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Infestation Patterns of The Cowpea Weevil and The Common Bean Weevil on Cowpea and Common Bean

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Abstract

Callosobruchus maculatus (CM) (Cowpea weevil) and *Acanthoscelides obtectus* (AO) (Common bean weevil) are major post-harvest pests of cowpea and common bean, respectively. The objective of this study was to investigate the infestation patterns of these two weevils on common bean and cowpea. Twenty-four cowpea and 14 common bean genotypes were evaluated for resistance to CM and AO in a laboratory at the University of Zambia. CM successfully infested and damaged seed of all 24 cowpea genotypes. However, CM laid eggs on common bean, but no larvae hatched from the eggs, therefore, there was no seed damage. Significant variation was observed in the reaction of the 24 cowpea genotypes to infestation with AO. Of the 24, cowpea genotypes, 14 were resistant while ten were susceptible at 60 days post-infestation, demonstrating that AO successfully infested and damaged cowpea seed. However, the infestation and seed damage on cowpea by CM was more severe than by AO. The results of this study suggests that in common bean and cowpea production environments where both CM and AO are prevalent, the damage on cowpea is likely to be higher than on common bean because both CM and AO will damage cowpea while common bean may only be damaged by AO.

Keywords: Common bean weevil; cowpea weevil; common bean; cowpea; infestation

Introduction

Common bean (*Phaseolus vulgaris* L.) and Cowpea (*Vigna unguiculata* L.) are food security crops for many households in Africa. Post-harvest losses for both crops are high, and are a threat to household food security. One major contributing factor to these post – harvest losses are storage pests (Murdock et al., 2003; Jones et al., 2018).

Callosobruchus maculatus (CM) (Cowpea weevil) is a major post-harvest pest of cowpea, and may cause cowpea yield losses of up to 90% in storage depending on a varietal susceptibility, storage environment and length of storage (Beck and Blumer, 2014; Hajam et al., 2022). CM larvae burrow and feed on seed causing holes or perforations resulting in losses of seed weight, germination viability, and market value of the crop. Because of fears for these losses, farmers sale the crop immediately after harvesting usually at a cheaper price (Allotey and Oyewo, 1993; Murdock et al., 2003).

Acanthoscelides obtectus (AO) (Common bean weevil) is the most important post-harvest pest of common bean seed. Similar to CM, AO causes perforations in the seed resulting in loss of seed quality and yield (Kamfwa et al., 2018; Stathers et al., 2020). AO may cause up to 100% yield losses depending on severity of infestation, varietal susceptibility, storage conditions and duration (Slumpa and Ampofo, 1991; Chinji et al., 2024).

Majority of smallholder farmers do not have access to effective grain storage infrastructure (Nwaigwe, 2019) and chemical control to mitigate the losses caused by AO and CM. Some farmers in Africa grow both cowpea and common bean, and the two crops are normally stored in the same building (granary) or in close proximity. Anecdotal evidence suggests that AO does infest cowpea and vise-versa CM infests common bean. There is no previous empirical study conducted in Zambia to investigate the infestation patterns and damages of CM and AO on cowpea and common bean. The objective of this study was to investigate the infestation patterns of the cowpea weevil and the common bean weevil on cowpea and common bean.

Materials and Methods

Plant Materials

In this study, a total of 24 cowpea and 14 common bean genotypes were used. The 24 cowpea genotypes were comprised of 22 M4 mutant lines and their two wild type parents (Namuseba and Mutilizi). Both Mutilizi and Namuseba are Zambian varieties. Namuseba has a cream white seedcoat while Muilizi has a brown seedcoat. Of the 22 mutants, ten were derived from Mutilizi while twelve were from Namuseba using 150 grays of gamma irradiation in an International Atomic Energy Agency (IAEA) laboratory in Seibersdorf, Austria. Advancement of generations from M1 to M4 was conducted at the University of Zambia in Zambia. The 14 genotypes of common bean were comprised of four varieties and ten breeding lines. Of the four varieties three are resistant to AO while one (ADP1) is susceptible (Chinji et al., 2024). All ten breeding lines were purposely developed for AO resistance (Chinji et al., 2024).

Screening for Resistance to CM and AO

The 38 cowpea and common bean genotypes were evaluated for resistance to CM and AO in the laboratory at the University of Zambia between June and August 2023 using a previously described protocol (Kamfwa et al., 2018; Chinji et al., 2024). Three sets of experiments were conducted concurrently: (i) cowpea genotypes infested with CM, (ii) common bean genotypes infested with AO, and (iii) cowpea genotypes infested with AO. All three experiments used a Completely Randomized Design with four replications. The experimental unit was a 250 ml plastic bottle jar. Ten seeds of each genotype were placed in a jar, and then ten unsexed adult weevils were introduced into the jars. The AO and CM were obtained from the colonies maintained at the University of Zambia, by the Legume Breeding Program. The lids of the bottles were cut open on top and nets were placed on, to allow ventilation. The rearing jars were kept in the insectarium at 28 °C temperature, 60-70% relative humidity and 12L: 12D photoperiod for 60 days. At 60 days post-infestation (PI), the following parameters were assessed on the seed: total number of perforations on the ten seed, number of emerged adult weevils and percentage of damaged seed. A seed was considered damaged if it had at least one perforation. The total number of perforations on the ten seed was used to develop a perforation score scale of 1-5, where 1 = zero perforations, 2 = one to five perforations, 3 = 6 to 10 perforations, 4 = 11 to 15 perforations, and 5 = ≥ 16 perforations. Genotypes with perforation scores of ≤ 2 at 60 days PI were considered to be resistant while those > 2 were considered susceptible. In addition to these parameters that were recorded at 60 days PI, observations were made on the infestation patterns of CM and AO on the seed.

Data Analyses

Data analysis was conducted using R statistical software, version 4.4.1 (R Core Team, 2024). The data for number of emerged adult weevils, percentage of damaged seed and perforation scores were first checked for normality of distribution using the Shapiro-Wilk test. Since the data for all the three traits did not conform to the normality assumption, the data was transformed using Box Cox transformation before it was tested using Analysis of Variance (ANOVA), following statistical model below:

$$Y = \mu + g + e$$

where: Y was the response variable, e.g., seed perforation score; μ was the overall mean effect; g was the random variable effect of genotype; e was random error.

Results and Discussion

Cowpea Genotypes Infested with CM

At seven days PI, CM in all bottles were still alive and active. Weevils only died during the beginning of the second week. At 30 days PI, at least 50% of the seeds in each bottle in all replications had perforations. This observed infestation pattern of CM on cowpea is in contrast to what happens in common bean infested with AO where it is rare to have an over 50% seed damage at 30 days PI even in highly susceptible common bean genotypes (Chinji et al., 2024; Kamfwa et al., 2028). At 60 days PI, all 24 cowpea genotypes were highly susceptible to CM (perforation score of 5), and recorded 100% seed damage. The number of emerged adult CM in each bottle ranged between 33 – 63 with a mean of 49.9 (Figure 1; Table 1). These results showed that neither the two wild type parents nor their 24 mutants possessed resistance to CM.

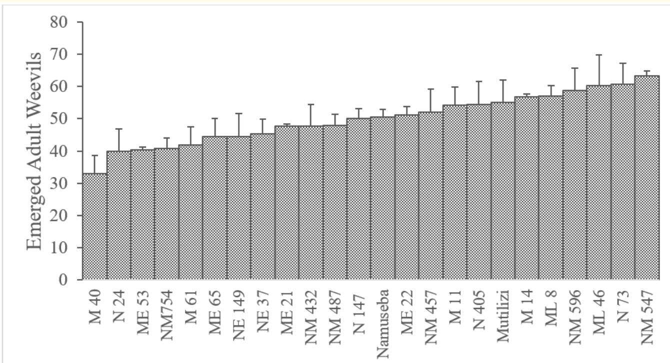

Figure 1: Means for the number of emerged adult weevils for the 24 cowpea genotypes infested with *C. maculatus* (cowpea weevil) in the insectarium at University of Zambia.

Crop	***Weevil Type***	***Parameter***	***Range***	***Mean***	***ANOVA***
Cowpea	*C. maculatus*	Perforation Score	NA	5	NA
Cowpea	*C. maculatus*	Emerged Adult Weevils	33 - 63	50	**
Cowpea	*C. maculatus*	Percentage of Damaged Seed	NA	100	NA
Cowpea	*A. obtectus*	Perforation Score	1.0 - 3.8	1.9	**
Cowpea	*A. obtectus*	Emerged Adult Weevils	0 - 11.5	3	**
Cowpea	*A. obtectus*	Percentage of Damaged Seed	0 - 75	18.3	**
Common Bean	*C. maculatus*	Perforation Score	NA	1	NA
Common Bean	*C. maculatus*	Emerged Adult Weevils	NA	0	NA
Common Bean	*C. maculatus*	Percentage of Damaged Seed	NA	0	NA

** = highly significant at α = 0.05; NA = Not applicable; ANOVA = Analysis of Variance.

Table 1: Range, mean and analysis of variance for perforation score, number of emerged adult and percentage of damaged seed of the 24 cowpea genotypes and 14 common bean genotypes infested with *C. maculatus* (cowpea weevil) and *A. obtectus* (common bean weevil) in the insectarium at University of Zambia.

Cowpea Genotypes Infested with AO

Significant differences (P < 0.05) were observed among the 24 cowpea genotypes in perforation scores, emerged adult weevils, percentage of damaged seed at 60 days PI with AO (Table 1). The number of emerged adult weevils in the bottle ranged from 0 – 11.5 (Figure 2) with a mean of 3 while the percentage of damaged seed ranged from 0 - 75% and a mean of 18.3% (Figure 3; Table 1). The perforation score ranged between 1 – 3.8 with a mean of 1.9 (Figure 4). Of the 24 cowpea genotypes, five were resistant (score of ≤2) while 10 were susceptible (score of >2). This result confirms that AO does infest and damages cowpea in storage. However, it appeared that AO infestation and seed damage on cowpea was less severe than that of CM (18.3% seed damage by AO compared to 100% by CM).

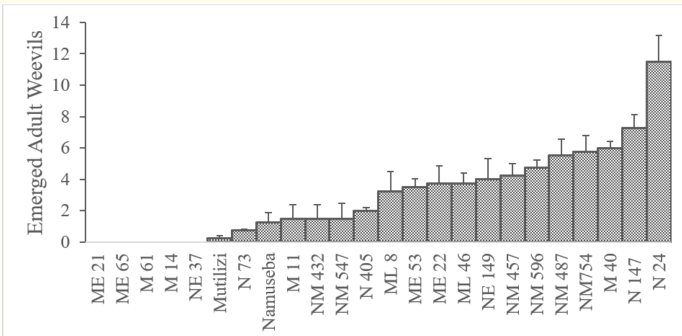

Figure 2: Means for the number of emerged adult weevils for the 24 cowpea genotypes infested with *A. obtectus* (common bean weevil) in the insectarium at University of Zambia.

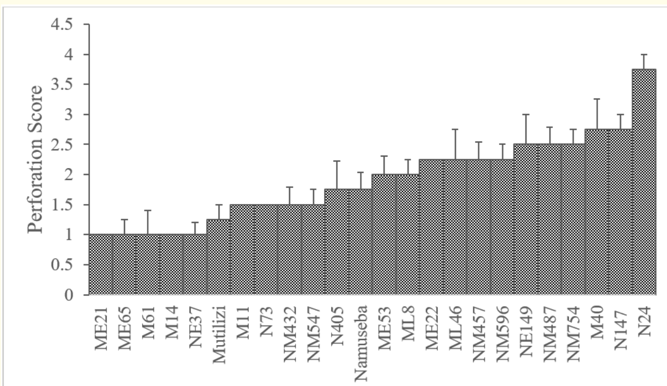

Figure 3: Mean perforation scores for the 24 cowpea genotypes infested with *A. obtectus* (common bean weevil) in the insectarium at University of Zambia.

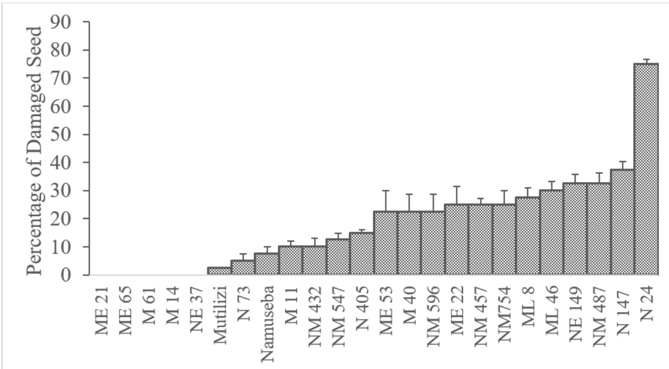

Figure 4: Percentage of damaged seed means for the 24 cowpea genotypes infested with *A. obtectus* (common bean weevil) in the insectarium at University of Zambia.

Common Bean Genotypes Infested with CM

Although CM successfully laid eggs on common bean seed, infestation did not progress beyond this stage, therefore, there was no seed damage to common bean seed infested with CM at 60 days PI (Table 1). This observation is consistent with previous studies that reported reduced CM oviposition of eggs, lack of progression of the laid eggs to the larval stage or death of the larvae on common bean seed (Janzen, 1977; de Sá et al., 2014; Nwosu and Ikodie, 2021).). This lack of successful development of CM on common bean seed has been attributed to the chemical and physical properties of the seed particularly the seedcoat (Janzen, 1977; Silva et al., 2004; de Sá et al., 2014). The results of this study suggests that in common bean and cowpea production environments where both CM and AO are prevalent, the damage on cowpea is likely to be higher than on common bean because both CM and AO will damage cowpea while common bean may only be damaged by AO.

Conclusion

This study has demonstrated that CM successfully infested and damaged seed of the 24 cowpea genotypes. However, CM laid eggs on common bean , but no larvae hatched from the eggs, resulting in no seed damage. Significant variation was observed in the reaction of the 24 cowpea genotypes to infestation with AO. Of the 24, cowpea genotypes, 14 were resistant while ten were susceptible. CM severely infested and damaged cowpea more than AO.

Conflict of Interest Statement

The authors declare that there is no conflict of interest.

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