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**Effectiveness of Local Botanicals as Protectants of Stored Beans
(*Phaseolus vulgaris* L.) Against Bean Bruchid (*Zabrotes subfasciatus* Boh)
(Genera: *Zabrotes*. Family: *Bruchidae*)**

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Abstract: The experiment was conducted at the Crop Science and Production Department Laboratory of the Sokoine University of Agriculture, Morogoro, Tanzania. The general objective was to investigate the potential and effectiveness of botanicals in controlling the bruchid beetle *Z. subfasciatus*. Bean grains of two commercial bean cultivars viz: SUA 90 and Kablanketi were used as test materials. Botanicals which were used during the experiment include pyrethrum flower powder, garlic powder and nyongwe powder. Standard Actellic super dusts as a synthetic chemical and without pesticide as controls were also used. A split plot experiment in a Completely Randomized Design (CRD) was used for arrangement of treatments. Data collected included number of live insects, number of holes per seed, damaged seeds, percentage damage and weight loss. Results showed that both bean varieties and treatments differed significantly for all the investigated variables. Kablanketi had more live *Z. subfasciatus*, number of holes seed⁻¹, damaged seeds; percentage damaged and weight loss than SUA 90. Number of live insects was less in seeds treated with Actellic super dust than no pesticide application treatment. Seeds treated with Actellic super dust and pyrethrum excelled other treatments by having low number of holes per seed, damaged seeds, percent of damaged seeds and weight loss. On other hand, Garlic and nyongwe performed better in reducing number of holes per seed, damaged seeds, percentage damaged seeds and weight loss than no pesticide application treatment. Therefore, these three botanicals possess insecticidal properties that can be used in the control of insect pests on stored beans.

Key words: Botanicals, bruchid beetles, damage, pesticides, weight loss, *Zabrotes subfasciatus*

INTRODUCTION

Throughout the whole of Sub-Saharan African, an estimated 25-40% of grain crop is lost in stores each year due to insects because of inadequate village level storage caused by poor storage structures, expensive and scarcely available storage chemical pesticides (Golob and Kilminster, 1982; Koon and Njoya, 2004). Little attention seems to be given to this astonishing fact of crop losses in stores due to storage pests. Agricultural extension programmes tend to concentrate on improving means of storing agricultural products (Singh, 1990). It is between harvesting and consumption that the high losses occur to the individual farmers' grain losses (Nchimbi-Msolla and Misangu, 2002).

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The grain of common bean varieties is vulnerable to attack by seed beetles (Reddy and Reddy, 1987). The identified economic bruchid pests come from six genera, viz., Bruchus, Bruchidius, Callosobruchus, Acanthoscelides, Zabrotes and *Corydon callosobruchus* (Hill, 1990). The genus of the Bruchidae, which contains the greater number of pest species is *Callosobruchus*, *Acanthoscelides obtectus* (Say.) and *Z. subfasciatus* are serious pests of stored legume seed (Singh, 1990). They are highly adaptive and have an increasing geographical distribution from seed movement through exportation and importation of seeds, food aids and sometimes displacement of refugees (Mian *et al.*, 1987). However, two species of bruchids are major pests of stored beans, the common bean weevil, *Acanthoscelides obtectus* (Say) and the Mexican bean weevil *Zabrotes subfasciatus* (Boh) (Nchimbi-Msolla and Misangu, 2002). *Acanthoscelides obtectus* (Say.) starts to infest beans in the field and continue to infest beans in storage while *Z. subfasciatus* infest beans only in storage (Kiula and Karel, 1985).

A considerable volume of information is available on losses to stored common beans from bruchid infestation (Kabungo *et al.*, 1998). Bruchid damage reduces the weight, quality and viability of bean seed (Reuben *et al.*, 2006). The degree of loss due to bruchid damage is quite variable and depends on the storage period and storage conditions. In Tanzania, for example, bean losses of up to 40% due to bean bruchids have been reported (Kiula and Karel, 1985). It has been reported also that the damage increases as storage period is prolonged (Singh, 1990).

Synthetic pesticides have for long been effective and the most important in grain storage, however, there are several disadvantages accompanied with their use. Most of the synthetic pesticides in use have persistent residues, which can hardly be removed during grain processing (Kabungo *et al.*, 1998) and are neither user nor environment friendly; can result in harmful residues in foodstuff and development of resistance in the target insect populations (Reddy and Reddy, 1987; Zettler and Cuperus, 1990). Farmers treat their produce with synthetic insecticides during storage of which majority of them still lack the knowledge on proper, safe and effective use (Baier and Webster, 1990). These synthetic chemicals have become expensive; therefore, resource poor farmers fail to utilize them at the recommended dose rendering them ineffective and making pests control difficult (Bhaduri *et al.*, 1985; Talukder and Howse, 1994). Synthetic pesticides also may cause serious health hazards, insect pest resistance, resurgence, environmental pollution, ecological imbalance and residues in market produce (Bhaduri *et al.*, 1985).

In an attempt to control the situation, some farmers in Tanzania have gone back to their traditional produce storage practices, which include the use of insecticidal plants and inert materials. These pesticides are safe, less hazardous and biodegradable (Talukder and Howse, 1994, 1995). The plants of original insecticides have therefore, drawn attention for extensive research, which are now highly encouraged in order to meet the demands of Integrated Pest Management (IPM) and environmental safety (Reddy and Reddy, 1987). Therefore, the use of safer materials of botanic origin offers a promising alternative for the protection of stored bean grain against insect pests (Reddy and Reddy, 1987). Botanicals have shown no negative impact following their use (Baier and Webster, 1990).

The insecticidal activity of many plant derivatives against several storage pests has been demonstrated (Baier and Webster, 1990). For example, Neem, *Lantana camara* and other natural plants have long history of use primarily against household and storage pests (Singh, 1990). *Lantana camara* is a repellent; therefore, can be used as a protectant of stored beans (Dua *et al.*, 2003). It has been further reported that powder from leaves of *Lantana camara* can be used to protect maize grains from damage against the maize weevil *S. zeamais* (Koon and Njoya, 2004). Garlic (*Allium sativum* L.) has an effective range of insecticidal repellent (Fields *et al.*, 2001), antifeedant, bactericidal, fungicidal and nematocidal (Bodnaryk *et al.*, 1999). This study, therefore, aimed at investigating the potential and effectiveness of locally available botanicals in controlling the bruchid beetle *Z. subfasciatus*.

MATERIALS AND METHODS

Location of the Study

The experiment was conducted from October, 2005 to May, 2006 at the Crop Science and Production Department Laboratory of the Sokoine University of Agriculture, Morogoro, Tanzania. The area is located at latitude 6°56'S and longitude of 35°37'E, with an altitude of 525 m above sea level (a.s.l.).

Treatments

Bean Samples

Clean, well-sieved bean grains of two commercial bean cultivars viz., SUA 90 and Kablanketi were used as test materials. These bean varieties were collected from the Bean Improvement Programme of the Sokoine University of Agriculture, Morogoro. The grains were dried at 12% moisture content and were not previously treated with any chemical. The undamaged bean seeds of each variety were placed in a cold room for two weeks so as to sterilize the seeds.

Bean Weevils

The bean weevils (*Z. subfasciatus*) were collected from the stored culture in 1 L kilner jars at 28-30°C temperature and 70% Relative Humidity from Pest Management Centre at Sokoine University of Agriculture.

Plant Materials

Three botanicals pesticides viz., Nyongwe (*Neuratanenia mitis*) powder, pyrethrum grist (*Chrysanthemum cinerariaefolium*) and Garlic powder (*A. sativa*) were used. Nyongwe powder was made from small slices of the plant tubers when dried in diffused light for 14 days. The dried slices were pulverized into smaller particles and were sieved using 0.2 mm sieve size. The process of pulverization and sieving was continued until no more powder was released but fibrous matter remained on the sieve mash. Pyrethrum flower powder was obtained from dried flowers for 7 days then ground them and sieving using 0.2 mm sieve size until enough powder was collected. For garlic, the bulb parts which are called cloves were removed of their scales, dried under diffuse light for one month and grounded into a paste.

The five treatments used were composed of without pesticides (T₀), 2% (w/w) of Nyongwe powder (T1), 2% (w/w) Pyrethrum flower powder (T2), 2% (w/w) garlic powder (T3), 1% standard Actellic super dust (T4) as a synthetic chemical.

Layout of Experiment

A split plot experiment in a Completely Randomized Design (CRD) was used for the arrangement of the treatments. The two bean cultivars were the main plot factor (Factor A) while five insecticidal pesticides were the sub-plot factor (Factor B). Thirty glass bottles each containing 50 g of bean seeds were replicated three times. Different insecticidal pesticides under study were introduced except in bottles of the control in which no pesticides were applied to beans. The bean grains and pesticide powder of all chemicals were tumble mixed thoroughly for about 5 min. To each bottle, 14 Bruchids were introduced, viz., 7 males and 7 females. Freshly emerged bruchids were introduced to already two weeks dusted beans with insecticidal pesticides into their respective bottles and their replicates. The bottles were then covered with perforated lids for aeration and placed randomly in the three replications.

Data Collection

Data on the effect of bean weevils on stored bean grains were collected at the 13th week after bean bruchids were introduced as follows:

Number of Live Insects

Number of bruchids was obtained by counting live bruchids in each bottle.

Number of Holes Per Seed

Average number of holes per seed was obtained by dividing the total number of holes in all seeds in a glass bottle by number of seeds.

Number of Damaged Seeds

This was obtained by counting all seeds in each glass bottle with at least one hole from bruchid infestation.

Number of Undamaged Seeds

It was obtained by counting all seeds in each glass bottle that contain no hole from bruchid infestation.

Percent Damaged Seeds

This was obtained by dividing the number of damaged seeds with total number of seeds placed in the bottle and multiplied by 100.

Weight Loss

This was determined by weighing both damaged (grains with characteristics holes) and undamaged grains. Then the recorded weight was subtracted from the initial weight.

Data Analysis

All the data collected were subjected to Analysis of Variance (ANOVA) procedure (SAS, 1997) and Multivariate Analysis of Variance (MANOVA) for calculating partial correlation coefficients for investigated variables. All variables recorded were analysed according to the following statistical model:

$$X_{ijk} = \mu + V_i + E(a) + T_j + (VT)_{ij} + E_{ijk}$$

where: X_{ijk} = an observation i^{th} variety and j^{th} treatment, μ = the general effect, V_i = the i^{th} varietal effect, $E(a)$ = main plot error, T_j = the j^{th} treatment effect, Vt_{ij} = the i^{th} varietal and j^{th} treatment interaction and E_{ijk} = Experimental error.

The comparison of significant differences of mean values was done through means separation test using Least Significant Difference (LSD) test method.

RESULTS

Significant varietal effects were observed for numbers of live insects, holes per seed, damaged seeds, percentage damaged seeds and weight loss (Table 1). Similarly, significant differences between treatments were observed for all the studied variables.

SUA 90 showed superiority on all investigated variables having lower numbers of live insects, holes per seed, damaged seeds, percentage damaged seeds and weight loss (Table 2). The Actellic Super Dust (T4) and pyrethrum flower powder (T2) were superior in all the variables studied followed by garlic (T3) and nyongwe (T1).

There were significant and positive correlations among percentage weight loss, percent damaged seeds, number of damaged seeds and number of holes per seed (Table 3).

Table 1: ANOVA summary for investigated variables (Means squares given)

Source of variation	df	Means squares				
		Live insects	No. of holes/seed	No. of damaged seeds	(%) damaged seeds	(%) weight loss
Replication	2	50.80	60.28	29.14	329.01	117.38
Cultivars	1	208.54***	1913.61***	431.21***	3563.66***	1622.82***
Error (a)	2	52.58	119.08	73.81	657.95	291.62
Treatment	4	32.18***	867.71***	183.79***	1456.63***	691.89***
Cult x Treat	4	32.04	731.28***	117.16***	1059.70***	442.43***
Error (b)	76	15.50	18.34	7.19	64.60	28.01
Total	89					

p<0.01, *p<0.001

Table 2: Effect of bean cultivars and pesticides on variables investigated

	Variables investigated				
	Live insects	No. of holes/seed	No. of damaged seeds	(%) damaged seeds	(%) weight loss
(A) Cultivars					
SUA 90	0.378	0.911	0.800	1.708	1.546
Kablanketi	3.422	10.133	5.178	14.293	10.038
\bar{x}	1.900	5.522	2.989	8.001	5.792
LSD _{0.05}	1.653	1.798	1.126	3.375	2.222
(B) Pesticides					
Without pesticides (Control)	3.778	16.833	7.556	21.573	14.684
Ngongwe powder	2.000	6.778	4.444	11.279	8.545
Pyrethrum flower	1.833	0.000	0.000	0.000	0.000
Garlic powder	1.889	4.000	2.944	7.151	5.730
Actellic super dust	0.000	0.000	0.000	0.000	0.000
\bar{x}	19.000	5.52	2.990	8.001	5.7918
SE \bar{x}	0.481	1.121	0.546	1.600	1.066
LSD _{0.05}	2.614	2.844	1.779	5.336	3.513

Table 3: Partial correlation coefficients among variables investigated

Variables	1	2	3	4	5
1. Live insects	1	0.07	0.053	-0.062	0.075
2. No. of holes		1	0.841***	0.808***	0.815***
3. No. of damaged seeds			1	0.985***	0.994***
4. Percent damaged seeds				1	0.974***
5. Weight loss					1

***p<0.001

DISCUSSION

Currently, synthetic insecticides are the only tools for stored pest management that are reliable for emergency action when insect pest population approaches or exceeds economic threshold level (Abate and Ampofo, 1996). Majority of farmers still lack the knowledge on proper, safe and effective use, in addition, these synthetic chemicals have become expensive (Bhaduri *et al.*, 1985; Talukder and Howse, 1994); cause serious health hazards and not environmental friendly. This study, therefore, aimed at studying the effect of locally available botanicals, viz., garlic, pyrethrum and nyongwe for controlling *Z. subfasciatus*. Results show that locally available plant products of nyongwe, garlic and pyrethrum possess insecticidal properties that can be used in the control of insect pests on stored beans. The low number of holes, percentage damage and weight loss for bean grains treated with these botanical pesticides provides clear evidence of their potentiality.

Results of this study show that fewer adult weevils were emerged from grains treated with these botanical pesticides as compared with the control that had no pesticide application. It has been reported that the garlic product when used reduces the insect movement and also causes death through desiccation of insects or through occlusion of their spiracles, thereby preventing respiration via the tracheal system (Koon and Njoya, 2004). Reuben *et al.* (2006) reported that garlic significantly excelled the control of no pesticide application in reducing severity and incidence of Diamond Back Moth (DBM) and having higher number and percentage of marketable leaves of cabbage in the field. Garlic has as well been reported to contain pesticidal properties (IPM DANIDA, 2003) while Zehnder *et al.* (1997) reported that garlic provides effective control of the caterpillars on lettuce and cabbage vegetables. In other studies, garlic oils have been found to have quick kill against aphids, cabbage loppers, ear wigs, June bugs, leafhoppers, squash bugs and white flies (Shier, 2000). It therefore, suggests that garlic is a broad spectrum insecticide that can be used to control a number of horticultural and stored pests. Garlic oil is also reported to be a non-selective insecticide with both antibiotic and antifungal properties (Singh, 2005).

The active substances in pyrethrum are contact poisons for wide range of storage and other insects (White and Leesch, 1995). A substance known as pyrethrin works by creating multiple potentials across the membranes by delaying the closing of the ion channel of communication of an insect. Therefore, this substance acts as contact poison affecting the insect's nervous system but even though they are a nerve poison, they are not an anticholinesterase as are organophosphate and carbamates (White and Leesch, 1995).

Similarly, the synthetic Actellic super dust is still the best in terms of effectiveness as it significantly excelled garlic and nyongwe for many of variables investigated. For example, in this study, it excelled in reducing numbers of holes, damaged seeds, percentages of damaged seeds and weight loss. In as much as this synthetic pesticide was significantly superior to the control of no pesticides application, nyongwe and garlic, it should be used with care, taking into consideration its availability, expense, environmental and health hazards during and after application.

Results showed that locally available plant products of garlic, nyongwe and pyrethrum possess insecticidal properties that can be used in the control of insect pests on stored beans. The use of these botanicals could reduce the serious health hazards to humans' life, insect pest resistance, resurgence, environmental pollution, ecological imbalance and residues in market produce. The variety SUA 90 showed a higher level of resistance against *Z. subfasciatus* as compared to Kablanketi variety. This is obviously due to the fact that the variety has a hard seed coat which made it difficult for larvae to penetrate inside the grains although due to palatability reasons people tend to prefer Kablanketi variety to SUA 90.

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