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The Response of Cowpea Bruchid, *Callosobruchus Maculatus* (Coleoptera: Bruchidae) to Some Cowpea Varieties Under Short- and Long-Term Storage Conditions

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Abstract

Callosobruchus maculatus is causing a considerable loss in stored cowpea in sub-Saharan Africa. The pest responds differently to different cowpea varieties; therefore, understanding the response of the cowpea bruchid to different cowpea varieties will help design better pest management practices during storage. SAMPEA-20T is a newly released cowpea variety resistant to cowpea pod borer. The response of C. maculatus to SAMPEA-20T has not been studied under storage conditions. A study was conducted to evaluate the response of C. maculatus to two improved cowpea varieties; SAMPEA-20T and SAMPEA-10, along with other local accessions; Kanannado and Ife-brown under short- and long-term storage. A hundred grams of each of the four varieties of cowpea Kilner jar were infested with 5 pairs of 1-2 days old adults C. maculatus. The experiment was laid out in a Completely Randomized Design (CRD) with three (3) repetitions. Observations were made on adult mortality, progeny emergence, percentage grain damage, and weight loss in short-term (30 days) and long-term (120 days) storage. The result indicated that SAMPEA-10 recorded significantly the highest adult mortality followed by SAMPEA-20T, Kanannado, and Ife-brown, on which no mortality was recorded. Progeny emergence at short and long-term storage was significantly higher in Ife-brown followed by Kanannado, SAMPEA-20T and SAMPEA-10 which had the least number of adult emergence at both short and long-term storage. There was a significantly higher percentage of grain weight loss and damage at long-term storage for Ife brown, than Kanannado, SAMPEA-20T and then SAMPEA-10 with the least. SAMPEA-20T significantly had the highest germination percentage than Kanannado which was statistically similar to SAMPEA-10 but significantly higher than that recorded for Ife-Brown. This study has shown that all varieties were susceptible to C. maculatus infestation, but SAMPEA-20T and SAMPEA-10 had a lesser infestation than Kanannado and Ife-brown.

Keywords: SAMPEA-20T, *Callosobruchus maculatus*, Infestation, Damage, Response

Introduction

Cowpea *Vigna unguiculata* (L) Walp is an important leguminous crop that is consumed worldwide. More than 4 million tons of all types of cowpeas are consumed worldwide, with more than 387,000 tons consumed in Africa (IITA, 2013). Nigeria is the largest producer and consumer of cowpea in the world, accounting for 61% of the production in Africa and 58% worldwide (IITA, 2015). More than 52% of African cowpea production is used for food, 13% as animal feed, 10% for seeds, 9% for other uses and 16% is wasted (FAO, 2002; Adaji *et al*., 2007; Egho 2009).

Cowpea is a highly nutritious crop that has high protein content (25%) and several vitamins and minerals (Moura *et al.,* 2014). All parts of the plant are nutritious and thus used as food for humans and animals (Islam *et al*., 2006). The immature pods are consumed as vegetables, while several snacks and main dishes are prepared from grains (Duke, 1981; Bittenbender *et al*., 1984). In Africa, cowpea plays a critical role in the lives of millions of people, where it serves as a major source of dietary protein that nutritionally complements low-protein staple cereals and tubers (Ddungu *et al.,* 2015). It is a valuable and reliable commodity that produces income for farmers and traders (Singh, 2002; Langyintuo *et al*., 2003), especially if well stored for sale during the off-season when a premium price is offered.

Cowpea storage is an important value chain in cowpea production that ensures its availability to consumers during the off-season. However, cowpea bruchid, *Callosobruchus maculatus* (Coleoptera: Bruchidae) is one of the major constraints of cowpea during storage (Jackai and Adalla,1997; Boeke *et al*., 2004), especially for long-time storage. *Callosobruchus maculatus* accounts for over 70% of cowpea grain loss during storage (Baoua *et al*., 2012). A single adult female can reproduce itself twenty-fold or more within 3-4 months of storage causing serious grain damage (Edvardsson and Tregenza, 2005) which can result in a loss of grain weight and seed viability (Baoua *et al*., 2012), loss of grain nutrients (Oke and Akintunde, 2013) and market value. The rate of pest attack and multiplication depends on the cowpea variety (Lale and Kolo, 1998; Maina *et al*., 2006; Pessu and Umeozor 2004), storage structure and control strategy used (Baoua *et al*., 2012; Bakoye, 2020), and environmental factors. Amusa *et al.* (2013); Ojumoola & Adesiyun (2014) reported that some varieties are more susceptible to the *C. maculatus* attack than others.

The cowpea (SAMPEA-20T) is a new variety recently developed and released for cultivation in Nigeria. After harvest, excess cowpea produced by farmers is usually stored to meet other future socioeconomic needs. The duration within which cowpea is stored depends on the farmer and his immediate socio-economic needs. However, *C. maculatus* infestation usually starts from the field and continues to storage with a manifestation of severe damage and loss of grain weight within 3-4 months of storage (Edvardsson *et al*., 2005). The response of *C. maculatus* to SAMPEA-20T is not known. Information on the response of *C. maculatus* to SAMPEA-20T will be very useful in designing a good storage management practice for this variety. Therefore, this article reports the response of *C. maculatus* to SAMPEA-20T and other varieties of cowpea (SAMPEA-10, Ife-brown and Kanannado) in short-term (30 days) and long-term (120 days) storage under laboratory conditions.

Materials and Methods

Experimental site

The experiment was carried out in the Legume Seed Entomology Laboratory in the Department of Crop Protection, Institute for Agricultural Research (IAR)/Faculty of Agriculture, Ahmadu Bello University, Samaru Zaria under laboratory conditions of 27^0C -30^0C and 50-70% relative humidity (RH).

Cowpea variety used

Four different varieties of cowpea; SAMPEA-10 (improved), Kanannado and Ife-Brown (local) and SAMPEA-20T (new improved variety). All varieties were

obtained from the IAR cowpea breeding unit, Department of Plant Science. The detailed characteristics of each variety are indicated in Table 1.

Table 1 Cowpea varieties used and their characteristics

Cowpea Variety	Seed Characteristics
SAMPEA-10	• Resistant to Striga and bacterial blight • Small seed size • White-seeded coat with a black eye • Medium maturing (70-80 days)
SAMPEA-20-T	• Transgenic and resistant to pod borer insect • Small seed size • White-seeded coat with a black eye • Medium maturing (70-80 days)
Kanannado	• Late maturity photosensitive type • Large seeds • Wrinkle seeds • Kidney shaped • White seed coat • Susceptible to several diseases and insect pests. • Tolerant to *C. maculatus*
Ife-Brown	• Brown seeds • Large seeds • Rhomboid shaped • Wrinkled • Susceptible to *C. maculatus*

Source: Onyibe *et al.* (2006); Henshaw (2008): (Ojumoola and Adesiyun 2014). Ishiyaku *et al*. (2019)

Source of insect and establishment of a colony

Callosobruchus maculatus were subcultured from a colony kept at the Storage Seed Entomology Laboratory, Department of Crop Protection, Faculty of Agriculture, Ahmadu Bello University, Zaria. Fifty unsexed adults of *C. maculatus* were sieved into two different 500ml Kilner jars each containing 100g of clean cowpea grain to mate and oviposit. The jars were left to stand on a laboratory bench at temperatures ranging from 27-30^{0}C and relative humidity of 50-70% until the adults emerged. At the period of 21 to 30 days, 1-2 days freshly emerged adult beetles of *C. maculatus* were sieved out and used for the experiment.

Evaluation of responses of *C. maculatus* to different cowpea varieties

The four different varieties of cowpea mentioned in Table 1 above were sorted for damage and the cleaned grains were disinfected with aluminium phosphide for 48 hours in an airtight Kilner jar. The cleaned grains were exposed on top of a laboratory bench to air dry for another 48 hours to remove any residue of the chemical before the start of the experiment. 100 grams of each cowpea variety were weighed into a 500 ml Kilner jar and 5 pairs of newly emerged adult bruchid (5 males and 5 females) were introduced into each Kilner jar and covered with a cheesecloth. The experiment was laid out in a completely randomized design with three repetitions. The mortality record was taken daily for seven days after infestation (DAI), after which all remaining parent adults were discarded. At 30 DAI; hereafter referred to as short-term storage, the emergence of progeny (adult population) was counted for both live and dead adults. The grain in each treatment was separated into damage (showing a visible exit hole on the grain surface) and clean grain (No exit

hole on the grain surface). Damage and undamaged parameters were used to determine the percentage of weight loss and grain damage using the formula below.

$$Weight\ loss\ of\ grains(\%) = \frac{(WUxNU)-(WD-ND)}{WUxNDxNU} x100$$ (Adams and Schulten, 1978)

ND = Number of damaged grains
WD = weight of damaged grains
NU = number of undamaged grains
WU = Weight of undamaged grains

The percentage of grain damage was calculated using the formula;

$$Grainsdamage\ (\%) = \frac{Number\ damaged\ in\ the\ treatment}{Total\ number\ of\ grains\ in\ the\ treatment} x100$$

The experiment was further kept for another 120DAI; hereafter refers to as long-term storage, after which, the progeny emergence, percentage grain damage and grain weight loss were calculated as indicated above. Furthermore, the viability of the grain was determined using a germination test. Twenty seeds were randomly selected from each Kilner jar and placed in a Petri dish (100mm x 15mm) lined with filter papers and pre-wet with distilled water. The filter paper was wetted with distilled water every day for up to 7 days. The number of germinated seeds was recorded for seven days and the germination percentage was calculated using the formula;

$$\text{Germination } (\%) = \frac{No.\ of\ grains\ germinated}{The\ total\ number\ of\ grains\ tested\ in\ each\ Petri\ dish} x100$$

The data collected were subjected to analysis of variance (ANOVA) using SAS and the means were separated and compared according to the least significant difference (LSD) at a probability level.

Results

The result in Fig.1 shows the mortality rate of adult *C. maculatus* on four cowpea varieties seven days after infestation. SAMPEA-10 significantly ($p<0.05$) had the highest percentage mortality of adult *C. maculatus*, followed by SAMPEA-20T, Kanannado, and Ife-brown. The mortality rate of the adult *C. maculatus* in SAMPEA-20T was significantly ($p<0.05$) higher than in Kanannado and Ife-brown. There was no significant difference in adult mortality between Kanannado and Ife-brown.

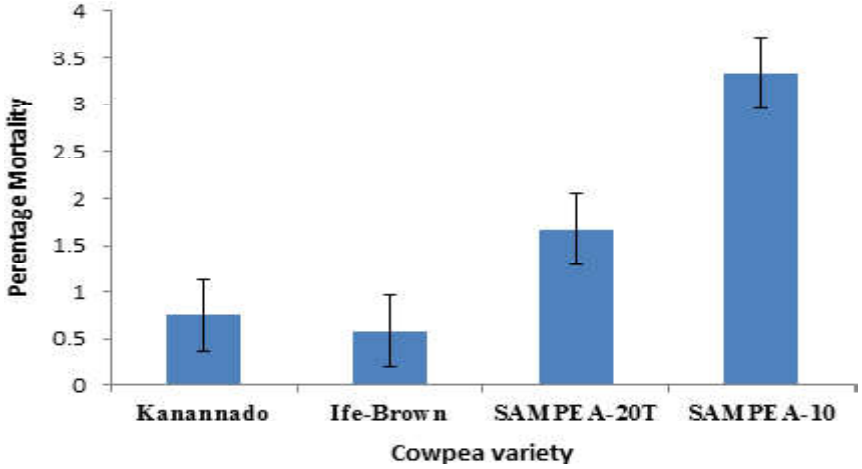

Fig. 1.Mean Percentage Mortality of adult *C. maculatus* on cowpea varieties.

Means with the same letter within the same bar are not significantly different at the probability level using the least significant difference (LSD).

The result in Table 2 shows the emergence of the F_1 progeny of *C. maculatus*, grain damage, grain weight loss, and seed germination of four cowpea varieties in short-term storage. The result shows that Ife-Brown had the highest number of F_1 progeny, percentage of grain damage, and weight loss which was significantly ($p<0.05$) different from all the varieties. The number of F_1 progeny that emerged in Kanannado was significantly ($p<0.05$) higher than in SAMPEA-10 and SAMPEA-20T. The F_1 progeny that emerged in SAMPEA-10 and SAMPEA-20T were statistically similar. The percentage of damaged grain in Kanannado was significantly ($p<0.05$) higher than in SAMPEA-10 and SAMPEA-20T. SAMPEA-10 had significantly ($p<0.05$) the least percentage of grain damaged by *C. maculatus.* The percentage of grain weight loss in Kanannado and SAMPEA-20T was similar but significantly higher than in SAMPEA-10. The percentage of seed germination in Kanannado, SAMPEA-10 and SAMPEA-20T were similar but significantly ($p<0.05$) higher than in Ife-Brown.

Table 2 Mean Percentage of F1 progeny emergence, grain weight loss, and grain damage by *C. maculatus* on cowpea varieties in short-term storage (30 DAI)

Variety	Adult Emergence	% Grain damage	% Grain Weight Loss	% Seeds Germination
Kanannado	28[b]	19.0[b]	8.20[b]	84.00[a]
Ife-Brown	43[a]	33.58[a]	12.22[a]	75.00[b]
SAMPEA-20T	20[c]	9.17[c]	7.45[b]	90.00[a]
SAMPEA-10	16[c]	4.0[d]	4.01[c]	85.00[a]
SE±	2.34	1.31	0.19	3.7

Means with the same letter within the same column are not significantly different at a 5% probability level using the least significant difference (LSD).

The result in Table 3 shows the number of *C. maculatus* progeny that emerged, grain damage, weight loss, and seed germination of the four cowpea varieties in long-term storage. The result shows that there was a significantly ($p<0.05$) higher number of progeny that emerged, damaged grain, and loss of grain weight in Ife-Brown than in all other varieties. The number of progeny that emerged in Kanannado, SAMPEA-20T, and SAMPEA-10 was similar. The percentage of grain damaged by *C. maculatus* in Kanannado was significantly ($p<0.05$) higher than in SAMPEA-20T and then SAMPEA -10 which were similar. Kanannado had grain weight loss significantly ($p<0.05$) higher than SAMPEA-20T and SAMPEA-10. The seed germination percentage in SAMPEA-20T and SAMPEA-10 were statistically similar but significantly higher than in the Kanannado and Ife-Brown. Ife-Brown significantly had the least seed germination percentage.

Table 3 Mean Percentage of grain weight loss, grain damage and seed germination as affected by *C. maculatus* on cowpea varieties in long-term storage (120DAI)

Variety	Adult Emergence	% Grain Damage	% Grain Weight Loss	% Seeds Germination
Kanannado	198[b]	56.06[b]	25.20[b]	60.00[b]
Ife-Brown	312[a]	86.22[a]	38.11[a]	40.00[b]
SAMPEA-20T	217[b]	45.15[c]	19.05[d]	75.00[a]
SAMPEA-10	174[b]	41.01[c]	26.30[c]	76.00[a]
SE±	24.3	2.75	2.78	4.12

Means with the same letter within the same column are not significantly different at a 5% probability level using the least significant difference (LSD)

Discussion

This study evaluated the response of *C. maculatus* to SAMPEA-20T together with SAMPEA-10, Kanannado, and Ife-brown. It was found that the mortality rate of *C. maculatus* was higher in SAMPEA-10 followed by SAMPEA-20T and then Kanannado and Ife-brown in this order. The significant differences in the mortality rate of parent adults in SAMPEA-20T and SAMPEA-10 compared to Kanannado and Ife brown may be due roughness and small to medium size of the SAMPEA-10 and SAMPEA-20T seeds compared to other seeds. Messina and Renwick (1985) reported that physical characteristics of seeds such as seed size can determine the acceptability of adult *C. maculatus* for oviposition. Similarly, Nwanze *et al.* (1975) showed that rough seeds were less acceptable to *C. maculatus* than smooth seeds. Furthermore, Murdock *et al.* (1997) indicated that *C. maculatus* responds less to rough-seeded cowpea varieties than to smooth and glossy seed coat verities.

Interestingly, the number of progeny that emerged, the percentage of grain damage and weight loss followed a similar pattern of SAMPEA-10 and SAMPEA-20T the least, followed by Kanannado and then Ife-brown in significant decreasing order in both short- and long-term storage, except for progeny that emerged for SAMPEA-20T in long-term storage (120days). Our findings are in agreement with the report of Oke and Olajide (2012) that cowpea varieties differ in their response to *C. maculatus* infestation. The difference in the response of *C. maculatus* to different varieties may be due to differences in some bioactive compounds in them (Torres, 2016). For instance, Southgate (1979); Gatehouse and Boutler, (1983) reported that the lipids, alkaloid, carbohydrate and amino acids composition of legume seeds confer resistance to weevil attack. Similarly, variability in cowpea grain characteristics such as seed size, testa thickness, and hardness has been found to influence the response of *C. maculatus* to cowpea attack (Lephale *et al.*, 2012). SAMPEA-10 and SAMPEA-20T are small to medium-seeded cowpeas, while Ife brown and Kanannado are large-seeded; thus, this may contribute to the low response of *C. maculatus* to SAMPEA-10 and SAMPEA-20T compared to Ife brown and Kanannado. Moreover, Dongre *et al.* (1996); Somta *et al.* (2006) reported that presence of some substances such as lipids, alkaloids, carbohydrates, amino acids, and other antinutritional factors in seeds can interfere with insect physiological processes as a result may prolong metamorphosis and consequently many parents died while only a few larvae survived to adulthood. It may be possible that SAMPEA-10 and SAMPEA-20T have some of these nutrients more than the other varieties, however, more research may be needed on the nutrient composition of these varieties and their effect on the development of *C. maculatus.*

The percentage of seed germination was observed to be higher (90%) in SAMPEA-20T and SAMPEA-10 (85%) in the short-term storage, although there was a significant reduction in germination 75% and 76% in SAMPEA-20T and SAMPEA-10 respectively in long-term storage. The reduction in the percentage of germination of SAMPEA-20T and SAMPEA-10 in long-term storage may be due to the high number of adults that result in increased seed damage. Melo *et al.* (2010); Mofunanya and Namg (2016) reported an inverse relationship between level of *C. maculatus* damage on seed and percentage of the seed germination.

Conclusions

This study indicated that all the varieties (SAMPEA-20T, SAMPEA-10, Kanannado and Ife-brown) were attacked by *C. maculatus* during both short and long-term storage, thus are all susceptible to *C. maculatus* attack, however, SAMPEA-20T and SAMPEA-10 were the least affected, thus SAMPEA-20T and SAMPEA-10 may be IPM compatible component. SAMPEA-20T and SAMPEA-10 will be suitable varieties to be stored where the cost of procuring storage chemicals is difficult. More research may be needed to understand the seed physical characteristics and bioactive compounds of SAMPEA-20T and

their influence on the development of *C. maculatus*.

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