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Effect of some vegetable oils on survival and progeny emergence of C*allosobruchus maculatus* Fabricius (Coleotera: Bruchidae) on stored cowpea in Zaria, Nigeria

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1 SUMMARY

Vegetable oils (groundnut, soybean and palm) at two levels of 5 ml and 10ml per 650g seed of cowpea (IAR 48 white) were tested against *Callosobruchus maculatus* Fabricius in the Department of Agric. Education entomology laboratory in 2008. The experiment comprised of forty eight plastic pots arranged in randomized completely block design with three replicates. Each treatment was carefully pipette into the plastic container, manually mixed and spread on the bench to dry. After drying, the treated seeds were reintroduced to the labeled containers, infested with the weevil at ratio of 3 male and 7 females and covered with cheese cloth and perforated lid to avoid insect escape. The experiment was repeated in two locations and means taken. Data were collected on insect survival and mortality, oviposition, insect emergence and grain perforation at weekly interval and subjected to analysis of variance (ANOVA) while means were separated using least significant different (P = 0.05). The efficacy of the oils was determined by weevil perforation index (WPI). Results showed that the oils significantly suppressed insect population at both 5ml and 10ml. However, groundnut oil gave the best result as it consistently and significantly (p = 0.05) suppressed population and inhibited progeny emergence (0.67 and 0.33 at 5ml and 10ml respectively) at 5th week as well as inhibited oviposition to 1.0 (5ml) and 0.33 (10 ml). Weevil perforation index (WPI) of 4.7% (5 ml) and 2.07% (10 ml) confirmed the efficacy of groundnut oil in the management of *C. maculatus*. Soybean and palm oils also inhibited development up to the 3rd week but significantly encouraged progeny emergence at the 5th week with very high WPI. The control was significantly higher in all the parameters. It is therefore recommended that groundnut oil (5-10ml/650g grain) should be integrated with adequate drying in an air tight condition to prolong shelf life of the grain and prevent weevil infestation.

2 INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is a widely distributed crop throughout the tropics and sub tropics of the world (Tenebe *et al.* 2007). Its centre for genetic diversity is still a controversy but evidences are available on the domestication of the crop in Ethiopia, Central

Africa, South Africa and West Africa (Zhukorskii, 1962, Steele, 1976, and Steele and Mehra, 1980). The crop is an important stable food mostly for the poor people in many developing countries as it provides half of the plant protein in human and animal diet. It is eaten in form of dry seed, green pods, green seed and tender leaves (Shinggu *et al.,* 2008). The seed contains about 24% protein, 62% soluble carbohydrates and small amount of other nutrients (Elias *et al*., 1964). It is also associated with soil conservation and soil fertility. Nigeria, Brazil and Niger are the major producers and account for 70% of world crop with Nigeria producing 900,000 tonnes annually (Jackai and Daoust, 1986). Cultivated land area is estimated at about 14 million hectares and an annual production of over 4.5 million metric tons (Mt) worldwide. Nigeria is the largest producer, covering about 5 million hectares, with 2.1 Mt. However, 80% of the crop is grown in small holdings in the semi-arid zones of the North under mixed cropping (Olabanji,*et al*., 2002). Mixed cropping increases yield potentials substantially through improved management practices (IITA, 2007 and Miko and Mohammed, 2008). Brazil cultivates about 1.9 million ha, with 0.7 Mt while Niger cultivates 3 million ha with 0.6 Mt (Singh, *et al*., 2003). Even though Nigeria is the largest producer of the crop in the world, fluctuation in production is common. Shinggu *et al.* (2008) reported that the current yield in Nigeria cowpea is one million tonnes per annum indicating an average of 300kg/ha while Singh *et al*. (1997) and Chambliss *et al*. (1997) reported that about 1,700,000 tonnes are produced annually in the Northern parts of the country. FAO (2004) further reported yield of about 2.4 million metric tonnes of cowpea grains from a total of 5.0 million hectares of land. Tenebe *et al.* (2007) further gave yield of 800,000 tonnes per annum from about 4.0 million hectares under traditional mixtures of cowpea and cereals like maize, millet and sorghum. This translated to average yield of 457.4 kg/ha (FMA, 2000). Yield under subsistence systems average about 150-200 kg/ha but with favorable conditions will exceed 1000kg/ha and up to 2000-3000kg/ha under experimental plots (Gida and Smith, 1981).The low and fluctuation yield is associated mostly with insect pests and diseases and prevalence of weeds. Other factors are insufficient information on the existing varieties, poor cultural practice, as well vagaries in weather conditions, lack of proper crop protection measures, inadequate and inappropriate use of fertilizers.

Unfortunately, cowpea is susceptible to a wide range of field and storage insect pests and diseases (Caswell, 1973 and Mudi, 2008) and large proportions' of the grains produced are damaged by storage insect pests (Ene, 1986 and Arong and Usua, 2006). The most significant and commonest insect pest of cowpea in Nigeria is the cowpea weevil (*C. maculatus* Fabricius (Coleotera: Bruchidea) (Arong, *et al*., 2011), whose larvae develops within the seeds and feed as primary pest. The insect is well distributed in the tropical and sub tropical areas with hot climates, hence it survives under temperature range of 18-35^0 C (optimum temperature of 30^0 C), relative humidity of 25-90% (optimum of 80%). These conditions enable the insect to complete its life cycle within 23 days (Gewinner *et al*., 1996). The distribution of bruchids in Africa is influenced by trade and accidental introduction. Infestation may result to 10-50% weight loss within 3-6 months of storage (Pascual-Villalobos and Ballesta-Acosta, 2003 and Gida and Smith, 1981). Lale and Kolo (1998) under traditional storage reported loss of 32% and 82% in Northern Nigeria for unthreshed and threshed cowpea respectively. Effective insect pest population management can boost production by 10-30% and prolong shelf life of stored grains. Several attempts have been made to suppress and manage storage pests of cowpea. Until recently, use of insecticides such as phosphine gas (Phostoxin) and pirimiphos methyl (actellic) dominated the management of *C. maculatus*. However, several synthetic insecticides are harmful to beneficial organisms, environment and causes residual poisoning to man and animals, pose danger to user safety, high cost and results to development of resistant strains (Gewinner *et al*., 1996 and Rajapakse and Ratnasekera, 2008). Consequent to this, emphasis are now on organic substances and materials. For instance, the efficacy of neem leaves (Tanzubil, 1991) and oil (Stoll, 2000) in the management of *C. maculatus* has been reported. Application of vegetable oils is simple, convenient, cost effective, environmentally safe and easily biodegradable with narrow spectrum (Attri and Prasad, 1980). Oil in general does not have adverse affect on viability, the palatability, the cooking quality and physical appearance of legume seeds. The oils coat the testate; acting as an ovicide by plugging the egg micropyle, thus hinder the oxygen supply to the embryo. Oil probably deter oviposition and could kill adult bruchids (Ranasinghe and Dharmasena, 1987). The efficacies of several oils have been reported (Murthy *et al*., 1981 and Pandey, *et al*. 1981). However, some oils become rancid and messy with time and easy to pick duct and debris during application (Murdock, *et al*., 1997) hence the level of acceptability is limited. The purpose of this investigation was to assess the development of cowpea weevil in some of the available oils: groundnut oil, soybean oil and palm oil, and to determine the efficacy of the oils in the management of *C. maculatus* with aim of reducing problems associated with use of insecticides such as scarcity and high price consequent of which farmers under use insecticides.

MATERIALS AND METHODS

The experiment was conducted in 2008 at the Federal College of Education Agricultural Entomology laboratory in Zaria, Kaduna State. The zone lies between 11^0 11`N. 07$^0$ 38`E and 686 m above sea level (Shinggu, *et al*., 2008), with annual rainfall of 1100 mm, temperature range of 26^{0}C to 33^{0}C and optimum relative humidity of 75%. Cowpea seeds (Kananado) infested by *C. maculatus* were obtained from Sabon Gari market, Zaria, Nigeria. The stock culture was maintained at 26±2 ^{0}C and 75 % relative humidity in the laboratory to build up enough population for the experiment between the month of May and June, 2008. Environmental condition during this period was antagonistic to emergence and as such, the insect culture was preserved until the required population was achieved for the experiment. A widely cultivated and highly consumed variety in Zaria, IAR 48 white was obtained from the breeder in the Institute for Agricultural research, Ahamdu Bello University, Samaru, Zaria (IAR/ABU) and used in this investigation. Thereafter, 48 plastic pots with perforated lids were disinfected after washing using diluted spirit and arranged on a disinfected laboratory bench in a randomized completely block design and replicated three times. Furthermore, 650g of the grain was weighed and introduced into each of the plastic pots. Three vegetable oils; groundnut, soybean and palm constituted the treatments and were assessed at 5ml and 10ml while the control pots were not treated. Each plot per replicate contained four pots (two for 5ml and two for 10ml treatments). The oils were introduced into the pots with calibrated pipettes and vigorously shaken to mix properly. The mixture was spread on the bench to dry. After drying, each treatment was reintroduced into the labeled pots and infested with adult *C. maculatus* using a suction tube at the ratio of 3 male: 7 female. The pots were covered with double folded cheese cloth and perforated lid to prevent insect escape. The procedure was repeated twice at room temperature in different laboratory benches making 96 pots with each treatment constituting 4 pots per level. The experiment lasted for five weeks and data were collected weekly on number of surviving insects, number of eggs (oviposition) and progeny emergence as well as grain perforation. Data was taken at the early hours of the day when the insects are less active to escape. Every seven days, each treatment was carefully and gently poured into a tray, and covered with a transparent net to avoid escape and then, numbers of live and dead insect were recorded. Dead insects were discarded. To determine oviposition, hand lens were used to magnify the eggs on ten randomly selected grains while number of grain perforations was counted and recorded.

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Data were subjected to analysis of variance (ANOVA) (Snedecor and Cochran, 1967) while means were separated with least significant difference (p = 0.05). The oils efficacy at 5ml and 10ml were determined using weevil perforation index (WPI). WPI value >50 indicated negative grain protection or enhancement of infestation by the weevil (Fatope, *et al.*, 1995).

WPI =
% of treated seed perforation
% of control seed perforated X 100 + % of treated seeds perforated

RESULTS

Effect of the 5ml oils on the survival of *C. maculates:* Results (Table 1) showed that groundnut oil consistently and significantly (p = 0.05) caused insect mortality from first week (7.00) to the fifth week (0.6), compared to the control which gave mean of 7.67 and 12.33 at 1st and 5th week. Soybean oil and palm oil gave a similar mortality result up to the 3rd week (4.00 and 5.35 respectively), however with no significant difference at 4th week. At the 5th week, progeny emergence was evident and significant (p = 0.05) as mean number of insects in soybean oil and palm oil treatment increased to 5.00 and 5.67 at 5th week compared to the control (12.33), indicating emergence of the insect.

Effect of 5ml of the different oils on egg laying : Results (Table 2) show that the insects started laying eggs at second week of infestation and the eggs increased significantly (P = 0.05) in soybean oil, palm oil treatments as well as in the control. Groundnut oil, palm oil and soybean oil significantly inhibited oviposition from the 3rd to 5th week compared to the control (21.00 eggs). Generally, groundnut oil treatment significantly inhibited egg production (1.00) compared to palm oil and soybean oil treatments (9.67) each at the 5th week. The implication is that, groundnut oil has ovicidal property that inhibits both oviposition and survival of the insect.

TABLE 1: Surviving insects at weekly interval in stored cowpea treated with five milliliters groundnut, soybean and palm oils.

	No. of weeks				
Types of oil	**1**	**2**	**3**	**4**	**5**
Groundnut oil	7.00^b	4.33^a	1.67^a	1.00^a	0.67^a
Soybean oil	5.33^a	4.33^a	4.00^b	3.33^b	5.00^b
Palm oil	7.67^b	5.67^b	5.35^c	4.33^b	5.67^b
Control	9.67^c	7.67^c	7.67^c	7.67^c	12.33^c
SED ±	0.56	0.54	1.04	0.92	1.03
LSD (P = 0.05)	1.37	1.32	2.54	2.25	2.52

Mean's within a column followed by the same later are not significantly different (P=0.05). Data are means of three replicates repeated two times

TABLE 2: Mean number of eggs laid in five milliliters of groundnut oil, palm oil soybean oil.

	No. of weeks				
Types of oil	**1**	**2**	**3**	**4**	**5**
Groundnut oil	0.00	1.00	1.33^a	1.67^a	1.00^a
Palm oil	0.00	1.33	4.33^b	4.67^b	9.67^{ab}
Soybean oil	0.00	1.00	3.33^{ab}	3.67^b	9.67^{ab}
Control	0.00	2.67	4.33^b	8.00^c	21.00^c
SED ±	0.00^{NS}	1.41^{NS}	0.82	0.68	0.90
LSD (P = 0.05)	0.00	3.45	2.01	1.66	2.23

Mean's within a column followed by the same later are not significantly different (P=0.05). Data are means of three replicates repeated two times.

TABLE 3: Surviving insects at weekly interval in stored cowpea treated with 10 ml , soybean and palm oils.

	No. of weeks				
Types of oil	**1**	**2**	**3**	**4**	**5**
Groundnut oil	5.67	3.67[a]	2.33[a]	0.67[a]	0.33[a]
Soybean oil	5.67	5.00[a]	4.33[b]	3.33[b]	4.00[b]
Palm oil	6.33	5.00[a]	4.00[b]	4.00[b]	6.00[c]
Control	8.67	7.00[b]	6.67[c]	6.67[c]	14.00[d]
SED ±	1.26[NS]	0.67	0.67	0.30	0.69
LSD (P = 0.05)	3.71	1.64	1.05	0.73	1.69

Mean's within a column followed by the same later are not significantly different (P=0.05). Data are means of three replicates repeated two times.

TABLE 4: Mean number of eggs laid per week at 10ml of the different oils

	No. of weeks				
Types of oil	**1**	**2**	**3**	**4**	**5**
Groundnut oil	0.00	1.67[ab]	0.33[a]	0.33[a]	0.33[a]
Palm oil	0.00	0.67[ab]	3.56[b]	4.33[b]	3.00[ab]
Soybean oil	0.00	2.00[ab]	3.67[b]	4.00[b]	6.67[b]
Control	0.00	2.33[b]	3.33[b]	5.00[b]	24.67[c]
SED ±		0.66	0.89	0.83	1.57
LSD (P = 0.05)		1.62	2.18	2.03	3.84

Mean's within a column followed by the same later are not significantly different (P=0.05). Data are means of three replicates repeated two times.

TABLE 5: Mean perforation and weevil perforation index of the oils on stored cowpea *C. maculatus* at 5ml and 10ml after 5 weeks

	No. of ml and WPI			
Types of oil	**5ml**	**5 WPI**	**10ml**	**10WPI**
Groundnut oil	0.67[a]	4.7	0.33[a]	2.07
Soybean oil	9.00[b]	63.88	9.33[b]	57.57
Palm oil	18.00[c]	127.9	16.33[c]	100.7
Control	20.00[c]		24.00[d]	
SED ±	2.08		1.55	
LSD (P = 0.05)	5.09		3.79	

Mean's within a column followed by the same later are not significantly different (P=0.05). Data are means of three replicates, repeated two times. Weevil perforation index (WPI)

Effect of 10ml oils on the survival of *C. maculatus* : Groundnut oil at 10ml consistently and significantly reduced the mean insect population from week one (5.67) to the 5th week (0.33) (Table 3). Similar to the observation at 5ml of the oils, soybean oil (4.00) and oil palm (6.00) significantly (p = 0.05) increased progeny emergence at the 5th week, an indication that the oils can only offer protection for four weeks. At 5th week, the control indicated emergence as the number of insects significantly increased to14.00.

Effect of different types of oils on oviposition at 10ml : Results (Table 4) showed significant differences (p = 0.05) in terms of egg laid from the 2nd week to the 5th week, however, groundnut oil inhibited oviposition more than any other oil beginning from 2nd (1.67) to the 5th week (0.33). Groundnut oil and palm oil (3.00) significantly inhibited egg laying at 10ml in the 5th week while the number of eggs increased in soybean oil (6.67). By implication, the higher the quantity of the oil the more the inhibition of egg lay. The insects in the control experiment laid significantly (p= 0.05) higher number of eggs at 5th week (24.67) compared to oil treatments.

Effect of the oils on grain perforation at 5ml and 10ml: Table 5 shows the mean number of grains perforated and the weevil perforation index (WPI) at both 5ml and 10ml of the oils after five weeks of infestation. The mean grain perforation of groundnut treatment were 0.67 and 0.33 for both 5ml and 10ml respectively which was significantly lower (p = 0.05) compared to the other oils and control (20.00 and 24.00). Furthermore, perforated grains in soybean oil 9.00 (5ml) and 9.33 (10ml) was significantly lower compared to palm oil 18.00 (5ml) and 16.33 (10ml). Similarly, the WPI at both levels groundnut oil indicated the effectiveness in the management of stored cowpea against *C.maculatus* with WPI of 4.7 and 2.07 at 5ml and 10ml respectively. Soybean oil (63.88% and 57.57%) and palm oil (127.9% and 100.7%) at 5ml and 10ml respectively were higher than the standard (>50). Indicating that 10 ml of the oils reduced insect perforation more compared to 5 ml.

DISCUSSION

There are four different but complementary mechanisms in the use of vegetable oils on insect pest of stored product (Lienard, *et al.*,1993) which involves the following; (i) toxicity to the eggs and first instar larvae is the consequence of the occlusion of a short funnel at the posterior end of the egg, (ii) The oil coat leads to reduction of egg adherence on the treated seed which prevents the first instar larvae from penetrating the seed, (iii) some oil constituents have a direct toxic effect and (iv). The various fatty acids contained in the oil have a toxic effect. The use of organic materials such as vegetable oils in the management of cowpea weevil is effective, less costly, available, easy to apply and environmentally friendly. Within the limit of this experimental error, groundnut oil significantly and consistently at 5ml and 10ml per 650g weight of cowpea grain provided an evidence of protecting stored cowpea against *C. maculatus* in terms of motility, inhibition of oviposition, prohibition of progeny emergence with weevil perforation indexes of 4.7 and 2.07 respectively. Even though soybean oil and oil palm gave similar results, their performance was inconsistent as the oils encouraged progeny emergence at the 5th week. Furthermore, weevil perforation indexes at both levels of soybean oil (64 % and 58 %) and palm oil (128% and 101 %) were more than >50% which is the minimum acceptable WPI (Fatope, *et al*., 1995) for the management of cowpea weevil. This implies that the ovicidal properties of groundnut oil was effective within the 5 weeks as very few eggs were laid at 5ml and 10ml after 28 days, but in soybean oil and palm oil treatments, relatively higher number of eggs were laid which resulted to insect emergence at 35 days after infestation. The result of this investigation was supported by Stoll, (2000) who reported that adult females avoid laying eggs on seeds treated with oil for more than 7 days and Mina and Mukasa (1985) who reported that the toxic effect of oil on eggs and young larvae decreases over time possibly due to microclimate of the storage facility which influenced the duration of the protective properties of the oil. In practice, this means that the protective coating of the oil must be renewed periodically.

CONCLUSION

The investigation showed enhanced toxicity and persistence of groundnut oil in mortality and reduced oviposition of *Callosobruchus maculatus* on cowpea and as such could be incorporated into the management of *C. maculatus*. The use of groundnut oil as alternative is necessary mostly in rural environment where the cost of insecticides are high or supply is erratic, causing farmers to reduce rates for monetary benefit. It is therefore suggested that, more work be carried out for synergistic effect soybean oil and palm oil while extended duration should be tested.

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