PLANT OILS AS COMMON BEAN (*PHASEOLUS VULGARIS* L.) SEED PROTECTANTS AGAINST INFESTATIONS BY THE MEXICAN BEAN WEEVIL *ZABROTES SUBFASCIATUS* (BOH.)

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Abstract: Five plant oils from sesame (*Sesamum indicum*), oil-palm (*Elaeis guineensis),* cotton (*Gossypium hirsutum*), castor (*Ricinus communis*) and maize (*Zea mays*) at a dosage of 5 ml/kg of common bean seeds and a control of malathion dust 2% active substance (a.s.) at a dose 0.5 g/kg of seeds were evaluated for their ability to suppress the populations of *Z. subfasciatus.* Castor and palm oils resulted in effective protection comparable to that of malathion. There were a significant low percentage seed damage and weight loss in seeds treated with malathion, castor and palm oils. Total number of weevils in these treatments were least, compared to other plant oils studied. All treatments did not show adverse effect on germination capability of the seeds. This study showed that it is possible to use castor or palm oils to protect common bean seeds against *Z. subfasciatus* infestations. These products can be obtained locally at a reasonable cost.

Key words: sesame, palm, cotton, castor, maize, malathion

INTRODUCTION

Bean storage over long periods, especially at small scale subsistence farming levels, is limited due to bruchid infestation that results in heavy losses. Two species of bruchids namely the bean weevil, *Acanthoscelides obtectus* (Say) and the Mexican bean weevil, *Zabrotes subfasciatus* (Boheman) are very devastating.

Z. subfasciatus is a destructive pest in areas below 1500 m above sea level. In Tanzania, bean weevils can cause losses of up to 40% (Kiula and Karel 1985). Usually their attack results in yield reduction, poor quality and loss of seed viability. It may also result in unsuitable foodstuff for human consumption.

In controlling this pest, farmers are using several methods which include the use of plant materials with insecticidal properties (Swella and Mushobozy 2007), hermetic storage solarisation, sunning and sieving regimes (Akintobi and Adebisi 2001), contact insecticides and fumigants. The serious problems of genetic resistance of insect species, pest resurgence, residual toxicity, phototoxicity, vertebrate toxicity, widespread environmental hazards, are more important; the increasing costs of application and using synthetic pesticides have created the need for effective, biodegradable pesticides (Elhag 2000).

Vegetable oils are known to control bruchids. Cotton seed, peanut, African palm, soybean and maize oils have been commonly used by some small-scale farmers. Neem seed oil, mustard, sesame, castor, *Khaya senegalensis* and olive oils are known to control the cowpea bruchids (Aheer *et al*. 1996). Some of the plant oils have been reported to be effective in bruchid control near or above the synthetic insecticides (Swella and Mushobozy 2007; Cardet *et al*. 2005). Oil extracts of plants reduce oviposition rate and suppress adult emergence of bruchids, and also reduce seed damage rate (Swella and Mushobozy 2007; Tapondjou *et al.* 2002). Limited work has been done on the use of plant oil extracts of plants obtained locally for the control of *Z. subfasciatus*. It was therefore, the objective of this study to evaluate the efficacy of some plant oils as common bean protectants against the Mexican Bean Weevil.

MATERIALS AND METHODS

The study was conducted in the laboratory of Department of Crop Science and Production, Sokoine University of Agriculture, Morogoro, Tanzania in 2004.

Rearing of experimental insects

A small population of *Z. subfasciatus* beetles was obtained from the on going experiments. These were reared under laboratory conditions, on a diet of Canadian Wonder variety of common bean in a growth chamber at

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27±2°C and RH of 80±10%. Initially, 50 pairs of 1–2 days old Z. *subfasciatus* were placed in two glass jars each with a capacity of 1 kg of beans. The jars were then covered with perforated lids before they were placed inside the growth chamber mantained at the same conditions.

Experimental design

The experiment was a completely randomized design with six treatments, each replicated four times. Treatments were five commercial plant oils and a recommended synthetic insecticide.

Commercial plant oils were derived from the following plants: African palm *(Elaies guineensis*), cotton (*Gossypium hirsutum*), castor (*Ricinus communis*), sesame (*Sesame indicum*) and maize (*Zea mays*). The recommended synthetic insecticide used was malathion dust 2% a.s.

Plant oils were applied at the dose of 5 ml/kg of bean seeds. Common bean seeds of a variety "Masai Red" were weighed and mixed with the respective oil at a dose of 5 ml/kg in a plastic bowl for 2 min by stirring with a brush. The beans were then placed in a glass vial. Malathion dust 2% ai was applied at a dose of 0.5 g/kg of seeds. Then, 30 g of bean seeds for each treatment were placed in glass vials. Five pairs (5 females and 5 males) of newly hatched Mexican bean weevil were released in each glass vial which was then closed with a perforated lid before being placed in the growth chamber maintained at a temperature 27±2°C and 80±10% RH.

Observations were made at two weeks interval starting from 14 days after infestation (DAI) up to 42 DAI. At 42 DAI a germination test was done by putting 10 seeds from each treatment on moist filter paper in a Petri dish for 4 days after which a number of germinating seeds was obtained. Afterwards, the germination percentage was calculated.

Data collected

Data were collected after sieving the insects through a 3 mm sieve. Data collected included the number of damaged and undamaged seeds, weight of damaged and undamaged seeds, the number of live and dead bruchids. Percentage of damaged seeds and percentage weight loss were calculated following the formula by Adams and Schulten (1978). Germination percentage was calculated using the formula:

$$\frac{\text{Number of seeds germinated}}{\text{Total numer of seeds in a petri dish}} \times 100$$

Statistical analysis

Analysis of variance (ANOVA) was done on the data using a 2-way ANOVA of the MSTAT-C statistical package. Means were separated at $P < 0.05$ by Duncan's (1955) new multiple range test.

RESULTS

The mean number of damaged and undamaged bean seeds is presented on table 1. Seeds treated with malathion dust, castor and palm oils had significantly ($p < 0.05$) the highest number of undamaged seeds. Maize oil treated seeds had significantly the lowest number of undamaged seeds throughout the study period.

Seeds samples which had higher number of undamaged seeds recorded the lowest number of damaged seeds and vice versa. In all the treatments, the number of undamaged seeds decreased with the storage duration. Castor oil showed comparable effectiveness to a synthetic insecticide malathion in controlling the pest. It was very closely followed by palm oil.

Table 2 shows the mean weight of undamaged and damaged bean seeds following treatment with various plant oils and the insecticide control. Bean seeds coated with malathion dust, castor and palm oils had significantly ($p < 0.05$) the highest weight of undamaged seeds while those coated with cotton and sesame had significantly low weight followed by those treated with maize oil.

The mean number of live and dead Mexican bean weevils differed significantly among the treatments (Table 3). There were significantly higher numbers of live bruchids in maize and cotton oil treated seeds whereas the least were recorded in seeds treated with malathion dust, castor and sesame oils.

In all treatments, there was generally an increase in the total number of live and dead bruchids with an increase in the study period. Throughout the study period,

Table 1. Mean number of damaged and undamaged been seeds following treatment with various plant oils against *Z. subfasciatus*

Treatment	Storage duration					
	14 days		28 days		42 days	
	number of seeds					
	undamaged	damaged	undamaged	damaged	undamaged	damaged
Cotton oil	50.70 b	17.10 b	36.90 c	30.45 a	34.05 bc	33.30 a
Castor oil	62.25 a	5.40 bc	53.55 a	13.94 c	46.80 ab	21.00 b
Maize oil	40.80 bc	26.55 a	34.65 c	33.15 a	27.90c	39.90 a
Malathion	64.50 a	2.40 d	58.80 a	8.10 c	54.60 a	12.30 c
Sesame oil	49.35 b	19.35 a	45.30 b	23.40 ab	43.20 b	25.50 ab
Palm oil	56.40 ab	8.40 c	46.35 ab	18.45 b	43.05 b	21.75 b
Mean	54.00	13.20	45.92	21.27	41.58	25.62
CV [%]	5.27	28.65	17.60	23.74	13.56	21.14
LSD (0.05)	6.04	3.31	6.85	6.39	6.95	6.60

In a column, means followed by the same letter (s) are not significantly different [$p < 0.05$; Duncan's (1955) multiple range test]

Table 2. Mean weight (g) of undamaged and damaged bean seeds following treatment with various plant oils against infestation by *Z. subfasciatus*

Treatment	Storage duration					
	14 days		28 days		42 days	
	weight of seeds [g]					
	undamaged	damaged	undamaged	damaged	undamaged	damaged
Cotton oil	23.94 b	5.23 a	20.67 b	8.10 a	19.24 b	8.86 a
Castor oil	28.27 a	1.30 b	25.77 a	2.97 c	23.86 a	3.66 c
Maize oil	23.58 b	5.73 a	20.19 ab	8.58 a	17.20 b	10.53 a
Malathion	28.53 a	0.75 b	26.83 a	2.02 c	25.10 a	3.47 c
Sesame oil	24.22 b	5.25 a	22.80 b	6.52 a	20.55	7.00 b
Palm oil	26.43 a	2.53 b	23.91ab	4.89 ab	22.06 ab	5.38 b
Mean	25.85	3.47	23.26	5.47	21.33	6.32
CV [%]	2.87	21.30	3.15	23.48	3.96	17.50
LSD (0.05)	1.24	1.32	1.56	1.50	1.46	1.46

In a column, means followed by the same letter (s) are not significantly different [$p < 0.05$; Duncan's (1955) multiple range test]

Table 3. Mean number of live and dead *Z. subfasciatus* following treatment with various plant oils

Treatment	Storage duration					
	14 days		28 days		42 days	
	number of weevils					
	live	dead	live	dead	live	dead
Cotton oil	8.50 a	1.50 b	23.75 a	13.25 b	31.50 a	17.87 b
Castor oil	3.37 bc	6.63 a	9.00 b	14.63 a	13.75 c	20.87 a
Maize oil	8.89 a	1.11 b	24.25 a	13.75 b	32.37 a	17.75 b
Malathion	1.75 bc	8.25 a	7.50 b	16.75 a	10.00 c	20.87 a
Sesame oil	4.75 b	5.25 ab	7.87 b	11.00 b	15.12 b	12.50 b
Palm oil	4.12 b	5.87 ab	10.87 b	14.12 b	16.25 b	20.62 a
Mean	5.23	4.77	11.37	11.41	15.71	14.56
CV [%]	28.12	30.15	37.14	8.45	16.56	10.17
LSD (0.05)	2.35	2.35	2.30	1.27	3.56	1.75

In a column, means followed by the same letter (s) are not significantly different [$p < 0.05$; Duncan's (1955) multiple range test]

Table 4. Mean percentage of damaged bean seeds following treatment with various plant oils against infestation by *Z. subfasciatus*

Treatment	Storage duration		
	14 days	28 days	42 days
Cotton oil	25.22 b	41.32 a	37.25 b
Castor oil	7.90 cd	20.60 bc	30.87 cd
Maize oil	39.47 a	45.30 a	58.75 a
Malathion	3.57 d	12.07 c	18.27 d
Sesame oil	29.62 ab	34.17 ab	49.57 c
Palm oil	13.02 c	28.52 b	33.65 c
Mean	19.80	30.33	38.06
CV [%]	20.80	30.80	16.20
LSD (0.05)	6.15	8.87	3.16

In a column, means followed by the same letter (s) are not significantly different [$p < 0.05$; Duncan's (1955) multiple range test]

Table 5. Mean percentage weight loss and germination percentage of bean seeds following treatment with various protectants against infestation by *Z. subfasciatus*

Treatment	Storage duration			Germination percentage at 42 DAI
	14 days	28 days	42 days	
Cotton oil	8.85	24.25	26.27	95.00
Castor oil	3.62	11.67	15.90	95.00
Maize oil	23.81	27.12	33.77	87.50
Malathion	1.02	5.50	10.25	90.00
Sesame oil	12.82	14.85	20.35	90.00
Palm oil	4.80	13.97	17.55	87.50
Mean	9.31	16.23	20.68	90.83
CV [%]	33.30	29.80	26.50	14.30
LSD (0.05)	4.60	6.19	5.15	8.21

In a column, means followed by the same letter (s) are not significantly different [$p< 0.05$; Duncan's (1955) multiple range test]

the number of live and dead *Z. subfasciatus* was significantly different among treatments.

There were significant ($p < 0.05$) differences in the mean percentage of damaged bean seeds among the treatments following infestation by *Z. subfasciatus* (Table 4). Significantly lowest percentage of damaged bean seeds was recorded in those treated with malathion dust, followed by castor and palm oil treated seeds. Bean seeds treated with maize oil recorded the highest percentage of damage over the study period.

Table 5 presents the mean percentage weight loss of bean seeds following infestation by the Mexican bean weevil. Seeds which were treated with maize and cotton oils significantly inflicted the biggest weight losses as compared to other treatments. Seeds treated with malathion recorded the lowest weight loss. Weight losses in all treatments increased as the time of storage increased. Seeds treated with malathion dust, castor and palm oils recorded the least weight loss.

The mean germination percentage of bean seeds following treatment with various oils is also shown on table 5. There was no significant ($p < 0.05$) difference in germination percentage between the various treatments. However, cotton and castor oils treated seeds had comparatively better germination.

DISCUSSION

In general, malathion provided the best protection. Malathion, applied as a spray or dust formulation is often used as a grain protectant to prevent infestation of stored products insects (Storey *et al*. 1982). Dust formulation is reported to be more effective. Palm oil among other plant oils studied was found to be effective in controlling *Cryptolestes pusillus* and *Rhyzopertha dominica* in maize and sorghum (Obeng-Ofori 1995). Castor and sesame oils gave a good control of cowpea bruchids (Aheer *et al.* 1996).

Treatments which recorded the highest weight of undamaged seeds had correspondingly the lowest weight of damaged seeds. In all treatments, the weight of undamaged seeds decreased with the duration of storage. This observation is supported by other studies on common beans (Busungu and Mushobozy 1991) and on cowpea bruchids (Swella and Mushobozy 2007).

Bean seeds treated with malathion, castor and palm oils had significantly the highest weight of undamaged seeds which were a result of the highest number of undamaged seed, consequently these seeds had the least percentage of damaged seeds and weight loss. Busungu and Mushobozy (1991) reported that Actellic super dust and coconut oil which were effective in protecting bean seeds against *Z. subfasciatus* had the highest number of undamaged seeds, weight of undamaged seeds, the lowest percentage damage and weight loss. The increase of percentage of damaged bean seeds and weight loss with time may be attributed to the increase in the total number of bruchids and degradation in the efficacy of oils with time (Swella and Mushobozy 2007). Vegetable oils are known to have a good initial control of bruchids which later declines as the oils age and loose their efficacy in about 24 weeks in storage (Ramzan 1994).

Throughout the study period, the number of live and dead *Z. subfasciatus* was significantly different among treatments. This showed that different plant oils had differing effect on the life cycle of the bruchids. Also, the fact that there was an increase in the total number of bruchids as storage days increased shows that different plant oils did not completely kill all the eggs laid by the bruchids.

Percentage damage and weight loss were in positive correlation with the total number of bruchids because treatments with high total number of bruchids inflicted more damage and weight loss. These results are in accordance with other reports on a positive relationship between bruchid density and damage on common bean (Schoonhoven 1978; Busungu and Mushobozy 1991), Also, similar observations were obtained with *C. maculatus* on cowpea (Swella and Mushobozy 2007; Ramzan 1994). Castor oil gave 97.5% mortality of the test insect in a laboratory evaluation of the efficacy of different plant derived oils against *Callosobruchus analis* attacking stored grain (Aheer *et al.* 1996). Also, castor oil among other five studied plant oils, acted as a surface protectant against *Callosobruchus maculatus* population growth by reducing the seed damage rate and the number of F_1 adults that emerged (Rahman and Talukder 2006). Ketker (1989) observed that different oils of coconut, neem and castor acted as surface protectants on green grain to check the pulse beetle.

Groundnut, coconut, African palm, sesame, soybean, maize and cotton oils have been reported to give better control of bruchids; especially the cowpea bruchids *Callosobruchus maculatus* (Schoonhoven 1978; Gwinner *et al*. 1996; Shaaya *et al.* 1997).

Castor and palm oil are saturated oils which are known to remain on the seed surface, hence giving a better control of bruchid (Hall and Harman 1991; Akintobi and Adebisi 2001). Highly unsaturated lipids penetrate the testas and accumulate on the cotyledon surface, whereas saturated lipids solidify on the seed surface. They do not penetrate the seed and thus, remain on the surface where they coat well the bruchid eggs' surface cutting off oxygen supply to the eggs' embryo causing suffocation and hence death of eggs (ovicidal effect). They may also exhibit adulticidal effects.

The findings of the present study indicated that plant oils might be useful as control agents of *Z. subfasciatus* in stored common bean seeds. Castor and palm oils proved to be very effective near to the synthetic insecticide malathion used as a control. Sesame and cotton oils were effective to some extent in reducing the ovipositional preferences and bruchid emergence thereby reducing the damage to bean seeds. Maize oil was the least effective.

The main advantage is that plant oils are more readily biodegradable; they may be easily and cheaply produced by farmers and small scale industries as crude or partially purified extracts. Application of plant oils to common bean seeds for storage is an inexpensive and effective technique and its easy adaptability will give additional advantages leading to acceptance of this technology by farmers. However, it is important to note that plant oils are not completely free from certain risks like toxicity to human beings. The findings have late indicated that seed viability was not affected by the oils and insecticide treatments which is an advantage to the rural poor farmers who usually store seeds for planting on subsequent season(s).

Studies to improve the effectiveness through the choice of effective type of oil(s), purity and the appropriate rate of application should be undertaken.

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POLISH SUMMARY

OLEJKI ROŚLINNE JAKO CZYNNIKI CHRONIĄCE NASIONA FASOLI ZWYCZAJNEJ (*PHASEOLUS VULGARIS* L.) PRZED ZAKAŻENIEM MEKSYKAŃSKA PCHEŁKĄ FASOLI *ZABROTES SUBFASCIATUS* (BOH.)

Testowano skuteczność pięciu olejków roślinnych: z sezamu (*Sesamum indicum*), palmy olejowej (*Elaeis guineensis),* bawełny (*Gossypium hirsutum*), rącznika (*Ricinus communis*), kukurydzy (*Zea mays*) i 2% proszku malathionu, użytych w dawce 0,5 g na 1 kg nasion, pod względem skuteczności ograniczania populacji *Zabrotes subfasciatus*. Olejki z rączniaka i palmy olejowej efektywnie zwalczały patogena, podobnie jak malathion. W tych kombinacjach doświadczalnych stwierdzono istotnie niższe uszkodzenie nasion i niższą utratę wagi. Ogólna liczba pchełek w tych trzech kombinacjach była najniższa w porównaniu do innych olejków roślinnych. Nie stwierdzono niekorzystnych skutków w odniesieniu do kiełkowania nasion w żadnej z kombinacji doświadczalnych.

Przeprowadzone badania wykazały, że istnieje możliwość ochrony nasion fasoli zwyczajnej przed zakażeniem *Z. subfasciatus* przy użyciu olejków z rączniaka i palmy olejowej. Produkty te można łatwo otrzymać lokalnie, za umiarkowana cenę.