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The Use of Three Edible Oils in the Management of *Caryedon serratus* (Olivier) (Coleoptera: Bruchidea) Infesting Stored Groundnut Seed Pods in Lafia, Nigeria.

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Abstract

Three edible plant product oils, West African Black Pepper (WABP) Piper guineense Schum and Thonn, Clove, Syzgium aromaticum (L.) Merril and Percy, Ethiopian pepper oil, Xylopia aethiopica (Dum) A. Rich, were studied for their effectiveness in the control and management of the Caryedon serratus Olivier. The oil was used at different dosage rates of 0.5, 1.0, 1.5, and 2.0 mg/70 g of unshelled groundnut pods against the groundnut bruchid C. serratus. The experiment was carried out as treatment before infestation (TBI) in the laboratory. The entire plant product oil significantly ($P<0.05$) reduced oviposition by C. serratus when compared with oviposition in the control treatments. Clove and WABP oil at the highest dosage rate completely reduced oviposition and hence deterred adult emergence at the F_1 generation respectively while Clove oil deterred adult emergence of the F_2 generation at the dosage rates of 1.5 and 2.0mg and WABP oil also completely deterred F_2 adult emergence at the dosage rates of 0.5, 1.0 and 2.0mg respectively. The potential effectiveness of all the three edible plant product oils implies that stored unshelled groundnut pods could be adequately protected against Caryedon serratus, thus reducing their infestation and damage on groundnut.

Keywords: *Edible plant product oil, West African Black Pepper (WABP) Piper guineense, Clove, Syzgium aromaticum, Ethiopian pepper, Xylopia aethiopica, groundnut seed beetle, Caryedon serratus, treatment before infestation.*

Introduction

Groundnut (*Arachis hypogeae* Linn.) is a premier oil seed crop. It belongs to the family Leguminosae (Fabacea) (Beghnin and Sewadah, 2003). It is originated from South America and was introduced to Nigeria by the Portuguese during the 16th century exploration and its production spread to the Northern part of the country (Adeyemi, 1968). Groundnut is currently grown on over 22.2 million hectares worldwide with a total production of over 35 million metric tons (ICRISAT, 1984). India and China are the world largest producers of groundnut, accounting for over 41% of the world production. Nigeria produces 2,937,000 million metric tons on 2,880,000 of hectarage (Malgwi and Onu, 2004). Groundnut thrives best on a well-drained sandy-loam soil because such soil facilitate easy penetration of pegs and development, hence ease of harvesting (Yayock, 1984). Temperature range of 25-30^{o}C, rainfall of 500-1000 mm and a pH range of 6.0-6.5 are considered optimum for groundnut production. Groundnut seed contains 44-56% oil and 22-30% protein on a dry seed basis and is a rich source of minerals (P, Ca, Mg, K) and vitamins (E, K, B group) (Savage and Keenan, 1994).

During storage, groundnut pods/seeds are susceptible to the attack of many insect pests including groundnut seed beetle (Bruchid), *Carryedon serratus* (Olivier). The grubs of *C. serratus* mostly cause damage to the kernels (Devi and Rao, 2005; Singh *et al.,* 2002). In northern Nigeria alone, yield loss of groundnut due to *C. serratus* infestation is estimated at 150,000 - 250,000 tons annually, resulting to several million naira loss to the country (Dick, 1987; IITA, 2001). It has been reported that under artificial infestation, *C. serratus* could give up to 80 and 90% loss on unshelled and shelled groundnuts, respectively within three months of storage (NAERLS, 2006). For protection of groundnut from the infestation of *C. serratus*, various synthetic insecticides and fumigants have been used. However, the negative environmental impacts, increasing cost of application, development of resistant strains and erratic supply due to foreign exchange constraints (Schwab *et al.*, 1995: Don-Pedro, 1990) have necessitated research interest on the development of alternative methods of insect control measures. To minimize the use of these insecticides, the use of plant products to control insect pest population has been advocated. The oil extracts obtained from Clove, West Africa Black Pepper and Ethiopian pepper have been reported to be effective in the control of stored product pest (Ajayi and Wintola, 2006; Olonisakin *et al.,* 2007). The present study was undertaken to assess the extracts of three edible oils of Clove, *Syzygium aromaticum* (L.) Merril and Percy, West African Black Pepper, *Piper guineense* Schum and Thonn and Ethiopian Pepper, *Xylopian aethiopica* (Dunn) A. Rich for the control of the groundnut seed beetle, *Caryedon serratus* (Olivier).

Materials and Methods

Location and Period of the Experiments

The experiment was carried out in the Agronomy Laboratory, Faculty of Agriculture, Nasarawa State University Keffi, Shabu-Lafia Campus, (08^{o}-33^{o}N and 08^{o}-32^{o}E) Nasarawa State of Nigeria, between June-September, 2013.

Preparations of Plant Materials and Oil Extraction

One hundred and fifty grammes of each of WABP *(Pipper guineense* Schum and Thonn) dried fruits of clove (*Syzgium aromaticum* L. Merril and percy) and dried fruits of Ethiopian pepper (*Xylopian aethiopica* (Dunn A. Rich) were purchased from the open market in Lafia, North Central, Nigeria. The seeds and fruits were separately ground into coarse powder and steam distilled in a claverger glass apparatus. Distillation was carried out for five hours in the Chemistry laboratory of Nasarawa State University, Keffi, Nigeria. The process yielded on the average 0.83% of *P. guineense* 7.4% *S. aromaticum* and 1.2% *X. aethiopica* ml of oil. The distilled oil was collected into a 50 ml glass jar and stored at laboratory temperature until ready for use.

Preparation of Groundnut Pods

Ten kilogram (10 kg) of clean and unifested stored groundnut pods of improved variety (Samm nuts 20-20) was purchased from Nasarawa Agricultural Development Programme (NADP), Nasarawa State. Pristine pods were fumigated with one tablet of phostoxin in an airtight enclosure for 72 hours to kill any insect pests harbouring in the seeds. Thereafter, the groundnut pods were aired in the laboratory under screen for three days to allow dissipation of the fumigant effect. The groundnut pods were kept in jute bags until ready for use.

Insect Culture

Ten kilogram (10 kg) of batch of infected local groundnut pods (Dandama) was purchased from Lafia market. The infested groundnut pod batch was sub-divided into two 6.5 litre polypropylene containers and covered at the mouth with a screen measuring 0.05 x 0.05 mm wire mesh. This culture was kept at a room temperature 32^0C and relative humidity 78%, for the adults to multiply. The emerging adults of *C. serratus* were further sub-cultured on an untreated groundnut pods under the same laboratory condition. Bruchids that emerged from this culture were used for the bioassay test at the 4^{th} filial generations.

Experimental Procedures

The experiment comprised of four treatments and an untreated control, with four replications. Extracts from the three edible oils (Clove, WABP and Ethiopian pepper) were weighed into (3 ml) glass jar using an electronic Laboratory scale (METTLER A.E) at four treatment levels, 0.5, 1.0, 1.5 and 2.0 mg respectively. The different dosage rates were carried in 1.5 ml of analytical grade acetone and applied onto the 70 g of groundnut pods in the glass jar (0.65 lt) bottle with lids. After application of the oil, the glass jar was stirred very well in order to have even spread of the oil over the groundnut pods. The glass jar containing the groundnut pods was left open in order for the acetone to evaporate or escape into the air. Afterwards, ten pairs of 1-2 day old adult *C. serratus* (male and female) were introduced into each of the glass jar containing the groundnut pods.

Effect of three edible plant product oils on mortality of *C. serratus*

The effect of the three edible oils to cause mortality on *Caryedon serratus* was determined at every 12 hours for seven days at the different dosage rates. At each time of observation in the treatments, dead *C. serratus* were removed and recorded. On the seventh day both live and dead *C. serratus* still remaining in the treatments were counted and removed.

Effect of three edible plant product oils on oviposition of *C. serratus*

On the seventh day, ten pods of groundnuts from each of the treatments with WABP, Clove and Ethiopian pepper were picked at random in order to examine and count the number of the eggs laid on each groundnut pods by the use of hand lens and recorded separately and appropriately.

Effect of three edible plant product oils on adult emergence of *C. serratus*

F_1 progeny that emerged in each glass jar containers was removed and recorded for fourteenth twelve consecutive days. On the fourteen day, all the *C. serratus* present in each glass container and treatments were removed in order to be able to determine the F_2 progeny. The F_2 progeny that emerged were also recorded and removed from the container, upto the fourteenth day.

Effect of *C. serratus* on Percentage Weight Loss of groundnut pods

The initial weight of the improved groundnut pod was taken and the final weight of groundnut was also taken, respectively in each treatment. The weight loss was determined by the formula below:

$$\text{Percentage weight loss} = \frac{\text{initial weight-final weight}}{\text{Initial weight}} \times 100$$

Data analysis

Data collected includes percentage mortality, weight loss and number of eggs laid in each glass jar container, progeny emergence in each treatment for F1 and F2 generations. All the bioassay test were laid out in a completely randomized block design with four replications. Data collected were subjected to one way analysis of variance (ANOVA). All percentage data were transformed and differences between means were compared using the Least Significant (LSD) test at P<0.05.

Results And Discussion

The results in Table 1 showed that the plant oils significantly deterred egg laying by the groundnut seed bruchid, *C. serratus* Olivier. There was significant difference (P<0.05) between the different treatment levels (0.5 1.0, 1.50 and 2.0 mg). Generally, there was significant difference (P<0.05) in the groundnut seed pods treated with the edible plant product oils (Clove, WABP and Ethiopian Pepper). On the average, the efficacy of the edible plant product oils were dose dependent, with corresponding lower eggs being laid as the dosage rates increased. However, the differences between the dosage rates of 1.50 and 2.0 mg/70 g was not significant (P<0.05) as can be seen in Table 1.

This study is in conformity with the findings of Oparaeke and Aria (2005); and Ofuya (1990) which also showed that *S. aromaticum* significantly (P<0.05) deterred oviposition by *C. maculatus*. Edible plant powders from the three plant products have also been reported to deterred oviposition by the cowpea bruchid (Ajayi and Wintola, 2006). Olonisakin *et al.* (2007) also reported the deterrence effect of extracted oil from clove, WABP and Ethiopian pepper on *C. maculatus. C. serratus* and *C. maculatus* are in no doubt, shared the same biology; hence the effect of the oils of the plant products was effective on suppressing the oviposition of *C. serratus*. In the mortality test, there were no significant differences (P>0.05) among the three oils as to their effect on the mortality of the adult bruchids. There was however, significance difference (P<0.05) among the effect of the dosage rates to cause mortality on *C. serratus* adults. At the highest dosage rate, the plant oils caused significantly (p<0.05) more number of adult *C. serratus* mortality when compared to the treatments in the control (Table 2). In mortality studies involving products obtained from other plant species, it has been reported that insect mortality could be due to the biologically active components of the plant products. For instance, Purseglove (1979) reported that the efficacy of clove against pests could be attributed to the presence of eugenol, an active ingredient in clove which has an insecticidal activity against pests. Don-Pedro (1990) reported that different acids contained in fixed vegetable oils are responsible for the biological efficacy of this class of plant oils and Obeng-Ofori and Reichmuth (1997) have shown that eugenol a major active ingredient in most essential oils confers the ability to cause mortality in most stored products pests. Although, this aspect was not investigated in the present study, it is reasonable to suggest that the toxic effects of the plant oils are probably caused by the active ingredients.

It has been suggested that some plant products release volatile oils when crushed (Lale, 1992). The volatile oils contained in the edible plant products might be the source of mortality action in the edible essential oils used on the groundnut seed bruchid. Active principles contained in the three plant products have been reported to be eugenol found in clove, B-phelladine, α-pinene and eucalyptol are the major constituents found in Ethiopian pepper while limoneme and α-peperine are the major compounds found in WABP (Olonisakin *et al.,* 2005; Olonisakin *et al.,* 2006; Olonisakin *et al.,* 2007). Some of these compounds are believed to be responsible for the insecticidal activity of the three essential oils in causing mortality to the groundnut seed bruchid.

Table 3 shows the emergence of adult *C. serratus* during the F_1 and F_2 progeny emergence among the treated and untreated seeds. The emergence of First generation adult bruchids was not significantly different (P>0.05) among the treatment oils. However, number of adult that emerged in the untreated grains (control) was significantly (P<0.05) higher than those recorded for treated seeds. There was relatively low number of adult emergence in all the treatment levels. Generally, number of adult emergence decreased with increase in dosage level. Emergence of the second generation of adult bruchid was significant among the treatment levels. Number of adults that emerged in seeds treated with Ethiopian pepper and Clove were lower when compared with seeds treated with WABP and this was not significantly different from each other (P=0.005). Adult emergence decreased with increase in dosage levels of the oil. The effect of the oil significantly deterred egg laying by *C. serratus* at the various dosage rates and this culminated in high egg mortality which significantly resulted in deterred adult emergence during the F_1 and F_2 progeny of groundnut seed beetles (Tables 2 and 3).

The results of this study have shown that groundnut pods can be protected with clove, WABP and Ethiopian pepper before infestation is initiated by the groundnut seed beetle, *Carryedon serratus* in stored groundnut pods. The reduction in progeny emergences was as a result of significant reduction in viable eggs that can give rise to new adults. Reduction in the number of progenies of *C. serratus* treated with the edible product oils therefore appears to have been achieved mainly through increased mortality of first instar larvae. Credland (1992) had earlier reported that plant oils have the ability to penetrate the chorion of insect eggs via the micropyle and cause the death of developing embryos through asphyxiation thus reducing the number of potential adult emergence. Lale and Mustapha (2000) had also shown that successful infestation by species of Bruchidae is determined by the number of eggs that hatch and the number of first instar larvae that are able to penetrate the cotyledons of pulse seeds. Plant extracts are widely known to cause significant mortality of first instar larvae when used to protect against infestation (Boughdad *et al.*, 1987; Lale, 1995; Lale and Mustapha, 2000). The efficacy of *X. aethiopica* seems to agree with the previous findings of Orji (1994) in which it was reported that cowpea and maize grain inoculated with weevils and treated with the ground seeds of *X. aethiopica* were free from infestation after 3 months of post infestation.

Conclusion

In this study, Ethiopian pepper, WABP and Clove at 0.5, 1.0, 1.5 and 2.0 mg per 70 g of groundnut were found to be effective for the control of *C. serratus*. Therefore, it is very important that groundnut seed/pods should be treated before storage. Also, considering their availability, safety, low cost and low technological requirement in processing as against the synthetic insecticides, there is need for their adoption as preservative or protectant of groundnut seeds/pods. It is also important to ascertain the quality in terms of general biological and chemical properties. The plant oils are also recommended for future trials in the control of other stored product insect pests wherever the plants are available.

Table 1 Mean Number of Eggs Laid by *C. serratus* Olivier on Groundnut Seeds Treated before Infestation with Edible Essential Oils of three Spices

	Sources of Oil			
Dosage of Oil (mg/10g)	Ethiopian pepper	Clove	WABP	Mean
0.00(control)	48.00	59.50	48.75	52.08
0.50	17.50	36.75	27.50	27.25
1.00	11.50	12.50	18.50	14.17
1.50	7.00	9.50	5.00	7.17
2.00	4.75	6.50	4.00	5.08
Mean	17.75	24.95	20.75	
	Significance	SEM	$LSD_{0.05}$	
Dosage	<0.001	0.115	0.328	
Oil source	<0.001	0.089	0.254	
Dosage x Oil source	<0.001	0.199	0.569	

Table 2 Mortality Rate of *C. serratus* Olivier from Groundnut Seeds Treated with Essential Oils of three Spices.

	Sources of Oil			
Dosage of Oil (mg/10g)	Ethiopian pepper	Clove	WABP	Mean
0.00(control)	0.00	0.00	0.71	0.24
0.50	1.07	2.14	0.71	1.31
1.00	3.21	4.64	2.50	3.45
1.50	6.43	7.86	6.43	6.91
2.00	9.29	10.36	8.93	9.53
Mean	0.40	0.50	0.386	
	Significance	SEM+	$LSD_{0.05}$	
Dosage	<0.001	0.621	1.729	
Oil source	0.189	0.481	NS*	
Dosage x Oil source	0.978	0.108	NS	

NS* = Not significant

Table 3 Generation of Adult Emergence of *C. serratus* Olivier from Groundnut Seeds Treated with Essential Oils three Spices.

Dosage rate(mg/10g)	F1-Generation			F2-Generation		
	Ethiopian pepper	Clove	WABP*	Ethiopian pepper	Clove	WABP*
0.00 (control)	3.833	4.021	4.375	2917	3.021	2958
0.50	2.75	2.50	2.479	1.813	1.813	1.813
1.00	1.646	1.688	1.583	0.896	1.063	1.063
1.50	1.104	1.104	1.042	0.583	0.708	0.625
2.00	0.729	0.708	0.729	0.292	0.396	0.354
	Significant	SEM+	LSD0.05		SEM+	$LSD_{0.05}$
Dosage	<0.001	0.078	0.217	<0.001	0.058	0.160
Source of oil	0.900	0.061	NS**	0.279	0.045	NS
Dos. X Sou.	0.206	0.135	NS	0.996	0.103	NS

*West African Black Pepper
**Not significant

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