Original Research Article

EVALUATION OF THE SUSCEPTIBILITY OF THE SEEDS OF FOUR VARIETIES OF V*IGNA UNGUICULATA* AGAINST *CALLOSOBRUCHUS MACULATUS* INFESTATIONS

ABSTRACT

Introduction: Post-harvest conservation remains a major challenge for most crops in developing countries. Among these is Cowpea one of the major legumes grown and consumed in the tropics and subtropics of countries. *Callosobruchus maculatus* infestations constitute are the most prominent threat for this particular crop.

Objective: The present research aimed at evaluating the susceptibility of four cowpea varieties against infestations of *C. maculatus*.

Place and Duration of Study: The study was conducted at the entomology laboratory of the cowpea section of the Regional Center for Agricultural Research of Maroua from November to December 2018.

Methodology: The experiments were carried out based on the factorial experiment by randomized complete design with five replications. 40 seeds of each variety were put in contact with 5 pairs of bruchids.

Results: The results show that the four cowpea varieties evaluated have different physical characteristics of the seeds. This variability would play an important role in inducing the ovipositional response of *C. maculatus* females. However, it is not enough on its own to explain the various degree of susceptibility to *C.maculatus* infestations. There was a positive perfect correlation between the number of adult emergence, growth index, weight loss, number of holes and Dobie susceptibility index. Also, BR-1 was found to be more resistant to *C. maculatus* followed by Lori-niébé, Vya and least resistance was observed in the Borno brown.

The multiple regression analysis reveals that there is a negative relationship between mortality rate of developmental stages, weight loss, F1 offspring production, and seed susceptibility.

Conclusion: The physical characteristics of the four cowpea varieties tested to affect the susceptibility of the grain to beetle attacks. A number of adult emergence, growth index, weight loss, and susceptibility index are the main indicators for the resistance of cowpea to *C. maculatus* damage. An analysis of the amino acids contained in the BR-1 is recommended for the introgression of its resistance alleles in susceptible varieties.

Keywords: Physical characteristics, Ovipositional response, Variability, Dobie Susceptibility index, Infestations, Resistant

1. INTRODUCTION

Cowpea [*Vigna unguiculata* (L.) Walp.] is one of the major legumes grown and consumed in the tropics and subtropics of Africa, Asia, Europe and America [1,2]. Globally, more than 14.5 million hectares of cowpea are harvested, of which 98.1% are from Africa [3]. According to [4], world production of dry cowpea grain in 2013 is estimated at 5.7 million tons. Throughout the country, cowpea is the widely adapted grain legume grown in the northern part of Cameroon. It represents the essential legume in the food security of the populations of these regions because it is one of the main sources of vegetable protein accessible to all social strata [5,6]. Cowpea production in Cameroon is estimated at 166 145 tones…. 3.4% of world production [7]. About 60-80% of cowpea production is stored by farmers in the tropics for food, sale or seed for the next season [8]. However, this production is subject to pest attacks, the most formidable of which are those of the Coleoptera *Callosobruchus maculatus* [9,10]. The attacks of this insect in addition to contaminating the seeds will induce quantitative and qualitative damages rendering them unsuitable as seed, marketing and human consumption [11,12]. This damage can reach 80 to 90% of the production [13, 14]. In Sub-Saharan Africa, several control methods are used to minimize losses during storage [15,16]. Chemical control remains the most common practice used by most farmers, despite the risks it presents for fragile ecosystems, acquisition of resistances, the health of farmers and consumers and their cost [17,18].

On the strength of this observation, there is a growing demand of resistant genotypes of cowpea. Thus, several authors in their work have reported that in order to reduce grain loss due to the attacks of *C. maculatus* and excessive dependence on chemicals for stock control, the use of resistant genotypes is a promising alternative especially for large stocks [19,20, 21,22]. Several local or improved varieties with different levels of field resistance and *C. maculatus* infestation or storage yield exist and are popularized in our study area. However, very little work has been done on the susceptibility of popularized and marketed varieties. This study aims to evaluate the susceptibility of four cowpea varieties commonly cultivated, eaten and marketed in the Far North Region of Cameroon.

2. MATERIALS AND METHODS

This study focused on two improved varieties (Lori-Niébé and BR-1) and two local varieties, one from Moutourwa (Vya) in Mayo Kani and one from the Borno state cultivated on the department of Logone and Chari in Far-north region. The study was conducted at the entomology laboratory of the cowpea section of the Regional Center for Agricultural Research of Maroua (CRRA-Maroua).

2.1. Collection and preparation of the cowpea lines used

Local varieties were harvested from farmers in each locality and improved varieties were collected from the head of the CRRA-Maroua cowpea section. The manipulations were conducted under ambient laboratory conditions (at a temperature of 27 ° C ± 2 ° C and relative humidity of 20 ± 2%). The procedure for sterilization of seeds is that described by [23].

2.2. Physical characteristics of the cowpea lines used

The seed coat texture and color were determined by visual examination of mature intact seeds. The grain height, the width and the length of the grain were measured using calipers according to [24, 25].

2.3. Insect culture

A culture of *C. maculatus* was obtained from infested cowpea products in the traditional storage structures of cowpea producers in Diamaré. 20 pairs of *C. maculatus* was introduced on jars containing 200 g of each variety of healthy cowpea according to the procedure described by [26]. These jars were then covered with a perforated net to prevent the burrows from escaping and the adults were sieved out after 3 days. The set up was left on the shelf for newborn adults (F1 progeny). The subsequent offspring freshly emerging of one day were then used for the experiment.

2.4. Susceptibility experiment of varieties tested

The experimental procedure adopted for susceptibility testing is described by [27, 28], with some modifications. 200 healthy cowpea seeds of each variety were distributed in 5 transparent Petri dishes. 5 pairs of *C. maculatus* aged 24 hours were added to each box. After 72 hours, the insects were removed with soft forceps [29]. The observations were then made for up to 40 days during which the data were collected. The experimental device used is that of four blocks completely randomized with five repetitions. Varieties Susceptibilities data were collected as soon as the first adult Bruchids emerged. Among other parameters recorded during the study were a number of eggs laid, Number of adults emergence, percentage of weight loss, number of holes and susceptibility Index [30].

2.5. Data analysis

Data from the five replicates were pooled and subjected to one-way analysis of variance (ANOVA) and significantly different averages were identified using the Turkey test (P = 0.05). Spearman's correlation coefficients (rho) were used to examine the association between susceptibility parameters, including the Dobie susceptibility index. Multiple linear regression analysis was used to identify which traits were better predictors of grain sensitivity (SI). All analyses were performed using the statistical software R.

3. RESULTS

The results obtained on the different parameters studied show a clear variability between the varieties tested against the attacks of *C. maculatus*.

3.1. Physical characteristics of the seeds of the varieties tested

The analysis of the physical characteristics of the integument of the four varieties of cowpeas tested shows that all these varieties present variability of the dimensions and the weight of the seeds (Table 1). Indeed, three of the four varieties have a rough texture and a white color (Lori-cowpea, Vya, and BR-1) and only the Borno Brown has a smooth texture and a brown color. The average grain mass of local varieties was larger than that of improved varieties. It ranged from 0.18 g for the BR-1 to 0.39 g for the Borno. Reading the grain size values reveals that the BR-1 is the variety with the lowest width and length but high average height. Thus, the average grain length ranged from 0.596 cm for BR-1 to 0.900 cm for Borno. Similarly, the width of the grain ranged from 0.3608 cm for the BR-1 to 0.704 cm for the Borno while the average height was 0.356 cm to 0.436 cm respectively for the BR-1 and the Borno.

Table 1: Summary of the physical characteristics of the seeds of four varieties of cowpeas tested

Varieties	Type	The curvature of cheeks (a)	Characteristics of the seed coat		Average weight (g)	Average grain size (cm)		
			Colour	Texture		Height	Width	Length
Borno	Local	†Convex (+++)	Brown	Smooth	0.392±0.006	0.356±0.013	0.704±0.019	0.900±0.019
Br-1	Improved	Concave (++)	White	Rought	0.185±0.004	0.436±0.018	0.368±0.009	0.596±0.017
Lori-Niebe	Improved	Convex (++)	White	Rought	0.218±0.003	0.412±0.010	0.656±0.017	0.804±0.023
Vya	Local	Concave (+)	White	Rought	0.277±0.011	0.413±0.010	0.502±0.004	0.680±0.019
Mean					0.268±0.009	0.404±0.007	0.558±0.015	0.745±0.015
CV					0.323	0.177	0.268	0.205
χ2					81.20	16.61	83.52	58.63
P-value					<0.0001	0.0008	<0.0001	<0.0001

Mean ± SE of 25 measurements of the 5 repetitions; † CV : coefficient of variation; χ2 : Chi square of Kruskal Wallis (a) +++ pronounced curvature ++ Medium curvature + slight curvature

3.2. Oviposition activity of *C. maculatus* females and Follow-up of eggs hatching

The observation of the results obtained makes it possible to distinguish two groups of varieties according to the number of eggs laid on the seeds and the number of fertile eggs, namely the "highly infested" varieties (local varieties and Lori-Niebe) and the "weakly infested" varieties (BR-1) (Table 2). This observation is supported by the amplitude of oviposition observed. In our experimental conditions, the seeds of Lori-niebe and Borno Brown which showed a more pronounced curvature (flat seeds) showed strong egg-laying activity. Similarly, the BR-1 seeds used had a less pronounced curvature of the cheeks than the other three varieties, hence the small number of eggs laid. Also, the highest average numbers of eggs laid 45.64 eggs, 44.08 eggs and 41.20 eggs were recorded respectively on Borno

Brown, Lori-cowpea and Vya. In contrast, the lowest number of eggs laid was counted on BR-1 (16.6 eggs).

Monitoring of hatching of eggs laid on grain shows that there is a significant difference between improved varieties and local varieties. However, the BR-1 variety differs from the other three with an average of 13.6 fertile eggs against 37.22, 39.68 and 42.80 fertile eggs respectively for Lori-niebe, Vya, and Borno Brown. The low average fertile eggs recorded on the improved varieties allow us to state that the improved varieties have an ovicidal effect as they inhibit the hatching of eggs of *C. maculatus* laid.

Similarly, the female fertility rate and the egg stage mortality rate vary significantly by varieties. In fact, the local varieties recorded a higher fertility rate than the improved varieties, namely 96.31%, 93.78%, 84.44%, and 81.93% respectively for Vya, Borno, Lori-niebe and BR-1. In contrast, the improved varieties showed a low relative rate of egg-age mortality. In fact, the improved varieties have the highest mortality rates at the egg stage 20.16% and 14.11% respectively for BR-1 and Lori-niébé against 5.86% and 4.06% respectively for Borno Brown and Vya.

Table 2: Summary of means of the analysis of oviposition and fertility rate of *C. maculatus* based on *V. unguiculata* varieties after 40 days of infestation

Varieties	† NEL	NFE	FR (%)	MER (%)
Borno Brown	45,64± 3,35 ^{b}	42,80±3,05 ^{b}	93,78±0,91 ^{b}	5.86±0,73 ^{a}
BR1	16,6± 1,13 ^{a}	13,6± 1,26 ^{a}	81,93±1,12 ^{a}	20,16±3,29 ^{b}
Lori-Niebe	44,08±2,87 ^{b}	37,22±2,78 ^{b}	84,44±0,91 ^{a}	14,11±2,49 ^{b}
Vya	41,20±1,80 ^{b}	39,68±1,87 ^{b}	96,31±1,03 ^{b}	4,06±0,94 ^{a}
F (3, 24)	31,06***	32,45***	12,15***	12.1**

Mean of five repetitions ± SE (n = 40 seeds); Means followed by the same letters are not significantly different at the 5% probability level; ^{ns} p-value >.05; * p-value < .05, **p-value<.001 *** P-value <.0001

† **Legend**: **NEL**: Number of Eggs Laid; **NFE**: Number of Fertile Eggs; **FR**: Fertility rate; **MER**: Mortality Egg stage Rate

3.3. Larval Survival and Growth Index

The examination of the viability of the eggs laid, the duration of overall development of the bruchids and the growth index shows that there is very significant difference viability of larval stages of *C. maculatus* between improved and local varieties. Indeed, the local varieties have the highest values of larval survival. On the other hand, the improved varieties recorded the highest rates of larval stage mortality (39.11%) and 23.05% respectively on BR-1 and Lori-niébé against 9.02% and 9.05% for Borno and Vya (Table 3).

The analysis of the overall duration of development of bruchids indicates that it is longer on improved varieties than on local varieties. It was 33.55, 29.20, 26.55 and 25.25 days respectively for BR-1, Lori, Vya, and Borno. Similarly, the growth index varied from lower to improved varieties than from local varieties and ranged from 1.76 to 2.35; 3.79 and 3.87 respectively for Br-1, Lori, Vya and Borno.

The data of offsprings production show that the number of adults emerging from *C.maculatus* and the emergence rate varies significantly by varieties. The highest average numbers of adults were recorded on local varieties, ie 38.92 adults for Borno and 36.08 adults for Vya. Similarly, the lowest mean numbers of emergence were observed on the improved varieties BR-1 (8.28 adults) and Lori-niebe (28.64 adults). However, the highest emergence rate was observed in Vya (87.57%) and lowest on BR-1 (48.88%)

Table 3: Summary of averages for *C. maculatus* larval survival, F1 offspring production, and growth index analyzes for *V. unguiculata* varieties after 40 days of infestation

Varieties	†LMR (%)	GI	GDD(Days)	LSR (%)	† NE	ER (%)
Borno Brown	9,02±0,01 [a]	3,87±0,07 [c]	25.25±0,91 [a]	90,32±1,52 [c]	38,92±3,05 [c]	85,27±0,91 [c]
BR1	39,11±0,18 [c]	1,76±0,15 [a]	33.55±1.15 [c]	57,83±4,26 [a]	8,28± 1,03 [a]	48,88±0,97 [a]
Lori-Niebe	23,05±0,03 [b]	2,35±0,13 [b]	29.20±0.89 [b]	74,59±3,91 [b]	28,64±2,79 [b]	64,97±0,97 [b]
Vya	9,05±1,30 [a]	3,79±0,06 [c]	26.55±0.51 [a]	90,95±1,30 [c]	36,08±1,77 [bc]	87,57±0,598 [c]
F (3, 24)	26.29***	91.5***	216.4***	26.28***	36.00***	42.93***

Mean of five repetitions ± SE (n = 40 seeds); Means followed by the same letters are not significantly different at the 5% probability level; [ns] p-value >.05; * p-value < .05, **p-value<.001 *** P-value <.0001

† **Legend**: **LMR**: larval mortality rate; **LSR**: Larval Survival Rate; **GI**: Growth index; **GDD**: Global Development Duration **NE**: Number of emergence; **ER**: Emergence rate

3.4. Evaluation of *C. maculatus* damage on seeds

Examination of the analyzes of the damage on seeds shows that there is a significant difference between the initial weight, the final weight, the residual weight, the percentage weight loss of the seeds, the number of holes and the pest susceptibility index of the four varieties used (Table 4).

The lowest weight losses were recorded on the improved varieties while the highest was registered on the local varieties, ie 0.13 g for the BR-1 and 0.45 g for the Lori-Niébé against 1.59 g for the Vya and 1.01 g for the Borno Brown. Similarly, the lowest percentages of weight loss were recorded on the improved varieties and the highest on the local varieties, ie (25.35%) for the Vya variety and (2.09%) for the BR1 variety. Moreover, our data show that the number of holes is coupled with the average number of emergences and varies according to the varieties. Also, the lowest average numbers were recorded on the improved varieties ie 8.16 holes and 26. 96 holes respectively on BR-1 and Lori-Niebe. The highest average numbers on the Borno Brown (37.64 holes) and the Vya (35.68 holes).

The analysis of the susceptibility index revealed that all varieties used show susceptibility to *C. maculatus* after 40 days of infestation. However, improved varieties show a significant difference with local varieties 16.31, 15.45, 11.96 and 7.05 respectively for Borno, Vya, Lori and BR-1. Examination of this index according to the Dobie scale makes it possible to affirm that the BR-1 is a moderately resistant variety whereas the Vya and Lori-niebe varieties are sensitive and the Borno Brown are very sensitive.

Table 4: Summary of varietal susceptibility performance analysis means of *V. unguiculata* before and after 40 days of infestation

Varieties	† IW (g)	FW (g)	RW (g)	NH	PWL (%)	SI
Borno Brown	8,30±0,03 [d]	7,29±0,04 [d]	1,01 ± 0,15 [c]	37,64±2,96 [c]	12,14 ± 0,38 [c]	16,31± 0,36 [c]
BR1	6,49±0,06 [b]	6,36±0,06 [b]	0,13 ± 0,33 [a]	8,16±1,01 [a]	2,09±0,11 [a]	7,05± 0,54 [a]
Lori-Niébé	7,39±0,05 [c]	6,94±0,04 [c]	0,45± 0,35 [b]	26,96±2,66 [b]	5,92± 0,92 [b]	11,96± 0,39 [b]
Vya	6,22±0,06 [a]	4,63±0,05 [a]	1,59± 0,43 [d]	35,68±1,77 [c]	25,35± 1,15 [d]	15,45± 0,23 [c]
F (3, 24)	328.8[ns]	570.2***	122.9[ns]	36.29***	179.8***	113.3***

Mean of five repetitions ± SE (n = 40 seeds); Means followed by the same letters are not significantly different at the 5% probability level; [ns] p-value >.05; * p-value < .05, **p-value<.001 *** P-value <.0001

† **Legend: IW**: Initial weight of the seed; **FW:** Final Weight of the seed; **PR**: Residual Weight of seeds; **NH**: Number of holes; **PWL**: Percentage of weight loss; **SI** susceptibility index

3.5. Correlation Analysis and Multiple Linear Regression of Performance Parameters

The results of the correlation analysis between the response parameters of *C. maculatus* infestations and the susceptibility index between the different varieties tested showed a strong and positive correlation of the susceptibility index with the growth index, the average number of holes, number of emergence, number of eggs laid and number of fertile eggs; the emergence rate; the weight loss and the percentage of weight loss and negative correlation with mortality rates at the egg and larval stages. These results suggest that the average number of eggs laid, number of holes and number of emergence; growth index and weight loss could be used as reliable indicators to identify the damage-resistant cowpea genotypes of *C. maculatus* (Table 5).

Table 5: Matrix of Spearman's Correlation analysis of the varietal performance of the four cowpea varieties

†	GI	SI	NE	NFE	NEL	NH	FW	IW	PWL	RW	ER	FR	LMR	MER	LSR
GI	1														
SI	0.91***	1													
NE	0.75***	0.90***	1												
NFE	0.61***	0.84***	0.95***	1											
NEL	0.51***	0.80***	0.93***	0.97***	1										
NH	0.76***	0.91***	1***	0.95***	0.91***	1									
FW	-0.24*	-0.13^{ns}	-0.08^{ns}	-0.03^{ns}	0.04^{ns}	-0.12^{ns}	1								
IW	0.26**	0.38***	0.37***	0.39***	0.41***	0.35***s	0.81^{ns}	1							
PWL	0.71***	0.67***	0.58***	0.52***	0.43***	0.61***	-0.71	-0.16^{ns}	1						
RW	0.76***	0.73***	0.65***	0.58***	0.50***	0.67***	-0.58	-0.01^{ns}	0.98***	1					
ER	0.98***	0.88***	0.75***	0.61***	0.51***	0.76***	-0.24*	0.21*	0.70***	0.70***	1				
FR	0.66***	0.60**	0.46***	0.50******	0.31**	0.48***	-0.22*	0.10^{ns}	0.50***	0.52***	0.68***	1			
LMR	-0,89***	-0.83***	-0.71***	-0.53***	-0.50***	-0.71***	0.16^{ns}	-0.22*	-0.55***	-0.59***	-0.93***	-0.42***	1		
MER	-0,66***	-0,61***	-0,46***	-0,50***	-0,31**	-0,48***	0,22*	-0,10^{ns}	-0,50***	-0,52***	-0,68***	-1***	0,42***	1	
LSR	0,89***	0.82***	0.71***	0.53***	0.51	0.71***	-0.16^{ns}	0.23*	0.55***	0.59***	0.93***	0.42***	-1***	-0.42***	1

^{ns} p-value >.05; * p-value < .05, **p-value<.001 *** P-value <.0001

†**Legend**: **NEL**: Number of Eggs Laid; **NFE**: Number of Fertile Eggs; **FR**: Fertility Rate; **LMR**: Larval Mortality Rate, **LSR**: Larval Survival Rate; **NE**: Number of Emergence; **ER**: Emergence Rate**; IW**: Initial Weight of the seed; **FW**: Final Weight of the seed; **RW**: Residual Weight of seeds; **NE**: Number of Emergence; **NH**: Number of Holes; **PWL**: Percentage of Weight Loss; **SI**: Susceptibility Index; **GI**: Growth Index

The Dobie susceptibility index was predicted by a multiple linear regression analysis that was performed to determine predictors of the susceptibility of varieties. Our results show that the regression model made it possible to explain almost all the dispersion of the susceptibility index thanks to the explanatory variables specified in the model (R^2 = 0.99). In addition, the examination of the regression coefficient analysis of the different explanatory variables reveals that there is a negative relationship between the susceptibility index and the egg stage mortality rate, the emergence rate, the fertility rate, weight loss, and average number of emergence and positive between number of eggs laid, growth index, number of fertile eggs, number of holes and larval survival rate (Table 6). In other words, susceptible varieties have a high index growth, an oviposition activity, and survival rate while resistant varieties have a low larval mortality rate, a number of adult's emergences, a weight loss and a fertility rate.

Table 6: Summary of the multiple regression analysis of the four cowpea varieties under artificial infestation of *C. maculatus*.

Parameters	Coefficient of regression	R^2	*P-value*
Intercept	7048.09***		<.0001
GI	4.33***		<.0001
NE	-0.11*		0.04
NFE	0.03^{ns}		0.47
NEL	0.16***		<.0001
NH	0.004^{ns}	0,986	0.92
IW	-3.78^{ns}		0.14
RW	-0.06^{ns}		0.67
ER	-0.14***		<.0001
FR	-70.47***		<.0001
MER	-70.51***		<.0001
LSR	0.06***		<.0001

^{ns} p-value >.05; * p-value < .05, **p-value<.001 *** P-value <.0001

† **Legend**: **NEL**: Number of Eggs Laid; **NFE**: Number of Fertile Eggs; **FR**: Fertility Rate; **LSR**: Larval Survival Rate; **ER**: Emergence Rate**; IW**: Initial Weight of the seed; **RW**: Residual Weight of seeds; **NE**: Number of Emergence; **NH**: Number of Holes; **PWL**: Percentage of Weight Loss; **GI**: Growth Index

4. DISCUSSION

Over the years, several authors have suggested the utilization of *V. unguiculata* insect-resistant varieties as an alternative control to minimize *C. maculatus* infestation and losses during storage and in production, as well as to reduce pesticide use, production costs, and food contamination [19, 20, 21, 22, 31].

Our results have suggested that…..Results suggested that the four cowpea varieties evaluated present variability of the physical characteristics of their seeds. This variability could induce a variability of the ovipositional responses of *C.maculatus* female and consequently a variability of the susceptibility of these seeds in front of the attacks of *C.maculatus* [32, 33]. From the results obtains, local varieties have greater weight, height and length grain than improved varieties. This supports the findings of [8, 34,35] who reported that dimensions of cowpea seeds vary from one variety to another. Similarly, females' spawning activity was more pronounced on local varieties and Lori-niébé. Indeed, our results demonstrate that increasing grain height reduced egg laying while increasing length and width increased egg-laying activity [24,36,37]. These results were corroborated by [25] who reported that grain characteristics influenced 70% of the spawning activity of *C.maculatus* females and 76.5% on F1 production making them a prime determining factor [25]. [37] reports that the number of eggs laid was not influenced by the size of the seed but the number of emerged adults was influenced by the seed size. However, according to several authors [24,38, 39,40] production of F1 offspring is not correlated with physical grain parameters but rather with anti-metabolic compounds that would inhibit the development of the insect's different larval stages by producing substances that would interrupt the metabolic activities of the insect. From the results obtained, mortality rates at different stages of development were higher (>20%) on improved varieties on the one hand and the larval survival rates were higher on local varieties (>90%) on the other hand. The growth index was higher in local varieties and the overall development time was greater on improved varieties. These observations make it possible to deduce that the improved varieties have an ovicidal effect on eggs laid and larvicidal effect on the different stages of development of *C. maculatus*. These results are supported by [37] who reported in their work that larger seeds allowed for better larval development because they gave them the opportunity to drill deep into the grain and resist attacks that could block their cycle development.

He was reported that variables such as adult emergence, Global….global development Duration…duration, growth index, weight loss, are the most reliable indicators cowpea susceptibility to C. maculatus damage [9, 29, 41, 42, 43, 44]. Previous studies on moderately resistant varieties such as

Marfo-Tuya, SARC 4-75, SARC 1-71-2 and IT95K-193-2 and the susceptible variety (Apabgaala) showed number emergences, weight loss seeds and an index of growth lower than that of the local variety (Apabgaala) [23]. Similar results have been reported by [45] who observed a reduced number of holes in resistant cowpea genotypes. [19] reported that the number of emergent adults determines the extent of damage and, as a result, seeds with faster and higher emergence levels will be more widely damaged.

Several studies have used the Dobie susceptibility index as a measure of the variety resistance to *C. maculatus* damage [19, 31]. Thus, according to the Dobie scale, the larger the index, the more susceptible the grain is to pests. In our case, the BR-1 is the variety with the lowest index and Borno Brown with the highest index, allows us to conclude that the variety BR1 is more resistant to infestations than the Borno. It had a hight height (0.436cm), but least emergence of adult C. maculatus (16.6), least weight of seeds (0.185g), least weight loss (2.09), least number of holes (8.16), least growth index (1.76 days) and long Global development Duration (33.55 days). [23] already argued that weight loss and, by extension, damage from *C. maculatus* infestation are generally strongly correlated with susceptibility index. Similar correlation results have been reported by [19, 29, 44,46, 47] on cowpea and, [48] on common beans.

5. CONCLUSION

Different parameters or indices were used to identify cowpea varieties susceptible to *C. maculatus*, including physical characteristics of grain, spawning activity, survival of larval stages, overall development time, growth index, weight loss, and susceptibility index. This study demonstrated that there is a variation in the physical characteristics of the four cowpea varieties tested. This variability could induce a variability of the ovipositional responses of C.maculatus female and consequently a variability of the susceptibility of these seeds in front to infestation and damage of *C. maculatus*. The variance of the grain sensitivity of the tested varieties would be related to the variability of the physical and/or biochemical characteristics of the seeds that will influence the ovipositional response, the viability of the different stages of development of the haystack, the growth index, the production of F1 and the weight loss of the seeds. The BR-1 improved variety with the lowest grain mass and the highest height was the only variety to show moderate susceptibility to *C. maculatus* attacks. Given that these variabilities could be used for introgression of resistance in less sensitive cowpea varieties, we therefore, recommend conducting biochemical studies of the BR-1 seeds in order to determine its chemical composition in the optics of the incorporation of its resistance alleles during the development of new resistant varieties.

8. REFERENCES

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