Evaluation of the Efficacy of Protectants against Cowpea Bruchids (*Callosobruchus maculatus* (F.)) on Cowpea Seeds (*Vigna unguiculata* (L.) Walp.)

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Abstract

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A laboratory experiment of a completely randomised design and replicated four times evaluated the effectiveness to control the bruchid, *Callosobruchus maculatus* in cowpea by the synthetic insecticide Actellic dust, and by the natural protectants ash, coconut oil, powdered cloves and black pepper. The data collected included the number of damaged and undamaged seeds, weight of damaged and undamaged seeds and the number of live and dead bruchids. Seeds treated with Actellic dust and black pepper powder had significantly low percentages of damaged seeds. Black pepper powder and coconut oil showed good potential in protecting cowpea against bruchid damage.

Keywords: actellic; ash; black pepper; cloves; coconut oil; damage; natural products

The production of cowpea – *Vigna unguiculata* (L.) Walp. is restricted by a number of biotic and abiotic factors both in the field and the seed in storage. Among the constraining biotic factors are insect pests. Storage of cowpea grain over long periods, especially at small scale farming levels, is limited due to cowpea bruchids – *Callosobruchus maculatus* (F.). Their damage causes loss of weight, nutritional value and viability of stored grains. Larvae developing within the grain do the largest damage.

Control of cowpea bruchids in the field and store has to be considered in relation to the economic importance of the crop, since it is evident that these weevils are capable of attacking cowpea both in the field and in storage. In the latter, where feasible, the use of synthetic insecticides is one of the methods used to control bruchids (Khalequzzaman & Chowdhury 2003). Insecticides may be applied as liquid or fumigant formulations. However, continuous use of chemical insecticides may lead to serious problems such as insecticide resistance. Non-chemical methods of bruchid control offer an attractive alternative because they neither leave chemical residues in the commodity nor could their use give rise to resistance in the pest. Such methods include periodic exposure of the grains to the sun, coating seeds with cooking oils, or admixing them with ash or sand (Busungu & Mushobozy 1991). Some plant materials have insecticidal properties that could help to control the invading pests (Jacobson & Crossby 1971).

Bamaiyi *et al.* (2006) reported *Khaya senegalensis* seed oil to significantly reduce the emergence of F_1 and F_2 progenies and to lower the damage to cowpea by *C. maculatus.* The performance of the oil was comparable to that of Pirimiphos methyl E.C.

In order to develop cost-effective and safe methods to control cowpea bruchids, it was the aim of this study to evaluate the efficacy of different protectants in reducing damage by *C. maculatus* on cowpea grains.

MATERIAL AND METHODS

This study was conducted in the laboratory of the Department of Crop Science and Production of Sokoine University of Agriculture, Morogoro, Tanzania, in 1999.

Rearing of experimental insects. Culture stocks of *C. maculatus* were collected from infested cowpea seeds from the Morogoro Municipality central market. They were maintained on cowpea in four large jars, each with a capacity of 1 kg. The jars were covered with perforated lids and kept in an incubator maintained at a temperature of 30 ± 1°C and 70 ± 2% relative humidity (RH). The aim was to produce a steady and sufficient supply of beetles of known age for experimental purposes.

The jars were shaken every day to improve aeration and to prevent attack by unwanted microorganisms. At 28 days after infestation (DAI) the bruchids were separated from the seed by sieving through a 3 mm mesh.

Experimental design. Treatments were arranged in a completely randomised design (CRD) and each was replicated four times. Cowpea seeds of the variety Tumaini were disinfested by keeping them in a deep freezer at a temperature of –2°C for 48 hours. The seeds were then conditioned to room temperature before being used for experimental purposes.

Treatments were five protectants and a control. Actellic Super Dust (25%) (pirimiphos methyl) was applied at a rate of 0.5 g per 50 g of cowpea seeds; coconut oil at a rate of 0.1 ml per 50 g of seed was mixed with the seed in a plastic bowl for 2 min by stirring with a brush. In the following three treatments, 50 g of seed were mixed in glass jars with either 5 g of ash collected from a kitchen fireplace, 5 g of powdered black pepper (*Piper* spp.), or 5 g of powdered cloves *(Eugenia caryophyllus*).

Ten pairs of newly emerged adults of *C. maculatus* were introduced into each glass jar that were then covered with perforated lids. The jars were placed in an incubator maintained at a temperature of 28 ± 2°C and 80 ± 10 % RH. Observations were made at 2-week intervals, starting from 14 up to 42 DAI.

Data collected. The insects were sifted off through a 3 mm sieve. Data collected included the number and weight of damaged and undamaged seeds, and the number of live and dead bruchids. The percentage of damaged seeds was calculated following the formula by Adams and Schulten (1978).

Statistical analysis. Analyses of variance (ANOVA) were done on the data using a 2-way ANOVA of the MSTAT-C statistical package. Means of the four replicates of treatments were tested by Duncan's new multiple range test (DNMR) for significance of their differences. In all cases a significance level of $P < 0.05$ was used unless otherwise stated.

RESULTS

There were significant differences between treatments in the mean number of cowpea seeds damaged and undamaged by *C. maculatus* (Table 1). In all treatments, the number of damaged seeds increased with an increase in length of storage period.

The mean weights of undamaged and damaged seeds were significantly different among the treatments (Table 1). Seed treated with clove powder, ash and the untreated control had significantly the lowest mean weight of undamaged seeds. The weight of undamaged seeds decreased with an increase in storage duration.

The mean percentages of damaged seeds differed significantly among the treatments (Table 2). Seeds treated with Actellic Super Dust recorded significantly the lowest percentage of seed damage for the whole study period. Among the natural protectants, clove powder had the highest seed damage, approaching that of the control.

There were significant differences between treatments in the number of live and dead bruchids over the study period (Table 3). Seeds treated with Actellic Super Dust had the lowest number of live bruchids, followed by treatment with black pepper powder. Treatments which had a low number of live insects recorded higher counts of dead insects 14 d after infestation.

Table 1. Mean number and mean weight of undamaged and damaged cowpea seeds following treatment with various protectants against infestation by *C. maculatus*

Treatment	Storage duration					
	14 days		28 days		42 days	
	undamaged	damaged	undamaged	damaged	undamaged	damaged
Mean number						
Actellic	107.50^{a}	4.00^{d}	98.00^{a}	13.50^{c}	91.00^{a}	20.50^{c}
Coconut oil	94.00^{ab}	14.00^{c}	77.25^{ab}	30.75^{b}	71.75^{b}	36.25^{b}
Cloves	84.50^{b}	28.50^{b}	61.50^{c}	50.75^{a}	56.75^{bc}	55.50^{a}
Black pepper	103.75^{a}	9.00^{bc}	89.25^{a}	23.50^{c}	78.00^{ab}	35.00^{b}
Ash	82.25^{b}	32.25^{a}	75.50^{b}	39.00^{ab}	72.00^{b}	42.50^{ab}
Control	68.00^{bc}	44.25^{a}	57.75^{c}	55.25^{a}	46.50^{c}	66.50^{a}
Mean	90.00	22.00	76.54	35.45	69.30	42.71
CV(%)	7.50	23.90	10.10	20.20	11.20	17.50
$LSD_{0.05}$	10.08	5.52	11.43	10.65	11.58	11.11
Mean weight (g)						
Actellic	47.55^{a}	1.25^{b}	44.72^{a}	3.37^{c}	41.82^{a}	4.12^{c}
Coconut oil	44.05^{a}	4.22^{b}	39.85^{ab}	8.15^{ab}	36.77^{ab}	8.97^{b}
Cloves	39.90^{b}	8.72^{a}	34.45^{b}	13.50^{a}	32.07^{bc}	14.77^{a}
Black pepper	47.12^{a}	2.17^{b}	42.95^{a}	4.95^{c}	39.77^{a}	6.10^{c}
Ash	40.37^{b}	8.75^{a}	36.97^{b}	10.87^{a}	34.25^{ab}	11.67^{b}
Control	39.30^{b}	9.55^{a}	33.65^{ab}	14.30^{a}	28.67^{b}	17.55^{a}
Mean	43.05	5.78	38.77	9.12	35.56	10.53
CV(%)	3.20	25.50	4.60	18.2	4.62	15.50
$LSD_{0.05}$	2.07	2.20	2.65	2.50	2.44	2.43

DISCUSSION

In all treatments, the percentage of damaged seeds increased with an increase in duration of the study period; this may be attributed to an increase in the total number of cowpea bruchids with time and degradation of the effectiveness of the protectants with time. Among the four natural protectants evaluated, black pepper powder was superior in providing protection to cowpea seeds. Its efficacy was similar to that provided by Actellic dust. However, the efficacies of different treatments varied, depending on the source of the active ingredient. Abdullahi and Muhammad (2004) showed that powders of *Piper guineense* had pronounced effects on the fecundity of *C. maculatus,* comparable to treatment with Actellic dust. While 83% to 100% mortality rates were observed in the treated samples, the rates in the untreated control ranged from 33.3% to 43.6%. Also, powder of *P. guineense* significantly affected survival and egg laying capacity of *C. maculatus* adults.

Coconut oil provided the next best protection of the natural products against cowpea bruchid. This result finds support from other studies which showed that coconut oil was effective in controlling *Zabrotes subfaciatus,* a Mexican bean weevil (Busungu & Mushobozy 1991). Oils may increase adult mortality, lower oviposition rates or interfere with larval development. Oils caused high mortality of eggs and larvae on the seed surface, but had no effect on individual larvae that successfully entered the seed. Purity, dosage and method

Table 2. Mean percentage of damaged cowpea seeds following treatment with various protectants against infestation by *C. maculatus*

Treatment	Storage duration		
	14 days	28 days	42 days
Actellic	3.57^{d}	12.07^{c}	18.27^{d}
Coconut oil	13.02^{c}	28.52^{b}	33.65^{c}
Cloves	25.22^{b}	41.32^{a}	49.57^{b}
Black pepper	7.90^{cd}	20.60^{bc}	30.87^{cd}
Ash	29.62^{ab}	34.17^{ab}	37.25^{c}
Control	39.47^{a}	45.30^{a}	58.75^{a}
Mean	19.80	30.33	38.06
CV(%)	20.80	30.80	16.20
$LSD_{0.05}$	6.15	8.87	3.16

of mixing may have affected the performance of coconut oil in this study.

Clove powder provided poor protection of cowpea seed against *C. maculatus* damage in the present study. Cloves are known to have about 17–20% volatile oils, tannic acid and some salicyclic acids (Watt & Breyer-Brandwijk 1962) which may have no insecticidal properties to control *C. maculatus.* Although ash is known to be effective in controlling storage pests, mainly Coleopterae (Gwinner *et al.* 1996), the results from this study are in contrast with those observations. Different plant species contain different chemical compounds which may also be contained in the ashes they produce. Since the ash used in this study was collected from a fireplace where various types of woods were burnt, it is possible that those tree species were not the types suitable for controlling *C. maculatus.* Wood ashes from *Khaya senegalensis, Eucalyptus* spp., *Afzelia africana, Ceiba pentranda* and *Parkia africana* are particularly recommended for the control of development stages of Coleopterae living on grains (Gwinner *et al.* 1996). Also, the amount of ash used in this study was probably too low to control the bruchids. The lowest weights of undamaged seeds in the treatments with clove powder, ash and in the untreated control could be attributed

Table 3. Mean number of live and dead *C. maculatus* following treatment with various protectants

Treatment	Storage duration					
	14 days		28 days		42 days	
	live	dead	live	dead	live	dead
Actellic	3.50^{bc}	16.50^{a}	9.00^{b}	27.50^{a}	10.50^{c}	35.50^{a}
Coconut oil	8.25^{b}	11.75^{ab}	15.75^{b}	22.25^{b}	22.50^{b}	31.25^{a}
Cloves	17.00^{a}	3.00^{b}	41.50^{a}	20.50^{b}	53.00^{a}	25.75^{b}
Black pepper	6.75^{bc}	13.25^{a}	12.00^{b}	23.25^{a}	17.50^{c}	31.75^{a}
Ash	9.50^{b}	10.50^{ab}	15.75^{b}	22.00^{b}	30.25^{b}	25.00^{b}
Control	17.75^{a}	2.25^{b}	42.50^{a}	21.50^{b}	54.75^{a}	25.50^{b}
Mean	10.46	9.54	22.75	22.83	31.42	29.12
CV(%)	30.59	33.54	13.57	7.50	15.29	8.10
$LSD_{0.05}$	4.75	4.75	4.59	2.54	7.13	3.50

to the high mean number of bruchids recorded in these treatments. This shows that the higher the number of bruchids is, the higher will be the loss in quantity (weight) and quality (nutritional and germination) of the cowpeas.

From this study it can be concluded that black pepper powder and coconut oil, being similarly effective as the synthetic Actellic dust, have the potential to protect cowpea grains in storage against *C. maculatus* damage, if timely applications are made.

However, more investigations, for example on amounts and method of application, would be required before any recommendations can be made to farmers. Black pepper and coconut are indigenous and, therefore, readily available to small scale farmers. The biodegradable nature of most plant extracts also minimises the hazard of environmental pollution. As synthetic insecticides are either not easily available to most subsistence farmers or they cannot afford them, the use of natural products like black pepper and coconut, which can be easily grown by such farmers, should be encouraged.

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