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Evaluation of Malathion-Impregnated Sawdust for Control of Bean Weevil (*Piezotrachelus varium* Wagn.) in Stored Kersting's Groundnut

Der Einsatz mit Malathion behandeltem Sägemehl zur Kontrolle von Bohnenkäfern bei der Lagerung von Erdbohnen (*Kerstingiella geocarpa* Harms)

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1 Introduction

Kersting's groundnut (*Macrotyloma geocarpum* H.) is an important legume crop predominantly grown in Nigeria and other parts of tropical Africa. Both seeds and leaves are widely used in human nutrition. The Seed is, in storage, easily infested by insect pests among which the bean weevil (*Piezotrachelus varium* Wagn) is of paticular importance (OBASI, 1989). Several control measures are conventionally carried out by farmers, traders and government agencies to protect harvested produce against damage and deterioration by biological agents. Such measures of preventing or minimizing post-harvest losses include the use of contact insecticides, they are suitable for use on stored food products to a limited extent only due to problems related to taint and toxic residues.

Malathion (0,0-dimethyl S-1,2 di (ethoxycarbonyl) ethylphosphorodithioate) is the insecticide of choice in many developing countries because of its toxicity to a wide range of storage insects and its low mammalian toxicity (MARTIN and WORTHING, 1977). Some shortcomings of this contact insecticide are linked (a) to its instability on produce of high moisture levels (WATTERS, 1976) or on surfaces of high alkalinity (SLOMINSKI and GOJMERAC, 1972), the dust formulations of malathion widely applied in developing countries break down rapidly into products which are not insecticidal (HALL, 1980), or (b) to inadequate mixing of the insecticide with the produce. Malathion appears to be more stable on materials that are of

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almost neutral pH such as wood than on materials with high pH such as concrete (WATTERS, 1976). Thus, testing insecticides against storage pests is to select insecticide(s) and formulation(s) which can be applied profitably, easily and safely by largely illiterate farming populations. The objective of this study was to assess chemically and by bioassay the efficacy of malathion incorporated into sawdust for the control of the bean weevil (*Piezotrachelus varium*) in stored kersting's groundnut.

2 Materials and Methods

2.1 Test materials

Eucalyptus (*Eucalyptus niphophila* L.) sawdust was sieved with a mesh to obtain a particle size with a range between 0.425 and 0.840 mm. The water content of the sawdust determined by oven drying was 4.10 $\pm$ 0.05%. Premium grade malathion of 83.6% emulsifiable concentrate was diluted with distilled water to provide concentrations of 0.5, 1.0, and 2.0% active ingredient (ai). The aqueous emulsions of the insecticide were applied to the sawdust using a sprayer (Paasche Airbrush Co., Chicago, USA), fitted with a H-1 nozzle and operated at a constant pressure of 0.70 kg/cm^3. The nozzle was held 15 cm above the sawdust surface. Fifteen lots of 10.0 g of the sawdust were treated by insecticide dosage and pooled. After the insecticide application, each treatment was placed in a 30-litre sealed steel metal container and mechanically tumbled for 30 minutes. The treated sawdust was then left for 24 hours at 25 $\pm$ 1.5°c to allow the moisture balance out with surrounding air before being used for the tests. Sawdust sprayed with distilled water was prepared as a control. Clean, uninfested Kersting's groundnut seeds, variety 'NSK-1', of 12.5% moisture content was used for the studies.

The test insects were adults of P. varium reared on seeds in a cabinet maintained at 28.5°C and 70% relative humidity. The insects were 4-5 weeks old at the time of the tests.

2.2 Admixture of seed with treated sawdust

Samples of 150 g seed were admixed with 5 g sawdust treated for each dosage level and placed in 500 ml Kilner jars. The jars were then covered with muslin cloth, secured with rubber bands and stored at 27 $\pm$ 1.5° c and 60-70% relative air humidity. Each dosage treatment was repeated 4 times at each period of assessment. Similarly, four samples of 150 g seed admixed with 5g sawdust sprayed with distilled water were set as control.

The transfer of malthion into seed from the treated sawdust was chemically and biologically assayed 1,2,4,8,16 and 32 weeks after the seed has been mixed with treated sawdust.

2.3 Chemical analysis of residue

For chemical analysis of malathion residues after each period of storage, the sawdust was sifted from the seed and placed into clean mason jars of 227 ml capacity. Sub-samples of 50 g seed from each insecticide treatment level and from the control treatment were then taken for chemical assay by gas-liquid chromatography. Malathion that translocated into the stored seed was determined by the method of LEVI and NOWICKI (1974). A volume of 30 ml glass-distilled methanol was used to extract malathion residues from 10 g sample of ground seed by a ball-milling extraction method. The residues were analysed by a Tracor MT-220 gas chromatography set equiped with a Melpar flame photometric detector and a 526 nm phosphorus filter. Malathion analysis was done by injecting 2-5 ug/l of the methanolic extract into the gas chromatography. The insecticide residues were quantified by peak heights in relation to a standard calibration curve, and the residues were based on the parent compound. Similarly malathion residues remaining on the sawdust after each period of storage were determined. Subsamples of treated and control sawdust weighing 1.5 g were used for this analyses.

2.4 Seed bioassay

The bioassay was performed on the remaining 100 g of the stored seed. Subsamples were placed in 500 ml Kilner jars and infested with 50 adults of P. varium taken at random from standard laboratory stock cultures. The jars were then covered and stored under room conditions ($25 \pm 2^{\circ}$ C and 60-70% RH) for 7 days when mortality was assessed. The values for percentage mortality were corrected for control mortality using ABBOTT's (1925) formula.

After assessing the mortality, the insects were discarded and the seed returned to the jars. The jars were stored under room conditions for further 6 weeks at which time presence of F_1 adults was assessed.

2.5 Statistical design and analysis

The experiment was set up as a randomized complete block with four replications at the Research and Teaching Farm on the University of Nigeria Nsukka during 1988 and 1989. The chemical assay, bioassay and the F_1 progeny data were all subjected to analysis of variance. The mean values were compared using Fishers least significant difference (F-LSD).

3. Results and Discussion

3.1 Malthion residues

The amounts of malathion that was transferred into stored groundnut seed mixed with sawdust treated with the test insecticide rates are presented in Table 1. There was significant difference ($P = 0.01$) between the dosage rates applied to the sawdust and the duration of seed storing, the rate duration interaction was also significant ($P = 0.01$).

Significantly ($P = 0.01$) higher amounts of malathion were transferred into seed mixed with 2.0% malathion - impregnated sawdust than at the other two rates at each period of assessment. Malathion residues recovered from seed mixed with 2.0% malathion - impregnated sawdust increased progressively with the period of storage, reaching the maximum of 12.80 ppm at 8 weeks after treatment it thereafter declined to 4.6 ppm at 32 weeks.

Table 1: Mean malathion residues (ppm) on stored Kersting's groundnut seed mixed with malathion-impregnated sawdust.

Dosage applied (% ai.)	Weeks after treatment					
	1	2	4	8	16	32
0.5	1.61	0.91	0.32	0.22	0.07	0.01
1.0	5.00	5.19	5.07	4.76	3.13	0.85
2.0	9.50	10.25	11.14	12.80	8.97	4.61

F-LSD (0.05) = 0.26; (0.01) = 0.38 between the interaction of any 2 means of malathion dosage applied and weeks after treatment or vice versa.

Except at 32 weeks, the residue levels, exceeded the tolerance level of 8 ppm for malathion in raw food grains (ANON, 1986). The highest levels of malathion recovered from seed mixed with 0,5 and 1,0% insecticide-impregnated sawdust were 1.61 ppm at 1 week and 5.19 ppm at 2 weeks, respectively, which is within the level of tolerance. MENSAH et al (1979) had reported similar levels of uptake of malathion into stored grains treated at 1.0 g ai/m^2.

The mean levels of malathion residue recovered from treated sawdust after mixing with groundnut seed are shown in Table 2.

Table 2: Mean level of malathion (ppm x 1000) recovered from treated sawdust after mixture woth Kersting´s groundnut seed.

Dosage applied (% ai.)	Weeks after treatment						
	0*	1	2	4	8	16	32
0.5	4.680	3.842	3.864	2.014	1.254	1.000	0.805
1.0	8.765	7.821	7.215	4.176	4.000	3.285	3.064
2.0	19.481	17.668	16.456	9.813	9.742	8.366	8.021

F-LSD (0.05) = 0.211; (0.01 = 0.275 between the interaction of any 2 means of malathion dosage applied and weeks after treatment or vice versa.

*Zero week residue indicates malathion recovered immediately after insecticide application.

Significantly (P = 0.01) higher levels of malathion were recovered from sawdust treated with 2.0% ai. than with 0.5 and 1.0% ai. at each period of assessment. In all reates applied, there was a progressive decrease in malathion residues with the duration of storing. The percentage rate of decrease from week 0 to week 32 in 0.5% malathion - impregnated sawdust (82.8%) was, however, significantly (P = 0.01) greater than in either 1.0% (65.0%) or 2.0% malathion

- impregnated sawdust (58.8%). The relative rate of decrease was thus closely related to the amount of active ingredient of malathion applied to the sawdust.

3.2 Seed bioassay - primary effects on insects

The biological effectiveness of malathion that was transferred into the stored seed from the treated sawdust is presented in Table 3. Sufficient malathion was transferred to the seed when mixed with sawdust treated at 2.0% ai. to cause 100% mortality of P. varium throughout the 32 weeks. Stored groundnut seed mixed with 0.5 and 1.0% malathion - impregnated sawdust were toxic to P. varium for up to 1 week and 16 weeks respectively, thus reflecting the level of active ingredient that was transferred into the seeds. Similar results on the effectiveness of Lindane for control of insects in stored rice and cowpea have been reported by OSBORN et al. (1988). For presenting less hazard to consumers, carried on sawdust appears as a promising formulation for use in storage inseet control.

Table 3: Mean percent mortality of Piezotrachelus varium adults exposed for 7 days on Kersting's groundnut seed that has been previously mixed with malathion-treated sawdust.

Dosage applied (%ai.)	Weeks after treatment					
	1	2	4	8	16	32
0.5	85.2	36.4	6.5	0	0	0
1.0	100	100	100	100	90.3	35.0
2.0	100	100	100	100	100	100

F-LSD (0.05) = 5.2; (0.01) = 7.3 between the interaction of any 2 means of malathion dosage applied and weeks after treatment or vice versa

3.3 Seed Bioassay – effects on F_1 progeny

Table 4 shows the emergence of F_1 adults of P. varium in stored groundnut seed previously mixed with untreated sawdust (control) and malathion-impregnated sawdust. Significantly (P=0.01) more adult insects emerged in the control treatment than in the treated seed samples up to 8 weeks after treatment. At 16 and 32 weeks, there were similar numers of F_1 adults in the control treatment and in the 0.5% malathion-treatment probably because of high insect survival in the latter. There were no F_1 adults in the 2.0% malathion-treatment. Emergence of F_1 adults in seed treated with 1.0% malathion-impregnated sawdust was only observed at 32 weeks. This, however, was significantly (P=0.01) lower than those of the control and the 0.5% treatment. As with the results of the bioassay, the emergence of F_1 adult weevils was a reflection of the amount of malathion that was transferred into stored groundnut seed. Commercially prepared malathion dust formulations which usually consist of low-grade flour containing 0.5, 1.0, and 2.0% ai. are similar in prinicple to the malathion-impregnated sawdust. These commercial dusts, formulated primarily for use with food grains, in most circumstances have been found to offer shorter periods of effective control probably because of the physical and chemical nature of the carrier material. Malathion is more stable on wood surfaces. Sawdust would therefore appear to be a more suitable carrier material for malathion, providing significant residual protection to stored seed than surfaces, such as concrete, that cause insecticides to degrade rapidly. The use of malathion-impregnated sawdust would also be advantageous to workers handling the formulation; the large particle size would minimize dust-related problems, including hazards to human health. The economic feasibility of applying malathion-impregnated sawdust is enhanced by comparatively low prices of both malathion and sawdust. Relation also presents very low mammalian toxicity. Moreover, after use with the stored seed, the sawdust can be sifted for reuse.

Table 4: Emergence of F_1 progeny of Piezotrachelus varium adults from stored Kersting's groundnut seed previously mixed with malathion-impregnated sawdust.

Dosage applied (% ai.)	Weeks after treatment					
	1	2	4	8	16	32
Control	79.5	77.9	82.4	76.8	65.2	84.5
0.5	0	20.4	44.4	49.9	63.1	86.0
1.0	0	0	0	0	0	20.7
2.0	0	0	0	0	0	0

F-LSD (0.05) = 11.6% (0.01) = 15.4 between the interaction of any 2 means of malathion dosage applied and weeks afer treatment or vice versa.

4 Conclusions

The study has demonstrated that malathion-impregnated sawdust is a useful formulation material for controlling insects in stored seed because of the physical and chemical characteristics of the carrier material. For seed storage up to 4 months, effective control of P. varium could be achieved by applying 1.0% malathion-impregnated sawdust without toxic hazards to consumers. Seed that would have to be stored for longer periods would, however, require the use of 2.0% malathion-impregnated sawdust.

5 Summary

Eucalyptus (*Eucalyptus niphophila* L.) sawdust, of particle size 0.425-0.840 mm, was treated with an aqueous solution of malathion 83.6% EC(0.0-dimethyl S-1,2 di (ethoxycarbonyl) ethylphosphorodithioate) at 0.5, 1.0, and 2.0% ai. and assayed at predetermined intervals by chemical and biological methods to determine whether impregnated sawdust was an effective formulation to control insect infestations in stored kerstings's groundnut seed. The chemical assay of malathion residues was done by gas-liquid chromotagraphy and the bioassay by exposure of adult weevils (*Piezotrachelus varium* Wagn.) to seed previously mixed with malathion-impregnated sawdust.

Significantly (P = 0.01) higher amounts of malathion (4.61 - 12.80 ppm) were transferred into stored seed which was mixed with sawdust initially treated at 2.0% ai. than at 0.5 and 1.0% ai. at each period of assessment. Similarly, greater quantity of malathion residue was recovered from sawdust treated at 2.0% ai. Sufficient malathion was transferred into seed mixed with 2.0% malathion-impregnated sawdust to cause 100% mortality of P. varium for 32 weeks, and also to prevent emergence of F_1 adults. Seed mixed with 0.5 and 1.0% malathion-impregnated sawdust were toxic to P. varium for up to 1 and 16 weeks respectively after treatment. Thus, for seed storage not exceeding 4 months, effective control of P. varium could be achieved by applying 1.0% malathion-impregnated sawdust without toxic hazards to consumers. Long-lasting storage of seed would, however, require the use of 2.0% malathion-impregnated sawdust. The relative effectiveness, ease of handling and the economics of the use of malathion-impreganted sawdust indicate its suetability as a formulation material to control storage insects.

Zusammenfassung

Eukalyptussägemehl, präpariert mit Malathion 83,6% EC in verschiedenen Konzentrationen, wurde bei der Lagerung von Erdbohnen gegen Insektenbefall, speziell dem Bohnenkäfer eingesetzt. Die Ergebnisse der verschiedenen Applikationen werden beschrieben. Die relativ gute Wirkung, die einfache Handhabung der Anwendung und die Wirtschaftlichkeit von Malathion imprägniertem Sägemehl ist eine geeignete Formulation um Schäden beim Lagern von Erdbohnen durch Insekten zu verhindern.

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