sun-dried and pulverized into powder using an electric 5.0Hp kitchen grinder and was sieved through a 40 holes/mm^2 mesh screen. Each of the plant powders was kept in a separate plastic container with a tightly fitted lid until use.

Extraction and concentration of plant materials

Cold extraction method was employed using 95 % ethanol as the solvent. The extracts of grounded plant materials were prepared at the Entomology Research Laboratory, Department of Zoology, University of Ibadan, Nigeria. About 300 g each of ground samples of *D. tripetala* and *C. frutescens* were separately loaded into 5L aspirator bottle and the for a period of 72 hours (3 days) with 30 ml of ethanol. The mixture was filtered using bulker funnel, conical flask, aspirator flask and suction pump and the filtrate extracted using simple distillation method. The extract was concentrated using a rotary evaporator until a syrupy crude extract was obtained.

Effects of ethanol extracts of D. *tripetala* and C. *frutescens* on Mortality of *Sitophilus zeamais*

Serial dilution of the portion of the syrupy crude extracts obtained from both *D. tripetala* and *C. frutescence* extracts obtained above was done with ethanol (95%) to obtain three different concentrations, 10 – 30 %v/v and a control (0 %v/v) as ethanol only. Fifty grammes (50g) of whole maize grains of a susceptible variety (TZPB – SR) was weighed into Kilner jars. Using a micro syringe, 0.5 ml of each concentration was applied to the grains and shaken for 5 minutes to allow for effective coverage of the surface. Grains were infested with ten (1♀: 1♂) day-old *S. zeamais* and the experiment laid out in a completely randomized design (CRD) with four replications. Mortality was recorded at 24, 48, 72 and 96 hours after infestation and corrected with Abbott’s formula [26]. Data were analyzed and means separated using the Duncan Multiple Range Test (DMRT) at 5% level of significance.

Effect of D. *tripetala* and C. *frutescens* on oviposition by S. *zeamais*

Twenty (20) grammes of clean (TZPB) maize grains were placed in each petri-dish and 0.5 ml of each of the concentration of both extracts was added. The maize grains and the oil extracts were thoroughly mixed and air-dried as described earlier before the introduction of five pairs (1 male : 1 female) of newly emerged adult *S. zeamais*. The petri-dishes were then covered with petri plates. A control experiment containing untreated grains was also set up. There were seven treatments in four replications. The treatments were left for 10 days in a wooden cage in the laboratory. Afterward, the total number of eggs laid was counted and recorded using the egg-plug staining/detection technique described by [28] and modified by [29]. Data obtained were analyzed and means separated using the Duncan Multiple Range Test (DMRT) at 5% level of significance.

Effect of D.*tripetala* and C. *frutescens* extracts on F_1 progeny of S. *zeamais*, percentage weight loss in grains and germination of maize seeds

The grains in the mortality experiment above were left undisturbed for 30 days and this followed by daily observation and recording of F_1 progeny until emergence was complete. Data on emerged F_1 progeny were analyzed and means separated using the Duncan Multiple Range Test (DMRT). After three months of storage, maize grains from the experiment above were sieved to remove the dust produced from adult feeding and re-weighed by using a Metler Weighing balance and the percentage loss in weight determined as follows:

$$\text{Percentage (\%) weight loss} = \frac{\text{initial weight - final weight}}{\text{final weight}} \times 100$$

In order to assess the viability of seeds, germination test was conducted using twenty (20) undamaged seeds from each jar. The seeds were placed on moist filter paper in plastic Petri dishes and kept in an incubator at 25°C and the number of germinated seed was counted and recorded after 7 days and seed germination was thereafter determined and expressed as percentage of total grains sown [2].

Repellent effects of extracts of D. *tripetala* and C. *frutescens* on *Sitophilus zeamais*

Repellent activity of crude extract of *D. tripetala* and *C. frutescens* against *S. zeamais* was evaluated using the area preference method described by [32]. The test area consisted of 11.0 cm whatman No. 1 filter papers cut in halves and 200µl of each of the three concentrations of *D. tripetala* and *C. frutescence* was applied uniformly to half-filter-paper disc with a micro syringe. The other filter paper halves were treated with ethanol (control). The half discs were air-dried for 10 minutes to allow the solvent to evaporate completely. Full discs were re-made by attaching treated halves to untreated halves of the same dimensions with cellotape and each placed in a petri dish with ten adult weevils released separately at the centre of each filter paper disc in the Petri dish covered. Treatments (concentrations) were arranged in a completely randomized design (CRD) in four replications. The number of insects presents on the control (untreated) and treated half discs were recorded after 30 minutes exposure. Percent Repellency (PR) for each replicate was estimated as:

$$PR = [(Nc - Nt)/ (Nc + Nt)] \times 100$$

Where (Nt) = number of insects present on the treated half disc and;

(Nc) = number of insects present on the untreated (control) half disc,

A negative PR value was taken as zero and data on percent repellence were analysed.

Statistical analysis

All percentage data were angular transformed prior to statistical analysis, in order to equalise variances. All data were analysed and significant differences were compared at 0.05 significant level using Duncan's Multiple Range Test (DMRT) [25].

RESULTS

Table 1 shows the effect of extracts from *Dennettia tripetala* and *capsicum frutescens* fruits on the adult mortality of *Sitophilus zeamais* over 4 days post treatment. There were significant differences ($p < 0.05$) between the higher concentrations of the extracts and the control at 48 hours infestation. Highest percentage mortality (80%) was obtained with 30 %v/v concentration of *D. tripetala* and this was significantly ($p < 0.05$) different from the control. Table 2 shows that the number of eggs laid by adult *S. zeamais* varied with the concentrations of the extracts. In the control, the mean number of eggs laid by *S. zeamais* was significantly higher ($p < 0.05$) than any other treatment, except with the least concentration (10 %v/v) of *C. frutescens.* Mean number of eggs laid by adult *S. zeamais* decreased with increasing concentrations of both *D. tripetala* and *C. frutescens*. There was significant reduction ($p < 0.05$) in the number of adult emergence in the treated grains compared with the control. As low as 3.00 F_1 progeny was recorded on maize grains treated with 30% v/v concentration of *D. tripetala* compared with the highest significant value (23.00) in the control. Adult emergence decreased with increase in concentration of both extracts (Table 2). Table 3 shows that the weight loss caused by the feeding activity of both larvae and adult *S. zeamais* was significantly ($P < 0.05$) higher in the control compared with grains treated with the extracts of *D. tripetala* and *C. frutescens*. Grains treated with concentrations of the extracts gave better protection against infestation by *S. zeamais* compared to the untreated grains. The least grain weight loss (0.85%) was recorded on grains with highest concentration of *D. tripetala* and not significantly ($p > 0.05$) differentfrom 30 % *C. frutescens*. There was no significant difference ($p > 0.05$) in viability of treated and untreated seeds, even though percentage germination was highest in the untreated seeds. All the concentrations of both extracts were repellent to adult *S. zeamais*, with 30 % (v/v) of both extracts, evoking the highest repellent action (Table 3).

DISCUSSION

Results reported in this study show that *Capsicum frutescens* and *Dennettia tripetala* have insecticidal effects on the maize weevil, *S. zeamais* but varied with the concentrations of the extracts. The two plant species were very effective in causing mortality to *S. zeamais* with a high significant difference from the control. They also reduced oviposition and inhibited F_1 progeny development. This shows that the plant species probably have oviposition deterrent, ovicidal and lavicidal properties. The observed activities may be due to the "pepperich" nature and pungency of the species. For instance, the pungency of *Capsicum* species was attributed to the presence of capsacin [6] and result obtained is in agreement with the reports of [30], and [31]. They both found that *C. frutescens* considerably reduced all stages of *C. maculatus* [11]. Plants

Table1. *Effects of Dennettia tripetala and Capsicum frutescens on mortality of Sitophilus zeamais*

Percentage mortality at 1-4 days post treatment					
Plant Materials	***Conc. (%v/v)***	***24h***	***48h***	***72h***	***96h***
Capsicum frutescens	10.00	$2.50^{ab} \pm 9.22$	$10.00^{ab} \pm 11.25$	$15.\ 00^{a} \pm 11.75$	$20.00^{ab} \pm 15.03$
	20.00	$2.50^{ab} \pm 9.22$	$15.00^{b} \pm 13.28$	$17.50^{a} \pm 12.92$	$35.00^{bc} \pm 12.96$
	30.00	$5.00^{ab} \pm 10.65$	$17.50^{b} \pm 16.44$	$37.50^{b} \pm 6.66$	$47.5^{0c} \pm 13.04$
Dennetia tripetala	10.00	$5.00^{ab} \pm 9.22$	$7.50^{ab} \pm 9.22$	$15.00^{a} \pm 16.61$	$25.00^{abc} \pm 9.64$
	20.00	$5.00^{ab} \pm 9.22$	$22.50^{b} \pm 8.59$	$35.00^{b} \pm 6.27$	$45.00^{c} \pm 6.19$
	30.00	$12.50^{b} \pm 13.60$	$22.50^{b} \pm 8.59$	$50.00^{b} \pm 3.88$	$80.00^{d} \pm 7.58$
Control (Solvent)	0.00	$0.00^{a} \pm 0.00$	$0.00^{a} \pm 0.00$	$5.00^{a} \pm 10.64$	$7.50^{a} \pm 9.22$

Means followed by common letters in the same column are not significantly different at 5% level

Table2.*Effects of Dennettia tripetala and Capsicum frutescens on oviposition and F1 progeny of Sitophilus zeamais*

Plant Materials	Conc. (%v/v)	Mean no. of eggs laid (±S.D)	Mean no. of F_1 progeny (±S.D)
Capsicum frutescens	10.00	$20.50^{de} \pm 1.92$	$17.00^{c} \pm 3.46$
	20.00	$15.00^{bc} \pm 3.92$	$15.00^{c} \pm 1.83$
	30.00	$11.50^{b} \pm 2.08$	9.75b ± 2.22
Dennetia tripetala	10.00	$18.25^{cd} \pm 1.71$	15.50c ± 3.32
	20.00	$12.50^{b} \pm 2.38$	9.25b ± 3.40
	30.00	$2.75^{a} \pm 2.36$	3.00a ± 1.41
Control (solvent)	0.00	$24.50^{e} \pm 4.66$	23.00d ± 2.94

Means followed by common letters in the same column are not significantly different at 5% level

such as *Capsicum frutescens, C. annum* fruit and *Citrus sinensis* peel have previously been shown to cause mortality of adult *Dasyses rugosella* in yam tuber [6]. [21] reported

that *Capsicum* species seeds and fruits powders were significantly toxic to *Sitophilus zeamais* and *C. maculatus* in stored maize and cowpea seeds, respectively. As well, [27] reported that seed powders of pepper fruits, *Dennettia tripetala* at 1.5 g/25 g maize seed achieved 100 % *S. zeamais* mortality in 24 hours. Previous studies also revealed that the powders and extracts of *P. guineense* and *D. tripetala* inhibited adult emergence of *Callosobruchus maculatus* and Sitophillus *zeamais* completely and that the extracts from both fruits are very protective against infestation of dried fish by *Dermestes* *maculatus* [20]. [4] also reported that hexane extract of Dennetlia tripetala was toxic to *A. eagypti* larvae as the toxicity of the extract was gradual and persisted throughout the 96-hour test period. Results obtained from this study thus demonstrate active potential of these plant products as plant-derived insecticides against maize weevil and provide a scientific rationale for the use of these botanicals as alternative to synthetic insecticides in post harvest protection. Further investigations are required particularly on their isolation and biological evaluation test to determine the efficacy and the active ingredients present in the plants as well as synthesize them and make scientific formulations for effective use in controlling insect pests of stored products, especially maize.

Table 3.*Effects of Dennettia tripetala and Capsicum frutescens on percentage grain weight loss, seed germination and repellency to Sitophilus zeamais*

Plant Materials	Conc. (% v/v)	% grain weight loss (±S.D)	% Seed germination(±S.D)	% Repellency (±S.D)
Capsicum frutescens	10.00	$4.63^{e} \pm 0.56$	78.75 ± 2.50	$50.00^{b} \pm 15.23$
	20.00	$3.53^{d} \pm 0.43$	78.75 ± 7.50	$81.25^{cd} \pm 7.99$
	30.00	$1.29^{a} \pm 0.19$	78.75 ± 2.50	$91.68^{d} \pm 6.82$
Dennetia tripetala	10.00	$2.93^{c} \pm 0.56$	80.00 ± 4.08	$64.58^{bc} \pm 8.00$
	20.00	$1.95^{b} \pm 0.11$	77.50 ± 2.89	$64.58^{bc} \pm 8.00$
	30.00	$0.85^{a} \pm 0.20$	81.25 ± 4.79	$89.58^{d} \pm 8.00$
Control	0.00	$8.32^{f} \pm 0.23$	83.75 ± 6.29	$0.00^{a} \pm 0.00$

Means followed by common letters in the same column are not significantly different at 5% level

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