Varietal Susceptibility Of Cowpea (*Vigna Unguiculata* L.) To The Storage Beetle, *Callosobruchus Maculatus* F. (Coleoptera: Bruchidae)

Badii, K. B. Asante, S. K. and Sowley E. N. K.

Abstract: - Twenty-two cowpea genotypes, comprising eighteen elite lines from the CSIR-Savanna Agricultural Research Institute, and three improved cultivars from the International Institute of Tropical Agriculture were evaluated for their susceptibility to infestation and damage by the storage beetle, *Callosobruchus maculatus* F. The assessment of their relative susceptibilities was based on oviposition, mean developmental period, adult emergence, seed weight loss and growth index. The results showed that the number of eggs laid on the seeds was significantly different among the genotypes. More eggs were laid on seeds of SARC 3-122-2, Marfo-Tuya and SARC 1-119-2, while SARC 1-132-1, SARC 1-91-1 and SARC1-13-2 recorded the least egg load. The mean development period was also significantly higher on SARC 3-122-2, SARC 4-75 and Marfo-Tuya (21.1-21.5 days), and lower on SARC 1-57-2, SARC 1-136-2 and Apabgaala (18.4-18.9 days). A significantly higher number of adults emerged from SARC 1-34-2, SARC 1-136-2 and Apabgaala, while SARC 1-132-1, SARC 3-103-1 and SARC 1-119-2 recorded the least. Moreover, Apabgaala, SARC 1-36-1 and Marfo-Tuya recorded the highest percentage weight loss (24.0-29.4%) while SARC 1-132-1, SARC 3-90-2 and SARC 3-103-1 recorded the least (4.3-9.6%). Overall, SARC 1-132-1, SARC 3-90-2, SARC 1-91-1, SARC 1-13-2 and SARC 3-103-1 consistently demonstrated high tolerance to to infestation by *C. maculatus* and therefore, should be promoted or incorporated into further breeding programmes to help minimize the high grain losses incurred by farmers during storage.

Index Terms: - Cowpea genotypes, *Callosobruchus maculatus*, infestation, susceptibility.

INTRODUCTION

Cowpea, *Vigna unguiculata* (L.) Walpers, is one of the most important grain legumes widely cultivated in the tropics as food, feed and for soil fertility enrichment (Singh and van Emden, 1979; Jackai and Daoust, 1986). Cowpea provides more than half of the plant protein consumed by many poor people in Africa, and is a source of income (Rachie 1985). A major constraint to the sustainable production and postharvest preservation of cowpea in the tropics is infestation by the storage bruchid, *Callosobruchus maculatus* (F.), a cosmopolitan and most destructive pest of stored pulse grains which causes severe economic losses to farmers and traders (Prevett, 1961; Southgate, 1979; Caswell, 1981). This pest is capable of rendering unprotected grains unsuitable for food or seed within 2-4 months of storage (Seck *et al*., 1991; Wolfson *et al*., 1991). The control of this pest is crucial to the increased and sustainable production of cowpea in tropical Africa. While there are several synthetic insecticides such as chemical grain protectants and fumigants for the control of *C. maculatus* in cowpea, their use has not been sustainable owing to their high costs, unavailability in local markets and associated health and environmental risks (Egwuatu, 1987; Wolfson *et al*., 1991).

- Badii, K. B. & Sowley, E. N. K.: Lecturers, Department of Agronomy, University for Development Studies, P. O. Box TL 1882, Tamale, N/R, Ghana. E-mail: benbadii@yahoo.com; esowley@gmail.com
- Asante, S. K.: Research Scientist, CSIR-Savanna Agricultural Research Institute, P. O. Box TL 52, Tamale, N/R, Ghana. E-mail: skasante@yahoo.com

In order to reduce both over-dependence on chemicals for control, and seed loss due to bruchid attack, the search for host plant resistance in cowpea seeds has increasingly become the option of choice in recent years. The development and use of resistant cowpea cultivars offer a simple, cheap and attractive way for the reduction of bruchid damage since it requires little knowledge by farmers, free of extra cost to farmers and also enhances the effectiveness of other pest management tactics such as cultural and biological control (Thomas and Waage, 1995). Hence, it is pertinent that a study of bruchid responses to improved cowpea cultivars intended to be released to farmers for cultivation be conducted periodically in different ecologies. The CSIR-Savanna Agricultural Research Institute (CSIR-SARI) has recently generated a number of improved cowpea genotypes from crosses between the adapted parents (Apagbaala, IT x P148-2 and Marfo-Tuya, sul 518-2) and the exotic line (viz., UCR01-15-52). These improved genotypes, known as Savanna Agricultural Research Cowpea (SARC), have been tested on-farm and four promising cultivars have been released to farmers. This study seeks to evaluate the susceptibility of these genotypes or cultivars to infestation and damage by *C. maculatus* with the aim to selecting those with inherent resistance for inclusion in breeding programmes.

MATERIALS AND METHODS

Source of cowpea genotypes

Seeds of twenty-two (22) cowpea genoypes were used for the study at the Entomology Laboratory of the Savanna Agricultural Research Institute (SARI), Nyankpala, Ghana, between November and December 2011. The genotypes were SARC 1-57-2, IT98K-506-1, Apabgaala (IT x P148-2), SARC 1-136-2, SARC 3-74A-2, SARC 3-90-2, SARC 1-91-2, SARC 1-71-2, SARC 1-132-1, SARC 3-154-1, SARC 1-94A-2, SARC 1-119-2, SARC 1-34-2, SARC 1-13-2, Marfo-Tuya (Sul 518-2),

SARC 3-122-2, SARC 4-75, SARC 1-36-1, IT95K-193-2, IT97K-499-35, SARC 3-103-1 and SARC-L02 (a local variety included as a check) (Table 1). The varieties were obtained from the breeding unit of the SARI in Nyankpala, Ghana. The seeds were first cleaned and sorted out from all foreign materials. Prior to the experiment, the seeds were stored in the SARI cold room and maintained at 5 ºC, 70-100% RH for a period of 4 weeks to ensure that they were free from infestation by any post-harvest insect or pathogen. They were later conditioned to room temperature before being used for the experimental purposes.

Rearing of Experimental Insects

Experimental beetles were reared for both choice and no-choice experiments. Rearing of insects for the no-choice experiment followed the procedure described by Swella and Mushobozy (2007). The adults of *C*. *maculatus* were originally obtained from infested samples of cowpea seeds in a laboratory stock. They were reared and bred under diet of cowpea seeds inside a growth chamber at a temperature of 27 ± 2°C and 70 ± 5% RH. Initially, 50 pairs of newly emerged (1-24 hrs old) adults were placed in jars containing the various seeds. The jars were covered with perforated lids to allow for aeration, and a maximum of 3 days were allowed for mating and oviposition. The parent insects were removed afterwards and the seeds containing the eggs were transferred to fresh seeds in rearing jars which were covered with pieces of cloth, fastened with rubber bands to prevent the contamination of the seeds and escape of the beetles. The subsequent progenies emerging from the stock were then used as parental generation for the experiment. Experimental insects for the choice experiment were reared from the culture of insects for the no-choice experiment described above. One glass jar each of a capacity of 1 kg contained respective seeds of the cowpea genotypes. The aim was to precondition the bruchids so as to eliminate any short term changes in behavior associated with the change of host variety from that used for culturing to that being tested (Dobie 1974). The rearing procedure followed the method described by Swella and Mushobozy (2009).

Experimental Design and Procedure

The experimental procedure used for this study was based on Asante and Mensah (2007), Adam and Baidoo (2008) and Swella and Mushobozy (2009), with some modifications. For the no-choice experiment with seeds of the different cowpea genotypes, a completely randomized design (CRD) with four replications was used. For a choice experiment, seeds of the five landraces were mixed in all possible pairings, and each replicated four times. Two hundred (200) sound seeds of each cultivar were then placed in a glass jar after being weighed to determine their initial weight. Five pairs of the bruchids (24 hrs old) emerging from the insect culture were selected and introduced into each seed sample in the glass jar. The jars were then closed with perforated covers and kept in an incubator maintained at conditions described above. The insects were then allowed for 48 hours to mate and lay eggs after which they were removed from the jars. Observations were then made for a maximum of four weeks during which period the appropriate data were collected. The observations were terminated 27 days from the date of the first adult emergence after which the final weight of seeds in each treatment was determined.

Data Collection and Analysis

The variables that were determined from the experimental set up were: number of eggs laid, mean development period, adult emergence, seed weight loss and susceptibility index. The number of eggs laid on the seeds of each sample were counted separately by following the method described by Lambert *et al*. (1985), and recorded for each treatment 7 days after the infestation, by which time most eggs had hatched and the larvae had bored into the seeds, leaving behind the cream-coloured shells. The various treatments were then examined daily for adult emergence (i.e. proportions of adults that emerged from the number of eggs laid on the seeds, including hatched and unhatched) following the method of Asante and Mensah (2007). The emerged adults were removed from each sample with an aspirator and counted daily under illuminated magnifier. Mean development period was recorded as the time period taken for the insects to develop from egg to adult stages. Percentage weight loss (PWL) in seeds was estimated following the method given by Jackai and Asante (2003) as: $PWL = \frac{Initial\ seed\ weight - Final\ seed\ weight}{Initial\ seed\ weight} \times 100$. The index of susceptibility (Si) was calculated from the number of emerged weevils using the formula of Dobie (1977) as follows: $SI = \frac{Log\ FI}{D} \times 100$. Where, F_I = Total number of emergence adults, and D = Mean developmental period (days), estimated as the time from middle of oviposition to the emergence of 50% of the F_I generations. Using the one-way analysis of variance (ANOVA), the differences in susceptibility of the various treatments were determined based on the above parameters. All percentages and numerical data were square root and arcsine transformed before the analysis. Where ANOVA test indicated significant difference between the treatments, the least significant difference (LSD) test was used to separate the means.

Table 1: Description of test cowpea genotypes based on parentage or source.

Cowpea genotype	Description
Apagaala	Prima/Tvu4552/California Black eye
Marfo-Tuya	No. 5/7977 (Cultivar from SARI, Ghana)
IT97K-499-35*	Sumbrisogla/518-2 (Cultivar from SARI, Ghana)
IT98K-506-1	Breeding line from IITA, Nigeria
IT95K193-2*	Breeding line from IITA, Nigeria
SARC 1-119-2	Breeding line from IITA, Nigeria
SARC 1-12-2	Apagbaala x UCR 01-15-52
SARC 1-132-1	Apagbaala x UCR 01-15-52
SARC 1-136-2	Apagbaala x UCR 01-15-52
SARC 1-34-2	Apagbaala x UCR 01-15-52
SARC 1-36-1	Apagbaala x UCR 01-15-52
SARC 157-2	Apagbaala x UCR 01-15-52
SARC 1-71-2	Apagbaala x UCR 01-15-52
SARC 1-91-1	Apagbaala x UCR 01-15-52
SARC 1-94A-2	Apagbaala x UCR 01-15-52
SARC 3-103-1	Apagbaala x UCR 01-15-52
SARC 3-122-2*	Marfo-Tuya x UCR 01-15-52
SARC 3-154-1	Marfo-Tuya x UCR 01-15-52
SARC 3-74A-2	Marfo-Tuya x UCR 01-15-52
SARC 3-90-2	Marfo-Tuya x UCR 01-15-52
SARC 4-75*	Marfo-Tuya x UCR 01-15-52
SARC L02	Local variety

*SARC = Savanna Agricultural Research Cowpea; SARI = Savanna Agricultural Research Institute; IITA = International Institute of Tropical Agriculture; UCR = University of California, Riverside. * Genotypes (cultivars) released by CSIR-SARI in 2008.*

RESULTS

Oviposition and developmental period

The number of eggs laid on seeds of different cowpea genotypes by adult females of *C. maculatus* is presented in Table 2. The results showed that number of eggs laid on seeds were significantly different among the 22 genotypes. Significantly more eggs were laid on the seeds of SARC 3-122-1, Marfo-Tuya, SARC 1-119-2, SARC 4-75 and IT97K-499-35 whereas SARC 1-132-1, SARC 1-91-1, SARC 1-13-2, SARC 3-90-2 and SARC 1-57-2 recorded the least number of eggs laid. Similarly, the developmental period (days) of *C. maculatus* on seeds of the different genotypes showed a significant difference among them ($F = 28.0$, $df = 21, 66$, $P < 0.05$). SARC 3-122-2, recorded the highest number of days (21.5 days) while Apabgaala recorded the least (18.4 days). Also, SARC 4-75 and Marfo-Tuya recorded 21.4 days and 21.1days, respectively.

Adult Emergence

Emergence of adult *C. maculatus* from seeds of the different cowpea genotypes is presented in Table 3. Adult emergence was generally high among the genotypes, ranging from 47.3 to 92.8%. Significantly ($F = 2.36$, $df = 21, 66$, $P < 0.05$) more adults emerged from SARC 3-122-2, Marfo-Tuya, SARC 1-36-1, SARC 4-75 and IT97K-499-35, while SARC 1-132-1, SARC 1-91-1, SARC 1-13-2, SARC 3-90-2 and SARC 1-94A-2 recorded the least adult emergence, with the rest of the genotypes being in between. There were significant differences among the genotypes with respect percentage adult emergence ($F = 1.76$, $df = 21,66$, $P < 0.05$). The genotypes that recorded the highest percentage adult emergence included: SARC 1-34-2, SARC 1-136-2, SARC 1-57-2, Aabgaala, SARC-L02, and SARC 1-36-1, while those that recorded the least were SARC 1-132-1, SARC 3-103-1, SARC 1-119-2 and SARC 1-94A-2 (Table 3). The progenies from Apabgaala appeared to show extremely higher percentage adult emergence than those from Marfo-Tuya (Table 3). Percentage adult emergence was found to correlate positively with the growth or susceptibility index ($P < 0.01$, $r = 0.605$,) of *C. maculatus*.

Table 2: Oviposition and egg-adult developmental periods of *Callosobruchus maculatus* F. on seeds of different cowpea genotypes.

Cowpea genotype	Mean number of eggs laid on seeds, n = 40	Mean developmental period (days)
Apabgaala	41.5	18.4
SARC 1-136-2	36.5	18.8
SARC 1-57-2	35.5	18.9
SARC 1-94A-2	40.0	18.9
SARC 1-132-1	16.0	19.1
SARC 1-13-2	24.5	19.1
SARC 1-34-2	46.0	19.2
SARC 1-91-1	22.5	19.3
SARC 1-119-2	71.5	19.3
SARC 3-103-1	41.3	19.5
IT98K-506-1	39.5	19.5
SARC L02	41.8	19.6
SARC 1-71-2	63.8	19.8
SARC 3-154-1	44.5	19.9
IT95K-193-2*	53.3	19.9
SARC 1-36-1	43.5	19.9
SARC 3-74A-2	50.8	20.2
SARC 3-90-2	30.3	20.3
IT7K-499-35*	82.5	20.7
Marfo-Tuya	128.6	21.1
SARC 4-75*	69.8	21.4
SARC 3-122-2*	149.5	21.5
P-value	*< 0.05*	*< 0.01*
CV (%)	*31.0*	*9.2*
LSD (5%)	*64.8*	*0.49*

N = number of seeds sampled
** Genotypes (cultivars) released by CSIR-SARI in 2008.*

Table 3: The emergence of adults of *Callosobruchus maculatus* F. on seeds of different cowpea genotypes.

Cowpea genotypes	Mean number of adults emerged	Percentage adult emergence
SARC 1-132-1	8.3	47.3
SARC 3-103-1	23.5	60.8
SARC 1-119-2	46.3	65.9
SARC 1-94A-2	28.5	68.1
SARC 3-90-2	22.8	68.4
SARC 3-154-1	31.8	69.7
SARC 3-74A-2	40.0	72.5
IT97K-499-35*	54.0	74.7
SARC 3-122-2*	111.3	76.5
SARC 1-13-2	20.0	76.6
SARC 4-75*	59.0	77.7
SARC 1-71-2	41.5	78.0
Marfo Tuya	100.0	78.6
IT98K-506-1	33.5	79.5
IT95K-193-2*	41.3	79.7
SARC 1-91-1	18.3	81.5
SARC 1-36-1	90.0	84.4
Apagbaala	35.0	85.1
SARC 1-57-2	31.0	85.2
SARC -L02	37.0	87.1
SARC 1-136-2	32.3	87.4
SARC 1-34-2	40.0	92.8
P-vavue	*< 0.01*	*< 0.05*
CV (%)	*29.4*	*17.4*
LSD (5%)	*47.4*	*21.7*

** Genotypes (cultivars) released by CSIR-SARI in 2008.*

Seed weight loss

The losses in weight of cowpea seeds due to infestation by *C. maculatus* are presented in Table 4. Weight loss was found to be significantly different among the genoypes ($F = 1.87$, $df = 21, 66$, $p < 0.05$). Also, when seeds weight losses were converted into percentages, significant differences were observed among the genotypes ($F = 2.70$, $df = 21,66$, $p < 0.05$) with Apabgaala, SARC 1-36-11, SARC 1-119-2, Marfo-Tuya, having the highest percentage weight loss, whereas SARC 1-36-1, SARC 3-90-2, SARC 3-90-2, SARC 3-103-1 and SARC 1-13-2 recorded the least weight loss, with the rest of the genotypes in-between. Overall, seventeen (17) genotypes suffered more than 10 percent weight loss whilst four genotypes sustained less than 10 percent weight loss in seeds. Also, percentage weight loss was found to correlate positively with growth or susceptibility index ($P < 0.01$, $r = 0.839$).

Growth index

The growth index (GI) of the 22 genotypes ranged from 0.053 to 0.084 but there were no significant differences among them ($F = 1.04$, $df = 21, 66$, $P = 0.43$) (Table 5). Apabgaala recorded the highest GI value of 0.08, whereas SARC 1-132-1 recorded the least (0.053). Overall, SARC 1-132-1, SARC 3-90-2, and SARC 1-13-2, were found to be the least preferred, with GI ranging from 0.053 to 0.063. On the other hand, Apabgaala, SARC 1-119-2 SARC 3-122-2 and SARC 1-34-2 appeared to be the most preferred, with GI ranging from 0.079 to 0.084. Furthermore when the genotypes were ranked in order of their relative susceptibilities using parameters such as oviposition, adult emergence, seeds weight loss and growth index, SARC 3-103-2, SARC 1-13-2 and SARC 1-91-1 were still found to be the least preferred genotypes while SARC 1-119-2, Marfo-Tuya, SARC 1-34-2, SARC 3-122-2 and Apabgaala were the most preferred or susceptible genotypes to *C. maculatus* attack (Table 6).

Table 4: Weight loss in seeds of cowpea genotypes due to infestation by *Callosobruchus maculatus* F.

Cowpea genotypes	Seed weight loss (g)	Percentage weight loss
SARC 1-132-1	0.3	4.3
SARC 3-90-1	0.8	7.6
SARC 3-103-1	0.8	8.3
SARC 1-13-2	0.7	9.6
SARC 1-91-1	0.6	10.1
SARC 3-74A-2	1.1	11.0
SARC 1-94A-2	0.9	12.8
SARC 4-75*	1.3	13.0
SARC 3-154-1	1.2	14.9
SARC 1-34-2	1.2	15.8
SARC 1-136-2	1.1	17.4
IT97K-499-35*	1.1	17.5
IT98K-193-2*	0.9	18.4
SARC 1-71-2	1.4	18.9
SARC 1-57-2	1.4	19.0
SARC 3-122-2*	1.9	20.4
IT98K-506-1	1.3	20.7
SARC –L02	1.7	23.6
Marfo-Tuya	1.3	24.0
SARC 1-119-2	1.6	25.0
SARC 1-36-1	1.4	26.2
Apabgaala	1.4	29.4
P-value	*< 0.05*	*< 0.01*
CV (%)	*23.0*	*22.0*
LSD (5%)	*0.8*	*9.3*

* Genotypes (cultivars) released by CSIR-SARI in 2008.

Table 5: Suitability of seeds of different cowpea genotypes for growth of *Callosobruchus maculatus* F.

Cowpea genotypes	Growth index (GI)[1]
SARC 1-132-1	0.053
SARC 3-90-2	0.061
SARC 1-91-1	0.063
SARC 1-13-2	0.064
SARC 3-103-1	0.066
SARC 3-74A-2	0.067
IT98K-506-1	0.070
SARC 3-154-1	0.074
SARC 1-94A-2	0.075
SARC 1-36-1	0.074
Marfo-Tuya	0.076
SARC 4-75*	0.077
SARC 1-71-2	0.076
IT95K-193-2*	0.079
SARC-L02	0.077
IT97K-499-35*	0.077
SARC 1-57-2	0.078
SARC 1-136-2	0.079
SARC 1-34-2	0.079
SARC 3-122-2*	0.079
SARC 1-199-2	0.082
Apabgaala	0.084
P-value	*> 0.05, ns*
CV (%)	*20.5*

[1]Low GI values indicate tolerance or resistance whereas high GI values indicate susceptibility.
** Genotypes (cultivars) released by CSIR-SARI in 2008.*

Table 6: Ranking of the different cowpea genotypes in order of relative susceptibility to *Callosobruchus maculatus* F.

Cowpea genotypes	Mean No. of eggs laid	% adult emergence	% seed weight loss	Growth index	Total ranks	Mean ranks
SARC 1-132-1	1	1	1	1	4	1.0
SARC 3-90-2	4	5	2	2	13	3.3
SARC 3-103-2	9	2	3	5	19	4.8
SARC 1-13-2	3	10	4	4	21	5.3
SARC 1-91-1	2	16	5	3	26	6.5
SARC 1-94A-2	8	4	7	9	28	7.0
SARC 3-74-2	15	7	6	6	34	8.5
SARC 3-154-1	13	6	9	8	36	9.0
IT98K-506-1	7	14	17	7	45	11.3
SARC 4-75*	18	11	8	12	49	12.3
SARC 1-57-2	5	19	15	16	55	13.8
SARC 1-136-2	6	21	11	17	55	13.8
SARC 1-71-2	17	12	14	13	56	14.0
IT97K-499-35*	20	8	12	17	57	14.3
IT95K-193-2*	16	5	13	14	58	14.5
SARC 1-36-1	12	17	21	10	60	15.0
SARC 1-119-2	19	3	20	21	63	15.8
Marfo-Tuya	21	13	19	11	64	16.0
SARC -L02	11	20	18	15	64	16.0
SARC 1-34-2	14	22	10	19	65	16.3
SARC3-122-2*	22	9	16	20	67	17.8
Apabgaala	10	18	22	22	72	18.0

Infestation and damage: 1 = least susceptible/infested, 22 = most susceptible/infested
** Genotypes (cultivars) released by CSIR-SARI in 2008.*

DISCUSSION

The study has shown that some of the cowpea genotypes obtain from crosses between Apabaala (IT x P148-2), Marfo-Tuya (Sul 518-2) and UCRO 1-15-52 such as SARC 1- 132-1, SARC 3-90-2, SARC 1-91-1, SARC 1-13-2 and SARC 3-103-1 posses genes that confer some degree of resistance to *C. maculatus*. Significant differences among the genotypes were obtained for all the parameters used for the assessment, with the exception of the growth index. It has been reported that variables such as adult emergence, developmental period, weight loss and growth index are the most reliable indicators for resistance of cowpea to damage by *C. maculatus* (Redden and McGuire, 1983; Jackai and Asante, 2003). More eggs were deposited on the seeds of some moderately resistant genotypes such as Marfo-Tuya, SARC 4-75, SARC 1-71-2 and IT95K-193-2 than the most susceptible genotypes (Apabgaala) although adult emergence, seed weight loss and growth index were lower on these genotypes than that of Apabgaala. The suitability of cowpea seed type for oviposition by *C. maculatus* is influenced by surface area and curvature of the seeds (Avidov *et al*., 1965; Nwanze and Horber, 1976; Wasserman, 1981; Fitzner *et al*., 1985). Nwanze *et al*. (1975) reported that *C. maculatus* prefers smooth-coated and well-filled seeds to their rough and wrinkled counterparts for oviposition. Mbata (1992) also reported that the surface area of cowpea seeds varies among varieties, and number of eggs laid per seed is positively correlated with the surface area. Although the surface area and the smoothness of seed coat were not determined in the present study, these factors may well explain why eggs were not equally distributed among seeds of the different cowpea genotypes used. On the other hand, both adult emergence and seed weight loss were found to be highly correlated with susceptibility (growth) index. Percentage adult emergence also correlated positively with percentage seed weight loss. These observations confirm that of Mbata (1993) who reported that weight loss is generally highly correlated with susceptibility index. Singh *et al*. (1985) reported that the number of emerging adult determines the extent of damage, and consequently, seeds permitting more rapid and higher levels of adult emergence will be more extensively damaged. Beside factors such as the surface area, nature, coat texture and curvature of the seeds, previous studies have also revealed chemical factors (antibiosis) to be responsible for bruchid resistance in cowpea. Adjadi *et al*. (1995) conducted a detailed study on the genetics of bruchid resistance in cowpea and observed that two recessive genes (rcm1 rcm1 rcm2 rcm2) are required in the homozygous condition to confer resistance to bruchids. Gatehouse *et al*. (1979) found higher level of trypsin inhibitors (about 2 fold increases) in Tvu 2027 compared to the susceptible varieties of cowpea, and attributed bruchid resistance in cowpea to this factor. They also showed that trypsin inhibitors isolated from cowpea and mixed in ground cotyledons of a susceptible cowpea variety (Tvu 57) reduced the survival rate of bruchid eggs. Baker *et al*. (1989) analyzed trypsin inhibitors activity in resistance varieties in ten Tvu 2027 derived from a bruchid resistant breeding lines, and susceptible lines, and concluded that the trypsin inhibitors activity in resistant breeding lines was higher than in susceptible lines. Other studies have indicated that typsin alone may not account for bruchid resistance in cowpea. Osborn *et al*. (1988) identified arcelin, a major seed protein in wild *Phaseolus vulgaris L.* as the factor responsible for resistance to the bean bruchid, *Zabrotes subfasciatus* (Boheman). Similarly, para-aminophenylalanine in several wild *Vigna* species was shown to be toxic to *Z. subfasciatus* as well as to *C. maculatus* (Birch *et al*., 1986). Also Ishimoto and Kitamura (1988) showed that a water soluble substance present in kidney beans strongly inhibits the larval growth of *C. chinensis*. Therefore, further work is needed to elucidate the factor(s) responsible for the differences in the susceptibility of these twenty-two cowpea genotypes to *C. maculatus* infestation and damage.

CONCLUSION

The results of the present study have shown that among the cowpea genotypes, SARC 1-132-1, SARC 3-90-2, SARC 3-103-1, SARC 1-13-2 and SARC 1-91-1 have consistently demonstrated lower susceptibility to the infestation and damage by *C. maculatus* in most of the parameters evaluated**.** This might be due to physical characteristics such as surface area, smoothness and curvature, as well as chemical inhibitors such as trypsin, arcelin and aminophenylalanine, which may be present in the seeds. These genotypes may thus serve as promising alternatives for inclusion in the SARI breeding progammes for release to farmers to help minimize the rampant losses to stored cowpea in Ghana. However, further work is needed to elucidate the resistance-conferring factor(s) in these new genotypes.

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REFERENCES

[1]. Adjadi, O., Singh, B. B. and Singh, S. R. (1995). Inheritance of bruchid resistance in cowpea. *Crop Science* 25, 740-742.

[2]. Avidov, Z., Berlinger, M. J. and Applebaum, S. W. (1965). Physiological aspects of host specificity in the Bruchidae. III. Effect of curvature and surface area on oviposition of *Callosobruchus chinensis L*. *Animal Behaviour 13, 178-180.*

[3]. Baker, T. A., Nielson, S. S., Shade, R. E. and Singh, B. B. (1989). Physical and chemical attributes of cowpea lines resistant and susceptible to *Callosobruchus maculatus* (F.) (Coleoptera*:* Bruchidae). *Journal of Stored Products Research* 25, 1-8.

[4]. Birch, A. N. E., Fellows, L. E., Evans, S. V. and Doharty, K. (1986). Para-amino phenylalanine in *Vigna*: Posible taxonomic and ecological significance as a seed defense against bruchids. *Phytochemistry* 25, 2745-2749.

[5]. Caswell, G. H. (1981). Damage to stored cowpea in the Northern part of Nigeria. *Samaru Journal of Agricultural Research 1, 11-19.*

[6]. Dobie, P. (1974). Laboratory assessment of the inherent susceptibility of maize to post harvest infestation by *Sitophilus zeamais* Motsch. (Coleoptera: Curculionidae). *Journal of Stored*

Products Research 10: 183-197.

[7]. Egwuatu, R. I. (1987). Current status of conventional insecticides in the management of stored product pests in the tropics. *Insect Science and its Application 8, 695-701.*

[8]. Fitzner, M. S., Hagstrum, D. W., Knauft, D. A., Bhur, K. L. and Mclaughlin, J. R. (1985).Genotypic diversity in the suitability of cowpea (Rosales: Leguminosae) pods and seeds for cowpea weevils (Coleopteran: Bruchidae) oviposition and development. *Journal of Economic Entomology* 78, 806-810.

[9]. Gatehouse, A. M. R., Gatehouse, J. A., Dobie, P., Kilminster, A. M. and Boulter, D. (1979).

[10]. Biochemical basis of insect resistance in *Vigna unguiculata*. *Journal of Science, Food and Agriculture 30, 948-958.*

[11]. Hedin, P. A. (1983). *Plant Resistance to Insects*. ACS symposium series 208, American Chemical Society, Washington, D.C.

[12]. Howe, R. W. (1971). A parameter for expressing the suitability of environment for insect development. *Journal of Stored Products Research 7, 63*-65*.*

[13]. Ishismoto, M. and Kitamura, K. (1988). Identification of growth inhibitor on Azuki bean weevil in kidney bean (*Phaseolus vulgaris* L*.) Japan Journal of Breeding 38, 367-370.*

[14]. Jackai, L. E. N. and Daoust, R. A. (1986). Insect pests of cowpea. *Annual Review of Entomology 38, 95-119.*

[15]. Jackai, L. E. N. and Asante, S. K. (2003). A case for the standardization of protocols used in screening cowpea, *Vigna unguiculata* for resistance to *Callosobruchus maculatus* F. (Coleoptera: Bruchidae). *Journal of Stored Products Research 39,251-263.*

[16]. Mbata, G. N. (1993). Evaluation of susceptibility of varieties of cowpea to *Callosobruchus maculatus (F.)* and *Callosobruchus subinnotatus* (Pic.) (Coleoptera: Bruchidae). *Journal of Stored Products Research 22, 207-213.*

[17]. Mbata, G. N. (1992). Egg distribution on seeds by *Callosobruchus subinnotatus* (Pic.) (Coleoptera: Bruchidae). *Journal of Stored Products Research 28, 301-305.*

[18]. Nwanze, K. F. and Horber, E. (1976). Seed coats of cowpeas affect oviposition and larval development of *Callosobruchus maculatus. Environmental Entomology 5, 213-218.*

[19]. Nwanze, K. F., Horber, E., Pitts, C. W. P. (1975). Evidence of ovipositional preference of *Callosobruchus maculatus* for cowpea varieties. *Environmental Entomology. 4: 409-412.*

[20]. Osborn, T. C., Alexander, D. C., Sun, S. S. M., Cardona, C. and Bliss, F. A. (1988). Insecticidal activity and lectin homology of arcelin seed protein*. Science 240, 207-210.*

[21]. Prevett, P. F. (1961). Field infestation of cowpea (*Vigna unguiculata*) pods by beetles of the families Bruchidae and Curculionidea in northern Nigeria. *Bulletin of Entomological Research 52, 635-646.*

[22]. Rachie, K. O. (1985). Introduction. *In*: S.R.Singh and K.O.Rachie (Eds.) *Cowpea research, production and utilization* 21-28pp, Wiley, London, UK.

[23]. Redden, R. J. and McGuire, J. (1983). The genetic evaluation of bruchid resistance in seeds of cowpea. *Australian Journal of Agricultural Research 34, 707-715.*

[24]. Seck, D., Sidibe´ B., Haubruge, E., Hemptinne, J. L. and Gasper, C. (1991). La protection chimique des stock de niebe´ et de mais contre les insects au Senegal*. Mededelingen van de Faculteit Landbouwetensohappen Prijksuniversiteit Gent 56, 1225-1234.*

[25]. Singh, B. B. and van Emden, H. F. (1979). Insect pests of grain legumes. *Annual Review of Entomology 24,255-278*.

[26]. Singh, B. B., Singh, S. R. and Adjadi, O. (1985). Bruchid resistance in cowpea. *Crop Science 25, 736-739.*

[27]. Southgate, B. J. (1979). Biology of the Bruchidae. *Annual Review of Entomology 24, 449-473*.

[28]. Thomas, M. B. and Waage, J. K. (1995). Integration of biological control and host plant resistance breeding for control of insect pests. CTA-IAF. IIBC Seminar, 9-14 October 1995, Addis Ababa, Ethiopia.

[29]. Wasserman, S. S. (1981). Host-induced oviposition preferences and oviposition markers in the cowpea weevil, *Callosobruchus maculatus*. *Annals of the Entomological Society of America 72,242-245.*

[30]. Wolfson, J. L., Shade, R. E., Mentzer, P. E. and Murdock, L. L. (1991). Efficacy of ash for control of *Callosobruchus maculatus* (F). (Coleoptera: Bruchidae) in stored cowpea. *Journal of Stored Product Research 27, 239-243.*