# EFFICACY OF *CANARIUM SCHWEINFURTHII* (ENGL.) PRODUCTS FOR THE CONTROL OF *CALLOSOBRUCHUS MACULATUS* (F.) (COLEOPTERA: BRUCHIDAE) ON STORED *CAJANUS CAJAN* (L.) MILLSP.

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**ABSTRACT**

*The study was carried out to investigate the insecticidal properties of Canarium schweinfurthii (African elemi) plant products (oil, stem bark and leaf) on Callosobruchus maculatus (Cowpea seed beetle) infesting Cajanus cajan (Pigeon pea) in storage. C. schweinfurthii was processed into oil and powders and were applied at four (4) different rates of 0.5, 1.5, 2.5 and 3.5 ml/100 g seeds for the oil and 2.5, 5.0, 7.5 and 10.0 mg/100 g seeds and arranged in a randomize complete design (RCD). C. schweinfurthii plant products were tested alongside with Actellic EC (Pirimiphos methyl) (25 %) and dust (2 %) as standard checks for oil and dust, respectively. Results showed that the effect of C. schweinfurthii oil and standard check (Actellic EC) on oviposition, progeny emergence and damage within the levels of application were found to be at the same level of significance having mean values of 1.12 for each using Student Newman Keul's (SNK) test at $P \leq 0.05$. The oil significantly inhibited test insect survival, suppressed oviposition and progeny emergence and also prevented damage. Application of plant powders (stem bark and leaf) at higher dosages of 7.5 and 10.0 mg/100 g of seeds was more effective at 7.5 and 10.0 mg/100 g of seed. Results of progeny emergence and percentage damage observed were a reflection of the potency of the C. schweinfurthii.*

**Keywords**: *Canarium schweinfurthii* (African elemi), *Callosobruchus maculatus, Cajanus cajan* (Pigeon pea).

## INTRODUCTION

Throughout history, man has found it difficult to isolate his crop from the small harbors of insect pests than the larger pests. This is because most small insect species reproduce in great numbers and their total destructive capacity is very high. The significance of insects as pest is highly felt in the area of health, food supply, as well as crop and animal losses. Man's efforts are affected by the activities of numerous pest organisms both in the field and during storage. Reports of insect pests' damage to stored grain in Nigeria without adequate protection ranged from 68 – 70% for sorghum stored for 9 – 12 months to 58% for maize in 7 months and 30 – 50% for legumes in 3 months and may be up to 100% in 6 months in heavy infestation (Olusegun, 2003). Generally, about 12 -15% food grains production are lost annually due to insect pests (Jelle, 1990; Rai and Mauria 2006). The capacity to preserve food is directly related to the level of technological development. Indeed, simple and low cost traditional pest control techniques are the bed rock of small scale food grain production enterprise and their contributions to the economy are enormous. They are vital to reducing: pest resurgence, post-harvest/food loss and increasing food availability with a balance ecosystem. Research has proven that *Canarium schweinfurthii* is safe or not hazardous to man his livestock and the environment. According to Burkil, (1985) and De Smet, (2000) the fruit, seed kernel and oil extracted from the fruit is a good source of food. The bark decoction, root, and leaves has been reported to be used for medicinal purpose against skin disease, chest pain, fever, stomach pain, ulcer, rheumatism among others. It was found to be a substitute for gum-mastic for wound dressing during the World War II. Katunku *et al*. (2014) showed that contact toxicity of *C. schweinfurthii* tissues (cotyledon and mesocarp powder) caused 25 - 97% and 42.5 - 95% mortality, respectively, commercially processed mesocarp oil caused 55 - 100% and laboratory processed cotyledon oil caused 62 - 100% mortality to *C. maculatus.* The highest mortality against *C. maculatus* were observed in methanol extract and petroleum ether of the mesocarp tissues which caused 80 - 100% and 90 – 100% mortality, respectively at the application rates of 1.25 and 2.5ml/50 g grain within 3 days post-treatment.

Pigeon pea *Cajanus cajan* (L.) Millspaugh, though largely considered as a poor man's or an orphan's crop, is a multipurpose species of legume that is extensively used as a good source of protein food grain, fodder, green manure crop for soil fertility amelioration in local cropping systems and agroforestry (Raemaekers, 2001; Yeboah *et al*., 2009). Root preparations are taken to treat cough, stomach problems and syphilis while the stem ash is applied on wounds and stalk and root are chewed against toothache and powdered seeds serve as poultice on swellings, leaves are used to clean teeth (Odeny, 2007).

*Callosobruchus maculatus* has been reported to be the most important pest of stored pigeon pea and other legumes in the tropics and it is responsible for significant loss in weight and quality of pigeon pea and some other grain legumes (Lale, 2002; Amatobi, 2007).The bruchid, *Callosobruchus maculatus* may cause up to 30 – 40% damage of seeds and render it almost unfit for human consumption within a storage period of 3 months. In heavy infestation, losses of up to 100% are possible within 3 – 5 months (Ajayi *et al.,* 1995). Although pesticides are still one of the most effective strategies to control pests, they have neither solved the purely agricultural problem of the small scale farmer nor have they improved his financial situation. Their use in the long run resulted in a series of consequences which are self-defeating. Plant materials (essential oils and powders) have been reported to act as repellants, anti-feedants, growth regulators, poisons and fumigants (Lale, 2002; Olusegun, 2003; Singh and Govil, 2009). They contain volatile secondary metabolites that plant produces for their own needs other than nutrition (i.e. protectants or attractants) to protect the plant from attack by insects and microbial pathogens. The volatile oils disrupt the metabolic pathways and cause rapid death, interfere with the life cycle of the insects causing asphyxiation. The success of these plant materials to small scale farmers serve as measure for exploring the utilization of natural indigenous resources (botanicals) for small scale produce protection and for possible industrial scale product protection. Plant oils cause more than 90% mortality when applied to *C. maculatus* eggs it occlude the funnel and thus lead to the death of developing insect by asphyxiation, eggs laid on seeds treated with oil are less firmly attached, it reduces egg laying (oviposition), reduced longevity of insect and larval development of most insects before they penetrate legume. It also significantly reduces the emergence of progenies and lower damage of cowpea seeds by *C. maculatus* (Lale, 2002).

Most plant materials (botanicals) have been reported to have unique useful properties such as contact poison when it touch the skin of the target pest or through ingestion, safety flushing action, fast breakdown, their use give no rise to resistance in pest because nature has presented their constituents to mimic closely the natural constitution of the human somatic system (Olusegun, 2003; Ivbijaro *et al.,* 2006). This reduces toxicity problem on mammals to the barest minimum level. Research on plant oils and other plant products as protectants has been conducted on stored insects on stored products, but a very little work has been done on the storage of pigeon pea grains using *C. schweinfurthii* oils and powders from the plant has been carried out against *Callosobruchus maculatus* except that on Bambara groundnut by Katunku *et al.* 2014. The aim of the research is to explore the use of *Canarium schweinfurthii* a natural substance of plant origin for the control of the cowpea bruchid, *Callosobruchus maculatus* (F.). The objectives were:

i. To evaluate the efficacy of oil and powders of *Canarium schweinfurthii* for its insecticidal properties against *C. maculatus*.

ii. To determine the most effective dosage rate of the oil and plant part powder against *C. maculatus* (F.) infesting stored pigeon pea, *Cajanus cajan* (L.) Millsp.

## MATERIALS AND METHOD

The laboratory experiments were conducted in the Storage Entomology laboratory of the Department of Crop Protection, Institute for Agricultural Research, Ahmadu Bello University, Zaria. Two experiments were carried out. The first experiment was conducted between warm wet period of 2009 and the second experiment was carried out between the hot dried period of 2010. The periods varied slightly in temperature and relative humidity which are important factors in the Biology of storage insects.

The fresh fruits of *Canarium schweinfurthii* Engl. and the pigeon pea grains *Cajanus cajan* were purchased at the local market of Kagoro, Kaura Local Government Area of Kaduna State. The leaves and stem bark of the tree of *C. schweinfurthii* were collected from farmers farms within the Local Government Area. The insect pest– *Callosobruchus maculatus* was collected from pigeon pea already infested from the farmers' store. Actellic EC (25% EC) and Actellic Dust (2% dust) were purchased from an Agro-Allied shop at Samaru – Zaria.

### Experimental Design and Data Collection

Treatments were arranged in a Randomized Complete Design (RCD) on a bench in the laboratory for 12 weeks and each replicated three times. Five pairs (male and female) of freshly emerged *C. maculatus* adults were placed into each kilner jar containing 100 g of seeds. The treatments included plant oil, leaf powder, Stem bark powder, Actellic EC (25%) and Dust (2%) and the untreated control.

Data collected included oviposition count recorded at ten (10) days after infestation. Progeny emergence was collected, from 28 – 35 days and 56 to 70 days after infestation for $F_1$ ad $F_2$, respectively. Percentage damage of grains and germination test of treated grains were conducted and recorded.

### Methods of Evaluating Effectiveness of *C. schweinfurthii* Products, Actellic EC and Dust

One hundred grammes of disinfected pigeon pea grains were weighed and placed into each kilner jars. Powders of each plant part were measured out and applied at four different levels of 2.5, 5.0, 7.5 and 10.0 mg per 100 g of pigeon pea grains. The rates of actellic EC and Dust, which are the standard checks, were maintained at the manufacturer's recommended dose of 2.5 mls and 2.0 mg, respectively. Plant oil was measured and applied at four different levels of 0.5, 1.5, 2.5 and 3.5 mls per 100 g of grains. Each of these was replicated three times. All the jars containing treatments were vigorously shaken in order to mix grains and treatments very well. Five pairs of day old *C. maculatus* adults were placed into each labeled kilner jar, which was covered with a muslin cloth and were arranged on the laboratory bench in a Randomized Complete Design (RCD) at room temperature of 20 – 35$^o$C and 50 - 80 percent relative humidity for a period of 12 weeks which were measured using a thermohydrograph.

Observations were made for each treatment for the toxicity symptoms by physical discomfort, loss of direction motionlessness even after probing with a pin and finally death. After 10 days of beetles exposure to treatments, all introduced insects that died or alive were sieved out and sampled grains were returned to their respective jars. 100 grains of pigeon pea were randomly picked from each jar to ascertain the number of eggs laid on them. All newly emerged adults were sieved out and counted for each case.

At the end of the 12 weeks, percentage grain damage in each of the treatment was evaluated by picking 100 seeds randomly from each jar and recording the number of emergence holes in each jar. To determine the percentage of damaged seeds, the following formula by Bamaiyi *et al*. (2006) was used:

$$\%damage = \frac{\text{Total number of damaged grains}}{\text{Total number of grains}} \times 100$$

**Data Analysis**

The data collected for each treatment under a complete randomized design (CRD) were subjected to Statistical Analytical System (SAS) for analysis of variance (ANOVA) tests to determine the variation in the treatments. The Student Newman Keul's (SNK) test was used to compare and separate means of treatments at $P \leq 0.05$ level of significant (SAS, 2000).

## RESULTS AND DISCUSSION

Results on oviposition 10 days after exposure of test insect to treatments indicates that the *C. schweinfurthii* oil and Actellic EC were statistically similar (P = 0.05) on their effect in deterring oviposition (egg laying) at all dosage rates (0.5, 1.5, 2.5, 3.5 ml/100 g seeds) (Table 1). The results corroborated with the report of Swella and Mushobozy (2007) who evaluated the efficacy of coconut oil against cowpea bruchids on stored cowpea seeds, and found out that the oils have good potentials against the cowpea bruchids. Priyani *et al*. (2003) reported deterrent effects of Sri Lanka essential oils on oviposition and progeny production of cowpea bruchid. The effect of the oil on the adult beetle might be because of the oil ability to spread and coat insect body, thus blocking the insect spiracles thereby interfering with normal respiration of the insects resulting in suffocation and eventual death of the insects.

**Table 1. Effect of *Canarium schweinfurthii* Oil on Ovipositionof Adult *C. maculatus* 10 days Post Treatment on *Cajanus cajan***

| | Mean Oviposition 10 days post treatment ml/100 g seeds | | | |
|---|---|---|---|---|
| Treatments | 0.5 | 1.5 | 2.5 | 3.5 |
| Oil | $1.12^b$ | $1.12^b$ | $1.12^b$ | $1.12^b$ |
| Actellic EC** | $1.12^b$ | $1.12^b$ | $1.12^b$ | |
| Control | $164.00^a$ | $164.00^a$ | $164.00^a$ | |
| *SE | 0.033 | 0.033 | 0.033 | 0.033 |

* Means followed by the same letter(s) in the same column are not significantly different at P < 0.05 significance using SNK

** Actellic EC was applied at a single rate of 2.5 mls according to manufacturer's recommendation

For the powders, the results showed that, all the treated seeds significantly suppressed oviposition at all the concentrations tested. At 7.5 and 10.0 mg/100 g seeds, the plant powder caused significant suppression ($P \leq 0.05$) of oviposition compared to Actellic dust. The highest number of eggs laid (164.00) on the grains was observed in the untreated control (Table 2). The use of inert dust has been reported to be abrasive on cuticle of insects thereby causing injury on insect cuticle resulting in dehydration which led to their death or affect further development of female insect pest that may lay eggs (Ajayi *et al.* 1995). The effect of each powder was probably dependent on the rates of toxic powder that adheres to insect cuticle and joints.

**Table 2. Effect of *Canarium schweinfurthii* Stem bark and Leaf on Oviposition of Adult *C. maculatus* 10 days Post Treatment on *Cajanus cajan***

| | Mean Oviposition 10 days post treatment mg/100 g seeds | | | |
|---|---|---|---|---|
| Treatments | 2.5 | 5.0 | 7.5 | 10.0 |
| Stem bark | $9.20^b$ | $9.12^b$ | $8.28^c$ | $8.01^c$ |
| Leaf | $9.52^b$ | $9.27^b$ | $8.79^c$ | $7.99^c$ |
| Actellic dust** | $9.04^b$ | $9.04^b$ | $9.04^b$ | $9.04^b$ |
| Control | $164.00^a$ | $164.00^a$ | $164.00^a$ | $164.00^a$ |
| *SE | 0.555 | 0.786 | 0.592 | 0.465 |

* Means followed by the same letter(s) in the same column are not significantly different at P < 0.05 significant using SNK

** Actellic dust was applied at a single rate of 2.0 g according to manufacturer's recommendation.

The effect of treatments on progeny ($F_1$ and $F_2$) emergence at 35 and 70 Days after Treatment, showed that the number of adult insect emergence (1.12) were significantly ($P \leq 0.05$) reduced compared with the control (118.30, 154.80) in $F_1$ and $F_2$, respectively (Table 3). The effect of the oil is highly effective because the oil inhibited progeny emergence within hours of exposure to treatment, prevented oviposition and further reproduction of progenies by the adult *C. maculatus*. These findings corroborated the report of Khalequzzaman *et al*. (2007) who reported that essential oils treated on eggs occlude their funnel and thus lead to the death of developing insect by asphyxiation.

**TABLE 3: Effect of *Canarium schweinfurthii* Oil on Progeny ($F_1$ and $F_2$) Emergence of Adult C. *maculatus* at 35 and 70 days Post Treatment**

| | $F_1$ ml/100 g seeds | | | | $F_2$ ml/100 g seeds | | | |
|---|---|---|---|---|---|---|---|---|
| Treatments | 0.5 | 1.5 | 2.5 | 3.5 | 0.5 | 1.5 | 2.5` | 3.5 |
| Oil | $1.12^b$ | $1.12^b$ | $1.12^b$ | $1.12^b$ | $1.12^b$ | $1.12^b$ | $1.12^b$ | $1.12^b$ |
| Actellic EC** | $1.12^b$ | $1.12^b$ | $1.12^b$ | $1.12^b$ | $1.12^b$ | $1.12^b$ | $1.12^b$ | $1.12^b$ |
| Control | $118.30^a$ | $118.30^a$ | $118.30^a$ | $118.30^a$ | $154.80^a$ | $154.80^a$ | $154.80^a$ | $154.80^a$ |
| *SE | 0.125 | 0.125 | 0.125 | 0.125 | 0.721 | 0.721 | 0.721 | 0.721 |

* Means followed by the same letter(s) in the same column are not significantly different at P < 0.05 significant using SNK

** Actellic EC was applied at a single rate of 2.5 mls according to manufacturer's recommendation.

The effect of *C. schweinfurthii* powders on progeny ($F_1$ and $F_2$) emergence was also observed to be significant. Significant protection inference (6.29, 7.42; 4.43, 6.78) was recorded when 7.5 g/100 g seeds of plant powder and 10.0 g *C. schweinfurthii* stem bark and leaf powders were applied and when compared with other rates, fewer numbers of adult insect emerge ( 4.10, 4.43 and 6.01, 6.78) in $F_1$ and $F_2$, respectively. The results indicated that stem bark and leaf powder were not different in their effect in reducing progeny emergence (P = 0.05) (Table 4). The powders significantly ($P \leq 0.05$) reduced progeny emergence at all the concentration levels than the untreated (118.30; 154.80). Although, there was oviposition, the powders might have interfered with the normal egg development by lengthening larval and pupal period which subsequently reduced or deterred adult emergence (Lale, 2002).

**TABLE 4: Effect of *Canarium schweinfurthii* Stem bark and Leaf on Progeny ($F_1$ and $F_2$) Emergence of Adult *C. maculatus* at 45 and 80 days Post Treatment**

| | $F_1$ | | | | $F_2$ | | | |
|---|---|---|---|---|---|---|---|---|
| | mg/100 g seeds | | | | mg/100 g seeds | | | |
| Treatments | 2.5 | 5.0 | 7.5 | 10.0 | 2.5 | 5.0 | 7.5 | 10.0 |
| Stem bark | 8.84[b] | 8.60[c] | 6.51[b] | 4.10[c] | 8.14[b] | 7.04[c] | 6.60[c] | 6.51[c] |
| Leaf | 9.87[b] | 9.56[b] | 6.29[b] | 4.43[c] | 8.29[b] | 8.14[b] | 7.42[b] | 6.78[b] |
| Actellic dust** | 5.80[c] | 5.80[c] | 5.80[c] | 5.80[b] | 5.58[c] | 5.58[d] | 5.58[d] | 5.58[d] |
| Control | 118.30[a] | 118.30[a] | 118.30[a] | 118.30 [a] | 154.80[a] | 154.80[a] | 154.80 [a] | 154.80 [a] |
| *SE | 1.134 | 0.951 | 0.304 | 0.355 | 0.863 | 0.315 | 0.896 | 0.399 |

* Means followed by the same letter(s) in the same column are not significantly different at P < 0.05 significant using SNK
** Actellic dust was applied at a single rate of 2.0 g according to manufacturer's recommendation.

Results on percentage damage of stored pigeon pea seeds by *C. maculatus* revealed that plant oil significantly prevented seed damage at 12 weeks post treatment at all rates of application. The effect of plant oil and Actellic EC were found to be statistically the same in preventing seed damage by *C. maculatus* (Table 5). The results obtained from the present study are in agreement with Guillaume *et al*. (2002) and Asawalam and Emosairue (2006) who reported the susceptibility of *C. maculatus* to essential oils. Significant protection against grain damage was however, recorded at the higher dosage rates (7.5 and 10.0 mg) of powders. Emergence holes in treated seeds (6.22, 6.20; 7.05, 7.01) were not significantly different from treatment with Actellic dust. Grain damage only increased significantly with decrease in rate of application of powder, but the lowest dosage (2.5mg) was significantly better than untreated control in reducing damage for both powders (stem bark and leaf) (Table 6). The finding agrees with Asawalam and Emosairue (2006) in their investigation on comparative efficacy of *Piper guineense* (Schum and Thonn) powder and pirimiphos methyl dust against *Sitophilus zeamais* in stored maize.

**TABLE 5: Effect of *Canarium schweinfurthii* Oil on Percentage Damage of *Cajanus cajan* by Adult C. *maculatus* 12 weeks Post Treatment.**

| | Damage 12 weeks Post Treatment ml/100g seeds | | | |
|---|---|---|---|---|
| Treatments | 0.5 | 1.5 | 2.5 | 3.5 |
| Oil | 1.12[b] | 1.12[b] | 1.12[b] | 1.12[b] |
| Actellic EC** | 1.12[b] | 1.12[b] | 1.12[b] | 1.12[b] |
| Control | 138.40[a] | 138.40[a] | 138.40[a] | 138.40[a] |
| *SE | 0.097 | 0.097 | 0.097 | 0.097 |

* Means followed by the same letter(s) in the same column are not significantly different at P < 0.05 significant using SNK
** Actellic EC was applied at a single rate of 2.5 mls according to manufacturer's recommendation.

**Table 6. Effect of *Canarium schweinfurthii* Stem bark and Leaf on Percentage Damage of *Cajanus cajan* by Adult C. *maculatus* 12 weeks Post Treatment.**

| | Damage 12 weeks Post Treatment mg/100g seeds | | | |
|---|---|---|---|---|
| Treatments | 2.5 | 5.0 | 7.5 | 10.0 |
| Stem bark | 8.53[c] | 8.07[c] | 6.22[d] | 6.20[d] |
| Leaf | 9.64[b] | 9.80[b] | 7.05[d] | 7.01[d] |
| Actellic dust** | 6.37[d] | 6.37[d] | 6.37[d] | |
| Control | 138.40[a] | 138.40[a] | 138.40[a] | |
| *SE | 0.416 | 0.340 | 0.892 | 0.876 |

* Means followed by the same letter(s) in the same column are not significantly different at P < 0.05 significant using SNK
** Actellic dust was applied at a single rate of 2.0 g according to manufacturer's recommendation.

## CONCLUSION

Based on findings, the lowest rate (0.5 ml/100 g seeds) of oil applied was as effective as the highest rate (3.5 ml/100 g seeds). It will be wasteful to use dosages above 0.5 ml. For the powders, the number of insect pest emergence was reduced at higher dosage rates (7.5 and 10.0 mg/100 g seeds) which were found to have significant ($P \leq 0.05$) effect for the parameters assessed. The effect of plant products in the reduction of damage was appreciable when compared with the untreated control. The study has explored the utilization of *C. schweinfurthii* products as an alternative natural insecticide to synthetic insecticides for small scale pigeon pea protection against *C. maculatus* and for possible industrial scale produce protection during storage. The plant products had oviposition, progeny emergence and grain damage deterrence effect against *C. maculatus*. The oil was most effective followed by the stem bark and leaf powders.

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