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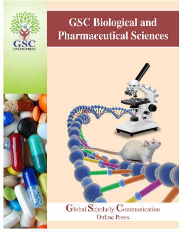

(RESEARCH ARTICLE)

Effect of plant oil treatments against *Sitophilus zeamais* Motsch. (Coleoptera: Curculionidae) on stored maize

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Abstract

The effect of plant oil treatments extracted from *Khaya ivorensis* and *Azadirachta indica* was evaluated on adult maize weevils *Sitophilus zeamais* reared on maize grain. Four replicates of each treatment oils were constituted at 0% (control untreated), 1 ml, 2 ml, and 3 ml doses. Each of the pytochemical oil and the synthetic chemical (Daksh-Dichlorvos 100% EC w/v) was introduced into experimental jars (300 cm^3) at graded levels, before 20 g of clean maize grain was incorporated. The treatment oils were separated from the grains with perforated white paper, before 10 newly emerged adult *S. zeamais* was added to the experimental jars including the control (untreated) experiment, which contain 20 g of maize grain but no treatment was added. The plant oils were evaluated for their toxic effect on *S. zeamais*, oviposition, F1 progeny emergence, grain damage and weight loss. Data collected were analyzed using ANOVA. The means were separated using LSD at P>0.05.The results revealed that treatment oils were toxic to the maize weevils when compared with the control (untreated) experiment. Among the plants, essential oil of *K. ivorensis* significantly (P>0.05) suppressed egg laying, F1 progeny emergence and grain damage. Therefore, the essential oil of *K. ivorensis* and *A. indica* is useful in the control of *S. zeamais*.

Keywords: *Azadirachta indica*; *Khaya ivorensis*; Maize; Plant oil; *Sitophilus zeamais*

1. Introduction

The storage of maize grains by the farmers is necessary from one harvest to the next in order to maintain the constancy of supply throughout the year and also to preserve its quality until required for use. In sub-tropical Africa, small scale farmers store maize for the purpose of ensuring household food supply and seeds for planting [1]. But unfortunately, the infestation of the grains by the maize weevils aggravates shortage of supply both in quality and quantity, particularly in the sub-tropic and tropic regions of Africa. Postharvest loss of maize grains between 20% and 30% has been reported [2]. Worldwide, about 66% of maize is used for feeding livestock, 25% for human consumption and 9% for industrial purposes [3]. In the developing world, about 50% of all maize is consumed as food while 43% is used for feeding of livestock and 7% for industrial purposes [3]. In Nigeria, about 50-70% constitutes livestock feeds [4].

Maize is an important source of carbohydrate in the tropics and is a major staple in Nigeria for large human populations, important feed for poultry and also used for industrial purposes [1]. It is also rich in protein [5]. Despite

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its importance, the production of maize suffers great losses in storage due to insect pest infestation, which necessitates farmers and researchers all over the world to find an alternative storage measures. The pest affecting maize includes *Sitophilus zeamais* Motschulski [6]. Generally the storage control of insect like *S. zeamais* has involved mainly the use of synthetic insecticides. Even though, synthetic chemicals continue to play an important role in reducing storage losses due to insect pest activities [7], but insecticide resistance [8], toxic residues in food and environmental pollution, adverse effects on beneficial and non-target insects, increased risk of workers safety and the high cost of chemical insecticides make them less attractive [7, 9]. These problems have necessitated the search for alternatively eco-friendly insect pest control method among, which are the use of plant oils. Plant derived materials are more readily biodegradable. Farmers can easily and cheaply produce these plant materials for their use.

Many plant oils have been employed for the control of post-harvest losses due to insect pest activities with varying degrees of success [10, 11]. Many plant essential oils show different activities against controlling pest. The oils also have long tradition of use in controlling and protecting stored products. Research showed that some chemical constituents of these oils interfere with the Octapaminergic nervous system in insects [12]. Shaaya et al. reported that edible oils are potential control agents against *S. zeamais* and can play an important role in stored grain production [13]. Koul et al*.* also observed that the oils of neem and mahogany oil acted as surface protectant on green gram to check the impulse beetles and among them, neem oil was found to be the best surface protectant [12]. In this study, the efficacy of plaint oils extracted from *K. ivorensis* and *A. indica* was evaluated on *S. zeamais* reared on maize grains in Mubi.

2. Material and methods

2.1. Study Area

This experiment was carried out in the Laboratory of Biological Sciences, Adamawa State University Mubi. Mubi is a town in Adamawa State, Nigeria located on latitude 10^{o} 12' N and longitude 13^{o} 10' E. It is characterized with two seasons i.e. dry and rainy seasons. The average annual rainfall ranges from 700 mm to 1050 mm. The average minimum temperature is 15.2 ˚C in the month of December and January, with maximum temperature of 42 ˚C [14].

2.2. Sources of plant oil treatments and synthetic chemical

The plant oil treatments used in this study was sourced from the seeds of *Azadirachta indica* and *Khaya ivorensis*. These were obtained freshly from a plantation in Fadama Rake, Hong, Adamawa State. The seeds were dried in a dark cupboard and were subsequently shelled and pulverized into fine powders using electric blender. For each plant powder, the oil was extracted as described by Wahedi et al. [15], as follows: Boiled water was added gently on the plant powder in a wider container and was moulded to form a dough-like substance. This was continually pressed on a clean wood plant until the oils are out. The oil was collected and stored in a dark bottle with tight lids. Synthetic chemical Daksh (Dichlorvos 100% EC w/v) was obtained from agrochemical store in Mubi main market, and was used as the positive control.

2.3. Maize grain

Clean maize grain was obtained from a farmer in Fadama Rake in Hong LGA and was dried to a constant weight in an oven between 30 ˚C and 35 ˚C for 5 days. It was subsequently air–dried for about 30 minutes and was wrapped tightly in a container.

2.4. Insect culture

Initial stock (parent stock) of maize weevils *Sitophilus zeamais* was obtained from already infested maize grains in a storage room in Mubi main market. The insects were thereafter exposed to a clean maize grain in about 500 cm^3 culture jar. They were subsequently discarded after 3days, and the infested grains were maintained under laboratory conditions for adult *S. zeamais* emergence. This helped in raising adult *S. zeamais* of uniform size and age*.*

2.5. Method of application

Each of the treatment was constituted as follows: 1 ml, 2 ml, and 3 ml. The treatments were first introduced into the rearing jars using a calibrated syringe. The treatments were thereafter covered with perforated paper to prevent a direct contact of the weevils with the oil treatments. 20 g of maize each was added to the rearing jars before the introduction of the experimental insects. 10 newly emerged adult *S. zeamais* were introduced into the rearing jars and were covered with muslin cloth using rubber band in order to prevent the insects from escaping and to allow entry of oxygen. The control jar, also contain 20 g of maize grains and 10 newly emerged adult weevils but no treatment in it was constituted.

2.6. Data collection

2.6.1. Mortality

Mortality count of adult *S. zeamais* was noted and recorded for four days post treatment. This was done by emptying the content of the rearing jars on a clean silver tray and noting the number of death insects. The inability of the insect to respond to a touch using a broom stick indicated mortality. Thereafter, the content of the jars were subsequently put back after the death insects have been retrieved.

2.6.2. Oviposition

The number of eggs per jar was determined using the acid fuschin staining method. Ten maize grains from each jar were randomly selected on the 12th day post treatment, soaked in warm water for 2-3 minutes, drained and subsequently immersed in 0.5% acid Fuschin for about 2-5 minutes. The grains were rinsed in water and examined for the red gelatinous egg plugs. The number of egg plugs noticed on the ten grains was then extrapolated for the entire jar using an average number of 96 maize grains per jar [16].

2.6.3. F1 generation:

The number of F1 adult progeny of *S. zeamais* that emerged per jar was noted and recorded between 7-8 weeks of setting up the experiment.

2.6.4. Grain damage

The number of grain damaged was noted by counting the number of punctures and holes on the grains. 10 seeds were randomly selected from each treatment jar and were noted for the damage. The numbers of damages recorded were extrapolated using an average number of seeds (96) per jar as described in oviposition above.

2.6.5. Weight loss

Weight loss by the maize grain per jar was calculated as the difference between the initial weight and the final weight of the grains as shown in the formula below.

Weight loss = final weight - initial weight.

2.7. Data analysis

Data collected was subjected to Analysis of Variance (ANOVA) using statistical analysis software (SAS) at 5% (P>0.05) level of significance, while the mean differences were separated using Least Significant Difference (LSD).

3. Results

3.1. Mortality

Table 1 Effect different oil treatments on the mortality of adult *Sitophilus* zeamais reared on maize grain

Treatment	Dose (ml)	Days (Mean±SD)			
		1	2	3	4
Control	0.0	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
Khaya ivorensis	1.0	0.50±1.00^{a}	1.50±0.58^{b}	3.00±0.82^{b}	4.50±2.38^{b}
	2.0	1.25±1.25^{ab}	2.25±.50^{bc}	4.25±0.71^{b}	2.25±1.71^{ab}
	3.0	2.75±1.25^{b}	3.00±0.81^{c}	2.75±1.50^{b}	1.00±1.41^{a}
Azadirachta indica	1.0	1.25±1.25^{b}	2.25±0.96^{b}	2.50±1.00^{b}	4.00±2.16^{b}
	2.0	1.75±1.26^{b}	2.75±0.96^{b}	2.75±1.50^{b}	2.75±1.71^{bc}
	3.0	4.00±1.00^{c}	3.00±0.82^{b}	2.25±0.82^{b}	1.00±0.82^{ab}
Daksh	1.0	4.75±1.26^{b}	2.25±0.50^{b}	2.00±0.81^{b}	1.00±0.82^{ab}
	2.0	5.50±0.56^{bc}	1.25±0.50^{ab}	2.25±0.50^{b}	1.00±0.82^{ab}
	3.0	6.50±1.29^{c}	1.00±1.41^{ab}	0.50±0.56^{a}	0.75±0.95^{b}

Values are means of four replicates. Means carrying the same alphabet along the columns are not significantly different at (P>0.05).

Table 1 shows the toxicity effect of treatments (*K. ivorensis* and *A. indica*) on adult *Sitophilus zeamais* on stored maize. Although the mortality was spread across the four days of exposure, there was significant differences (P>0.05) in the mortality recorded per treatment across the period of exposure. No mortality (0.00) was recorded in the control (untreated) experiment throughout the four days. The overall results on mortality revealed that the treatment oils were quick active as they recorded a significant (P>0.05) number of mortality in all the treatments after 24 hrs of exposure.

3.2. Oviposition, F1 generation emergence, grain damage and grain weight loss

The effect of the phytochemical oils in the suppression of adult *S. zeamais* from egg laying and F1 emergence as well as the protection of maize grain from damage and subsequent weight loss is shown in Table 2. Although the phytochemicals could not stop the adult weevils *S. zeamais* from laying eggs completely, there was a significant difference (P>0.05) in the number of eggs laid as well as the F1 progeny emergence, when compared with the control (untreated) experiment. The number of eggs laid as well as the number of F1 adults emerged do not differ significantly (P>0.05) per treatment at different doses. No F1 adult (0.00±0.00) emergence was recorded on maize grain treated with *K. ivorensis* in all the treatment doses (1.0 ml, 2.0 ml and 3.0 ml) as well as *A. indica* at 3.0 ml treatment dose respectively.

The result also revealed that there was a significant difference (P>0.05) in the number of grain damage and subsequent weight loss by the maize grain compared with the control (untreated) experiment. The control experiment significantly (P>0.05) recorded higher grain damage (42.00) as well as the weight loss (2.00). Among the phytochemical oils, no significance difference (P>0.05) was observed at all doses.

Table 2 Effects of treatments on oviposition, F1 adult emergence of *Sitophilus zeamais* and maize grain damage and weight loss

Treatment	Dose (ml)	Parameters (Mean±SD)			
		Oviposition	F1 emergence	Grain damage	Weight loss (g)
Control	0.0	51.85±17.73[b]	4.25±0.95[b]	42.00±5.43[b]	2.00±0.71[b]
Khaya ivorensis	1.0	16.45±14.10[a]	0.00±0.00[a]	7.05±4.70[a]	1.15±0.07[a]
	2.0	9.40±7.67[a]	0.00±.00[a]	0.00±0.00[a]	0.82±0.33[a]
	3.0	18.8±7.67[a]	0.00±0.00[a]	4.70±5.42[a]	0.72±0.00[a]
Azadirachta indica	1.0	25.85±16.05[a]	0.25±0.50[a]	4.70±5.42[a]	1.20±0.24[a]
	2.0	23.50±12.13[a]	0.25±0.50[a]	2.35±4.70[a]	1.07±0.22[a]
	3.0	23.65±19.61[a]	0.00±0.00[a]	2.35±4.70[a]	0.77±0.15[a]
Daksh	1.0	40.10±8.73[a]	1.00±0.00[a]	16.45±14.10[a]	0.97±0.35[a]
	2.0	39.95±16.05[a]	0.75±0.50[a]	11.75±17.79[a]	0.55±0.23[a]
	3.0	35.25±11.82[a]	0.00±0.00[a]	11.75±17.79[a]	0.50±0.21[a]

Values are means of four replicates, means carrying similar alphabets along the columns are not significantly different (P>0.05).

4. Discussion

The oils tested were found to be effective in the control of adult *S. zeamais* on stored maize. *A. indica* and *K. ivorensis* gave 100% mortality in all the treatment doses used (1.0 ml, 2.0 ml and 3.0 ml) after 4 days of exposure, equal to the synthetic insecticides. This confirms the efficacy of the oil treatments used; thus could be a suitable replacement for the insecticides which are toxic to its users and the environment, relatively not affordable to local farmers, as well as its effect on non-target organisms. The plant oils were quick in action as they recorded significant (P>0.05) mortality after 24 hrs of exposure. The treatment doses showed no significant difference (P>0.05) in the number of adult mortality, but performed significantly (P>0.05) better when compared with the control (untreated) experiment. The results achieved in this study agrees with the work reported by Wahedi among previous studies, who reported that *A. indica* significantly caused high mortality of *S. zeamais* reared on stored maize; and that the toxicity of the treatment was associated with the occurrence of chemical components such as tritepenoids, which comprise azadirachtin [17].

The significant number of adult mortality recorded and a significant (P>0.05) suppression of adult emergence of *S. zeamais* by the plant oil treatments suggests that the seeds are have toxic compounds that have insecticidal properties [18]. The oil on application on the grain serve as food poison to the weevils, the odour penetrated into the endosperm and germ layer thereby preventing oviposition and larval development as reported by Arannilewa et al. [18].

The observed low emergence of F1 generation of *S. zeamais* on maize grains treated with two plants oils could be as a result of a significant (P>0.05) high mortality earlier recorded on adult *S. zeamais*, thus affected their mating process and sexual communication as well as deterring females from lying eggs; and hence, a complete suppression of the developmental stages of the insects. The trial has showed that treating maize grain with *A. indica* and *K. ivorensis* oil at all treatment doses, prevented adult *S. zeamais* emergence, suppressed weight loss and grain damage caused by S. *zeamais* activities. This also coincides with the findings of Wahedi [17] and Yusuf et al. [19], who reported a reduction in weight loss of maize grains treated with neem seed oil.

5. Conclusion

In conclusion, the plant oil treatments extracted from *A. indica* and *K. ivorensis* no doubt hold some promising effects in respect of the control of stored grains against insect pest infestation. More so, the fact that they are readily available and environmentally friendly put them in a stead of tapping as an alternative to the chemical pesticides, which are toxic to humans.

Compliance with ethical standards

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Disclosure of conflict of interest

This work was collaboratively carried out between all authors as follows: Author Wahedi JA, designed and supervised the study, wrote the protocol, and wrote the first draft of the manuscript; Author Zakariya R, identified and performed the extraction plant treatment oils; Authors Wilson C, and Vincent VM, performed the experiment; Authors Elkanah OS, Danba EP, and Ishuwa MN, managed the literature searches. All authors read and approved the final manuscript.

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