ASSESSMENT OF THE RESISTANCE OF PODWALL OF COWPEAS (*Vigna unguiculata*) TO BRUCHIDS

***D. C. A. AKINTOBI [1] AND A.W SALAU[2]**

1. Department of Plant Breeding and Seed Technology
E-mail: dakintobi@yahoo.com
2. Department of Horticulture, University of Agriculture, Abeokuta.
* To whom all correspondence should be addressed.

ABSTRACT

This study was carried out to evaluate podwall resistance of ten cowpea genotypes to storage pest, bruchids (*Callosobruchus maculatus* (f) and *Bruchids atrolineatus*) in four locations in Nigeria. The pods were stored in sealed brown paper bags at ambient conditions for 50days after which they were assessed for bruchid infestation. Two genotypes, Tvnu 72 and Tvu 2027, expressed high pod wall resistance having recorded the lowest number of eggs and adult emergence and pod damage, while Danila with the highest number, had low resistance. Similarly, seeds of Tvnu 72, Tvu 2027 and IT 84S – 2246 – 4 were highly resistant while seeds of Danila were highly susceptible. There was locational effect in the expression of podwall resistance. Ibadan, with the highest number of eggs, adult emergence and pod damage, had low podwall resistance, while Mokwa and Onne had high resistance. Podwall resistance appeared to have been influenced by location and storage conditions such as temperature and relative humidity rather than genotypic differences.

Keywords: Bruchids, Cowpea, Podwall, Resistance, Oviposition

INTRODUCTION

Infestation of cowpeas by cowpea weevil or bruchids (*Callosobruchus maculatus*) (F.) usually begins in the field when pods mature but expand rapidly in storage. In Nigeria losses of 50 – 100% of stored grains have been attributed to bruchids in 6 – 9 months of storage (Caswell, 1981). The female bruchids in the field or from infested seeds in storage (Taylor and Aluko, 1974) lay eggs directly on pods or slip inside the pods through holes made by other pests and lay directly on the seed (Singh and Jackai,1985). The eggs are cemented on the dry surfaces of the pods and the larvae bore through the pods into the seeds where the development continues in the storage (Nwanze, 1973).

The development of bruchids has been found to be rapid at optimal temperature of 30^0C and 70 – 90% relative humidity (Howe and Currie, 1964 Akintobi 2007). Under these conditions there is a peak of adult emergence between 23 – 25 days after oviposition. Under Nigerian environment, Mookherjee and Chawla (1964) and Caswell (1960) reported a mean development period of 25 days in March and 30 days in June.

Some cowpeas genotypes have been found to possess some physical properties which hinder oviposition. These include barriers created by hard and thick testa and pod wall resistance. This study was designed to assess the degree of resistance of cowpea pod walls to bruchid attack.

MATERIALS AND METHODS

The experiments were conducted in 1992 and 1993 at four different locations in Nigeria. The locations were Kano (8^0 30^1E, 12^0, 02^1N) in Sudan Savanna, Mokwa (5^05^1E, 9^030^1N) in Southern Guinea Savanna, Ibadan (3^054^1, 7^030^1N) in Forest Transition Zone and Onne (7^001^1E, 4^043^1N) in Humid Forest Zone. The weather records for the locations are presented in Table 1. Ten cowpea genotypes (IT 84D – 448, IT 84S – 2246 – 4, Ife Brown, TV x 3236, TVu 2027, Danila, TV x 1948-O1F, Vita 7, IT89 KD – 260 and Tvnu 72 (a wild Vigna) were used for this study. *Collosobruchus maculatus* and *Bruchidus atrolineatus* reported to be principal field-to-store pests of cowpea in Nigeria (Caswell, 1961; Prevett, 1961 and Booker, 1967) were chosen for this study. The experimental design was a Randomized Complete Block (RCB) in a 10 x 4 factorial arrangement, replicated two times. The factors were 10 cowpea genotypes and 4 locations. The plot size was 4 x 4 m while the total land area was $490m^2$. The experimental site was ploughed and harrowed to provide fine tilth. Planting was carried out on 13 July at Kano, 28 August at Mokwa, 15 September at Ibadan and 12 October at Onne. The crops were planted at a spacing of 1m apart along the row and 25cm within rows. The plots were hand weeded twice at 4 and 8 weeks after planting, after an initial basal application of a pre-emergence herbicide (Galex 500 EC at 2.5kg a.i ha^{-1} with Paraquat at 2.5 kg a.i ha^{-1}. The insecticide Cymbush ED was applied three times at 600ml ha^{-1} for each application. Three dry, mature and intact (undamaged) pods were harvested per plot. The eggs laid by *C. maculatus* and *B. atrolineatus* on each pod were counted to determine the infestation level in the field for each genotype.

The position of the eggs on the pod was used for the identification of the two bruchids i.e. *C. maculatus* lays its eggs on the surface of the pod, whereas *C. atrolineatus* lays its eggs on sutures of the pod. The pods were stored in sealed brown paper bags at ambient conditions for 50 days to enable the eggs to hatch.

Data were collected on number and weight of emerged adults for each bruchid species, pod and seed damage in terms of number of holes per pod, number of seeds per pod, number of seeds with holes, total number of bruchid adults that emerged per pod. Seed damage was calculated as number of seeds with holes/total number of seeds in the pod. Data were transformed into square root prior to analysis. Analysis of variance (ANOVA) was calculated on the main effects and their interactions. Simple correlation coefficient was computed between pod wall damage and seed damage, percentage pod weight loss and percentage adult emergence.

Table 1: Agroecological characteristics of the four study locations

Characteristics	Kano	Mokwa	Ibadan	Onne
Latitude	12°02'N	9°30'N	7°30'N	4°43'N
Longitude	8°30'E	5°5'E	3°54'E	7°01'E
Zone	Northern Guinea Savanna	Southern Guinea Savanna	Forest Transition	Humid Forest
Soil type	Eutric Regosols	Ferric Luyisols	Ferric Luvisols	Thionic fluvisols
Annual Rainfall	750-1000mm	1000-1250mm	1250-1500mm	2500-3000mm
Mean daily rainfall	4.1mm	4.21mm	5.13mm	3.4mm
Temperature range				
Maximum	29-37°C	27-35°C	27-34°C	28-32°C
Minimum	12-23°C	18-26°C	20-23°C	21-23°C
Rel. Humidity (RH)*	53%	77%	82%	76%

*Temperature and RH data were collected on the field. Rainfall data were collected from the nearest weather station to each of the four locations.

RESULTS

The percentage of eggs that hatched (% adult emergence) on pods by both *C. maculatus* and *B atrolineatus* and the percentage damage on both pods and seeds of the 10 cowpea genotypes are presented in Tables 2 and 3. The number of eggs and adult emergence were highest among pods produced at Ibadan and lowest in Onne. Sixty four percent (64%) of the eggs laid on Ibadan pods emerged while forty Nine percent (49%) of those of Kano emerged. Furthermore, pods from Onne had 10% adult emergence while there was no emergence from pods harvested at Mokwa.

The highest number of eggs and percentage adult emergence from pods was recorded in IT84D-448 and lowest in Tvu 2027, whereas there was no emergence in Tvnu 72 because no eggs were laid (Table 1). However, the highest percentage pod damage was recorded in Danila while Tvu 2027 had the least pod damage (Table 3). No damage was recorded in Tvnu 72. Seed damage was equally highest in Danila and lowest in Vita 7, with no damage in Tvnu 72 which is a wild vigna. Across the four locations, the highest pod and seed damage were recorded at Ibadan, followed by Kano and declined from Onne to Mokwa, where no damage was recorded. Percentage loss in pod and seed weight across the four locations also showed similar trend (Table 4). The mean square of variables measured in the cowpea pod wall resistance to bruchids (Table 5) showed that only the number of eggs laid on the pod samples and percentage loss in pod weight, differed significantly among genotypes. However, all the variables differed significantly with location while location x genotype interaction was significant only for the loss in pod weight.

The correlation coefficient among the variables assessed for pod wall resistance to bruchids across the four locations (Table 6) showed a significant and positive relationship between total number of eggs laid and percentage pod and seed damage (r = 0.42*** and 0.32***, respectively), and between number of eggs laid and total number of adults that emerged from the pods (r = 0.36***) (Table 6).

A significant and negative correlation was obtained between percentage loss in pod weight and number of seeds per pod (r = 0.27*), percentage pod damage (r= 0.23*) and seed weight per pod. (r = 0.27*). The percentage pod damage was also significantly and positively correlated with percentage seed damage (r = 0.78***) and total number of adults that emerged from pods (r = 0.68***). Similar result was obtained between percentage seed damage and the total emerged adults from pods (r = 0.71***).

Table 2. **Mean percentage of eggs of *C. maculatus* (CM) and *B. atrolineatus* (BA) that hatched from the pods of 10 cowpea genotypes (n=78).**

Genotype	Kano		Mokwa		Ibadan		Onne	
	BA	CM	BA	CM	BA	CM	BA	CM
Tvnu 72	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IT89KD-260	50.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
Vita 7	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
TVx1948-01F	33.3	0.0	0.0	0.0	0.0	5.0	0.0	0.0
Danila	62.5	0.0	0.0	0.0	20.0	10.0	0.0	0.0
TVu 2027	-c	-c	0.0	0.0	0.0	50.0	-c	-c
IT84S-2246-4	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0
TVx 3236	0.0	0.0	0.0	0.0	20.0	58.3	0.0	0.0
Ife Brown	0.0	100.0	0.0	0.0	100.0	0.0	0.0	0.0
IT84D-448	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0
[a]Mean	27.3b	22.2a	0.0d	0.0c	44.0a	19.8a	10.0c	0.0b
SE	12.99	15.59	0.0	0.0	16.27	8.22	10.54	0.00

C = No seeds formed.
Percentage hatched eggs ranged from 10 to 100% (data was log transformed)
D = Location means followed by the same letter are not significantly different at 5% probability level.

Table 3: Mean percentages of pod (P) and seed (S) damage by bruchids on 10 genotypes in four locations (n = 78).

Genotype	Kano		Mokwa		Ibadan		Onne	
	P	S	P	S	P	S	P	S
Tvnu 72	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
IT 89KD-260	16.7	2.3	0.0	0.0	33.3	4.8	33.3	4.8
Vita 7	16.7	1.1	0.0	0.0	33.3	0.0	0.0	0.0
TVx 1948-01F	33.3	4.0	0.0	0.0	16.7	0.0	0.0	0.0
Danila	100.0	8.2	0.0	0.0	83.3	3.7	0.0	0.0
Tvu 2027	-c	-c	0.0	0.0	16.7	3.0	-c	-c
IT84S–2246-4	33.3	4.0	0.0	0.0	0.0	0.0	0.0	0.0
TVx 3236	0.0	0.0	0.0	0.0	16.7	0.0	0.0	0.0
Ife Brown	16.7	1.3	0.0	0.0	66.7	5.6	16.7	2.6
IT84D-448	33.3	2.1	0.0	0.0	50.0	3.4	0.0	0.0
Mean	27.8	2.6	0.0	0.0	31.7	2.0	5.0	0.74
SE	10.62	0.91	0.0	0.0	9.24	0.76	1.97	0.31
CV (%)	108.0	99.0	0.0	0.0	87.4	113.8	293.0	288.9

C = No seeds formed.
Location means followed by the same letter are not significantly different at 5% probability level.

Table 4: Pod and seed weights of cowpea and the percentage weight loss in four locations

Location	Initial pod weight (g)	Final pod weight (g)	Loss in pod weight (%)	Initial seed weight (g)	Final seed weight (g)	Loss in seed weight (%)
Kano	2.83b	2.60c	8.85c	2.44c	2.22c	9.49b
Mokwa	4.46a	4.27a	4.45d	3.21a	3.11a	3.21d
Ibadan	4.31a	3.89b	10.79a	3.19a	2.80b	13.92a
Onne	4.54a	4.21a	6.84b	2.82b	2.67b	5.61c
Mean	4.04	3.75	7.73	2.92	2.68	8.72

Means followed by the same letter are not significantly different at 5% probability level.

Table 5: Means square of variables measured in the cowpea pod wall resistance to bruchids

Variable	Location(L)	Genotype(G)	L x G	Error term
Number of eggs laid	3.389*	0.764*	0.421	0.329
Number of adults emerged	1.391***	0.174	0.185	0.150
% Pod damage	99.719***	7.770	7.274	5.502
% Seed damage	4.679**	0.542	0.494	0.315
% Pod weight loss	0.992**	0.151**	0.135**	0.046

*, **, *** = Significant at 5, 1 and 0.1% probability levels, respectively.

Table 6: Correlation coefficients between parameters studies in the assessment of dry pod walls of cowpea genotypes for resistance to bruchid attack across the four locations (n = 78).

	Total Number of eggs laid (1)	Initial pod weight (2)	Final pod weight (3) weight	% loss in pod pod (4)	Number of seeds (5)	% pod damage (6)	% seed damage (7)	Seed pod weight (8)
2	0.040							
3	0.043	1.000	-					
4.	-0.111	-0.280*	-0.35	-				
5.	-0.002	-0.036	-0.031	-0.267*	-			
6.	0.417***	0.062	0.068	-0.230*	-			
7.	0.389	0.059	0.062	-0.119	0.059	0.779***	-	
8.	0.089	0.968***	0.967***	-0.272*		-0.5057	0.120	0.106
9. Total Emerged Bruchid Adults From pods	0.362***	0.031	0.034	-0.101	0.033	0.684***	0.706***	0.097

* = $P<0.05$; ** = $P<0.01$; *** $P<0.001$.

DISCUSSION

The influence of locational differences in the survival ability of bruchids on cowpea had been stressed (Dick and Credland, 1986). Pods and seeds from Ibadan were the most infested by bruchids and could be described as the most susceptible location. The Ibadan location had the highest moisture regime (5.13mm rainfall and > 80% RH) during the crop growth period. Study by Zhu *et al.* (1994) showed that seeds lose their resistance when exposed to humidities greater than 75%. Seeds obtained from Mokwa and Ibadan were of medium weight and approximately equal in size. However, TVu 2027 from Ibadan had low resistance compared to TVu 2027 from Mokwa. This could either be due to a breakdown in resistance at Ibadan as reported by Zhu *et al.* (1994) or to a very poor quality of seeds harvested in this location. TVu 2027 from Ibadan had considerable number of shriveled and diseased seeds which might have greatly contributed to its low resistance to *C. maculatus*. .Conversely, seeds at Onne had the thickest testa and highest seed hardness. This attribute, coupled with lower moisture regime (3.8mm rainfall and < 75% RH), might have contributed to its high resistance to *C. maculatus*. Casswell (1960) observed that the combined eggs, larval and pupal periods decreased at higher humidities, especially so at 91%RH. It has also been reported that 30°C is the optimum temperature for rapid insect development (Howe and Currie, 1964, Akintobi, 2007).

The highest number of eggs and adult emergence found in the seeds of IT 84D – 448 (a smooth seeded genotype) and Ife Brown (a rough seeded genotype) indicated that there was no preference to oviposit on rough-seeded genotypes than on the smooth seeded genotypes. This differs from the findings of Lush and Evans (1980) and Nwanze and Horber (1976), who reported that bruchids laid more eggs on rough-seeded cowpeas.

The differences among genotypes with respect to pod and seed damage were significant, indicating levels of resistance in these genotypes. Tvnu 72 which had no pod and seed damage in all the locations was described as being highly resistant; IT 84S-2246-4, which recorded pod and seed damage, in only one location could also be described as resistance while Danila, with heavy pod and seed damage in two locations was described as highly susceptible (IITA, 1992). However, IT 84D-448 classified by IITA as moderately resistant (IITA, 1992) was susceptible in this study. The resistance in the classified resistant genotypes could be attributed to the combination of testa thickness and structure and high levels of combined antimetabolic compounds (Akintobi, 1996).

Nwanze *et al.*(1975), Vir (1980, 1981 and 1982) and Owusu-Akyaw (1986) also found no significant correlation between seed texture and adult emergence. Janzen (1977) reported that *C. maculatus* developed poorly on some cowpea varieities. Pondoler and Applebaum (1968) reported poor development of *C. chinensis* on broad beans.

These studies attributed their findings to the thick and hard testa of the seeds, which caused physical exhaustion and mortality of the larvae while boring through the testa to reach the cotyledon. However, Akintobi (1996) showed that there were susceptible genotypes with very thick testa and very hard seeds (Vita 7, IT 84D-448 and TV x 1948-01F), whereas highly resistant genotypes such as IT 84S – 2246-4 had very thin testa and medium hard seeds. From this study, it is obvious that no single attribute accounts for the observed level of seed resistance to bruchid infestation, although structural blocks to bruchid infestation seem to retard the entry of bruchid into cowpea seeds.

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