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Leaf powders utilization for *Cola nitida* protection against kola weevils (*Balanogastris kolae* and *Sophrorhinus* spp.) in storage

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The effectiveness of five plant species (*Nicotiana tabacum* L., *Hyptis sauvolens* Poit, *Ocimum gratissimum* L., *Cymbopogon citrtus* Stapf and *Lantana camara* L.) were investigated using their leaf powders at 0, 5, 10, 15 and 20 g w/w as protectants of kolanuts against weevils. *Nicotiana tabacum* and *C. citrtus* suppressed the rate of *Balanogastris kolae* development at the treatment level of 15 g with mean adult emergence of 4.71 and 5.21, respectively, which differed significantly (p<0.05) from their control treatment (19.46). The various treatments of all the powder at 10 g treatment level (0.21 to 0.29) significantly (p<0.05) suppressed the rate of *Sophrorhinus* species development and emergence from the stored kolanuts. At the highest treatment levels of 20 g, there was no significance difference (p>0.05) between the control treatment mean colour change of 0.58 when compared with values recorded for *H. sauvolens* (0.58), *O. gratissimum* (1.17), *C. citrtus* (0.96) and *L. camara* (0.83). The mean number of exit holes found on the kolanuts decreased with increased concentrations of the various powder treatment levels 5 g (17.0 to 32.0), 10 g (13.21 to 28.83), 15 g (8.17 to 17.67) and 20 g (6.5 to 10.5). The plant powders did not impart any undesirable quality on the nuts.

Key words: Kolanuts, weevils, development, emergence, treatments.

INTRODUCTION

The *Cola* species of economic importance are *Cola acuminata* and *Cola nitida* (Quarco, 1973; Daramola, 1978a). *Cola nitida*, which is referred to as “the true kola of commerce”, has featured in the internal trade of West Africa for a number of centuries (Nzekwu, 1961; Eijnatten, 1969). Kolanuts are common sight in African markets, cities and villages. Many Africans consume kolanuts regularly, even daily, for the medicinal, stimulating and sustaining properties. Kolanuts contain caffeine (2 to 3%) and smaller amounts of theobromin and kolanin, which dispel sleep, thirst and hunger and act as a stimulant and anti-depressant. They are also thought to reduce fatigue, aid digestion and work as an aphrodisiac. The nuts are nutritious, containing nearly 1% protein, 1.35% fats and 45% starch (FDA, 1973).

Kola like many other crops is susceptible to various

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insect pests in Nigeria. The kola weevils, *Balanogastris kolae* (Desbr) and *Sophrorhinus* species (Coleoptera: Curculionidae) are the most destructive pests of kolanut in West Africa. They attack nuts from the field to storage and infestation ranges from 30 to 100% depending on the sanitary condition on the farm at time of harvest and in storage (Groormanns and Pujol, 1955; Daramola, 1973, 1978b; Ndubuaku, 1989; Idowu and Ojelade, 1994, 1995). The infestation of kolanuts by these weevils significantly reduces the caffeine content of such nuts (Lale and Okunade, 2000). The larva feeds extensively on the nuts thereby reducing the kola to brown powdery mass, which drastically lowers their market value. The average period from oviposition to the emergence of the adults of *B. kolae* is 29 and 31 days for *Sophrorhinus* spp. Breeding was noted to continue throughout the year on left-over nuts and nuts produced between the main harvest seasons (Alibert and Mallamaire, 1955; Daramola, 1974; NRI, 1996).

Many conventional insecticidal dusts (pirimiphos methyl, permethrin) and fumigants such as aluminum phosphide have been reported to be effective against storage pests (Jackai and Daoust, 1986; Ivbijaro, 1976). However, synthetic insecticides involve risks for human health and the environment especially when improperly used, which may be common among rural farmers in Africa (Ofuya, 2003). Their high costs as well as environmental pollution and hazards to human and livestock health have resulted in the exploration of plant materials for the control of insect pests in storage (Ivbijaro and Agbaje, 1986; Dike and Mbah, 1992; Lale, 1995; Adedire and Ajayi, 1996). The use of plant powders and extracts in the control of insect pests of stored products is an ancient practice. Many medicinal plants and spices have been used as pest control agents (Lale, 1992; Ofuya and Dawodu, 2002). Several powders, extracts and oils are often used in the control of stored product pests (Coleoptera) because of their relative high efficacy (Ashamo, 2007).

The impetus for screening medicinal plants for kola storage pest control ability is to identify the most effective, which may serve as replacements for usually deleterious synthetic pesticides used by kola farmers and vendors. The present study evaluated pulverized parts of five (5) plant materials (*Nicotiana tabacum* L., *Hyptis sauvolens* Poit, *Ocimum gratissimum* L., *Cymbopogon citrtus* Stapf and *Lantana camara* L) under storage conditions for their relative toxicities on the kola weevils, *B. kolae* (Desbr) and *Sophrorhinus* spp. (Coleoptera: Curculionidae) on stored kolanuts.

MATERIALS AND METHODS

Two baskets of unskinned kolanuts for this experiment were procured from Ogunmakin market in Ogun State. The nuts were skinned, washed and cured (aerated) for 72 h before use. The fresh leaves of five common plant species (Table 1) were collected from the natural forest of the Cocoa Research Institute of Nigeria (CRIN), Ibadan. The identity of each sample was confirmed at the herbarium of the Forestry Research Institute of Nigeria (FRIN), Ibadan. The leaves were processed into fine powders of particle size 300 µ according to methods used by Ofuya et al. (2005). In the process of blending, the plant samples emitted a pungent smell that was repulsive to workers and also stimulated the lachrymal glands, which led to lachrymator (tears shedding). The treatments consisted four concentrations (5, 10, 15 and 20 g) of leaf powders with a no treatment control (0 g), which were added to a set of 20 randomly selected kolanuts each in a black light gauge polythene bag of dimension 42.5 × 21.0 cm. The concentrations were weighed out with an electronic sensitive scale and each treatment was replicated four times. The grinding and weighing of the leaf powder were quickly done and the open ends of the polythene bags were closed up most of the time so as to minimize possible loss of volatile insecticidal components in the powders. The kolanuts and the powders were thoroughly shaken together to mix up very well before the bags were tied up. All the treatments were stored under laboratory conditions of temperature and relative humidity of 28 ± 3°C and 75 ± 5%, respectively. A space of 20 cm was maintained between replicates.

The various treatment levels in separate polythene bags were sieved every fortnight to determine the rate of development and emergence of adult *B. kolae* and *Sophrorhinus* spp. by direct counting of newly emerged adult weevils until 112 days after treatment (DAT). The efficacy and suitability of the various leaf powders were also considered by determining the number of weevil exit holes on the kolanuts and the number of kolanuts with colour change in each treatment. Data obtained were subjected to the analysis of variance and significant means were separated at 5% level using Tukey's Studentized Range (HSD) Test.

RESULTS

The effect of the various leaf powder treatments was able to minimally suppress the rate of the weevil development and emergence from treated stored kolanuts. The rate of weevil development and emergence was not effectively affected by the increased concentrations of the various treatments (Tables 2 and 3). *Nicotiana tabacum* and *C. citrtus* powders were found to be very effective as they suppressed the rate of *B. kolae* development at 15 and 20 g treatment levels with mean adult emergence of 4.71 to 3.21 and 5.21 to 4.42, respectively, which significantly ($p < 0.05$) differed from their control. All the plant powders at 5 g (8.13 to 13.21) and 10 g (6.0 to 11.0) treatment levels were not significantly different ($P > 0.05$) from each other and their control treatment mean emergence of 19.46. However, at the highest treatment level of 20 g, the rate of *B. kolae* development and emergence from all the stored treated kolanuts (3.21 to 4.42) were not significantly lower ($p > 0.05$) than that of 5 g (8.13 to 13.21), 10 g (6.0 to 11.0) and 15 g (4.71 to 7.08), but differed significantly ($p < 0.05$) from their control treatment (19.46) (Table 2). The rate of *Sophrorhinus* spp. development and emergence from the stored kolanuts was significantly ($p < 0.05$) suppressed by all the leaf powders at 10 g treatment level (0.21 to 0.29) (Table 3). *L. camara* achieved a high suppression rate of *Sophrorhinus* spp. at 5 g treatment level (0.29), which however, did not differ significantly ($p > 0.05$) with the mean number of adult emergence recorded at 10 g (0.25)

Table 1. Medicinal plants screened for effectiveness in the control of *Balanogastris kolae* and *Sophorhinus* spp. infesting kolanut.

Scientific name	Common name	Family	Part used
Nicotiana tabacum L.	Tobacco	Solanaceae	Leaf
Hyptis sauvolens Poit.	Hyptis	Labiatae	Leaf
Ocimum gratissimum L.	Basil	Meliaceae	Leaf
Cymbopogon citrtus Stapf.	Lemon grass	Poaceae	Leaf
Lantana camara L.	Lantana	Verbenaceae	Leaf

Table 2. Effect of various leaf powder treatments on the development and emergence of *Balanogastris kolae* from stored kolanuts.

Powder concentration (g)	Mean number of adult *B. kolae* emergence (n = 80)*				
	0 g	5 g	10 g	15 g	20 g**
Nicotiana tabacum	19.46^{a}	8.13^{ab}	6.00^{ab}	4.71^{b}	3.21^{b}
Hyptis sauvolens	19.46^{a}	10.04^{ab}	7.21^{ab}	5.83^{ab}	4.38^{b}
Ocimum gratissimum	19.46^{a}	11.46^{ab}	9.33^{ab}	7.08^{ab}	3.21^{b}
Cymbopogon citrtus	19.46^{a}	8.21^{ab}	6.13^{ab}	5.21^{b}	4.42^{b}
Lantana camara	19.46^{a}	13.21^{ab}	11.00^{ab}	6.58^{ab}	4.00^{b}

*Means with the same superscript are not significantly different (p > 0.05) by Tukey's test. **Each value represents mean of three replicates.

Table 3. Effect of various leaf powder treatments on the development and emergence of *Sophorhinus* sp.p from stored kolanuts.

Powder concentration (g)	Mean number of adult *Sophorhinus* spp. emergence (n = 80)*				
	0 g	5 g	10 g	15 g	20 g**
Nicotiana tabacum	0.96^{a}	0.46^{a}	0.25^{b}	0.17^{b}	0.17^{b}
Hyptis sauvolens	0.96^{a}	0.38^{a}	0.21^{b}	0.13^{c}	0.08^{c}
Ocimum gratissimum	0.96^{a}	0.42^{a}	0.29^{b}	0.13^{c}	0.08^{c}
Cymbopogon citrtus	0.96^{a}	0.38^{a}	0.25^{b}	0.17^{b}	0.08^{c}
Lantana camara	0.96^{a}	0.29^{b}	0.25^{b}	0.17^{b}	0.13^{c}

*Means with the same superscript are not significantly different (p > 0.05) by Tukey's test. **Each value represents mean of three replicates.

and 15 g (0.17) treatment levels, respectively. However, *H. sauvolens*, *O. gratissimum* and *C. citrtus* at 15 g treatment levels greatly suppressed the rate of *Sophrorhinus* spp. development with a mean adult emergence of 0.13, 0.13 and 0.17, respectively.

The few colour changes recorded in the treated stored kolanuts did not follow a definite pattern. At the highest treatment levels of 20 g, there was no significance difference (p > 0.05) between the control treatment mean colour change of 0.58 when compared with values recorded for *H. sauvolens* (0.58), *O. gratissimum* (1.17), *C. citrtus* (0.96) and *L. camara* (0.83) (Table 4). Therefore, the colour changes observed could have been as a result of physiological factors associated with storing fresh nuts in polythene bags and not from the plant powders used. The mean number of exit holes found on the kolanuts decreased with increased concentrations of the various powder treatment levels 5 g (17.0 to 32.0), 10 g (13.21 to 28.83), 15 g (8.17 to 17.67) and 20 g (6.5 to 10.5). The various mean number of weevil exit holes recorded for *N. tabacum, H. sauvolens*, *O. gratissimum* and *C. citrtus* at the treatment levels of 10 g (13.21 to 28.83), 15 g (8.17 to 17.67) and 20 g (6.5 to 10.5) differed significantly (p < 0.05) from their control treatment (38.21), but showed no significant difference (p > 0.05) amongst each other (Table 5).

DISCUSSION

The minimal protection of kolanuts achieved with these plant powder materials are in line with earlier report by

Table 4. Effect of various leaf powder treatments on the number of stored kolanuts with colour change.

Powder concentration (g)	Mean number of kolanuts with colour change (n = 80)*				
	0 g	**5 g**	**10 g**	**15 g**	**20 g****
Nicotiana tabacum	0.58^{fgh}	0.67^{efgh}	2.04^{b}	0.75^{defgh}	2.04^{b}
Hyptis sauvolens	0.58^{fgh}	1.50^{bcde}	1.92^{bc}	3.38^{c}	0.58^{fgh}
Ocimum gratissimum	0.58^{fgh}	0.33^{gh}	0.58^{fgh}	1.54^{bcd}	1.17^{cdefg}
Cymbopogon citrtus	0.58^{fgh}	0.33^{gh}	0.00^{h}	1.83^{bc}	0.96^{defg}
Lantana camara	0.58^{fgh}	0.00^{h}	0.33^{gh}	1.33^{bcdef}	0.83^{defgh}

*Means with the same superscript are not significantly different (p > 0.05) by Tukey's test. **Each value represents mean of three replicates.

Table 5. Effect of various leaf powder treatments on the number of weevil exit holes on stored kolanuts.

Powder concentration (g)	Mean number of weevil exit holes per treatment (n = 80)*				
	0 g	**5 g**	**10 g**	**15 g**	**20 g****
Nicotiana tabacum	38.21^{a}	18.38^{bcd}	13.21^{cd}	10.79^{d}	6.50^{d}
Hyptis sauvolens	38.21^{a}	18.71^{bcd}	14.13^{cd}	8.17^{d}	9.79^{d}
Ocimum gratissimum	38.21^{a}	22.96^{abcd}	18.67^{bcd}	17.67^{bcd}	7.17^{d}
Cymbopogon citrtus	38.21^{a}	17.00^{bcd}	15.08^{bcd}	12.83^{cd}	10.25^{d}
Lantana camara	38.21^{a}	32.00^{ab}	28.83^{abc}	15.75^{bcd}	10.50^{d}

*Means with the same superscript are not significantly different (p > 0.05) by Tukey's test. **Each value represents mean of three replicates.

Anikwe and Ojelade (2005), with powders of *Tetrapleura tetraptera* (Schum and Thonn). The results of this study on Coleoptera: Curculionidae are consistent with observations by earlier workers on Coleoptera: Bruchidae with powders of *C. citrtus (leaves)*, *H. sauvolens* (leaves), *Piper nigrum* (fruit), *Piper guineense* (fruit), *Azadirachta indica* (seed), *Eugenia aromatica* (buds), *Dennetia tripetala* (seeds), *Zanthoxylum zanthoxyloides* (root bark) and *Carica papaya* (trunk) (Su, 1977; Ivbijaro, 1983; Ivbijaro and Agbaje, 1986; Olaifa and Erhum, 1988; Olaifa et al., 1987; Shikaan and Uvah, 1992; Dike and Mbah, 1992; Lale, 1994; Ogunwolu and Idowu, 1994; Ogunwolu and Odunlami, 1996; Lajide et al., 1998; Adedire and Lajide, 2001; Ofuya and Salami, 2002). However, plant extracts are slow acting and degrades easily in the environment. There is therefore the need for high rates of their application at an increased frequency to achieve very effective weevil control, which is in line with earlier research findings (Golob et al., 1982; Sharaby, 1988; Ofuya et al., 1992; Ewete et al., 1996).

The loss in quality of kolanuts due to weevil infestation as observed in this study may be related both to the time of harvest and storage. According to Daramola (1976), the longer it takes for mature kola pods to be harvested, the higher the proportion of infested pods and the higher the intensity of the infestation in individual nuts. The farmers usually wait for the kola pods to mature and fall to the ground before they extract the nuts and sell in the market as unskinned nuts. A damage level of 38 to 56% of the kolanuts in storage by these weevils reported by Okunade and Lale (1998) conforms to the level of infestation recorded by earlier workers in Nigeria (Daramola, 1973, 1974; Daramola and Taylor, 1975; Idowu and Ojelade, 1994, 1995).

Only cultural and environmental/user friendly methods are recommended for the control of kola weevils in storage. The use of pesticides are discouraged because the nuts are consumed in its raw form without any further known post-harvest processing and the health hazards posed by the long term effects of pesticide residues on consumers is of concern to experts and various stakeholders. The use of cultural practices involving early harvesting of mature kola pods, prompt removal of fallen and hanging mature pods at the end of the season, as well as the removal of dead and moribund pods between crops are effective and economic methods of reducing the level of insect pest infestation in kola plantations (Daramola, 1974, 1976, 1978a; Ojelade, 2000). Idowu and Ojelade (1994, 1995) observed that minimal level of weevil damage was recorded on kolanuts which were obtained from timely harvested pods (35.42%) when compared with the nuts obtained from pods whose harvest were delayed (58.25 to 83.3%).

CONCLUSION AND RECOMMENDATION

The plants studied here can be seen as potential source of useful insecticidal plants for the storage of kolanuts. All the plant powders could be used at the rate of 10 g w/w to effectively reduce the development and emergence of only *Sophrorhinus* spp. from stored kolanuts. The plant powders did not impart any undesirable quality (severe colour changes) on the nuts, which could affect their ecstatic or commercial value. However, further studies should be carried out on these plants in order to isolate, identify, characterize and elucidate the structure of their bioactive compounds.

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Conflict of Interest

Authors have not declared any conflict of interest.

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