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Research article

EFFECTS OF INITIAL INFESTATION ON THE DEVELOPMENT OF *Callosobruchus maculatus* (Fab.) and *Sitophilus zeamais* Motsch. IN STORED COWPEA AND MAIZE

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ABSTRACT : The aim of the study was to determine the influence of varying levels of *Callosobruchus maculatus* (F.) and *Sitophilus zeamais* Motsch. infestation on survival and development of the insects in stored cowpea and maize seeds respectively. Three levels of infestation (1, 2 or 3 pairs) of the insects` species each were used to infest 100 g of the commodities. The data from the storage experiment were collected using a total number of 12 experimental units arranged in completely randomized design (CRD) for each test insect. Counts of adult mortality of the insects, number of eggs laid, progeny emergence and percentage weight loss of the stored seeds were recorded after keen observation and examination. Based on the results, there was significant difference (P < 0.05) in the number of adult insects that died in the cowpea and maize seeds infested with 2 and 3 pairs of *C. maculatus* and *S. zeamais* compared to non - infested seeds. Significant differences were also recorded in the number of eggs laid by the insects, number of emerged adults and seed weight loss in the levels of infestation and the non - infested control. Results showed that levels of infestation exposed the seeds to the destructive activities of stored product insect pests under prevailing ambient conditions. It is therefore suggested that environmental hygiene and appropriate storage devices that could prevent cross infestation are necessary to sustain national food security.

Key words: Bruchids, curculionids, ovipos ition, population dynamics, survival, mortality

INTRODUCTION

Cowpea, *Vigna unguiculata* (L.) Walp, is an important dietary protein in Africa where *Callosobruchus maculatus* (F.) has become a major storage insect pest of the seeds. The magnitude of competition between *C. maculatus* and human beings for this important crop has contributed to food shortage and affected self sufficiency [13]. A total of 2,663.390 tonnes of cowpea is produced from an estimated area of 9,441, 562 ha [7].

Maize, *Zea mays* L. is a major food crop in Africa and it is usually stored to provide food reserve and also seed material for planting [2]. It is an import crop in confectionery and pharmaceutical industries. Meanwhile, cowpea and maize production are threatened by heavy insect infestation (even in storage) resulting in colossal economic loss to both farmers and consumers. These losses constitute net reductions in the amount of nutrients available to the consumer (economic loss) or both quantitative and qualitative losses. Stored seeds are severely damaged by insects and may be reduced to powdery form unfit for human consumption and other uses. Once infestation is naturally or artificially established, insect pests cause uninterrupted destruction as a result of their feeding activities leading to grain damage, grain weight loss, nutritional and physical loss of stored grains.

The economic situation in a developing country, like Nigeria, has been adversely affected mostly by the post-harvest losses of commodities which are usually encountered, especially during storage [3]. For these reasons, food situation has remained insecure and unpredictable in sub-saharan Africa, leading to high levels of cyclic famine and poverty [14]. These reasons justify the need for extensive studies on *C. maculatus* and *S. zeamais* as primary insect pests of stored cowpea and maize respectively. It was against this background that this study was designed to evaluate the effects of different levels of *C. maculatus* and *S. zeamais* infestation on their survival, development and threat in the stored commodities.

MATERIALS AND METHODS

Test insect

The experiment was carried out in 2009. seeds of cowpea and maize infested separately by *C. maculatus* and *S. zeamais* were obtained from National Stored Products and Research Institute, Ilorin, Nigeria and used to establish laboratory cultures of the two insect species. The cultures were maintained subsequently by replacement of damaged seeds with fresh seeds in 500 ml Kilner jars covered with muslin cloth to allow air circulation. One–to-two–day-old teneral adults were used for the experiment. The cultures were raised under fluctuating laboratory conditions (28±2^{0}C and 70±5% relative humidity).

Experimental procedure

One hundred grammes of cowpea and maize seeds each which had been disinfested in the deep freeze for 14 days and air-dried for 7 days were placed in transparent plastic containers (12 cm in diameter). The cowpea or maize seeds in each container were infested with 1, 2 or 3 pairs of teneral adults of *C. maculatus* and *S. zeamais* respectively. An non-infested control was taken as the protected seeds against infestation for comparison; all infested (unprotected) and non-infested (protected) treatments were replicated three times. The seeds in the respective containers were covered with muslin cloth to allow air circulation and then left undisturbed for 7 days to allow mating and laying of eggs by female beetles and weevils. The procedure of Beck and Blumer [4] was used for sex determination in the beetles. The external sex differences of the maize weevil were used according to Halstead [11].

Oviposition of *S. zeamais* was determined according to the procedure of Frankenfeld [8] while the number of eggs laid by beetles on the surface of cowpea seeds was carefully examined with the aid of magnifying lens. The beetles and weevils were examined for adult mortality at 10, 15 and 20 days after infestation (DAI). The numbers of adult beetles and weevils that emerged were counted and recorded as the F_1 generation at 25, 26 and 27 DAI. The F_1 adult progeny that emerged were allowed to mate and the females were allowed to lay eggs before they were removed and discarded. The emergents were counted and recorded as the F_2 adult progeny at 50, 51 and 52 DAI.

At 3 months post-infestation, adult beetles and weevils were sieved out, and the seeds reweighed to examine seed weight loss. The difference between the initial and final weight was represented as percentage seed weight loss.

Data analysis

Data obtained were subjected to analysis of variance (ANOVA) and significantly different means were separated using the Least Significant Difference (LSD) at 5% level of probability [9].

RESULTS

The effects of levels of infestation of adults of *C. maculatus* and *S. zeamais* on their mortality in stored cowpea and maize are presented in Table 1. Significant differences (P<0.05) occurred in the number of insects that died in cowpea and maize seeds infested with different levels of the insects (Table 1) at 10, 15 and 20 days after infestation (DAI).

Significant differences occurred in the number of adults of *C. maculatus* that died in the cowpea seeds infested with 2 and 3 pairs of the insect compared to the non-infested control at 10 DAI. There was also significant difference in adult mortality of the beetle at 2 and 3 pairs of infestation compared to 1 pair of infestation. All levels of infestation were significantly higher (P<0.05) compared to the non-infested control. However, the number of *C. maculatus* adult mortality counts at 3 pairs of insect infestation was significantly higher (P<0.05) compared to lower levels of infestation at 20 DAI. Only the 3 pairs of beetle infestation caused significant difference in adult mortality compared to the non-infested control at 20 DAI. The lowest *C. maculatus adult* mortality counts were recorded in the 1 pair of insect infestation with 1.25, 1.75 and 2.00 insects at 10, 15 and 20 DAI respectively. The results showed that insect infestation, irrespective of rates, could lead to food shortage.

Similarly, significant differences were recorded in the number of adults of *S. zeamais* that died in maize seeds infested with 1, 2 and 3 pairs of the insect at 15 and 20 DAI (Table 1). Maize seeds infested with 1 pair of *S. zeamais* showed significant difference (P<0.05) in the number of adult mortality compared to 2 and 3 pairs of infestation at 15 DAI. However, the three levels of insect infestation were significantly different from one another at 20 DAI. There was no infestation of the cowpea and maize seeds in the control treatment which was further covered to prevent entry of insects. This emphasizes the relevance of seed protection against cross infestation within the first month of experimental set up.

Table 1. Effects of levels of infestation of *Callosobruchus maculatus* and *Sitophilus zeamais* on their mortality in stored cowpea and maize

	Mortality of *Callosobruchus maculatus* (DAI)			Mortality of *Sitophilus zeamais* (DAI)		
Initial infestation	10	15	20	10	15	20
1 pair	1.25^{ab}	1.75^{c}	2.00^{b}	0.00^{a}	0.25^{b}	2.00^{c}
2 pairs	3.00^{a}	3.75^{b}	4.00^{b}	0.75^{a}	2.00^{a}	3.75^{b}
3 pairs	2.75^{a}	5.00^{a}	5.80^{a}	1.25^{a}	2.50^{a}	5.00^{a}
No insect	0.00^{b}	0.00^{d}	0.00^{b}	0.00^{a}	0.00^{b}	0.00^{d}
SE±	1.44	0.38	2.39	0.48	0.49	0.12

Values with the same superscript in the same column are not significantly different at 5% level of probability Least Significant Difference (LSD) SE = Standard error DAI = Days after infestation

Table 2 shows the effects of levels of infestation of *C. maculatus* and *S. zeamais* on their egg-laying capacity in stored cowpea and maize. The mean numbers of eggs laid by *C. maculatus* in cowpea seeds infested with 1, 2 and 3 pairs of the insect were 25.75, 51.00 and 61.25 eggs respectively. There were however, significant differences ($P<0.05$) between the mean numbers of eggs laid by the female beetles. Similarly, significant differences occurred between the mean numbers of eggs laid by *S. zeamais* in maize. The mean numbers of eggs laid by *S. zeamais* in maize seeds infested with 1, 2 and 3 pairs of the insect were 57.75, 119.25 and 165.50 eggs respectively. The level of infestation determined the population of immature stages and adults. The mean number of eggs laid by *C. maculatus* in cowpea and *S. zeamais* in maize was significantly ($P<0.05$) higher in the levels of infestation compared to the uninfested control (Table 2).

Table 2. Effects of levels of infestation of *Callosobruchus maculatus* and *Sitophilus zeamais* on their egg-laying capacity in stored cowpea and maize

Initial level of infestation	Mean No. Eggs laid by *C. maculatus* on cowpea	Mean No. Eggs laid by *S. zeamais* on maize
1 pair of insects	25.75^{c}	57.75^{c}
2pairs of insects	51.00^{b}	119.25^{b}
3 pairs of insects	61.25^{a}	165.5^{a}
No insect	0.00^{d}	0.00^{d}
SE±	0.56	12.08

Values with the same superscript in the same column are not significantly different at 5% level of probability Least Significant Difference (LSD) SE = Standard error DAI = Days after infestation

Table 3 shows the effects of levels of infestation of *C. maculatus* on the first and second filial progeny emergence in stored cowpea. The number of beetles that emerged on 3 pairs of *C. maculatus* infestation was significantly higher ($P<0.05$) compared to the number recorded on lower levels of infestation at 25 DAI. However, the number of beetles that emerged on 2 pairs of infestation was significantly higher compared to the number counted on 1 and 3 pairs of infestation at 26 and 27 DAI. The number of *C. maculatus* adult progeny emergence was significantly lower at 1 pair of insect infestation (14.25) and higher at 2 pairs of insect infestation (31.50) compared to the non-infested control at 27 DAI. On the second filial generation, the number of *C. maculatus* that emerged on 3 pairs of insect infestation was significantly higher ($P<0.05$) compared to the number on 1 and 2 pairs of infestation and the non-infested seeds (control). The emergence of *C. maculatus* on the non-infested seeds may be due to cross infestation or inherent qualities of the seeds, e.g., loss of vigour. The highest number of insects was recorded on 3 pairs of insect infestation. Highest level of infestation produced highest number of progeny (30.00) compared to lowest level of infestation (11.75) at 52 DAI. Table 4 shows the effects of levels of infestation of *S. zeamais* on F_1 and F_2 progeny emergence in stored maize seeds. The numbers of *S. zeamais* that emerged at the three levels of infestation were significantly different compared to the control at 25, 26 and 27 DAI. There was no visual detection of infestation in the non-infested seeds. Results showed that the adult weevil emergence increases with increasing levels of infestation.

Similarly, the second filial generation F_2 showed significant differences between the levels of infestation at 50, 51 and 52 DAI. At the 52 DAI, number of adult progeny was lowest in 1 pair of infestation (12.25) and highest in 3 pairs of infestation (24.75), the differences were significant at P<0.05. The rate of infestation in the uninfested maize seeds was lower cowpared to the cowpea seeds. Significantly higher number of F_1 and F_2 adult progeny emerged at the levels of infestation compared to the control treatment (Tables 3 & 4). Percentages of cowpea and maize seed weight losses are presented in Table 5. Percentage cowpea seed weight loss was significantly higher (P<0.05) in the 3 pairs of infestation compared to lower levels of infestation. There was significantly lower (P<0.05) percentage seed weight loss in the lowest level of infestation than higher level of infestation. After completing the F_2 progeny emergence, percentage cowpea seed weight loss ranged from 34.3 to 48.2% while 33.9 to 45.6% was recorded for maize (Table 5).

Table 3. Effects of levels of infestation of *Callosobruchus maculatus* on progeny emergence in stored cowpea

	F_1 progeny emergence			F_2 progeny emergence		
Infestation	25 DAI	26 DAI	27 DAI	50 DAI	51 DAI	52 DAI
1 pair	3.50^c	11.75^b	14.25^c	6.25^c	9.00^c	11.75^c
2 pairs	5.00^b	26.50^a	31.50^a	8.75^b	13.25^b	17.75^b
3 pairs	9.00^a	11.75^b	20.75^b	14.75^a	23.5^a	30.00^a
No insect	0.00^d	0.00^c	0.00^d	0.75^d	1.25^d	2.25^d
SE±	1.06	5.72	3.62	0.68	0.60	1.16

Values with the same superscript in the same column are not significantly different at 5% level of probability Least Significant Difference (LSD) SE = Standard error DAI = Days after infestation

Table 4. Effects of levels of infestation of *Sitophilus zeamais* on progeny emergence in stored maize

	F_1 progeny emergence			F_2 progeny emergence		
Infestation	25 DAI	26DAI	27 DAI	50 DAI	51 DAI	52 DAI
1 pair	2.25^b	3.75^c	3.75^c	6.75^c	9.00^c	12.25^c
2 pairs	3.50^b	6.25^b	7.50^b	9.00^b	12.00^b	16.25^b
3 pairs	7.00^a	10.75^a	13.25^a	14.00^a	19.50^c	24.75^a
No insect	0.00^c	0.00^d	0.00^d	0.75^d	1.00^d	1.25^d
SE±	0.91	0.71	0.78	0.63	0.84	1.34

Values with the same superscript in the same column are not significantly different at 5% level of probability Least Significant Difference (LSD) SE = Standard error DAI = Days after infestation

Seeds of cowpea and maize infested with 3 pairs of beetles or weevils suffered significantly more weight loss compared to those at the 1 and 2 pairs of insect infestation. However, 1 and 2 pairs of insects showed no significant differences (Table 5) in the percentage weight loss of cowpea and maize after 3 months storage period. In all, percentage weight losses increased with increasing levels of infestation. Insects therefore, constitute a major cause of food scarcity and shortage in areas plagued by the insect pests.

Table 5. Initial infestation of *Callosobruchus maculatus* and *Sitophilus zeamais* on percentage weight loss of cowpea and maize after three-month storage period

Level of insect infestation	% Wt. loss of cowpea by *C. Maculates*	% Wt. loss of maize by *S. Zeamais*
1 pair of insects	34.33^b	33.87^b
2 pairs of insects	34.48^b	35.38^b
3 pairs of insects	48.25^a	45.60^a
No insect	22.50^c	14.98^c
SE±	3.73	1.83

Values with the same superscript in the same column are not significantly different at 5% level of probability Least Significant Difference (LSD) SE = Standard error

DISCUSSION

Peasant farmers predominantly store their staple food (cowpea and maize seeds) in traditional granaries and bags, with a mean storage duration of 5 months. The study showed that the different levels of infestation of cowpea and maize significantly favoured development of beetles and weevils respectively. The nutritional values of the food crops could have been responsible for their easy attack by the insects. The results have shown that *C. maculatus* produced significantly higher number of adult progeny than *S. zeamais* at F_1 and F_2 generations under the prevailing environmental conditions. Also, *C. maculatus* caused more damage and greater losses of infested cowpea than *S. zeamais* on infested maize. This feature was ascribed to a higher pest status on *C. maculatus* (Maina and Lale, 2004), but both *C. maculatus* and *S. zeamais* produced large numbers of eggs and have shorter developmental period. Competition for egg-laying site by the female and the mating ability of the male could be responsible for the number of eggs laid by *C. maculatu*s and *S. zeamais* adults under heavy infestation. Akinneye and Ashamo [1] attributed the egg-laying capacity of *Ephestia cautella* to nutritional composition of the diets and the vigour of individual female. These levels of infestation are known to expand rapidly and this leads to significant losses under the very conducive environment in the store [10]. The findings reported here on the grain loss in maize and cowpea agrees with the earlier study [6]. The results further indicates that exposing cowpea and maize to infestation offered a means of insect multiplication as the seeds had a number of eggs laid on them, higher number of adult emergence, suffered more seed weight loss compared to those protected against initial infestation.

It was found that different levels of infestation were associated with high insect pressure. Initial infestation encourages rapid loss of nutritional and aesthetic values of the edible seeds. This finding agrees with the previous report that considerable physical and nutritional losses are due to infestation of stored products by weevils, bruchids and other insects [5]. The seeds were observed to have been subjected to heavy infestation causing excessive powdery mass and large holes of the cowpea seeds rendering it completely damaged by the bruchids. Initial infestation of the grains significantly increased the rate of progeny emergence and consequently caused substantial percentage seed weight loss. This result suggests that stored-infested seeds are likely to suffer higher losses if left uncontrolled as shown after the F_2 progeny emergence. The findings in the current study suggest that appropriate storage devices are necessary to distort the population dynamics of these insects on stored seeds in Nigeria. [15].The results from this storage investigation are of practical consequence for poor resource farmers, who often leave their farm products exposed to infestation. Therefore, this study reaffirms the significance of protective storage facilities against insect pests.

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