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# Evaluation of the potential of some local spices as stored grain protectants against the maize weevil *Sitophilus zeamais* Mots (Coleoptera: Curculionidae)

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**ABSTRACT**: Five local spices (*Piper guineense*, *Allium sativum*, *Afromomum melequata*, *Xylopia aethiopica* and *Tetrapleura tetraptera*) were evaluated in the laboratory for their ability to protect stored maize against infestation by *S. zeamais*. Ground products of the spices were applied as direct admixtures at two concentration levels of 1% and 5% to assess for mortality, progeny emergence, damage and repellency. At 1% and 5% concentration, *P. guineense* caused significant ($P<0.05$) mortality of weevils. *A. melequata* and *P. guineense* were strongly repellent to the weevils while the other three spices showed moderate repellent activity. There was a significant ($P<0.05$) reduction in damage caused by the weevils with less damage recorded on grains treated with *P. guineense*, *A. sativum* and *T. tetrptera*. Progeny production was also significantly ($P<0.05$) influenced by *P. guineense* than the other four spices and the control. The possible protectant potentials of the five spices are discussed. @JASEM

In developing countries, food grain production and consumption often fall below demand as a result of post harvest loses caused by pests and other spoilage agents. Insect pest damage to stored grains results in major economic losses and in Africa where subsistence grain production supports the livelihood of majority of the population, grain loss caused by storage pests such as the maize weevil, *Sitphilus zeamais* (Mots.) threatens food security. Reduction of insect damage in stored grains is a serious problem in developing countries in the tropics due to favourable climatic conditions and poor storage structures (Bekele *et al*., 1997).

Insect pest control in stored food products relies heavily on the use of gaseous fumigants and residual contact insecticides. The implications of these are serious problems of toxic residues, health and environmental hazards, development of insect strains resistant to insecticides, increasing cost of application and erratic supply in developing countries due to foreign exchange constraints (Obeng-ofori *et al.*, 1997).

The need to find materials that effectively protect stored produce, that are readily available, affordable, relatively less poisonous and less detrimental to the environment had stimulated interest in the development of alternative control strategies and the re-evaluation of traditional botanical pest control agents (Niber, 1994; Talukder and Howse, 1995).

Resource poor farmers in developing countries use different plant materials to protect stored grains against pest infestation by mixing grains with protectants made up of plant products. This study describes laboratory bioassays to evaluate the efficacies of five local spices; *Piper guineense* Schum and Thonn, *Allium sativum* (L.), *Afromomum melequata* K. Schum., *Xylopia aethiopica* (Dunal) A. Rich. and *Tetrapleura tetraptera* (L.) as possible stored grain protectants against the maize weevil, *Sitophilus zeamais* (Mots.) (Coleoptera: Curculionidae) in the tropics.

## MATERIALS AND METHOD

*Culturing of insects: S. zeamais* were obtained from infested stock of maize at Uyo main market, Nigeria. The insects were reared on whole maize in 500 l glass jars after being treated for mites (Udo, 2000). The glass jars and grains were sterilized at an oven temperature of 40$^{o}$C for 4 hours (Santhoy and Rejesus, 1975). After three weeks of oviposition, the parent insects were removed and discarded by freezing while the emerging generation of same age insects were re-cultured at 28 $^{o}$C, 70% relative humidity (r.h.) and used for the different bioassays.

*Collection and preparation of spices*: The five spices were purchased from Uyo main market, Nigeria and washed in distilled water and air dried at 25 – 30 $^{o}$C and 65 – 70 % r.h. in the laboratory for 3 days. Prior to application, the spices were ground using a laboratory mill in order to avoid having to store the ground material, thus guarding against possible volatilization of active ingredients. The ground materials were added as direct admixtures to the grains at concentrations of 1% and 5% (Niber, 1994).

*Mortality, progeny and damage assessment assays:* The spices were added separately to 100 g of maize in 2 l glass jars at 1% and 5% concentrations, while

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the control treatment had no spices added. Twenty adult *S. zeamais* of 3 – 5 days old of mixed sexes were introduced into the jars containing the various treatments. The jars were covered with white muslin cloth held with rubber bands. Dead insects in each treatment were counted after 24 hours and up to 96 hours. Insects were considered dead on failure to respond to three probings with a blunt probe. Data were corrected for mortalities in the control by using Abbott's formula (1925) {[($S_c - S_t$) / $S_c$] where $S_c$ = % survival in control while $S_t$ = % survival in treated} and transformed before ANOVA.

In another experiment, 20 adult *S. zeamais* of 3 – 5 days old were introduced into treated and untreated jars replicated five times and left to stand undisturbed for five weeks in order to determine progeny production. At the end of the period, total number of insects present in both treated and untreated glass jars were counted.

Damage assessment was carried out on treated and untreated grains by taking samples of 100 grains from each jar. The numbers of damaged (grains with characteristic holes) and undamaged grains were counted and weighed with percent weight loss calculated following the method of FAO (1985) as:

$$\% \text{ Weight loss} = \frac{UaN - (U + D)}{UaN} .100$$

Where U = weight of undamaged fraction in the sample; N = total number of grains in the sample; Ua = average weight of one undamaged grain; D = weight of damaged fraction in the sample.

*Repellency:* The repellent action of the spices was assessed in a choice bioassay method. Two maize grains were coated in slurry of each of the spices and left to stand for 2 hours while the control grains was treated with distilled water only. The treated and untreated grains were placed adjacent to each other with a space between them in a petri dish (11 cm diameter). Ten adult S. zeamais of 3 – 5 days old were introduced into the middle of the petri dishes (Udo, 2000). Each treatment was replicated four times and the number of insects present on control ($N_c$) and treated ($N_t$) grains were recorded after one hour and up to six hours. Percent repellency (PR) was computed as: PR = [($N_c - N_t$) / ($N_c + N_t$)] X 100 and data analysed using ANOVA after transformation into arcsine values. All negative PR values were treated as zero (Obeng-Ofori *et al*., 1997).

## RESULT

*Insect mortalit:y* Percent mortality of the weevils after 96 hours exposure to the five spices at both 1% and 5% concentration levels is shown in Table one. All the spices killed more insects than in the control after 96 hours exposure with *P. guineense* significantly (P<0.05) causing 100% mortality at both concentration levels tested. There was an increasing mortality from 15 to 5% level for other spices with *T. tetraptera* showing a remarkable performance from 9% to 35% after 96 – hour exposure.

**Table 1.** Mean mortality of adult weevils after 96 hours exposure to the five spices.

**Hours after exposure**

| Spices | | | 24 | | 48 | | 72 | | 96 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 1% | | | | |
| | *P. guineense* | | $16^{b}$ | | $65^{a}$ | | $100^{a}$ | | $100^{a}$ | |
| | | *A. meleguata* | | $0^{c}$ | | $0^{d}$ | | $0^{c}$ | | $3^{d}$ |
| | | *T. tetraptera* | | $0^{c}$ | | $1^{d}$ | | $3^{c}$ | | $9^{d}$ |
| | | *X. aethiopica* | | $0^{c}$ | | $1^{d}$ | | $5^{c}$ | | $5^{d}$ |
| | | *A. sativum* | | $0^{c}$ | | $0^{d}$ | | $6^{c}$ | | $14^{d}$ |
| | | | | | | | 5% | | | |
| | *P. guineense* | | $59^{a}$ | | $99^{a}$ | | $100^{a}$ | | $100^{a}$ | |
| | | *A. meleguata* | | $6^{c}$ | | $9^{d}$ | | $9^{c}$ | | $10^{d}$ |
| | | *T. tetraptera* | | $1^{c}$ | | $3^{d}$ | | $8^{c}$ | | $35^{bc}$ |
| | | *X. aethiopica* | | $0^{c}$ | | $11^{cd}$ | | $15^{bc}$ | | $21^{c}$ |
| | | *A. sativum* | | $6^{c}$ | | $19^{c}$ | | $23^{b}$ | | $26^{c}$ |
| | | | | | | | | | | |
| Control | | $0^{c}$ | | $0^{d}$ | | $0^{c}$ | | $0^{d}$ | | |

Mean of 4 replicates of 20 insects each. Column means followed by different letter(s) are significantly different at the 0.05 level (Duncan's multiple range test).

*Progeny production:* Table two shows the number of F1 progeny produced by *S. zeamais* after being exposed to the different spices at 5% concentration. There was a significant (P<0.05) difference amongst the treatments over the control with *P. guineense* recording the lowest number of emergence. However, the other four spices affected progeny development minimally while the control recorded the highest progeny development of 85%.

*Damage assessment*: Damage done to treated and untreated maize grains by the weevil is shown in Table two. There was a significant (P<0.05) difference amongst the spices over the control in reducing damage caused by *S. zeamais*. *A. sativum*, *P. guineense* and *T. tetraptera* significantly (P<0.05) reduced damage caused than the remaining two spices and the control. None of the spices offered complete protection but the level of damage was very low.

**Table 2.** Mean percent damage and progeny development at 5% concentration.

| Spices | | | % Weight loss | | % Progeny development | |
|---|---|---|---|---|---|---|
| *P. guineense* | | $0.90^{c} \pm 0.04$ | | | | $7^{c} \pm 0.12$ |
| *A. meleguata* | | $2.14^{b} \pm 0.28$ | | | | $59^{ab} \pm 1.34$ |
| *T. tetraptera* | | $0.96^{c} \pm 0.08$ | | | | $44^{b} \pm 1.02$ |
| *X. aethiopica* | | $1.56^{b} \pm 0.17$ | | | | $35^{b} \pm 1.15$ |
| *A. sativum* | | $0.32^{c} \pm 0.02$ | | | | $43^{b} \pm 0.98$ |
| Control | | $5.22^{a} \pm 1.38$ | | | | $85^{a} \pm 1.52$ |

Mean of 5 replicates of 20 insects each. Column means followed by different letter(s) are significantly different at the 0.05 level (Duncan's multiple range test).

*Repellenc:y* The mean percent repellency observed for all the spices (Table three) showed that *P. guineense* and *A. meleguata* had the highest repellent effect of 80%. The five spices were sufficiently repellent to the weevil with an overall repellency of 67%. The lowest repellent effect of 52% was recorded by *T. tetraptera*. *A. sativum* and *X. aethiopica* had an appreciable repellent effect of 62% and 63%, respectively. This is an encouraging trend in integrated pest management particularly in traditional storage systems

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**Table 3.** Mean percent Repellency of adult weevil after 6 hours of exposure to the different spices.

| Spices | %repellency | *P. guineense* | $80^{a} \pm 1.80$ |
|---|---|---|---|
| *A. meleguata* | $80^{a} \pm 2.40$ | *T. tetraptera* | $52^{c} \pm 1.40$ |
| *X. aethiopica* | $63^{bc} \pm 1.20$ | *A. sativum* | $62^{bc} \pm 1.60$ |
| Control | $0^{d} \pm 0.00$ | Overall Repellency 67% | |

## DISCUSSION

Toxicity of *P. guineense* was higher at both 1% and %% concentration levels than the other four spices confirming the extremely pepperish nature of the spice. The overall mortality effect of the spices from the 1% level to 5% level is encouraging as it could be used in traditional smallholder grain storage of short duration. The significant mortality induced *P. guineense* suggests an excellent protectant potential for incorporation into an integrated management system of storage pests. The reduction in damage caused to stored maize using *A. sativum*, *P. guineense* and *T. tetraptera* indicates the possible presence of feeding deterrence in these spices. This could be due to the presence of strong pungent odour from the three spices. Generally, spices did not offer complete protection probably due to a decreasing activity caused by air movement. The situation might be different when tried in airtight containers. However, the level of damage observed could be described as tolerable and could be useful in traditional small holder storage system. Again, the inability to offer complete protection might be due to powder from the spices settling to the bottom of jars (Niber, 1994).

All the spices evaluated were repellent to the weevil and the high repellency of 80% from *P. guineense* and *A. meleguata* is a useful property for storage insect management indicating the protectant potential of the spices from weevil attack (Bekele *at al*., 1997). The spices evaluated variously affected progeny development with *P. guineense* recording the lowest number of emergence. This could be correlated with the high mortality observed on treated grains as well as the possible presence of oviposition deterrence in the spice. The bioactivity of the different spices against the weevil may depend on several factors like chemical composition, species susceptibility and variation in insect behaviour (Cassida, 1990).

*Conclusion:* The results obtained in this study indicate good potential of using the various spices as grain protectants in storage pest management systems. The spices are broad spectrum in pest control, readily available, safe to apply and can be afforded by resource poor farmers. Botanical pesticides thus represent an important potential for integrated pest management programmes in developing countries as they are based on local materials (Bekele *et al*., 1997). Future work being undertaken on possible combination of the spices for protection of stored maize would add to the development of traditional pesticides at the farm level for resource poor farmers who have no access to or can afford commercial pesticides. Also further trials are recommended on a wide range of storage insect pests to adequately advise farmers and policy makers.

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