Comparative Susceptibility of Different Legume Seeds to Infestation by Cowpea Bruchid *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae)

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Abstract

Swella G.B., Mushobozy D.M.K. (2009): **Comparative susceptibility of different legume seeds to infestation by cowpea bruchid** *Callosobruchus maculatus* (F.) (Coleoptera: Chrysomelidae). Plant Protect. Sci., **45**: 19–24.

The comparative susceptibility of seeds of ten legumes to infestation by *Callosobruchus maculatus* was studied in choice and no-choice experiments. Cowpea, garden pea and pigeon pea seeds recorded the significantly highest number of eggs oviposited and percentage adult emergence, the shortest developmental period, highest susceptibility indices and the highest weight loss. In a choice experiment, treatments which had a cowpea mixture recorded the maximum number of eggs deposited on that legume. The order for ovipositional preference for all legume seeds remained almost the same irrespective of the host on which *C. maculatus* had been reared. Also, there was no association between the seeds preferred for oviposition and culture on which the bruchid was reared. Cowpea and pigeon pea seeds were found to be highly susceptible to *C. maculatus,* whereas common bean, black gram and chickpea seeds were the least susceptible.

Keywords: *C. maculatus*; legume seeds; oviposition; development; susceptibility; host; selection; weight loss

The highest losses of grain legumes during storage are due to bruchids. About 12 species of bruchids are serious pests in the field and about six species are very serious pests during storage (Mphuru 1981).

The cowpea bruchid, *Callosobruchus maculatus* (F.), is a key pest to several grain legumes (Seifelnasr 1991; Lale 2002). It starts infestation in the field, but heavy damage is done in storage (Swella & Mushobozy 2007). It prefers to feed and develop on cowpea *(Vigna unguiculata* (L.) Walp), but it is also known to feed on other legume seeds (Applebaum *et al.* 1970). Subsistence agriculture requires that the farmer store a percentage of staple food to feed his family and livestock between harvests (Hindmarsh *et al.* 1978). The largest quantity of food in the tropics is stored in traditional farmer's granaries and in most cases under one roof (Lambert *et al.* 1985; Stathers *et al.* 2002).

This type of storage may lead to cross infestation among the stored products which are sharing a common pest. Although most of these are serious pests in the tropics, little is known about their biology, ecology, the damage they cause, their

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distribution, their host plants and their natural parasites and predators.

Knowledge of host, pest and the environment interaction is an important prerequisite when devising a cost-effective pest management package. For a polyphagous pest like *C. maculatus*, it is important to know its host range so that storage planning can be made to avoid cross-infestation among susceptible legume seeds species when stored in one place. This will prevent a heavy build-up of *C. maculatus* populations.

The present study was undertaken to determine the susceptibility and hence the suitability as host of some leguminous seeds for *C. maculatus.*

MATERIAL AND METHODS

Rearing of experimental insects. Adult cowpea bruchids were obtained from a laboratory culture of the ongoing experiments. Rearing of the bruchids for the no-choice experiment followed the procedure described by Swella and Mushobozy (2007).

Experimental insects for the choice experiment were reared from the culture of insects for a no-choice experiment. One glass jar each of a capacity of 1 kg contained respective seeds of one of the ten legume species studied (see below). The aim was to precondition the bruchids so as to eliminate any short term changes in behaviour associated with the change of host species from that used for culturing to that being tested (Dobie 1974). Rearing procedures were as described by Swella and Mushobozy (2007). Insects were reared for two generations before they were used in the experiments.

Experimental design. For a no-choice experiment with seeds of ten different legume species as treatments, a completely randomised design (CRD) with ten replications was used. The legume species studied were: bambara nuts (*Voandzeia subterranean* (L.) DC.), cowpea (*Vigna unguiculata* (L.) Walp), pigeon pea (*Cajanus cajan* (L.) Millsp.), chick pea (*Cicer arietinum* L.), green gram (*Vigna radiata* (L.) Wilcezk), broad bean (*Vicia faba* L.), common bean (*Phaseolus vulgaris* L.), garden pea (*Pisum sativum* L.), black gram (*Vigna mungo* (L.) Hepper) and soya bean (*Glycine max* (L.) Merrill). All these seeds were obtained from the Morogoro Municipality central market, Tanzania.

For both experiments, seeds were disinfested by keeping them in a deep freezer maintained at a temperature of 12°C for 48 hours. These seeds were then conditioned to a room temperature before being used for experimental purposes. In a no-choice experiment, 15 g of seeds of each studied legume were individually placed in small glass jars before ten pairs of newly emerged adults of *C. maculatus* were introduced. The jars were covered with perforated lids and then placed in an incubator maintained at a temperature of 30 ± 1°C and 70 ± 2% relative humidity (RH).

For a choice experiment, seeds of the ten legume species were mixed in all possible pairings. 7.5 g of seeds of each component in the mixture were introduced into a glass jar. Five pairs of bruchids emerging from each culture were taken and separately introduced into a glass jar. The jar was then covered with perforated covers and kept in an incubator maintained at conditions as described above. The experiment was repeated five times.

Data collected. In a no-choice experiment, 24 h after infestation, the number of laid eggs on different treatments was counted following the method as described by Lambert *et al.* (1985).

Seven days after infestation the adults were removed, the desiccators were aerated by opening them on alternate days while observations for emergence started 2 weeks after infestation.

The susceptibility index (SI) was calculated following the formula by (Dobie 1974):

$$SI = \frac{\text{Loge } F_1}{D} \times 100$$

where:

F_1 – total number of emerging adults

D – median developmental period (estimated as the time from the middle of oviposition to the emergence of 50% of the F_1 generation)

In a choice experiment, the bruchids were removed after 24 h and the number of eggs laid on different pulses was counted and a total count in a mixture recorded before the means were calculated.

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 ten replicates were separated by Duncan's new multiple range test (DNMR) for significance in their differences. In all cases, a significance level of $P < 0.05$ was used unless otherwise stated.

RESULTS AND DISCUSSION

The mean number of eggs deposited is presented on Table 1. The highest mean number of eggs was deposited on cowpea seeds (58.4), thus showing the highest ovipositional preference. The lowest oviposition was recorded on soya bean seeds (6.0). Cowpea bruchids are known to prefer to feed and develop on cowpea as their main hosts (Applebaum *et al.* 1970).

Considerable numbers of eggs were also laid on garden pea and pigeon pea seeds. No legume seeds in this study were totally rejected for oviposition by the bruchid beetles. Yadav and Pant (1974) observed that *Callosobruchus* spp. will oviposit on any seed, even though the seed may not be suitable for the development of these insects. On seven different legumes studied, Seifelnasr (1991) reported the highest total oviposition by C. *maculatus* on cowpea followed by garden pea, while the lowest was on chicken pea.

The number of eggs deposited by *Callosobruchus* spp. was found to be affected by seed size, curvature of the seed, colour of the seed, thickness of the seed coat, and smoothness of the seeds (Nwanze *et al.* 1975; Mphuru 1981). These may relate to the chemical composition of the seed. However, the number of eggs laid by an insect is less important than the rate of oviposition in its influence on the rate of multiplication (Howe 1971).

There was a significant difference in the percentage of adults which emerged in the legume seeds studied. Seeds of cowpea and garden pea had the highest percentage adult emergence followed by pigeon pea, bambara nut, chickpea and green gram. The lowest percentage adult emergence was observed in common bean seeds. Although slightly higher mean counts of eggs were laid on common bean than on black gram and soya bean, a smaller percentage of adults emerged from common bean. Seifelnasr (1991) observed a similar trend in haricot bean where a total of 41 eggs were deposited which was higher than the number deposited on chickpea (26) or on bambara nut (39) but none of the larvae survived to adulthood. Microscopic examinations revealed that the newly hatched larvae had died before boring the seed coats or cotyledons of haricot bean.

The inability of *C. maculatus* to develop on soya bean in this study can be attributed mainly to the high protein-carbohydrate ratio of the seed and in part to its saponin content (Applebaum *et al.* 1969). Also, this bruchid is known for not being capable of attacking seeds with a high fat content like soya bean (Mphuru 1981). Results from the present study also showed that there

Table 1. Mean number of eggs, percent of adult emergence and developmental period of *Callosobruchus maculatus* on 10 different legume seeds in a no-choice experiment

Seeds of legume	Mean number of eggs laid	Percent of adults emerged	Mean developmental period (days)
Bambara nut	19.8[b*]	58.3[c]	28.8[ab]
Black gram	6.4[a]	28.5[b]	33.6[b]
Broad bean	13.2[ab]	28.0[b]	29.1[ab]
Common bean	8.2[a]	1.8[a]	38.2[c]
Chickpea	15.2[b]	57.4[c]	34.0[b]
Cowpea	58.4[d]	88.1[d]	25.2[a]
Garden pea	39.9[c]	76.3[cd]	30.5[ab]
Green gram	16.0[b]	48.4[bc]	31.4[ab]
Pigeon pea	36.8[c]	60.8[c]	27.5[a]
Soya bean	6.0[a]	13.8[a]	34.6[b]
Mean	21.98	46.14	31.29
CV (%)	18.60	21.80	7.20
$LSD_{0.05}$	4.85	14.62	3.54

*Means in a column followed by the same letter(s) do not differ significantly at the 5% level by DNMRT was a considerable percentage of adult emergence from garden pea (76%), comparable to those from cowpea and pigeon pea (Table 1). This is contrary to the findings by Seifelnasr (1991) who observed poor adult emergence (15.2%). The differences in results may be attributed to varietal differences in beans which show a great deal of variations in their physical and chemical composition. In this study, a variety with a smooth surface of its testa was used. Podoler and Applebaum (1971), when studying the effect of carbohydrate composition on varietal resistance of garden pea to *C. chinensis,* had noted that wrinkled peas with high amylase content and poor nutritive value were resistant while smooth-skinned garden peas were susceptible. Another factor may be differences in the biotypes of *C. maculatus* used in the present study and/or Seifelnasr (1991) study.

Multiple range test calculation showed that the mean development period was significantly shorter in cowpea seeds (25.2 days) followed by pigeon pea (27.5 days). Common bean seeds had the longest (38.2 days) developmental period, followed by chickpea (34.0 days) and soya bean (34.6 days). Legume seeds which had the highest mean egg counts and high percent of adult emergence correspondingly had the shortest development period.

This shows that cowpea and pigeon pea are the most suitable hosts for *C. maculatus* oviposition and development. The developmental period is appreciably prolonged in non-host seeds, reaching a maximum of 38.2 days in common beans followed by soya bean, chick pea, black gram, green gram, garden pea, broad bean and bambara nut. The development and survival of *C. maculatus* is affected by certain nutritive and digestive factors (Applebaum & Birk 1972; Mphuru 1981). Yadav and Pant (1974) reported *C. chinensis* to breed successfully on many legume seeds except on black gram. This supports our findings in the present study on black gram which has a longer developmental period of 33.6 days.

The susceptibility index (SI_s) of the various legume seeds studied are presented in Table 2. There were significant differences between the treatments on their SI_s, hence their suitability as hosts for oviposition, development and feeding by *C. maculatus.* Cowpea and pigeon pea seeds had the significantly highest SI_s of 19.9 days and 18.2 days, respectively. Common bean, black gram and chickpea had the lowest SI_s of 15.1 days, 15.2 days and 15.5 days, respectively.

Those legume seeds with a low SI_s, for example common bean, could be regarded as being poor or non-hosts of *C. maculatus*, whereas cowpea and pigeon pea seeds with a high SI_s could be regarded as being suitable hosts for *C. maculatus.* The resistance of common bean to *C. maculatus* infestation is attributed to the presence of sapon-

Table 2. Mean susceptibility indices and weight loss following infestation by *Callosobruchus maculatus* on different legume seeds

Seeds of legume	Susceptibility index	Mean weight loss (g)
Bambara nut	16.5^{b*}	6.1^{c}
Black gram	15.2^{a}	3.0^{ab}
Broad bean	15.9^{ab}	3.9^{ab}
Common bean	15.1^{a}	2.7^{a}
Chickpea	15.5^{a}	3.3^{ab}
Cowpea	19.9^{c}	9.6^{e}
Garden pea	17.1^{b}	8.4^{d}
Green gram	15.3^{a}	4.5^{b}
Pigeon pea	18.2^{bc}	7.8^{d}
Soya bean	16.6^{b}	3.3^{ab}
Mean	16.53	5.26
CV(%)	8.64	11.20
$LSD_{0.05}$	1.42	1.18

*Means followed by the same letter(s) do not differ significantly at the 5% level by DNMRT ins which comprise 3.2% of the lipid-free bean meal or to the heteropolysaccharides (Applebaum & Guez 1972).

Also, asparagines which exist in association with the toxic substances beta-cyanoalanine and alpha-diaminobutyric acid were found to render resistance in haricot bean (Seifelnasr 1991). Yet it was not within the scope of this study to investigate the factors responsible for resistance against *C. maculatus.* Since the factors rendering inherent resistance are not yet known, it might be important to investigate the factors contributing to resistance of the seeds of certain legume species.

Cowpea seeds suffered the highest weight loss (9.6 g) among the treatments. Common bean, chickpea, soya bean, broad bean, and black gram had the lowest weight losses. The weight losses arising from the quantity of material eaten by developing larvae were correlated positively with the susceptibility indices (r = 0.7439, $P \leq 0.05$), with cowpea seeds being the most susceptible by losing 9.6 g compared to the least susceptible common bean seeds losing 2.7 g. Apart from weight loss, cowpea bruchid damage also cause nutritional and viability losses (Abdullahi & Muhammad 2004).

Table 3 presents the relative ovipositional preference by *C. maculatus* in a choice experiment. Treatments which had a cowpea mixture had a maximum number of oviposited eggs. Also, the order for ovipositional preference for all legume seeds remained almost the same irrespective of the host on which *C. maculatus* had been reared. This implies that seeds of some hosts are preferred for oviposition and certain others are not favoured (Wasserman 1981). The χ^2 test at P = 0.05 level of significance showed that there is no association between the seeds preferred for oviposition and culture on which the bruchid was reared.

Our results are in accordance with similar studies which found that with *C. maculatus, Acanthoscelides obtectus* and *C. chinensis* there was no correlation between host preference and previous conditioning of the bruchids on their hosts (Zaazon 1951).

From this study, it can be concluded that seeds of cowpea, garden pea and pigeon pea are the most susceptible legume seeds and thus the most suitable hosts for *C. maculatus.* These hosts had the highest number of eggs oviposited and percent adult emergence, the shortest developmental period, highest susceptibility index and largest weight loss. Conversely, common bean, black gram and chickpea seeds were found to be lowly susceptible. In the choice experiment, treatments which had a cowpea mixture also had a maximum number of eggs deposited. The order for ovipositional preference for all legume seeds remained the same irrespective of the host on which *C. maculatus* had been reared.

Farmers have to be advised not to store cowpea, garden pea and pigeon pea seeds in the same place and/or at the same time to avoid cross-infestation because of their high susceptibility to *C. maculatus.*

Table 3. Relative ovipositional preference by *Callosobruchus maculatus* on paired mixtures of legumes species seeds studied in a choice experiment

Seeds of legume	Bambara nut	Black gram	Broad bean	Common bean	Chick-pea	Cow-pea	Garden pea	Green gram	Pigeon pea	Soya bean
Bambara nut	8.5	7.9	7.3	6.9	7.0	8.6	6.3	8.2	5.7	8.8
Black gram	1.6	3.7	2.0	1.2	2.4	1.2	1.0	2.5	4.2	3.0
Broad bean	2.4	2.8	4.3	6.3	0.0	9.5	4.6	4.5	3.6	2.7
Common bean	2.2	6.9	3.5	4.6	2.2	1.0	5.5	3.7	2.3	3.7
Chickpea	0.5	1.0	1.2	4.0	0.5	1.4	2.0	1.5	2.2	0.8
Cowpea	35.5	35.3	33.9	30.5	35.6	38.3	33.9	34.9	37.2	32.5
Garden pea	18.3	16.4	15.9	14.7	15.6	15.7	24.5	13.7	14.3	15.9
Green gram	6.3	5.5	5.4	6.9	4.6	4.4	5.8	4.9	4.6	5.2
Pigeon pea	7.2	9.4	9.7	8.9	8.5	10.3	8.7	10.2	10.8	7.8
Soya bean	2.4	1.0	4.3	2.3	0.2	0.6	3.7	2.7	1.2	2.4

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