Global Journal of Agricultural Sciences. ISSN 1596-2903. Vol. 2, No 2, 2003.94 - 97

COMPARATIVE EFFICACY OF *Acorus calamus* POWDER AND TWO SYNTHETIC INSECTICIDES FOR CONTROL OF THREE MAJOR INSECT PESTS OF STORED CEREAL GRAINS.

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(Recieved 23 April 2002; Revision accepted 28January 2003)

ABSTRACT
The efficacy of the powder of a natural plant product (*Acorus calamus L.*) and two synthetic insecticides (i.e. Pirimiphos methyl and *Rotenone)* was compared in the laboratory for the control of *Sitophilus oryzea* (L), *Rhizopertha dominica* (F) and *Tribolium castaneum* (Herbst) in stored wheat grains. Seven concentrations of the test chemicals (i.e. 1.25, 2.5, 5.0, 10.0, 15.0, 20.0 and 25g per kilogramme of wheat grains) were used. The control treatment consisted of 1kg untreated wheat grains. Percentage mortality was recorded cumulatively at 48h intervals for 16 days. Pirimiphos-methyl at 5g/kg of wheat grains gave 100% mortality of *S. oryzea* as against *A. calamus* powder and Rotenone that gave 46.56% and 26.44%, respectively. Mortality observed on *R. dominica* indicated that 25g of *A. calamus* powder resulted in significantly (P 0.05) higher percentage mortality 83.22% than pirimiphos-methyl that gave 56.65% and Rotenone with 36.47%. Only pirimiphos-methyl and Rotenone was toxic to *T. castaneum*, *A. calamus* powder was not.

KEY WORDS: Natural chemicals, synthetic insecticides, wheat grains, cereals.

INTRODUCTION

The heavy post-harvest losses and quality deterioration caused by storage pests is a major problem throughout the world (Hill, 1990). Control of these insects by synthetic insecticides has been successful but their applications have created serious problems for the environment, human health and non-target organisms (Sighamony *et. al.*, 1986).

Pirimiphos-methyl is a contact fumigant and translaminar organo-phosphorus insecticide with relatively low toxicity (UK Pesticides Guide, 1995). It acts rapidly and has short persistence in plants, though spray or dust persists for long period on inert surfaces (UK Pesticide Guide, 1995). Rotenone, although of natural origin and a contact insecticide of low persistence, is dangerous to fish or aquatic life and is inflammable (UK Pesticide Guide, 1995). In contrast, the use of natural products of plant origin for pest management is relatively safe since they are biodegradable. Several studies have employed the use of plant powder and oil extracts from *Acorus calamus* rhizomes (Koul *et. al.*, 1990; Koul and Isman 1990; Schmidt and Streloke, 1994); onion bulb (*Allium cepa*); lemon grass (*Cymbopogon citratus*); *Aframomum melegueta; Piper nigrum*; neem (*Azadiracta indica*) leaves and roots (Dike and Mbah, 1992; Oparaeke and Dike, 1996; Adedire and Ajayi, 1996; Abdulrahman, 1999).

Acorus calamus L (Sweet flag) is widely distributed in Asia, North America and Europe but is apparently not cultivated in Africa except where it grows wild in obscure places (Schmidt and Streloke, 1994). In Nigeria, *Acorus calamus* L has been spotted growing at the swampy and mashy habitat of Owerri River (Opareke, 1996, personal communication). According to Saxena and Mathur (1996), Koul *et al.* (1977a, b), the vapour of the essential oil from *A. calamus* exhibits toxic and sterilizing effects to various insects. Schmidt and Streloke (1994) reported that its active ingredient is asarone, which has toxic and sterilizing effects on stored - product pests while Koul and Isman (1990) reported that *A. calamus* acts as anti-growth inhibitor, antifeedant especially to *Peridroma saucie*.

The present work was conducted to compare the efficacy of pirimiphos-methyl, Rotenone and *Acorus calamus* powder as protectants of wheat grains against infestation by *Sitophilus oryzea* (L.), *Rhizopertha dominica* (F) and *Tribolium castaneum* (Herbst).

MATERIALS AND METHOD

The experiments were carried out at the School of Agriculture, University of Edinburgh, West Mains Road, Edinburgh, UK. *Sitophilus oryzea*, *R. dominica* (F) and *T. castaneum* (Herbst) were used for the study. Thirty insects of each species were purchased from the Central Science Laboratory (CSL), Slough, England. The initial insect populations were sub-cultured in Kilner jars which individually contained 500g of wheat grains for *S. oryzea* and *R. dominica* and 500g of wheat flour for *T. castaneum*. They were kept for 5 days in an incubator at 28 1C and 70% r h. Adult insects were sieved out and killed by pouring boiled water on them. The wheat grains and flour which were contaminated with the insect eggs were put back in the incubator for 30 days and maintained throughout the rearing period at same temperature and rh as earlier mentioned for emergence of new progeny.

Preparation of extracts from *Acorus calamus* rhizome.

The School of Agriculture ordered *Acorus calamus* rhizomes from Nepal. The rhizomes were washed in sterile water, chopped into pieces and dried in an oven at 37° C for 4 days. The dried rhizomes were reduced to powder with a hammer-mill. It was then sieved through a fine mesh (250m) and kept in a dry Kilner jar until needed. Pirimiphos-methyl (as 1% Actellic dust, Zeneca, Surrey) and Rotenone (0.25% dust Rotenone, ICI, UK) were supplied from the pesticide store of the School of Agriculture, University of Edinburgh. Soluble starch (Anala grade®, BDH chemicals Ltd) at 15% moisture content was used to dilute pirimiphos methyl (1% Actellic dust) and *A. calamus* (0.25% *A. calamus* powder) to be of equal strength with 0.25% Rotenone.

Three sets of experiments were carried out concurrently thus:

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Exposure of *S. oryzea* to Pirimiphos-methyl, *Rotenone* and *A. calamus* powder.

Seven concentrations of each of the three chemicals were separately weighed into plastic cups containing one kilogram of wheat grains. A control treatment, which contained one kilogram of untreated wheat grain, was included. The chemicals and the wheat grains were thoroughly mixed by shaking. Ten 2-3 days old unsexed adults *S. oryzea* were introduced gently into the plastic cups and covered with perforated lids to provide ventilation and also avoid escape of the insects.

The treatments were replicated three times and arranged on a laboratory bench as a 2 factor factorial in a complete randomised design (CRD) at 28° C. Factor A (i.e. insecticides:) were at three levels thus: pirimiphos-methyl, *Acorus calamus* powder and Rotenone while factor B (i.e. concentration) was at 8 levels (i.e. 1.25, 2.5, 5.0, 10.0, 15.0, 20.0, 25 g/kg of wheat grains, giving a 3 x 8 factorial arrangement. The same procedure was repeated using *Rhizopertha dominica* and *Tribolium castaneum*.

Mortality counts were recorded every 48 hrs cumulatively for 16 days. Percentage insect mortality was corrected for natural mortality by means of Abbot's formula (1925). The corrected mortality was transformed using square root transformation vx+0.5 where mortality involved small values below 10 (Steel and Torrie 1980) before being subjected to analysis of variance. The means were separated using Duncan's Multiple Range Test (DMRT). The relative toxicity of the three insecticides on the three insects was analysed by comparing the pooled means mortality arising from the total of the concentrations and the control treatment.

RESULTS

The % mortality of *S. oryzea* in wheat grains treated with pirimiphos-methyl, Rotenone and *Acorus calamus* rhizome extract respectively, are presented in Table 1. The cumulative % mortality in each case is the mean for 16 days. 1.25g of pirimiphos-methyl/kg of wheat grains, caused significantly higher (p 0.05) mortality of *S. oryzea* on exposure than *A. calamus* extract and Rotenone respectively. Pirimiphos-methyl at all concentrations except 25g/kg of wheat grains resulted in significantly (p 0.05) higher mortality than did *A. calamus* extract and Rotenone. No significant difference (P 0.05) was observed on mortality caused at 1.25g of Rotenone and the control.

The mean cumulative % mortality caused by the three insecticides on *R. dominica* is shown on Table 2. *A. calamus* extract demonstrated superiority by being more toxic especially at higher concentrations such as 15, 20 and 25g/kg (w/w) of wheat grains, thus causing significantly (p 0.05) higher mortality than the two synthetic insecticides. Pirimiphos-methyl was however leading at lower concentrations of 1.25 and 2.5g.

Data presented on Table 3 show the effect of the three test insecticides on *T. castaneum*. Only pirimiphos-methyl and Rotenone caused mortality on the insect, with pirimiphos-methyl showing Significantly (p 0.05) higher % mortality at all concentrations than Rotenone. No mortality was observed when *T. castaneum* was exposed to *A. calamus* at all the concentrations.

Comparison of the effects of pirimiphos-methyl, Rotenone and *A. calamus* extract on *S. oryzea*, *R. dominica* and *T. castaneum*.

Pirimiphos-methyl was significantly (P 0.05) more toxic on *S. oryzea* and gave the highest pooled mean % cumulative mortality (i.e. 67.22%) than *A. calamus* extract (36.59%) and Rotenone (29.31%) (Fig.1). No significant (P 0.05) differences were observed on pirimiphos-methyl and *A. calamus* extract when tested on *R. dominica*. The two insecticides resulted in significantly higher % mortality of *R. dominica* than *Rotenone*. Pirimiphos-methyl tested on *T. castaneum* proved more toxic than Rotenone while *A. calamus* did not cause any mortality on the insect.

Table 1. Mean Cumulative % mortality of *Sitophilus oryzea* on exposure to pirimiphos-methyl, *Acorus calamus* extracts and Rotenone.

Weight of chemical (g/kg of wheat grains)	% Cumulative Mortality		
	Pirimiphos methyl	*Acorus calamus extracts*	Rotenone
0.0(Control)	0.71 ± 0.00 j(0.0)	0.71±0.0 j (0.0)	0.71 ± 0.0 j (0.0)
1.25	5.19 ± 0.33 h (26.44)	1.55 ± 0.84 j (1.90)	0.71 ± 0.0 j (0.0)
2.5	9.85 ± 0.17a (96.52)	6.08 ± 0.28 fgh (36.47)	3.67 ± 0.43 i (12.97)
5.0	10.02 ± 0.0 a (100)	6.86 ± 0.25 efg (46.56)	5.19 ± 0.33 h (26.44)
10.0	10.02 ± 0.0 a (100)	7.33 ± 0.22 de (53.23)	7.08 ± 0.41 def (49.63)
15.0	10.02 ± 0.0 a (100)	7.99 ± 0.21 cd (63.34)	8.19 ± 0.21 cd (66.58)
20.0	10.02 ± 0.0 a (100)	8.19 ± 0.21 bcd (66.58)	8.78 ± 0.19 abc (76.59)
25	10.02 ± 0.00 a (100)	9.99 ± 0.03 a (99.30)	9.33 ± 0.18 ab (86.55)
S.E. ± = 0.058			

% Mortality has been transformed using square root transformation vx+0.5.
Values in parentheses are untransformed means
Means followed by the same letters are not significantly different
(P= 0.05) from each other according to Duncan's Multiple Range Test (DMRT).

Table 2. Mean cumulative % mortality of *Rhizopertha dominica* on exposure to pirimiphos-methyl, *Acorus calamus* extracts and Rotenone.

Insecticide concentrations g/kg of wheat grains	% Cumulative mortality		
	Pirimiphos-methyl	*A.calamus* extracts	Rotenone
0.00 (control)	0.71 ± 0.00 k (0.00)	0.71±0.0 k (0.0)	0.71 ± 0.0 k (0.0)
1.25	5.19 ± 0.84 ij (5.26)	0.71 ± 0.0k (0.0)	1.55 ± 0.84 jk (1.90)
2.5	5.16 ± 0.33 efg (26.44)	2.40 ± 0.84 ij (5.26)	3.24 ± 0.0 hi (9.997)
5.0	6.08 ± 0.28 def (36.47)	6.61 ± 0.25 cde (43.19)	4.10 ± 0.43 fg (16.31)
10.0	6.86 ± 0.25 cd (46.56)	7.56 ± 0.22 bcd (56.65)	4.10 ± 0.43 gh (16.31)
15.0	6.86± 0.25 cd (46.56)	8.78 ± 0.19 ab (76.59)	4.86 ± 0.33 fg (23.12)
20.0	7.56 ± 0.22 bcd (56.65)	9.15 ± 0.18 ab (83.22)	6.08 ± 0.28 def (36.47)
25	7.99 ± 0.21 abc (63.34)	9.33± 0.18 a (86.55)	7.56 ± 0.22 bcd (56.65)
S.E. ± = 0.076			

% Mortality has been transformed using square root transformation vx+0.5.
Values in parentheses are untransformed means
Means followed by the same letters are not significantly different
(P= 0.05) from each other according to Duncan's Multiple Range Test (DMRT).

Table 3:
Mean % cumulative mortality of *Tribolium castaneum* on exposure to pirimiphos-methyl, *Acorus calamus* Extracts and Rotenone.

Insecticide concentrations g/kg of wheat grains	% Cumulative mortality		
	Pirimiphos-methyl	*A. calamus* extracts	Rotenone
0.00 (control)	0.71 ± 0.00 e (0.0)	0.71 ± 0.0 e (0.0)	0.71 ± 0.0 e (0.0)
1.25	4.43 ± 0.66 d (19.13)	0.71 ± 0.0 e (0.0)	0.71 ± 0.0 e (0.0)
2.5	10.02 ± 00 a (100.0)	0.71 ± 0.0 e (0.0)	4.86 ± 0.33 d (23.12)
5.0	10.02 ± 00 a (100.0)	0.71 ± 0.0 e (0.0)	4.86 ± 0.33 d (23.12)
10.0	10.02 ± 00 a (100.0)	0.71 ± 0.0 e (0.0)	4.86 ± 0.33 d (23.12)
15.0	10.02 ± 00 a (100.0)	0.71 ± 0.0 e (0.0)	6.08 ± 0.28 c (36.47)
20.0	10.02 ± 00 a (100.0)	0.71 ± 0.0 e (0.0)	6.08 ± 0.28 c (36.47)
25	10.02 ± 00 a (100.0)	0.71 ± 0.0 e (0.0)	7.33 ± 0.22 b (53.23)

S.E.± = 0.067

% Mortality has been transformed using the square root transformation x+0.5. Values in parentheses are untransformed means.
Means followed by the same letters within columns are not significantly ($p \geq 0.05$) different from each other according to Duncans Multiple Range Test (DMRT).

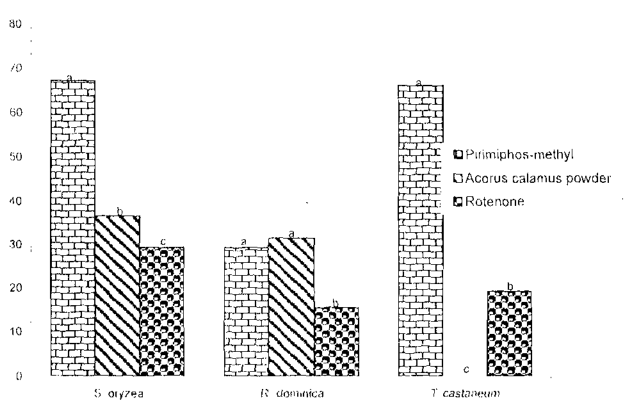

Fig. 1:Comparative effects of Pirimiphos-methyl, *Acorus calamus* extracts/powder and *Rotenone* on the morality of *S. oryzea*, *R. dominica* and *T. castaneum*.

* *Bars followed by the same letters are not significantly ($P \geq 0.05$) different from each other according to Duncan's Multiple Range Test (DMRT).*

DISCUSSION

The results of this study have confirmed the insecticidal potency of *A. calamus* reported by other researchers (Stoll, 1986; *Koul et. al.*, 1990; Schmidt and Streloke, 1994 and Umoetok, 2000). The results indicated that *A. calamus* powder was as good as the two synthetic insecticides (pirimiphos methyl, Rotenone), which are in the list of the insecticides recommended by UK Pesticides (1995) for control of stored grains. The study has further confirmed that *A. calamus* powder compared favourably with pirimiphos methyl and Rotenone in the control of *S. oryzea* and even better in controlling *R. dominica*. The non-toxic nature of *A. calamus* to *T. castaneum* as reported by some authors (Mammen *et al.*, 1968, Abraham *et al.*, 1972) is confirmed in the study. The result however, disagreed with these authors who reported that *A. calamus* powder is not toxic to *R. dominica* (F.). The non-toxic nature of *A. calamus* powder observed on *T. castaneum* is an indication that *A. calamus* exhibit a selective action, an attribute which adds to its choice among pesticides required in environmental pest management.

The insecticidal potency of *A. calamus* in controlling a wide species of insects in stored products is very encouraging. Its application is simple and can be adopted by the resource - poor farmers in Sub-Saharan Africa. Efforts should be made to encourage the cultivation and use of this wonderful plant in pest management in countries where the plant is not known, cultivated and used.

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