TOXICITY OF SOME BIOPESTICIDES TO *SITOPHILUS ZEAMAIS* MOTSCHULSKY ON MAIZE IN STORAGE

MBAH , O.I. AND M.N. OKORIE

Pest Management Technology, Federal College of Agriculture, P.M.B. 7008, Ishiagu, Ebonyi State, Nigeria. E-mail: oibomusmba@ yahoo.com Tel: 08039515944

ABSTRACT

Potentials of plant derived pesticides (Monodora myristica Gaertn) Dunal and Aframomum melegueta (Rosch) each at 3 concentrations of 5, 10 and 15g were evaluated in the laboratory against the stored pest of maize Sitophilus zeamais. The Aframomum treatments, which achieved adult mortality of 64%, 63% and 45% in week 1 at the three dosage levels of 15, 10 and 5g per 150g maize in that order was not as potent as Monodora powder in the control of S. zeamais. It was however, obvious that pirimiphos methyl and the two doses of Monodora proved very efficacious in the control of the weevil with 100%, 83% and 72% mortality respectively. Pirimiphos methyl offered complete inhibition of post-embryonic development, followed by Monodora treatments, which also remarkably halted progeny emergence. Aframomum treatments were less effective though significantly better than the control. Grains treated with pirimiphos methyl and Monodora were better protected against damage than Aframomum treatments. No weight loss was recorded in Pirimiphos methyl treated grains, and only marginal losses were observed in Monodora treatments as a result of insect activities compared to the increased weight loss in Aframomum treatments, which were nevertheless significantly heavier than the control grains. The test botanicals did not exert adverse effects on seed quality, taste and viability after storage.

KEY WORDS: Toxicity, biopesticides, *S. zeamais*, stored maize

INTRODUCTION

Maize is the most widely distributed cereal in the world and an important food in many tropical, sub-tropical and warm temperate countries, including most parts of tropical Africa (Onwueme and Sinha, 1991). It is also used extensively as the main source of calories in animal feeds and feed formulation.

Post harvest crop management is critical in crop production. This is due to the fact that substantial losses occur during storage especially in developing countries, a major part of it is due to insect attack. In tropical agriculture, quite a lot of food is lost to insect between harvest and consumption, and the most devastating effects of insect infestation and damage are felt greatly in the third world countries including Nigeria where the bulk of food production is in the hands of peasant farmers. *S. zeamais* (Motsch) has been discovered as a great source of maize loss both in store and in the field (Ashigidi and Okpara, 2002). Damage to grain by *S. zeamais* resulted to about 50% losses after six months storage period (Longstaff, 1981). Also weight loss of 30% has been observed after few months storage (Perking, 1982).

Problems created by the insect pests necessitated the discovery of pesticides in the early nineteen forties with the aim of alleviating the problem caused by these ravaging pests. One of the strategies adopted was the use of synthetic insecticides as a pest control measure. This was rather disappointing based on the environmental risks it poses to man. However, improper usage has led to toxicity to mammals and insect pest resistance problems (Perking, 1982). The high import bills incurred accentuated by devaluation of local currencies not only pose a serious drain on the economy of third world countries but also makes synthetic insecticides unaffordable to limited resource farmers. According to Salako (2002), this is rekindling a renewed interest in the use of insecticides of plant origin in pest and disease management schemes.

Onolemhemhem *et al,* (1991) revealed that various plant materials and plant extracts have been used extensively to control storage pests of cereals, legumes and to a limited extent field pests. Some of such materials or instances include neem, lemon grass, *Monodora myristica, Xylopia aethiopica, Piper guineenses* etc. Lajide *et al,* (1998) stated that leaf powder of bitter gourd protected maize grain from damage by *S. zeamais* but was not effective in causing mortality of the adult weevil. Oil palm bunch ash mixed with *Paperomia pellucida* proved effective in protecting maize grain against infestation by *S. zeamais* (Ibe and Nwufo, 2001). Ground components of *Piper nigrum* when used to surface treat a variety of maize susceptible to *S. zeamais* were found to be toxic and effective (Williams, 1983). Investigations carried out by Okonkwo and Okoye, (1996) revealed that seed powder of *M. myristica* achieved 50% mortality in adult *S. zeamais*. A study conducted by Mbah, (2006) showed that *M. myristica* at the rate of 30g per 7kg microplot was effective in the control of root-knot nematode. Lale, (1992) reported that fruit powder of *A. melegueta* caused significant mortality of *S. zeamais* within 24 hours. The study was thus targeted to assess the comparative efficacies of two indigenous plant powders in the control of *S. Zeamais* in stored maize.

MATERIALS AND METHODS

A laboratory experiment was conducted using two varieties of maize - the susceptible local variety (Bende white) for the insect culture and TZSRY for the experiment (bioassay). A culture of the insect pest under investigation (*S. zeamais*) was raised under laboratory conditions with room temperature of $28^0C \pm 2^0C$ and $70\% \pm 2\%$ relative humidity for 6 weeks using susceptible sterile maize grains as the media. Thereafter, freshly emerged adult *S. zeamais* were carefully sieved out preparatory for the experiment. The seeds of the African nutmeg *M. myristica* and the fruits of alligator pepper *A. melegueta* were obtained from the Eke market in Ishiagu, Ebonyi state, Nigeria. Fairly dried seeds of *M. myristica* were sun dried under shade for 5 days and later roasted to enhance shelling or separation of the kernels from the hard epicarp. Shelling was done to remove the epicarp and obtain the kernels. Ripped fruits of *A. melegueta* were first washed with clean water, then rinsed in a sterile distilled water, sun-dried for 7 days and mildly oven dried for 24 hours regulated at low temperature of 45^0C and ground into powders with an electric milling machine model Ed.5 as described by Mbah (2005). Prior to the experiment, the maize grains were fumigated for 48 hours with aluminium phosphide (phostoxin) to guarantee an insect free produce. The seeds were later ventilated for 48 hours to dissipate the toxic effect of the fumigant (poison).

Using an electric balance, 150g of maize was weighed into each aseptic kilner jar. Similarly, *M. myristica* and *A. melegueta* powders each at 15, 10 and 5g levels were weighed into the jars. As a standard, a 0.045g of pirimiphos methyl dust (formulated product) was also applied to the jars using a sensitive Metler balance. All the treated jars were vigorously shaken to ensure proper mixing of the chemical treatments with the grains. Each level of insecticidal treatment had four replicates. Four control jars were without chemical treatment. Treated and untreated jars were inoculated with 24 adult *S. zeamais*, later covered with muslin white cloth with perforated lid to ensure aeration and left on a laboratory table undisturbed in a completely randomized design. Adult mortality was observed at 1 and 4 weeks after treatment. Dead insects were sieved out, counted and the live ones returned to the jars with the treated grains and allowed for 3 months. Adult longevity of the maize weevil was evaluated thus:

Adult longevity = 100 (Number of dead insects) / (Total number of insects).

Abbott's (1925) formula was employed to correct percentage mortality of the weevil as:

$P_T = (Po - Pc) / (100 \; Pc)$.

Where P_T = corrected mortality (%), Po = observed mortality (%), Pc = Control mortality (%).

Adult emergence was observed 5 weeks after treatment storage. The F1 insects were counted to assess the potency of insecticidal treatments on progeny development. After 3 months of storage, grain damage was assessed by counting the number of grains with adult emergent holes from a random sample of 100 grains. The number of seeds perforated in the treated and control jars were counted for the determination of Weevil

Perforation Index (WPI), which was adopted for the assessment of damage according to Stoll, (2001) and calculated for each dosage for comparison of grain protectant effects of plant materials as: WPI = % of treated seeds perforated / % of control seeds perforated X 100 + percentage of treated seeds perforated.

A WPI value > 50 indicates negative grain protectant effect or enhancement of infestation by the weevil. At termination of the experiment, grains in each jar were re-weighed to determine the weight loss of grains and the concomitant percentage weight loss. Seed quality was assessed visually for possible changes in seed texture and colour. Taste of grains was conducted using a panel of seven judges. Grain viability was also evaluated after storage by a random selection of 10 grains from each kilner jar and plated in 32 petri dishes with subsequent germination count after 6 days.

Data Analysis

Data on adult longevity, progeny emergence, damage, weight loss and grain viability were statistically analyzed using analysis of variance (ANOVA) according to Steel and Torrie, (1980) and means separated by a Fisher Least Significant Difference (LSD).

RESULTS AND DISCUSSION

Table I shows the effect of biopesticides on adult longevity. The result revealed that the synthetic insecticide pirimiphos methyl (which was used as a check) significantly offered the most effective control of the insect and achieved 100% mortality within the first week of observation after insect inoculation. With mean percentage mortality of 83%, the highest concentration of *M. myristica* (15g) was the most potent among the insecticidal treatments of plant origin. That was closely followed by *Monodora* at 10g with 72 and 75% mortality in the 1st and 4th weeks of observation respectively. The *Aframomum* treatments were not as efficacious thus at 15 and 10g, they did not differ significantly from each other and the lowest dose (5g) of *Monodora* and recorded percentage mortality of 64, 63 and 66 in that order, which were discovered 1 week after treatment observation. The Aframomum powder was however better than the control, which did not record any death in week 1. The insect mortality discovered in control jars became apparent in the 4th and final week of observation. The toxicity of the trial insecticides to the insect increased with increase in concentration. The potency of these plant products against *S. zeamais* on stored maize could be attributed to contact toxicity of the powders to the weevil. The activity of *A. melegueta* on the weevil might have resulted from its fumigant effect due to the pungent (volatile) gaseous content usually associated with the fruits of *A. melegueta.* Onyenekwe *et al,* (1993) reported that the essential oil of African nutmeg (*M. myristica*) contains active principles such as phellandrene, p-cymene, and limonene, which have insecticidal properties, and might have been responsible for the observed contact action. Lajide *et al,* (1998) also reported the effectiveness of some of these plant powders in controlling *S. zeamais* by causing adult mortality of the weevil. The present result seems to tally with the previous discovery of Mbah, (2006) who found *Monodora* at the rate of 30g to be effective in the control of the root-knot nematode. Emosairue *et al,* (1998) similarly used ether extracts of *M. myristica* to obtain 50% control of *Podagrica spp* on okra. Fruit powder of *A. melegueta* caused 20% mortality in adult *S. zeamais* (Lajide *et al*, 1998).

The standard insecticide pirimiphos methyl completely suppressed post-embryonic development of the weevil, which was statistically the same with the result achieved by the two levels of *Monodora* (15 and 10g) with percentage F1 generation of 11% and 13% respectively (Table2). That was followed by the highest level of *Aframomum* with adult emergence of 34% and 42% in that order and were effective in retarding progeny emergence than the untreated control. Mbah (2005), similarly reported that 15g seed powder of *Xylopia aethiopica* completely retarded adult emergence of *Callosobruchus maculatus* on stored cowpea. Dike and Mbah, (1992) had stated that acute toxicity of biopesticides to the bean weevil and consequent inhibition of oviposition might be responsible for the reduction of progeny development of the bruchid. Similarly, Lale

(1994) used fruit powder of *Aframomum melegueta* at the rate of 200mg to reduce progeny emergence of *S. zeamais* 3 months after storage.

Table I: Effect of natural plant products on adult longevity/mortality of *S. zeamais* (1 and 4 weeks) after treatment.

Treatments	No. of insects Inoculated	Mean (%) mortality of the weevil **Week 1**	Corrected (%) mortality **4 Weeks**
Monodora 15g	24	83	78
Monodora 10g	24	72	75
Monodora 5g	24	66	69
Aframomum 15g	24	64	67
Aframomum 10g	24	63	67
Aframomum 5g	24	45	49
Pirimiphos methyl 0.045g	24	100	0
Control	24	0	0

Significant differences were detected among treatments on weight loss as shown in Table3 hence the candidate insecticide of natural origin *Monodora* at 15g and pirimiphos methyl were remarkably the most effective in inhibiting weight loss (protecting stored grains against weight loss) with 2 and zero percent weight losses respectively after 3months of storage. The lower rates of *Monodora* (10 and 5g) produced lower percentage weight loss of grains than the *Aframomum* treatments, which however, had reduced percentage weight loss than the control with 20.20% weight loss. The remarkably reduced percentage weight loss recorded by some of the insecticidal treatments is an indication of their potency against weevil infestation hence damage and subsequent weight loss. It is therefore, strongly believed that the damage inflicted on stored maize by the insect caused the differences in weight, which seem to follow the trend of potency of the chemical insecticides on insect knock down (mortality). A study conducted by Taylor (1977) showed that damage caused by *S. zeamais* resulted in 50% weight loss after 6 months of storage. In Table 4, treatments differed significantly in their protection against damage by the weevil. The untreated grains were the least protected and had the highest percentage damage of 21.25% and Weevil Perforation Index (WPI) of 100, whereas, pirimiphos methyl offered complete protection of the stored grain with WPI of zero. Among the trial insecticides, grains preserved with the fruit powder of *Aframomum* were significantly damaged especially at the lower concentrations than *Monodora* (15, 10 and 5g) treated grains with percentage grain damage of 6.75%, 8% and 11% and WPI of 31.36, 37.65 and 51.76 respectively.

However, *Aframomum* treated grains were better protected than the control grains. Maize treated with African nutmeg *M. myristica* may have been protected from damage due to the oil content of the material, which could have blocked or interfered with the respiratory tracks of the insect, resulting in increased mortality (Dike and Mbah, 1992). The result appear to be in agreement with Okonkwo and Okoye (1996), who reported that the seed powder of *M. myristica* achieved 50% mortality in adult *S. zeamais,* reduced emergence and protected the grains effectively for 5months.

Table 2: Effect of plant products (biopesticides) on progeny emergence

Treatments	No. of insects Inoculated	Mean F1 generation	% F1 generation
Monodora 15g	24	2.75^{c}	11.00
Monodora 10g	24	3.25^{c}	13.00
Monodora 5g	24	7.00^{bc}	28.00
Aframomum 15g	24	6.50^{bc}	26.00
Aframomum 10g	24	8.50^{b}	34.00
Aframomum 5g	24	10.50^{ab}	42.00
Pirimiphos methyl 0.045g	24	0^{c}	0.00
Control	24	12.75^{a}	51.00

Means within a column with different superscripts are significantly different ($P \leq 0.05$).

Table 3: Effect of biopesticides on the weight loss of grains of 3 months after storage.

Treatments	Initial weight of grains (g)	Mean weight of grains after storage (g)	%weight of grains	% weight loss
Monodora 15g	150	147^{a}	98.00	2.00
Monodora 10g	150	143.25^{ab}	95.30	4.70
Monodora 5g	150	141.50^{ab}	94.00	6.00
Aframomum 15g	150	133.00^{b}	88.70	11.30
Aframomum 10g	150	136.50^{b}	90.70	9.30
Aframomum 5g	150	130.50^{b}	86.70	13.30
Pirimiphos methyl 0.045g	150	150.00^{a}	100.00	0.00
Control	150	119.75^{c}	79.80	20.20

Means within a column with different superscripts are significantly different ($P \leq 0.05$).

Table 4: Effect of plant powders on grain damage

Treatments	No. of grains Sampled	Mean No. of grains with adult emergent holes	% grain damage
Monodora 15g	100	6.75^{b}	6.75
Monodora 10g	100	8.25^{b}	8.00
Monodora 5g	100	11.00^{b}	11.00
Aframomum 15g	100	9.00^{b}	9.00
Aframomum 10g	100	13.75^{ab}	13.75
Aframomum 5g	100	17.50^{ab}	17.50
Pirimiphos methyl 0.045g	100	0.00^{c}	0.00
Control	100	21.25^{a}	21.25

Means within a column with different superscripts are significantly different ($P \leq 0.05$).

On grain germinability test after 3 months storage, no significant differences were detected among treatments $P < 0.05$ (especially on insecticide treated grains). That however, does not reflect the remarkable differences between the percentage viability (80%) observed on *Monodora* 15g and the control grains, which were only 25% viable. The remarkable reduction of grain viability observed in the control might not be unconnected with the heavy weevil infestation and damage resulting from unprotected grains in storage, and further underscores the efficacy of the test botanicals.

The botanicals did not impart negatively on the taste of the maize grains, neither were there objectionable changes in the testa and colour of the grains.

Table 5: Effect of insecticidal materials of plant origin on grain viability after 3 months storage.

Treatment	No. of grains Sampled	Mean No. of grains that germinated	% grain germination
Monodora 15g	10	8.00	80.00
Monodora 10g	10	7.75	77.50
Monodora 5g	10	6.25	62.50
Aframomum 15g	10	7.25	72.50
Aframomum 10g	10	7.25	72.50
Aframomum 5g	10	7.50	75.50
Pirimiphos methyl 0.045g	10	9.75	97.50
Control	10	2.50	25.00

CONCLUSION

The insecticidal potential of these biopesticides cannot be over emphasized; rather, attention should be generated towards their exploitation and development. They do not exert adverse effects on seed quality and viability after storage. The present results support the view that *M. myristica* is a promising stored product insecticide that is economical for use in Nigeria and other countries where the plant is indigenous and synthetic pesticides are expensive and relatively difficult to obtain. The high cost of imported synthetic insecticides will probably lead to a decline in their use in developing countries, so the use of local plant materials for insect control will offer a ready alternative. There is therefore, obvious need to go back to the use of local herbs for increased sustainability and environmental safety.

REFERENCES

Abbott, W.S. (1925). A method of computing the effectiveness of an insecticide. *J. Econ. Entomol*. 18: 265-267.

Ashigidi, A.E. and Okpara, J.O. (2002). Comparative studies on the pesticidal properties of dried orange peels and Actellic on maize grain. In: Iloeje, M.U., Osuji, G .E., Herbert, U, Asumugha, G.N. (eds) *Proceedings of the 36th Annual Conf. Agric. Soc. of Nig.* , F.U.T. Owerri, Oct. 20-24 2002, pp.86-99.

Dike, M.C. and Mbah, O.I.(1992). Evaluation of lemon grass (*Cymbopogon citratus* Stapf) products in the control of *Callosobruchus maculatus* F on stored cowpea. *Nig. Journ. of Pl. Prot*. 14: 88-91.

Emosairue, S.O. and Uguru, I. (1998). Field Assessment of *Monodora myristica* (Gaertn) Dunal and *Jatropha curcas* for control of *Podagrica* spp (Coleoptera: Chrysomelidae) on okra (*Abelmoschus esculenta* (L) Moench in Umudike. *Book of Abstracts, 29th Ann. Conf. of Ent. Soc. of Nig*. Held at Nnamdi Azikiwe Univ. Awka, 5-8 Oct., 1998, 28p.

Ibe, A.E. and Nwufo, M.I. (2001). Protection of stored maize seed against the weevil *S. zeamais* using local plant materials. In: Salako, F.K., Lagoke, S.T.O. Aina, A.B.J., Eruvbetine, D and Dipeolu, A.U. (eds.). *Proc. of the 35th Ann. Conf. of the Agric Soc. of Nig.* 16-20 Sept 2001. Abeokuta, 368p.

Lajide, L., Adedire, C.O., Muse, W.A. and Angele, S.O. (1998). Insecticidal activity of some Nigerian plants against the maize weevil (*Sitophilus zeamais* Motsch) *Entomol. Soc. of Nigeria (ESN) Occasional. Publication* 31: 227-235.

Lale, N.E.S. (1992). A laboratory study of the comparative toxicity of products from three species to the maize weevil. *Post-harvest Biology and Technology* 2 (1): 61-64.

Lale, N.E.S. (1994). Laboratory assessment of the effectiveness and persistence of powder of four species on cowpea bruchid and maize weevil in air-tight storage facilities. *Samaru Journ. of Agric*. Res.11: 79-84.

Longstaff, B.C., (1981). Biology of the grain pest species of the genus *Sitophilus* (Coleoptera: Curculionidae): a critical review. *Protection Ecology*. 2: 83-130.

Mbah, O.I. (2005). The potency of oil palm bunch ash and seed powder of African Ethiopian pepper (*Xylopia aethiopica)* against cowpea weevil (*Callosobruchus maculatus* F) in storage. *Niger. Agric. J.* 36: 184-190.

Mbah, O.I. (2006). An assessment of the nematicidal potential of some plant products in the control of the root-knot nematode (*Meloidogyne incognita* Kofoid and White) on tomato plant (*Lycopersicon esculentum* Mill). In: Eluagu, L.S., Melifonwu, A.A., Okereke, D.I., Nwosu, E.C., Okafor, E.C., Ndukuba, J., Mbah, O.I., Okoronkwo, M.O., (eds) *Proc. of the Academic Seminar Series*, Fed. College of Agric. Ishiagu 2: 73-78.

Okonkwo, E.U. and Okoye, W.I. (1996). The efficacy of four seed powders and their essential oils as protectants of cowpea and maize grains against infestation by *Callosobruchus maculatus* (Fabricius) (Coleoptera: Curculionidae) in Nigeria. *Intern. J. Pest Managem* 42(3): 143-146.

Onolemhemhem, P.O. Bassey, E., and Okaka, V.P. (1991). Assessment of soyabean oil and fernasan D. for the control of *C. maculatus. Niger. Agric. Journ*. 30: 41-43.

Onwueme, I.C. and Sinha, T.D. (1991). *Field Crop Production in Tropical Africa*. CTA, Ede 159p.

Onyenekwe, P.C., Ogbadu, G.H., Deslauriers, H., Gagnon, M. and Collin, G.J. (1993). Volatile constituents of the essential oil of *Monodora myristica* (Gaertn) Dunal. *Journ. of Food and Agric*. 61: 379-381.

Perkings, H.H. (1982). Assessment of losses caused by insect pests of cowpea in the *Northern PANS*. 22: 229-233.

Salako, E.A. (2002). Plant protection for the resources- poor farmers. Paper Presented at the 30th Ann. Conf. of Nig. Soc. For Plant Prot. UNAAB, Abeokuta, Sept. 1-4. 1999, 21p.

Steel, R.D.G. and Torrie, J.H. (1980). *Principles and Procedures of Statistics: A Biometrical Approach*. 2nd Ed. McGraw Hill Books, New York. 84p.

Stoll, G. (2000). *Natural Crop Protection in the Tropics: Letting Information Come to Life*, 2nd Ed. Margraf Verlag, Weikersheim, 235p.

Taylor, R.A. (1977). *Crop Pests and Diseases*. Oxford University Press, Lagos, 70p.

Williams, J.O. (1983). Effect of testing maize with black pepper (*Piper nigrum* L.) on maize weevil, *Monthly Report, Nig. Stored Prod. Res. Inst. Tech. Report* 354: 348-349.