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INVESTIGATIONS INTO FUMIGANT EFFECT OF COMMERCIALLY PRODUCED EUCALYPTUS OIL AND EUGENIA AROMATICA DUST AGAINST CALLOSOBRUCHUS MACULATUS (FABRICIUS).

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Abstract—**Fumigant toxicity of mixed formulations of 'Silver bird *Eucalyptus* Oil, a commercially produced, 100% pure volatile oil and 212µm dust from the dry flower buds of clove tree *Eugenia aromatica* (Baill), was evaluated, in the control the cowpea bean beetle, *Callosobruchus maculatus* (Fabricius); under ambient laboratory condition, in Akure Nigeria. Treatment involved the suspension of 20g of C. maculatus infested Ife Brown cowpea seeds, over some quantity of the mixed formulations, in air-tight plastic containers. Number of dead adults and adults that emerged from fumigated seeds was used to measure fumigant toxicity. Record was also taken of the number of holed grains and weight loss from grains, after F_1 adult emergence. The number of eggs laid on treated cowpea seeds by the adult of *C. maculatus* was also counted. In one experiment, the fumigant effect and best rate of application of the botanical formulation, on mortality of the adult insects was determined. In another experiment, the number of eggs laid on fumigated cowpea seeds was counted; while the fumigant effect and best rate of application of the synergistic formulation or admixture on adult emergence of *C. maculatus* from seeds was determined. Percentage of holed grains and weight loss from both cowpea and maize seeds after F_1 adult emergence was also recorded. In the final experiment, the effect of volume of seed and volume of container on fumigant action of the botanical formulation or admixture was determined. Results show, that, at all formulation rates, the botanical admixture was able to effect a 100% control of *C. maculatus*, in all stages of its development. And the total kill, (100% mortality) of adult insects recorded in the experiments, was done within 24 hours of fumigation.**

Keywords: Investigations, Fumigant effect, Mixed formulations, Commercially-produced, Eucalyptus Oil, Eugenia aromatica Dust, Callosobruchus maculatus.

I. INTRODUCTION

Pulses (grain legumes) form the major staple food crops and source of dependence and sustainability for the livelihood of millions of people in many parts of the world; particularly, the less privileged people of Africa. In Nigeria, pulses occupy a prominent place in the nutrition of the people. Their edible grains form a cheap and rich source of alternative protein (Ofuya, 2003).

Of all the grain legumes grown, cowpea is the most widespread and commonly consumed all over the world; particularly, Nigeria. It is important from the standpoints of human and animal nutrition, soil improvement and protection, crop protection, internal trade and poverty alleviation. It is an important dietary staple in many countries of the tropics and the sub–tropical world, as a rich source of vegetable protein, minerals and vitamins. Some people relish the young leaves of cowpea, which are eaten in salad while the immature pods or immature seeds are used as vegetable. The mature seeds can be made into various local dishes, such as porridge, cakes and other snacks (*Ofuya, T.I., and Longe O.O., 2006*).

In spite of the great value of cowpea, its availability and utilization in many countries, particularly Nigeria, have been impaired due to seed damage by pests; particularly, the larvae of the cowpea seed beetle (*Callosobruchus maculatus*) Fabricius (Jackai and Daoust, 1986). Attack by these pests begins in the field and continues in storage, causing substantial damage to stored grains as the pest population rapidly increases (Ofuya, 2003).

The cowpea bruchid, *Callosobruchus maculatus,* is the major pest of stored cowpea in Nigeria (Ofuya, 2001) and has been responsible for not less than 5% of her stored cowpea grain losses (Singh et al., 1998). Enormous crop losses of up to 100% in unprotected seeds after about 5 months in store due to the beetles attack have also been frequently observed (Singh and Van Emden, 1979).

Attack by *C. maculatus* on stored cowpea seeds, not only cause reduced seed weight but also affects the aesthetic and nutritional quality of the seeds as well as its viability and market value (Ivbijaro et al., 1985; Lale, 1992a). It is therefore clear from the fore–going, that depredation of stored food commodities constitute a major constraint by insects to a successful cowpea production and utilization in the tropics (Ofuya, 2003) and a major factor militating against the crops availability and also food security in Nigeria (Lale, 2001). It is therefore imperative, that greater attention should be paid to the crop during storage in order to make them available for use throughout the year. Any reduction in loss between harvest and consumption would increase the availability of food grains and ensure a successful millennium development goal on food security.

II. MATERIALS AND METHODS

The experiments were carried out in the Research Laboratory of the Crop, Soil and Pest Management Department of the Federal University of Technology, Akure, under ambient conditions (28 ± 4^0 C and 65 ± 10 r.h). The cowpea storage beetle, *Callosobruchus maculatus* used was

obtained from cultures that were regularly maintained in the laboratory. Freshly emerged adults from the cultures were used for the bioassay and the cultures were maintained throughout the study. Ife Brown cowpea was the substrate used for *C. maculatus;* while the dust from the dry flower buds of the clove tree, *Eugenia aromatica* Baill, was the botanical materials used for the study.

In all experiments, infested cowpea were separately suspended on a mesh-covered, perforated inner lid over some quantities of the powder and oil admixture; in specially designed plastic fumigation chambers that measured 12 cm long and 8 cm wide. The fumigation container was designed in a way that created a seat for the inner lid to hang on, so as to enable it to hold the cowpea seeds in space and prevent their contact with the mixture of fumigants underneath.

Fumigant effect of the *E. aromatica* dust and *Eucalyptus oil* admixtures or mixed formulations*,* was tested at different application rates of 0.1 g + 0.1 ml, 0.2 g + 0.1 ml, 0.3 g + 0.1 ml, et c, against *C. maculatus* (See result tables for details).

For every treatment, there were four (4) replicates and a control with no fumigant in the container. The number of dead *C. maculatus* adults was counted at 24h., 36h., 48h., 60h. and 72h. after treatment. Number of *C. maculatus* adults that emerged from fumigated eggs and larvae was also counted.

Percentage fumigant toxicity was computed and transformed arcsine in all experiments. Analysis of variance (ANOVA) was carried out on the transformed data and significant means were separated using the Duncan's Multiple Range Test (DMRTa).

III. RESULTS

At all rates of application or synergistic formulation, fumes from the admixture caused a complete (100%) kill of all the twenty (20) unsexed *C. maculatus* adults introduced into the 20g of cowpea seeds in each fumigation chamber (*Table 1*). This was significantly higher ($P < 0.05$) than the zero percent (0%) kill recorded in the controls.

In table 2, all parameters assessed and at all levels of treatment, the mean number of *C. maculatus* eggs laid own cowpea seeds, the mean percentages of F_1 adults that emerge from beetle eggs / larvae in infested seeds and the mean percentage of punctured seeds and weight loss from seeds after F_1 adult emergence; were all significantly lower than the control.

TABLE 1: MEAN PERCENTAGE MORTALITY OF C. MACULATUS ADULTS FUMIGATED WITH MIXED FORMULATIONS OF E. AROMATICA DUST AND EUCALYPTUS OIL AT DIFFERENT APPLICATION RATES.

Rates of Formulation	**Mean % Mortality of *C. maculatus*, in: (n = 20)**				
	24hrs	**36hrs**	**48hrs**	**60hrs**	**72hrs**
Control	0.00a	0.00a	0.00a	0.00a	0.00a
0.1g+0.1ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.2g+0.1ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.3g+0.1ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.4g+0.1ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.5g+0.1ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.1g+0.2ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.2g+0.2ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.3g+0.2ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.4g+0.2ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.5g+0.2ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.1g+0.3ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.2g+0.3ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.3g+0.3ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.4g+0.3ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.5g+0.3ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.1g+0.4ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.2g+0.4ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.3g+0.4ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.4g+0.4ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.5g+0.4ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.1g+0.5ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.2g+0.5ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.3g+0.5ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.4 g+0.5ml	100.0b	100.0b	100.0b	100.0b	100.0b
0.5g+0.5ml	100.0b	100.0b	100.0b	100.0b	100.0b

**0.1g of E. aromatica dust is equal in weight to 0.1ml of Eucalyptus oil.*
Means in each column followed by the same letter are not significantly different at the 5% level of probability by Duncan's Multiple Range Test (DMRT[a]).

TABLE 2: MEANS OF OTHER PARAMETERS ASSESSED IN THE USE OF E. AROMATICA DUST & EUCALYPTUS OIL MIXED FORMULATIONS, AS FUMIGANT AGAINST C. MACULATUS, AT DIFFERENT FORMULATION RATES.

Rate of Fumigant Admixture (*E. aromatica* dust + *Eucalyptus* oil.)	**Mean Number of Eggs Laid on Seeds**	**Mean % F_1Adult Emergence of *C. maculatus* from Fumigated:**		**Mean % of holed seeds After F_1 Adult Emergence**	**Mean % Weight Loss from Seeds after F_1 Adult Emergence**
		Eggs (6 days old)	**Larvae (10–20 days)**		
Control	426.0 b	90.6 b	94.2 b	81.7 b	13.2 b
0.1g+0.1ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.2g+0.1ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.3g+0.1ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.4g+0.1ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.5g+0.1ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.1g+0.2ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.2g+0.2ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.3g+0.2ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.4g+0.2ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.5g+0.2ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.1g+0.3ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.2g+0.3ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.3g+0.3ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.4g+0.3ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.5g+0.3ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.1g+0.4ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.2g+0.4ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.3g+0.4ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.4g+0.4ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.5g+0.4ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.1g+0.5ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.2g+0.5ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.3g+0.5ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.4g+0.5ml	0.00a	0.00a	0.00a	0.00a	0.00a
0.5g+0.5ml	0.00a	0.00a	0.00a	0.00a	0.00a

Means in each column followed by the same letter are not significantly different at the 5% level of probability by Duncan's Multiple Range Test (DMRT[a]).

IV. DISCUSSION

This study has unequivocally shown that there is great potential in using *E. aromatica* bud dust and *Eucalyptus* oil mixed formulations as fumigants against cowpea seeds damage by the cowpea bruchid, *Callosobruchus maculatus*. The synergistic admixture caused 100% mortality in all the parameters tested in *C. maculatus* control. (Table 2).

The mechanism of insecticidal activity of the mixed formulations as fumigant in the study, can be deduced from the *great and rapid kill of the adult insects, strong inhibition of oviposition, and the remarkably high reduction in survival to adulthood of immature stages of the in comparison with the control.*

The observed fumigant toxicity of the mixed formulations to *C. maculatus* was rather fascinating. The rates of application at which complete mortality of all stages in the life cycle of the insects was achieved *(Less than 2% the weight of protected seed),* was also not excessive (Lale, 1995; Dales, 1996; Golob et al., 1999; Boeke et al., 2001).

With the fumigation of field infested cowpeas with the *E. aromatica* dust and Eucalyptus oil *admixtures*, all eggs laid by the founder insect in store, can be killed, and further proliferation and seeds damage halted. The act of admixing *Eucalyptus* oil and *E. aromatica* powder in this study, was aimed at producing a fumigant that is more potent in controlling the stored-product insect pests, as well as develop necessary safeguard against rapid pest build-up and resistance.

Apart from the aforementioned experimental proves that the mixed formulation is very effective as fumigants against *C. maculatus;* the botanical also possess a safety advantage in comparison with synthetic fumigants like Force Toxin® (Aluminium phosphide 57%). *Eugenia aromatica* Baill, with its characteristic sweet aroma, is widely used in 'pepper soup' spicing and soup seasoning. *Eucalyptus* oil can be inhaled by man, to treat colds, coughs, catarrh and headaches. The volatile oil is also useful as an antiseptic, deodorant and stimulant, and in the treatment of sprains, lumbago and rheumatic pains.

The aromatic volatile oil in the leaf glands of *Eucalyptus* species has anti-microbial and protective properties and is very useful traditionally in the prevention and treatment of ulcers and also protect against some disease causing organisms such as *E-coli, Candida albicans* and *Pseudomonia* Spp. (Oguntola, 2003). Therefore, using their admixture for *C. maculatus* control in stored cowpeas and maize will definitely not be hazardous to human beings and livestock.

Finally, as suggested by Ofuya (2003), agronomists, particularly in Nigeria need to study and evolve good husbandry methods for the two active insecticidal plants [*Eucalyptus* spp., particularly *E. citriodora* and the clove plant, *Eugenia aromatica*], that produced the active ingredients of the mixed formulations tested in this study*;* for th purpose of sustaining them for use in pest control and health promotion in humans and possibly livestock.

V. CONCLUSIONS AND RECOMMENDATIONS

- There is great potential in using botanical plant formulations as fumigant(s) against stored cowpea seeds damage by the cowpea bruchid, *C. maculatus.*
- That 'Silver Bird' *Eucalyptus* oil and the dust made from dry bud of *E. aromatica* against grain damage by *C. maculatus* was sufficiently insecticidal to merit scientific formulation into synergists, to enhance their action and delay selection for tolerance to them by the insect pest species.
- Vapour from the admixtures, applied at 1% the weight of protected cowpea seeds (0.1g + 0.1ml) was also 100% effective against *C. maculatus* at all stages of development.
- Environmental and health implications, indicate that it would be safer and more environmental friendly to use the botanical fumigant formulations in insect pests control, than to use the poisonous and hazardous' synthetic fumigants.
- The synergistic formulations from the combination of *E. aromatica* dust and *Eucalyptus* oil is hereby recommended as an effective fumigant for use in disinfesting small and large quantities of cowpea seeds and maize grains, against *C. maculatus* at any stage of their development.
- Pilot programmes involving households, traders and farmers should be carried to demonstrate the effectiveness of this botanical fumigant formulation and determine their adoption potential, for large scale seeds storage.
- The possibility of patenting this mixed synergistic formulation or admixture however, may need to be investigated.
- It is equally necessary for agronomists and plant scientists, particularly in Africa, to evolve good husbandry methods for the production of these identified insecticidal plants: *Eucalyptus* species, particularly *Eucalyptus citriodora* ('Gum' tree) and the Clove plant, *Eugenia. aromatica*, for sustainability.

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