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The Use of Vegetable Oils in the Control of *Callosobruchus maculatus* (F) (Coleoptera: Bruchidae) in Three Cowpea Varieties

K.E. Law-Ogbomo and R.K.A. Egharevba
Department of Crop Science, Faculty of Agriculture,
University of Benin, PMB 1154, Benin City 300001, Nigeria

Abstract: The use of some of vegetable oils (rubber seed oil, palm oil and palm kernel oil) was evaluated against cowpea weevil, *Callosobruchus maculatus* in three cowpea varieties (Ife white, Ife brown and Kano white). The trial involved exposing adult weevils to various levels of 0, 2.5, 5.0, 7.5 and 10.0 mL kg^{-1} of the oil admixed with cowpea seeds. All studies were undertaken under laboratory temperature of 28±3°C and 70±3% r.h. The results showed that all the plant oils tested have toxic effect on weevils in all cowpea varieties. The oil treatments showed significantly high ($p<0.001$) mortality of adult weevils (72-100%) at 10 Days after Treatment (DAT). Mean percentage adult weevils mortality in the treated grain (82.5%) was significantly higher than in the untreated control (0%). The treated grains gave adequate protection by recording lower oviposition (10.3%) than the untreated control (96.3%). Lower adult weevils' emergence (6.3%) was also associated with the treated grains as against untreated grains (88.2%). The plant oil treatments also significantly ($p<0.001$) reduced weight loss (2.1%) and grain damaged (9.1%) as compared with untreated control of (48.2%) and (93.2%) in weight loss and grain damaged, respectively. There was no adverse effect of the oils on grains quality. Of the three plant oils used, rubber seed oil was the most effective. Among the varieties used in this study, Ife brown was more resistant to cowpea weevil infestation than Ife white and Kano white in that order.

Key words: *Callosobruchus maculatus*, oviposition, plant oils, viability, weight loss

INTRODUCTION

Cowpea is usually stored to provide viable grains for human consumption as well as for planting. The loss of cowpea grains during storage due to insect pests has long been a serious problem to growers. In Nigeria, cowpea is a stable crop being a very good source of plant protein and *Callosobruchus maculatus*, the major storage pest (Mital, 1971). Loss of cowpea grains caused by *C. maculatus* means that the resources such as time, labour and money spent in growing the crop are wasted.

Various technologies which include the use of convectional insecticides are being used to reduce post harvest losses in Nigeria. Most of these are financially beyond the reach of the resource-poor growers. Furthermore, these technologies do not take into account such factors as cowpea varieties grown and local materials available to effectively deal with the pest. In addition to this is that the use of convectional insecticides had been known to be associated with weevil resistance, pollution, persistent and toxic to mammals and higher plants (Hall and Harman, 1991). These factors among other are known to affect to a large extent, the storage performance or susceptibility of the crop to cowpea weevil.

In recent years, many workers have given greater attention to the control of stored grain pests using vegetable, essential and mineral oils. Cowpea admixed with oils or coconut oil and palm kernel oil was demonstrated by Naik and Dumbre (1984) to be effective in the control of cowpea weevil. Onolemhemhem (2001) successfully protected rice grains against *Sitophilus oryzae* and the grains remained unaffected and undamaged. Pereira (1983) successfully evaluated six vegetable oils as protectants for cowpea and bambara nut. Su (1977) studied insecticidal activity of black pepper on *Sitophilus oryzae* (L.) and *C. maculatus*. Most of these trials mainly confound that natural products are useful in the control of stored pests. They didn't take into account the crop varieties and their levels of susceptibility to the stored insect pest.

This present study was carried out to evaluate the insecticidal activity and to test the efficacy of rubber seed oil, palm oil and palm kernel oil in protecting grains against damaged by *C. maculatus* in three selected cowpea varieties.

Corresponding Author: Dr. R.K.A. Egharevba, Department of Crop Science, Faculty of Agriculture, University of Benin, PMB 1154, Benin City 300001, Nigeria

MATERIALS AND METHODS

The efficacy of some plant oils as possible protectant of stored grains were evaluated at Benson Idahosa University, Benin City in 2004. Three cowpea varieties (Ife white, Ife brown and Kanowhite) were used for the trial. All samples were brought to 12% moisture content before used in a laboratory at a temperature of 28±3°C and 70±3% r.h. cultures of *C. maculatus* were maintained on Ife white variety from which batches of fifteen 1-2 day old (sex ratio 2:1 i.e., 10:5) weevils were removed and added to each kilner jar. Before the weevils were added to the kilner jar, oils of rubber seed, palm oil and palm kernel were added to the cowpea at the rates of 0, 2.5, 5.0, 7.5 and 10.0 mL kg^{-1} in a kilner jar, which was shaken to spread the oil uniformly (Onolemhemhem, 2001).

Mortality assessments were done every day until the 10 day after the exposure to treatment. Dead adult weevils being those which showed no visible movement after 20 sec observation time were removed and recorded. Following 7 days assessments, all adult weevils were removed from the kilner jars in anticipation of emerging F_1 progeny. At the end of the 7 day period, cumulative data on percentage adult weevil mortality were corrected using Abbott's (1925) formula as cited in Enobakhare and Law-Ogbomo (2002).

The effect of plant oils on the reproductive capacity of the cowpea adult weevils was determined by careful observation of each grains from each treatment on every day basis until, the adults start emerging from the seeds. The ovicidal and the larvicidal properties of the plant oils were determined by comparing the emerging F_1 adult weevils with the number of eggs lay after 180 DAT (Enobakhare and Law-Ogbomo, 2002).

The effect of plant oil treatments on cowpea grain was assessed from the percentage weight loss, percentage damaged grains and percentage germination which was obtained through germination test. Viability of the grain 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 from previously exposed to weevils (Enobakhare and Law-Ogbomo, 2002).

Data collected were analysed using analysis of variance and means separated using Turkey's Procedure as contained in SYSTAT programme version 11.

RESULTS

From the trial, it was observed that the tested oils caused adult weevil mortality with a percentage mean of 82.5% as compared to untreated control (0%) (Table 1).

Table 1: Mortality *C. maculatus* exposed to plant oils in three local cowpea varieties

Cowpea variety	Plant oil	Dosage (mL kg^{-1})	Means% mortality (n = 4; p<0.001*)	Varietal mean
Ife white	Rubber seed oil	0.0	0.00^{e}	
		2.5	77.00^{c}	
		5.0	80.00^{bc}	
		7.5	93.00^{ab}	
		10.0	94.00^{a}	
	Palm oil	0.0	0.00^{e}	
		2.5	74.00^{cd}	78^{b}
		5.0	77.00^{c}	
		7.5	86.00^{b}	
		10.5	92.00^{ab}	
	Palm kernel oil	0.0	0.00^{e}	
		2.5	72.00^{d}	
		5.0	74.00^{cd}	
		7.5	83.00^{b}	
		10.0	91.00^{b}	
Ife brown	Rubber seed oil	0.0	0^{e}	
		2.5	79.00^{c}	
		5.0	87.00^{b}	
		7.5	97.00^{a}	
		10.0	100.00^{a}	
	Palm oil	0.0	0.00^{e}	85^{a}
		2.5	77.00^{c}	
		5.0	83.00^{b}	
		7.5	97.00^{a}	
		10.0	97.00^{a}	
	Palm kernel oil	0.0	0.00^{e}	
		2.5	76.00^{c}	
		5.2	82.00^{bc}	
		7.5	88.00^{b}	
		10.0	95.00^{ab}	

Table 1: Continue

Cowpea variety	Plant oil	Dosage (mL kg^{-1})	Means% mortality (n = 4; p<0.001*)	Varietal mean
Kano white	Rubber seed oil	0.0	0.00^{e}	
		2.5	75.00^{cd}	
		5.0	78.00	
		7.5	93.00^{ab}	
		10.0	92.00^{ab}	
	Palm oil	0.0	0.00^{e}	72^{c}
		2.5	74.00^{cd}	
		5.0	73.00^{cd}	
		7.5	82.00^{c}	
		10.0	84.00^{b}	
	Palm kernel oil	0.0	0.00^{e}	
		2.5	73.00^{d}	
		5.0	73.00^{d}	
		7.5	84.00^{c}	
		10.0	90.00^{b}	
Treatment mortality = 82.5%	Control = 0%	CV: 4.5%		

*Mean followed by a common letter(s) is not significantly different at 0.1% probability level (comparison made vertically)

Table 2: Effect of plant oils oviposition and emergency of *C. maculatus* in three local cowpea varieties

Cowpea variety	Plant oil	Dosage (mL kg^{-1})	No. of egg laid (n = 4; p<0.001)	Means % adult emergency (n = 4; p<0.001*)	Variety mean
Ife white	Rubber seed oil	0.0	91.3^{a}	83.5^{a}	
		2.5	26.2^{b}	11.4^{b}	
		5.0	13.5^{b}	6.5^{c}	
		7.5	8.4^{c}	6.9^{c}	
		10.0	4.5^{c}	3.5^{d}	
	Palm oil	0.0	91.5^{a}	84.9^{a}	21.5^{b}
		2.5	22.3^{b}	11.7^{b}	
		5.0	10.5^{b}	6.2^{c}	
		7.5	7.4^{c}	3.3^{c}	
		10.5	4.2^{c}	0.9^{d}	
	Palm kernel oil	0.0	91.6^{a}	85.5^{a}	
		2.5	24.3^{b}	11.8^{b}	
		5.0	12.5^{b}	6.4^{c}	
		7.5	7.9^{c}	3.9^{c}	
		10.0	4.5^{c}	1.1^{d}	
Ife brown	Rubber seed oil	0.0	90.3^{a}	85.8^{a}	
		2.5	18.2^{b}	8.8^{b}	
		5.0	7.6^{b}	3.7^{c}	
		7.5	6.5^{c}	0.3^{d}	
		10.0	3.7^{c}	0^{d}	
	Palm oil	0.0	91.5^{a}	87.5^{a}	19.2^{c}
		2.5	25.5^{b}	9.7^{b}	
		5.0	11.5^{b}	4.9^{c}	
		7.5	7.8^{c}	2.4^{cd}	
		10.0	4.4^{c}	0.0^{cd}	
	Palm kernel oil	0.0	92.4^{a}	83.2^{a}	
		2.5	25.5^{b}	9.9^{b}	
		5.0	11.4^{b}	5.8^{c}	
		7.5	5.5^{c}	2.5^{cd}	
		10.0	3.3^{c}	0.4^{d}	
Kano white	Rubber seed oil	0.0	93.5^{a}	84.3^{a}	
		2.5	25.5^{b}	10.9^{b}	
		5.0	14.5^{b}	6.7^{c}	
		7.5	6.5^{b}	3.7^{c}	
		10.0	4.4^{c}	1.4^{d}	
	Palm oil	0.0	93.1^{a}	89.7^{a}	24.3^{a}
		2.5	25.4^{b}	11.7^{b}	
		5.0	12.7^{b}	6.2^{c}	
		7.5	7.9^{b}	3.6^{c}	
		10.0	5.7^{c}	0.9^{d}	
	Palm kernel oil	0.0	93.7^{a}	88.3^{a}	
		2.5	27.7^{b}	12.9^{b}	
		5.0	16.5^{b}	6.7^{c}	
		7.5	8.7^{b}	3.2^{c}	
		10.0	6.8^{c}	1.3^{d}	

Treatment number of egg laid = 10.3%, Treatment adult emergence = 6.3%, Control number of egg laid = 969.3%, Control adult emergence = 6.3%,
*Mean followed by a common letters is not significantly different at 0.1% probability level (comparison made vertically)

Mortality was highest with rubber seed oil at all application levels when compared with palm oil and palm kernel oil in that order. All treatments showed significant in the two-way analysis of variance ($p<0.001$).

Varietals effects on mortality were significant ($p<0.001$). Ife brown had the highest mortality (85%) followed by Ife white (78%) and Kano white (72%). There was significant interaction between variety and plant oils as well as the interaction among the three factors (plant oils, dosage and cowpea varieties).

The treated grains exhibited depressed oviposition (10.3%) as compared to untreated control (96.3%) (Table 2). The vegetable oils also had a suppressive effect on adult emergence of *C. maculatus* (6.3%) as against untreated control (88.2%). Inverse relationship between the adult weevil emergence and the vegetable application level (Table 2).The pattern of distribution of oviposition and adult emergence was the same as that adult mortality. At 10 mL kg^{-1} application of rubber seed oil and palm oil for Ife brown, no adult weevils' emergence was observed.

The percentage weight loss for treated grains ranged from 0.1-1.7% with a mean of 2.1% against 47.1-48.6% and a mean of 48.2% for untreated grains (Table 3). All plant oils were dosage dependent as they were more effective at higher dosage. Cowpea varieties showed different susceptibility to weevil infestation in terms of weight loss. The Ife brown had the least percentage weight loss of 1.2 (Table 3) followed by Ife white 2.8% and

Table 3: Weight Loss caused by *C. maculatus* as influenced by plant oils in three local cowpea varieties.

Cowpea variety	Plant oil	Dosage (mL kg^{-1})	Means % weight loss (n = 4; p<0.001*)	Variety mean
Ife white	Rubber seed oil	0.0	48.6^{a}	
		2.5	1.5^{b}	
		5.0	1.0^{b}	
		7.5	0.6^{b}	
		10.0	0.6^{b}	
	Palm oil	0.0	48.5^{a}	2.8^{b}
		2.5	1.6^{b}	
		5.0	1.4^{b}	
		7.5	1.0^{b}	
		10.5	0.6.^{b}	
	Palm kernel oil	0.0	47.1^{a}	
		2.5	1.7^{b}	
		5.0	1.3^{b}	
		7.5	1.0^{b}	
		10.0	0.5^{b}	
Ife brown	Rubber seed oil	0.0	48.1^{a}	
		2.5	1.2^{b}	
		5.0	0.8^{b}	
		7.5	0.5^{b}	
		10.0	0.1^{b}	
	Palm oil	0.0	48.3^{b}	2.1^{a}
		2.5	1.3^{b}	
		5.0	0.8^{b}	
		7.5	0.6^{b}	
		10.0	0.3^{b}	
	Palm kernel oil	0.0	48.3^{a}	
		2.5	1.7^{b}	
		5.0	1.0^{b}	
		7.5	0.8^{b}	
		10.0	0.5^{b}	
Kano white	Rubber seed oil	0.0	48.1^{a}	
		2.5	1.6^{b}	
		5.0	1.1^{b}	
		7.5	1.3^{b}	
		10.0	0.4^{b}	
	Palm oil	0.0	48.2^{a}	3.4^{c}
		2.5	1.7^{b}	
		5.0	1.5^{b}	
		7.5	1.2^{b}	
		10.0	0.4^{b}	
	Palm kernel oil	0.0	48.3^{a}	
		2.5	1.8^{b}	
		5.0	1.7^{b}	
		7.5	1.2^{b}	
		10.0	0.8^{b}	

Treatment weight loss = 1.2%, Control weight loss = 48.2%, CV: 502%, *Mean followed by a common letters is not significantly different at 0.1% probability level (comparison made vertically)

Table 4: Damaged caused by *C.maculatus* and viability test on treated cowpea grains

Cowpea Variety	Plant oil	Dosage (mL kg^{-1})	Means % punctured grain (n = 4; p<0.001*)	Varietal mean	% viability	Variety Mean
Ife white	Rubber seed oil	0.0	94		31	
		2.5	22		47	
		5.0	11		56	
		7.5	5		65	
		10.0	0		75	
	Palm oil	0.0	90		32	
		2.5	31		46	
		5.0	11		53	
		7.5	5		61	
		10.0	3		70	
	Palm kernel oil	0.0	90	28.5	35	52.5
		2.5	30		42	
		5.0	13		47	
		7.5	11		54	
		10.0	5		67	
Ife brown	Rubber seed oil	0.0	91		34	
		2.5	16		51	
		5.0	6		63	
		7.5	3		72	
		10.0	0		79	
	Palm oil	0.0	96	31.5	34	54.7
		2.5	32		46	
		5.0	18		60	
		7.5	16		62	
		10.0	5		68	
	Palm kernel oil	0.0	92		74	
		2.5	36		28	
		5.0	18		46	
		7.5	17		52	
		10.0	11		60	
Kano white	Rubber seed oil	0.0	92		68	
		2.5	38		30	
		5.0	22		40	
		7.5	21		50	
		10.0	14		58	
	Palm oil	0.0	92	37.7	60	43.2
		2.5	42		32	
		5.0	26		38	
		7.5	24		44	
		10.0	21		48	
	Palm kernel oil	0.0	46		60	
		2.5	31		30	
		5.0	28		34	
		7.5	26		40	
		10.0	24		46	

Treatment damaged grain = 9.1%, Control damaged grain = 93.2%, Treatment germination = 60%, Control germination = 28%, CV: 5.6%, SE = 0.54%, *Mean followed by a common letter(s) is not significantly different at 0.1% probability level (comparison made vertically)

Kano white was highest with 3.4%. The interaction among variety the three factors (plant oils, dosage and varieties was highly significant (p<0.001).

Seed viability was also significantly affected by plant oils (Table 4). The treated grains had a mean germination of 60% as against untreated control 28% (Table 4). The studied further revealed that the plant oils did not hinder seed viability. Ife brown treated with rubber seed oil at the rate of 10 mL kg^{-1} had the highest percentage germination of 79.

DISCUSSION

This trial had revealed that plant oils at all treated application levels admixed with the three cowpea varieties effectively controlled *C. maculatus* of cowpea grains below economic threshold level.

The plant oils were lethal to adult weevil by causing mortality. This insecticidal effect was in agreement with Singh *et al.* (1978), Ivbijaro (1984), Onolemhemhen (2001) and Law-Ogbomo and Enobakhare, 2004). Their mode of action could be as a result of the oil coating the treated cowpea grains which hinder contact between the grains and the weevils leading to starvation. They also impaired respiration as suggested by Hall and Harman (1991) as it blocks the spiracle hereby leading to suffocation. Other insecticidal effect could be attributed to toxicity and repellency by constituents.

The reduced oviposition observed in the treated grains could be attributed to high adult mortality

associated with them. The lower F_1 adult weevil emergences among the treated grains resulted from the ovicidal and larvicidal properties of the plant oils (Table 2). The ovicidal and larvicidal properties of the plant oils would have arisen from interference with normal respiration resulting in suffocation leading to progeny mortality. This idea is in conformity with that of Don-Pedro (1990), who suggested that egg mortality was caused by physical properties of the oil coating that blocked respiration rather than by a specific chemical effect. The larvicidal function of the plant oils may be due to both chemical toxicity and physical properties of the oils (Ivbijaro, 1984). The Lower percentage weight loss observed among the treated grains resulted from lower F_1 weevil emergence in treated grains which indicated that there will be very few emergent holes to be associated with treated grains than the untreated control. This could be attributed to low punctured grains observed in the oils treated grains (Table 4). In addition Lower adult emergence indicated lower uptake of nourishment from the grains for progeny development.

Among the cowpea varieties, the Ife brown was observed to have the least percentage weight loss indicating that it is more resistant to weevil damage than the Ife white or Kano white. The Kano white was observed to be more susceptible to weevil infestation as it recorded the highest weight loss.

Plant oils treatment at all levels did not adversely affect the viability of the grains. This is an indication that such oils could reduce the infestation of stored grain pests without any undesirable effect on the grain quality.

Plant oils are available in areas where other forms of protection against insect pests of stored products are difficult to obtain. The additional benefits of using oils are low cost and apparent minimal health risk to resource-poor farmers. The oils of rubber seed, palm fruits 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.

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