Journal of Entomology

ISSN 1812-5670

Academic Journals Inc.

www.academicjournals.com

Journal of Entomology 3 (1): 40-47, 2006
ISSN 1812-5670

Efficacy of Rubber Seed Oil, Palm Oil and Palm Kernel Oil as Grain Protectants against *Sitophilus zeamais* (Mots.) (Coleoptera: Curculionidae) in three Maize Varieties

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Abstract: The efficacy of rubber seed oil, palm oil and palm kernel oil as maize grain protectants against S*itophilus zeamais* was tested on three maize varieties ['Uselu' local, SUWAN-1 and Oba Super 1 (8321-18) using a 3x5x3 factorial arrangement in a Randomized Complete Block Design. There were four replications of each of the vegetable oils using application levels of 0, 2.5, 5.0, 7.5 and 10.0 mL kg^{-1} maize grain. All studies were undertaken under laboratory temperature of 28±3% r.h. Fifteen sexed adult insects were used for each replicate. In all the treatments, a range of significant percentage mortality of adult weevils (55-93%) at 21 days after treatment was obtained ($p<0.05$). Mean percentage adult weevil mortality in treated grain (70.5%) was significantly higher than in the control (0.0%). The treated grains gave adequate protection by having lower oviposition (19.8%) than the untreated control (94.5%). This was also observed to have lower adult weevil emergence (8.9%) than the untreated control (85.3%). The vegetable oils gave appreciable reduction in percentage weight loss (2.2%) when compared with the untreated control (47.3%) and had no adverse effects on grain quality. From the study, the plants could be ranked in order of effectiveness thus: rubber seed oil > palm oil> palm kernel oil. The "Uselu" local was found to be more resistant to maize weevil infestation than the improved varieties (SUWAN-1) and Oba super 1 (8321-18).

Key words: Adult weevil emergence, mortality, protectant, *Sitophilus zeamais*, viability, vegetable oils, oviposition, weight loss

Introduction

Maize is usually stored to provide viable grains for human and livestock consumption as well as for planting. The loss of maize grains during storage due to insect pests like *Sitophilus zeamais* (Mots.) has long been a serious problem to farmers in Nigeria. Loss of maize grain caused by *S. zeamais* means that the resources such as time, labour and money spent in growing the crop are wasted (Okelana and Osuyi, 1984).

Various technologies (e.g., use of insecticides) are being used to reduce post harvest losses in Sub-Saharan Africa. Most of these are financially beyond the reach of the resource poor farmers. Furthermore, these technologies do not always take into account such factors as the maize varieties

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grown and local materials available to effectively deal with the pests. These factors, among others are known to affect to a large extent, the storage performance or susceptibility of the crop to maize weevil.

In recent years, many workers have given greater attention to the control of stored grain pests using vegetable, essential and mineral oils. Cowpea mixed with oils of coconut, palm kernel (Naik and Dumbre, 1984) and rubber seed oil (Onolemhemhen, 1990), remain unattacked and undamaged. Pereira (1983) evaluated six vegetable oils as protectants for cowpea and Bambara nut. Su (1977) studied insecticidal activity of black pepper on *S. oryzae* (L.) and *Callosobruchus maculatus* (F.). Enobakhare and law-Ogbomo (2002) evaluated some plant products as protectants against maize weevil and equally proved successful.

This study has focused on the potential use and efficiency of rubber seed oil, palm oil and palm kernel oil as grain protectants for reduction of post harvest losses caused by *S. zeamais* in three selected maize varieties.

Materials and Methods

The three maize varieties used for this study were Oba super 1 (8321-18) from National Seed Service, SUWAN-1 from Ministry of Agriculture, Benin and 'Uselu' local from open market in Benin City, Nigeria. The grains were sun dried to a constant weight for four weeks and then placed in large transparent polythene bags. Grain moisture equilibration at 70±3% rh by the method of Dobie (1984). The three maize varieties were sterilized before they were used for the trial by cleaning the grains in 70% ethanol solution to free them from any pre-infestation (Pereira, 1983).

Oils of rubber seed, palm and palm kernel were added to the maize grains at the rates of 0, 2.5, 5.0, 7.5 and 10.0 mL kg^{-1} in a kilner jar and mechanically shaken for 5 min. Each treatment, including the comprised four replicates (4 jars) to each of which control was added batches of fifteen 1-3 days old (sex ratio 2:1 i.e., 10:5.) weevils taken from a laboratory culture maintained on 'Uselu' local. Mortality assessments were recorded 2, 3, 5, 6, 7, 10, 14, 17 and 21 days after exposure to treatment. Dead weevils, which showed no visible movement after 20 sec were recorded. After the 21 days assessment, all adult weevils were removed from the kilner jars in anticipation of the emerging F_1 progeny. At the end of the 21 days period, cumulative data on percentage adult weevil mortality were corrected using Abbot's (1925) formula, thus,

$$P_T = \frac{P_0 - P_c}{100 - P_c} \times 100$$

Where:
P_T = Corrected mortality%,
P_0 = Observed mortality and
P_c = Control mortality%.

At the end of 21 days period, the effect of vegetable oils on the reproductive capacity was determined by the use of egg plug staining technique (Ivbiaro, 1984). The F_1 progeny population was assessed on daily basis and removes up to a period of 4 weeks after the initial 21 days period. After period no weevil were emerging, four weeks after that period, the contents of each jar were sieved to remove the dust, frass and any insect present in the grains. Grains were re-weighed and the percentage loss in weight was computed thus:

$$\%Wt.\ Loss = \frac{(W_I - W_F)\ 100}{W_t}$$

Where:
W_I = Initial weight
W_F = Final weight

Viability of the grains was tested in petri dishes (9 cm diameter) lined with moist filter paper. Fifty grains were randomly selected from every treatment and placed in the petri dish for 96 h. The dishes were watered after 48 h. The grains used for viability test were those previously exposed to weevils in the study. The percentage of the germinated grains treatment gave an indication of the relative viability of the seed.

Data collected on percentages were subjected to Arc sine transformation while others were subjected to Log_{10} transformation before using analysis of variance and means were separated using Turkey's procedure as contained in the STATVIEW package used for the analysis of these data. However, data were transformed back to the original data and presented in Table 1-4.

Results and Discussion

This different properties and origin apart, the oils were amazingly effective in causing adult weevil mortality. This mortality may be attributed to a physical barrier to respiration as the oil blocks the spiracles, thus impairing respiration, respiration, repellents by constituents, starvation and desiccation (Don-Perdo, 1990; Hall and Harman, 1991; Dale, 1996; Onolemhenhen, 2001). At different dosages, for the three oils, *S. zeamais* responded linearly with mortality increasing to 70.5% at the highest concentration of 10 mL kg^{-1}. However, the rubber seed oil had the greatest impact compared with palm oil and palm kernel oil.

With respect to the three varieties of maize used, mortality of *S. zeamais* was recorded as highest in Uselu local (82.5%) followed by SUWAN-1 (72.3%) and Oba super 1 (8321-18) (62.4%) (Table 1). Evidently, it can be confirmed that the indigenous maize varieties traditionally grown by

Table 1: Mortality of *Sitophilus zeamais* as exposed to vegetable oils in three maize varieties

Maize variety	Oil	Dosage mL kg^{-1} grain	Mean % mortality ($n = 4$; $p<0.001$)*	Variety
Uselu Local	Rubber seed oil	0	0^{f}	
		2.5	75^{c}	
		5.0	80^{bc}	
		7.5	89^{b}	
		10.0	93^{a}	
	Palm oil	0	o^{f}	
		2.5	68^{c}	
		5.0	78^{c}	
		7.5	84^{b}	
		10.0	90^{ab}	
	Palm kernel oil	0	0^{f}	
		2.5	66^{c}	
		5.0	75^{c}	
		7.5	79^{bc}	
		10.0	91^{b}	82.5ns
SUWAN-1	Rubber seed oil	0	o^{f}	

Table 1: Continued

Maize variety	Oil	Dosage mL kg^{-1} grain	Mean % mortality (n = 4; p<0.001)*	Variety
		2.5	0^{d}	
		5.0	69^{cd}	
		7.5	80^{bc}	
	Palm oil	0	0^{f}	
		2.5	60^{d}	
		5.0	65^{d}	
		7.5	73^{c}	
		10.0	86^{b}	
	Palm kernel oil	0	0^{f}	
		2.5	60^{d}	
		5.0	64^{d}	
		7.5	70^{cd}	
		10.0	78^{c}	72.3ns
Oba Super 1 (8321-18)	Rubber seed oil	0	O^{f}	
		2.5	60^{d}	
		5.0	64^{d}	
		7.5	70^{cd}	
		10.0	75^{c}	
	Palm oil	0	o^{f}	
		2.5	58^{d}	
		5.0	63^{d}	
		7.5	68^{cd}	
		10.0	73^{c}	
	Palm kernel oil	0	o^{f}	
		2.5	55^{e}	
		5.0	63^{d}	
		7.5	70^{cd}	
		10.0	73^{c}	62.4ns
Treatment mortality =		70.5%	Control mortality 0%	C.V = 2.5%

* All vegetable oil treatments were significantly different from control at p<0.00 means followed by a common letter (s) are not significantly different at 5% probability level (comparison made only vertically)

resource-poor farmers are at least more moderately resistant to attack by maize weevils than the improved high yielding varieties (Enobakhare and Ogbomo, 2002).

Results from the use of egg plug staining technique revealed that *S. zeamais* deposited very few eggs on grains in jars in all the treatments. Application of vegetable oil at all levels significantly reduced oviposition (p<0.001). Thus, oviposition was highest with untreated control (94.5%) compared with all treated grains (19.8%) (Table 2).

The phenomenon of adult emergence from punctured grains by *S. zeamais* is an index of susceptibility. The reduction or complete avoidance of this by any substance innocuous to man is the objective of the main this trial. Hence, it was remarkable to observe that the vegetable oils used had a tremendous effect on *S. zeamais* adult emergence. With treated grains, emergence was 8.9% compared with the untreated control which gave 85.3% (Table 2). Using Uselu local with 10 mL kg^{-1} application of rubber seed and palm oil, no adult weevil emerged. The significantly reduced percentage adult weevil emergence in treated grains could have resulted from the action of ovicidal and larvicidal properties of the oils used which normally leads to suffocation (Hall and Harman, 1991). This reaction was earlier noted by Don-Pedro (1989) who postulated that egg mortality was caused by the physical properties of the oil coating which blocked respiration rather than by a specific chemical effect.

Overall, percentage weight loss of the weevil in treated grains was exceedingly lower (2.2%) than that recorded from treated control (47.3%) (Table 3). Grains treated with rubber seed oil, palm oil and

Table 2: The effect of oils of Rubber seed, palm fruit and palm kernel on oviposition and percentage emergence of *Sitophilus zeamais* in three maize varieties

Maize variety	Oil	Dosage (mL kg^{-1})	Nos of egg laid (n = 4; p< 0.001)*	Means % adult emergence (n = 4; p<0.001)	Variety mean
Uselu local	Rubber seed oil	0	90.5^{a}	82.1^{a}	
		2.5	20.2^{b}	10.3	
		5.0	10.3^{b}	5.2^{c}	
		7.5	8.4^{c}	2.6^{c}	
		10.0	5.2^{c}	0^{d}	
	Palm oil	0	90.3^{a}	84.1^{a}	21.1^{c}
		2.5	25.2^{b}	11.2^{b}	
		5.0	13.6^{b}	6.8^{c}	
		7.5	9.3^{c}	4.2^{c}	
		10.5	6.2^{c}	0^{d}	
	Palm kernel oil	0	90.8^{a}	84.6^{a}	
		2.5	26.3^{b}	11.2^{b}	
		5.0	14.2b	7.0 c	
		7.5	8.4c	4.5c	
		10.0	6.2c	2.3c	
SUWAN-1	Rubber seed oil	0	91.2^{a}	84.8^{a}	
		2.5	27.4^{b}	12.1^{b}	
		5.0	16.1^{b}	8.1^{c}	
		7.5	9.3^{c}	4.8^{c}	
		10.0	6.3^{c}	2.5^{c}	
	Palm oil	0	91.1^{a}	84.6^{a}	23.3^{b}
		2.5	28.1^{b}	13.0^{b}	
		5.0	16.4^{b}	8.3^{c}	
		7.5	9.6^{c}	5.1^{c}	
		10.0	6.5^{c}	2.8^{c}	
	Palm kernel oil	0	91.3^{a}	84.3^{a}	
		2.5	28.4^{b}	13.4^{b}	
		5.2	16.7^{b}	8.5^{c}	
		7.5	9.7^{c}	5.6^{c}	
		10.0	6.7^{c}	3.1^{c}	
Oba super 1 (8321-18)	Rubber seed oil	0	94.3^{a}	84.9^{a}	
		2.5	28.4^{b}	13.6^{b}	
		5.0	17.4^{b}	8.5^{c}	
		7.5	9.8^{b}	5.8^{c}	
		10.0	6.8^{b}	3.3^{c}	
	Palm oil	0	94.3^{a}	85.1^{a}	26.3^{b}
		2.5	28.1^{b}	13.8^{b}	
		5.0	17.8^{b}	8.8^{c}	
		7.5	10.1^{b}	5.9^{c}	
		10.0	7.2^{b}	3.5^{c}	
	Palm kernel oil	0	94.3^{a}	85.2^{a}	
		2.5	28.4^{b}	14.1^{b}	
		5.0	17.8^{b}	8.8^{b}	
		7.5	10.5^{b}	5.9^{b}	
		10	7.2^{b}	3.8^{b}	

Treatment number of egg laid = 19.8%, Treatment adult emergence = 8.9% , Control number of egg laid = 94.5%, Control adult emergence = 85.3%,

*All vegetable oil treatments were significantly different from control at p<0.00 means followed by a common, letter (s) are not significantly different at 5% probability level (comparison made only vertically)

palm kernel oil gave appreciable reduction in weight loss in that order. However, the oils were more effective at higher dosages ensuring lowered oviposition and F_1 adult emergence in the treated grains. Among the maize varieties, the "Uselu" local was observed to have the least percentage weight loss indicating that it is more resistant to weevil damage than either the Oba super 1 (8321-18) or

Table 3: Weight loss % caused by *Sitophilus zeamais* as influenced by vegetable oil in three maize varieties

Maize variety	Oil	Dosage (mL kg^{-1})	Means % weight loss (n=4; p<0.001)	Variety means
"Uselu" Local	Rubber seed oil	0	46.8^{b}	
		2.5	2.4^{b}	
		5.0	1.4^{b}	
		7.5	0.2^{b}	
		10.0	0.1^{b}	
	Palm oil	0	46.8^{a}	
		2.5	2.8^{b}	
		5.0	1.6^{b}	
		7.5	0.5^{b}	
		10.0	0.1^{b}	
	Palm Kernel oil	0	4 6.7^{a}	10.5^{c}
		2.5	2.9^{b}	
		5.0	1.8^{b}	
		7.5	1.5^{b}	
		10.0	0.2^{b}	
SUWAN-1	Rubber seed oil	0	48.1^{a}	
		2.5	2.6^{b}	
		5.0	2.1^{b}	
		7.5	1.6^{b}	
		10.0	0.4	
	Palm oil	0	48.5^{a}	
		2.0	2.8^{b}.	
		5.0	2.2^{b}	
		7.5	1.4^{b}	
		10.0	0.6^{b}	
	Palm kernel oil	0	48.3^{a}	13.4^{B}
		2.5	2.8^{b}	
		5.0	2.3^{b}	
		7.5	1.8	
		10.0	1.7	
Oba super 1 (8321-18)	Rubber seed oil	0.0	48.9^{a}	
		2.5	2.9^{b}	
		5.0	2.3^{b}	
		7.5	1.7^{b}	
		10.0	0.8^{b}	
	Palm oil	0	48.7^{a}	
		2.5	2.9^{b}	
		5.0	2.4^{b}	
		7.5	1.8^{b}	
		10.0	0.8^{b}	
	Palm kernel oil	0	48.8^{a}	15.3A
		2.5	2.9^{b}	
		5.0	2.6^{b}	
		7.5	2.0^{b}	
		10.0	1.2^{b}	

Treatment weight loss = 2.2%. Control weight loss = 47.3% , CV: 4.2% , * Means followed by common letter (s) are not significantly different at 5% probability level (comparison made only vertically)

SUWAN-1. Oba super 1 (8321-18) was found to be the most susceptible to weevil infestation and also had the highest weight loss. This study has confirmed more convincingly the previous findings, which the improved maize varieties do poorly in storage when compared, with indigenous unimproved crop grains (Enobakhare and Law-Ogbomo, 2002; Ivbino, 1984).

On testing for seed viability after treatment, the treated grains had 58.2% germination as against untreated control (30.2%) (Table 4). Rubber seed oil with application of rate of 10 mL kg^{-1} gave the highest percentage germination (80%). It is noteworthy that the oil treatments had no adverse effect

Table 4: The effect of vegetable oils and variety on viability

Variety	Oil	Dosage (mL kg^{-1})	% viability
Uselu local	Rubber seed oil	0	32
		2.5	50
		5.0	54
		7.5	60
		10.0	80
	Palm oil	0	30
		2.5	50
		5.0	52
		7.5	58
		10.0	70
	Palm Kernel oil	0	28
		2.5	48
		5.0	50
		7.5	58
		10.0	72
SUWAN-1	Rubber seed oil	0	30
		2.5	43
		5.0	50
		7.5	58
		10.0	68
	Palm oil	0	32
		2.0	46
		5.0	50
		7.5	62
		10.0	68
	Palm kernel oil	0	30
		2.5	44
		5.0	48
		7.5	58
		10.0	64
Oba super 1 (8321-18)	Rubber seed oil	0	32
		2.5	42
		5.0	46
		7.5	52
		10.0	60
	Palm oil	0	34
		2.5	40
		5.0	48
		7.5	52
		10.0	60
	Palm kernel oil	0	28
		2.5	40
		5.0	46
		7.5	50
		10.0	54

Treatment germination mean: 58.2%, control germination mean: 30.2% overall mean: 45.3% CV: 4.8% SE 0.36%

on the viability of grains at all levels of application this indicating that such oils could reduce infestation of stored grains pests without causing any adverse on grain quality.

Vegetable oils are available in areas where other forms of protection against insect pests of stored products are difficult to obtain. Obvious benefits of using oils are their low cost and apparent minimal health risk to resource-poor farmers. The oils of rubber seed, palm fruit and palm kernel will therefore be very useful as components of integrated storage pest management in reducing post-harvest losses experienced by resource-poor farmers.

Acknowledgements

I would like to extend my gratitude to my employer for placing her facilities at my disposal and for sponsoring this trial. I got many suggestions, information, materials and kind co-operation from my fellow staffs for conducting this trial and preparation of this report.

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