Evaluating the Impact of New Rice for Africa (Nerica) in the Management of Rice Stem Borers

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ABSTRACT

Rice is one of the major staple food crops in Nigeria and is grown in almost all the Nigerian ecologies. Unfortunately, rice yield is too low to keep pace with the rate of population growth, leading to serious food insecurity. The low yield has been associated with incidences of insect pests. Of the various insect pests attacking rice plant, stem borers are by far the most recalcitrant and injurious pest. In the present study, the impact of New Rice for Africa (NERICA) in the management of rice stem borers was evaluated in Nigeria during 2008/2009 farming seasons in relation to two other rice genotypes under cultivation using randomized complete block design. The results showed significance differences on the incidences of stem borers among the rice genotypes evaluated across the locations and years. The different levels of infestations (dead heart and white head) observed among the rice genotypes showed that different rice varieties responses differently to rice stem borers attack. Amongst the genotypes assessed, the TOG lines showed highest level of resistance to stem borers followed by the NERICA lines and then the *O. sativa* lines that was virtually susceptible. The screen house results corroborated the field results. The reduction in percentage infestation (dead heart and white head) recorded amongst the NERICA lines compare to the *O. sativa* lines used indicated that NERICA has significant potential for the management of stem borers and if adopted will enhance sustainable rice production in Nigeria.

Key words: Rice genotypes, stem borers' management, Nigeria

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INTRODUCTION

Rice is a staple food for the largest number of people on earth and is eaten by nearly half the world population¹. Rice field covers 11% of earth's arable land and by far the most important crop worldwide². Rice provides 21% of global human per capita energy and 15% of per capita proteins. In Sub-Saharan Africa, rice consumption is increasing faster than that of any other food crop in many countries in Africa^{3,4}. Unfortunately, rice is produced almost exclusively by small-scale farmers who have little or no hope of increasing their land-holding capacity in sub-Saharan African countries. Thus Africa is accounting for 32% of global rice importers in 2006^{5,6}. The increase in rice production observed in the recent years has been attributed to increase in area cropped to rice rather than quantitative increase¹. The production-consumption gap in this region is due to low yield of rice¹. The low yield has been attributed to insect pest infestation, inferior quality of domestic rice vis-à-vis imported rice and poor agricultural systems¹.

Insect pests constitute a major constraint in achieving the yield potentials of many varieties of rice in Africa⁷. Of all the insect pests of rice, stem borers appear to be the most recalcitrant insect pests of rice in all the rice ecologies (lowland, upland, fadama and irrigated rice) in the recent time^{8,9}. Out of 20 stem borer species identified causing damage to rice plant worldwide; four species are of economic importance in Nigeria. These include *Chilo zacconius* Bles, *Diopsis longicornis* Macquart, *Maliarpha separatala* Rag and *Sesamia calamistis* Hamp⁸. The distribution and abundance of these species vary between different ecological zones. These borers attack rice plant at different growth stages from vegetative stages to grain development. Feeding during the vegetable growth stage causes death of the central shoot causing what is referred to as 'Dead Heart' (DH). Damaged shoot do not produce a panicle and thus produce no grain. Feeding of stem borers during the reproductive stage (panicle initiation to milk grain) causes a severing of the developing panicle at its base. As a result, the panicle is unfilled and whitish in colour; rather than filled with grain and brownish in colour and is known as 'Whitehead' (WH)⁹.

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Rice stem borers have been reported to cause yield losses ranging from 30 to 80%. A 100% loss has been recorded in worst affected fields in Nigeria¹⁰ (Imolehin and Ukwungwu, 1992). In many parts of Africa it has been reported that borers destroy 30-50% of plant tillers during the wet cropping season thereby reducing significantly the whole harvest¹¹.

Management of rice stem borers in Africa for the past 20 years has been dominated by the use of insecticide, which have not given the desired results due to inability of the researchers to time the application of insecticides to coincide with the vulnerable stages of the pest. Furthermore, considering the side effect of chemicals on the environment and on human health, cost implication and pest resurgence, concerted efforts are being made to seek for alternative source of control. In the past two decades considerable efforts have been directed at integrating host plant resistance with biological agents for rice pests^{12,13}. And for an economical and relatively long lasting solution to the problem of rice stem borers in Africa lies therefore in the planting of resistance rice cultivars. Its integration with other control measures, may provide an equivalent level of control, with less adverse impact upon the environment than the use of chemicals^{3,14}.

In Nigeria three major rice genotypes are under cultivation. These are the Tropical *Oryza glaberrima* (TOG) Steud, the *Oryza sativa* Linn from Asia and the newly introduced interspecific rice varieties called NERICA (New Rice for Africa). The first two genotypes were popular in Africa but with serious problems. While the first has the problem of low yield and quality, the second genotype has the problem of severe infestation by various biotic/abiotic factors in the tropics, hence the need for an alternative biotype. The Africa Rice Center recent breakthrough in research breeding led to the introduction of new genotype, New Rice for Africa (NERICA) into the Africa farming system in 2002. As a new genotype, there is need to assess its potential to ascertain its ability to address some of these biotic factors that necessitated its introduction. Among these biotic factors are the incidences of rice insect pests that are responsible for most rice yield losses in most African countries.

Hence the present study assesses the reaction of NERICA rice genotype to rice stem borers attack. Understanding the influence of this rice variety on the incidence of rice stem borers is a fundamental issue in IPM and is of a practical concern with insects that could cause economic damage. Though a lot of researches have been conducted on rice resistance to stem borers but to the best of my knowledge, there has not been any empirical prior study on the effect of NERICA on the incidence of rice stem borers in Nigeria with resultant implication on yields. Thus, in the present study, the aim was to assess NERICA rice genotype lines in relation to the other two genotypes both in

the field and screen house to determine its impacts on the incidences of rice stem borers and yield.

MATERIALS AND METHODS

Experimental site: The field experiments were conducted at two areas in Nigeria for two consecutive years (2008/09). The two areas are in different agro ecological zones in Nigeria with different seasonal climatic patterns and long history of rice production and endemic areas to many insect pests of rice. The two areas/ecological zones were Ogidiga in Southeastern Nigeria and Edozhigi in North central Nigeria. Ogidiga is within the forest-savannah transition agro-ecological zone. It has geographical bearing of latitude 06°17'N, longitude 08°04'E and altitude 104.40 m above sea level. Edozhigi is within the Guinea Savannah agro ecological zone. It has geographical bearing of latitude 09°45'N, longitude 06°07'E and altitude 50.57 m above sea level. They have bimodal rainfall patterns with an average annual rainfall of about 1800-2200 and 900-1050 mm per annum for Ogidiga and Edozhigi respectively, that are distributed between May and October. They have average daily temperature that fluctuates between 20 and 35°C with an annual mean of 26.5 and 27.4°C, respectively. Their mean relative humidity was in the ranges of 64-83 and 52-73 for Ogidiga and Edozhigi, respectively.

Experiments: Two experiments were conducted; field and screen house experiments.

Field experiments: The rice varieties used for the field experiments were obtained from Africa Rice Centre, IITA Ibadan, Nigeria. The varieties consist of nine *Oryza sativa* lines that appeared promising, nine *Oryza glaberrima* lines and nine newly bred lowland NERICA-L lines were added to make a standard set of 27 varieties. The names, origin and species of the genotypes are shown in Table 1.

The fields were laid out in randomized complete block design under rain fed low land conditions. All the varieties were transplanted at 2 seedlings per hill after 21 days of seeding into 150 m² plots. Each variety occupied five rows transplanted at 25×25 cm inter and intra plant spacing and 25 seedlings per row. Supply was done at 7 and 14 days after transplanting to replace dead seedlings. All the transplanting at each location was done during the middle of July of each season to coincide with the period of heavy stem borer infestation. All the treatments were replicated three times. All cultural practices as recommended for the locations by WARD¹⁵ were observed. No insecticide was applied to allow natural infestation of the field by different stem borer species.

Data were collected on percent Dead Heart (DH) and Whitehead (WH) from 20 hills randomly selected from each plot. The 20 hills were randomly selected at set intervals along parallel transects through the crops,

Table 1: The selected rice varieties used to access the incidence of stem borers

Varieties	Species	Source of entry
WAS 186-B-8-B-1-WAS 2-WAS-1	Interspecific	Africa rice
WAS 127-IDSA-2-WAS-1-1-1	Interspecific	Africa rice
WAS 186-B-8-B-1-WAB-1-WAS-5	Interspecific	Africa rice
WAS 186-B-8-B-1-WAB-1-WAS-3	Interspecific	Africa rice
WAS 186-B-8-B-1-WAB-1-WAS-4	Interspecific	Africa rice
WAS 127-IDSA-12-WAS-11-3-1	Interspecific	Africa rice
WAS 127-IDSA-12-WAS-11-3-2	Interspecific	Africa rice
WAS 186-B-8-B-WAB-1-WAS-2	Interspecific	Africa rice
WAS 186-B-8-B-WAB-1-WAS-1	Interspecific	Africa rice
TOG 7106	<i>Oryza glaberimma</i>	Mali
TOG 7206	<i>Oryza glaberimma</i>	Cote d'ivoire
TOG 7442	<i>Oryza glaberimma</i>	Nigeria
TOG 5314	<i>Oryza glaberimma</i>	Nigeria
TOG 5882	<i>Oryza glaberimma</i>	Liberia
TOG 6309	<i>Oryza glaberimma</i>	Liberia
TOG 6270	<i>Oryza glaberimma</i>	Liberia
TOG 9066	<i>Oryza glaberimma</i>	Nigeria
TOG 6907	<i>Oryza glaberimma</i>	Siera leone
BW 348-1	<i>Oryza sativa</i>	Seri lanka
CISADANE	<i>Oryza sativa</i>	Indonesia
AGHANI	<i>Oryza sativa</i>	India
T 1477	<i>Oryza sativa</i>	India
MBAHI-1	<i>Oryza sativa</i>	Benin republic
JUMOBOR MANO	<i>Oryza sativa</i>	Benin republic
TOS 8091	<i>Oryza sativa</i>	Tanzania
TOS 14519	<i>Oryza sativa</i>	Gambia
ITA 306	<i>Oryza sativa</i>	Nigeria

while leaving the border rows. The selected plants were used for closer examination on incidence of stem borers' damage at 50 and 80 DAT (days after transplanting). Sampled rice hills were up rooted and dissected ten days before harvest to record different species of stem borers that were prevalent in the experimental plots.

Statistical analysis: Collected data were analyzed using ANOVA¹⁶. After ANOVA, the varieties were categorized using Standard Evaluation System (SES) for rice against stem borers as described by IRRI¹⁷ (Table 2).

Screen house evaluation of the rice varieties: The same rice varieties were planted as discussed above in a paddy screen house (25 × 20 × 3 m) in Africa Rice Center IITA Ibadan. At 40 days after transplanting, 4 females to 6 males, one-day-old each of the four major stem borers of rice in Nigeria (*C. zacconius*, *D. longicornis*, *M. separatala* and *S. calamistis*) from the insect culture were introduced into the screen house. Thereafter, the soil of the screen house was regularly flooded to maintain adequate water supply to facilitate the infestation and survival of the larvae in the rice culms. The set up was left in the screen house until dead heart and white head started to appear. Data were collected as stated in the field experiments above.

Table 2: Standard evaluation Systems for evaluating rice for resistance to stem borers¹⁷

Scale	Percentage dead heart infestation
0	No damage
1	1-10
3	11-20
5	21 - 30
7	31 - 60
9	61% and above
White head test	
0	No damage
1	1-5
3	6-10
5	11-15
7	16-25
9	26% and above
Scale	
0	Highly resistant
1	Resistant
3	Moderately tolerant
5	Moderately susceptible
7	Susceptible
9	Highly susceptible

RESULTS

The results of the investigation showed significance differences among the rice genotypes both within and across the locations on the incidences of stem borers. Table 3 and 4 showed the damage rating (% dead heart and white head infestation) recorded in the field at the two sites-Edozhigi and Ogidiga during 2008 and 2009 farming seasons respectively. The percentage dead heart and white head were found to have the same trends in the two locations with few exceptions as indicated in Table 3. However, among the genotypes under study, the TOG lines showed the highest level of resistance to stem borers' attack and differed significantly from other genotypes, followed by the NERICA lines while the Sativa lines were virtually susceptible to all the stem borers observed in the field.

At Ogidiga, all the TOG lines were resistant with TOG 7106 showing the highest level of resistance across the growth stages and years and TOG 6309 had the least level of resistance with three of the stem borers species recorded on it. Among the interspecific lines, WAS 127-IDSA-12-WAS-11-3-1 showed the highest level of resistance with the least number of dead heart and white head recorded and WAS 186-B-8-B-1-WAB-1-WAS-4 gave the least level of resistance throughout the period of the experiments and locations (Table 3, 4). However, the three common stem borer species were recorded on all the lines.

At Edozhigi the trend was the same with TOG 7106 showing the highest level of resistance and TOG 6309 had the least level of resistance for 2008 and 2009, respectively. Among the NERICA lines, WAS 127-IDSA-12-WAS-11-3-1 gave the highest level of resistance while WAS 186-B-8-B-1-WAB-1-WAS-4 the least level of

Table 3: Resistance rating of the rice genotypes based on percentage dead heart infestation of rice by stem borers at ogidiga and edozhigi during 2008/09 farming seasons

S/N	Varieties	Ogidiga				Edozhigi			
		2008		2009		2008		2009	
		% Infestation	SES rating	% Infestation	SES rating	% Infestation	SES rating	% Infestation	SES rating
1	AGHANI	10.2	MR	11.5	MR	12.2	MR	14.3	MR
2	BW 348-1	22.8	MS	20.3	MS	29.2	MS	20.4	MS
3	CISADANE	25.7	MS	21.6	MS	30.3	S	20.2	MS
4	ITA 306	27.9	MS	24.5	MS	35.1	S	25.0	MS
5	J. MANO	14.4	MR	12.7	MR	17.9	MR	23.1	MS
6	MBAHANI	11.7	MR	12.2	MR	12.1	MR	12.1	MR
7	TOS 14519	2.1	R	1.8	R	2.7	R	1.0	R
8	TOS 8091	12.1	MR	13.7	MR	15.9	MR	15.2	MR
9	T 1477	12.3	MR	13.4	MR	14.8	MR	13.5	MR
10	TOG 5314	2.1	R	3.3	R	1.9	R	1.1	R
11	TOG 6270	0.5	R	0.4	R	2.5	R	2.1	R
12	TOG 6309	0.7	R	0.9	R	2.7	R	3.2	R
13	TOG 7106	0.3	HR	0.3	HR	0.5	R	0.9	R
14	TOG 7206	0.2	HR	0.5	R	0.4	HR	0.8	R
15	TOG 7442	0.9	R	0.7	R	0.9	R	0.4	HR
16	TOG 9066	0.7	R	0.8	R	1.1	R	0.7	R
17	TOG5882	0.5	R	0.7	R	1.2	R	0.6	R
18	TOG6907	1.1	R	1.2	R	1.3	R	0.9	R
19	WAS 127-IDSA-12-WAS-11-3-1	1.0	R	1.4	R	2.0	R	3.3	R
20	WAS 186-B-8-B-WAB-1-WAS-1	3.5	R	2.1	R	2.1	R	3.0	R
21	WAS 186-B-8-B-1-WAB-1-WAS-3	2.8	R	2.3	R	2.4	R	1.7	R
22	WAS 127-IDSA-2-WAS-1-1-1	2.7	R	2.2	R	3.6	S	2.4	R
23	WAS 127-IDSA-12-WAS-11-3-2	3.9	R	2.9	R	3.9	R	3.8	R
24	WAS 186-B-8-B-WAB-1-WAS-2	4.3	R	1.9	R	3.7	R	3.7	S
25	WAS 186-B-8-B-1-WAS 2-WAS-1	3.6	R	3.4	R	4.1	R	2.3	R
26	WAS 186-B-8-B-1-WAB-1-WAS-4	10.5	MR	13.3	MR	11.7	MR	10.1	MR
27	WAS 186-B-8-B-1-WAB-1-WAS-5	4.3	R	3.7	R	3.3	R	2.7	R
	F-LSD (p<0.05)	1.1		1.0		1.3		1.5	

Highly Resistant (HR), Resistant (R), Moderately Resistant (MR), Moderately Susceptible (MS), Susceptible (S), Highly Susceptible (HS)

resistance for 2008 and 2009, respectively. Among the *Sativa* lines TOS 14519 showed the highest level of resistance and ITA 306 was the most susceptible variety across the sites, years and growing stages of rice. These resistant varieties were significantly less damaged than other varieties. Percentage infestations in these varieties were many times less than in the susceptible check ITA 306. The NERICA lines proved to be superior to the sativa lines used in this study.

In all the incidences of stem borer infestation during the 2009 farming season was rather lower than the previous 2008 farming season in both sites.

In the screen house, the mean percentage infestation ranged from 0.2 to 23.4% for dead heart with the least (0.2%) in TOGs 7102 and highest (23.4%) in ITA 306 and for the white head, the infestation ranges from 0.1 to 22.1 for TOGS 7102 and ITA 306 respectively. On the other hand, in the NERICA lines WAS 127-IDSA-12-WAS-11-3-1 had the least level of infestation while WAS 186-B-8-B-1-WAB-1-WAS-4 recorded the highest infestation level (Table 5).

Amongst the sativa lines with the exception of TOS14519, M. BAHANI and AGHANI that were resistance, others were either highly susceptible or

susceptible to stem borers infestation. Of all the varieties, ITA 306 had the highest percentage infestation level which differed significantly from the rest of the varieties, followed by Cisadane which had the second highest infestation.

The correlation between dead heart incidence and white head were significantly positive ($r = 0.73$ and $r = 0.67$, $p < 0.05$) for Ogidiga and Edozhigi, respectively.

DISCUSSION

NERICA rice genotype is newly bred rice with the intention to salvage problems encountered by farmers that were planting the two old existing rice genotypes (*O. sativa* and *O. glaberrima*) in Africa. Hence, the varietal evaluation was conducted with the intention to test and compare various rice genotypes grown in Nigeria to ascertain whether NERICA's mandates in relation to pest infestation are met. The differences in stem borer infestation observed across the rice genotypes showed that the genotypes react differently to stem borer attack. The lowest level of infestation recorded in the *glaberrima* lines showed that among the three genotypes, it has the highest level of resistance to insect pest infestation. This is in line with the result reported by Ogah *et al.*⁷ and

Table 4: Resistance rating of the rice genotypes based percentage White head infestation of rice by stem borers at ogidiga and edozhigi during 2008/09 farming seasons

Varieties	Ogidiga				Edozhigi			
	2008		2009		2008		2009	
	% Infestation	SES rating	% Infestation	SES rating	% Infestation	SES rating	% Infestation	SES rating
AGHANI	13.2	MS	21.3	S	20.2	S	28.5	HS
BW 348-1	31.1	HS	37.5	HS	34.9	HS	36.1	HS
CISADANE	34.1	HS	36.4	HS	38.0	HS	32.6	HS
ITA 306	39.0	HS	41.5	HS	35.3	HS	40.8	HS
J. MANO	17.0	S	29.0	HS	26.1	HS	30.1	HS
M BAHANI	10.0	MR	11.3	MS	12.2	MS	12.0	MS
TOS 14519	9.1	MR	12.4	MS	11.6	MS	10.1	MS
TOS 8091	12.6	MS	15.1	S	17.6	S	15.0	MS
T 1477	7.8	MR	6.0	MR	12.4	MS	12.8	MS
TOG 5314	2.0	R	2.7	R	3.0	R	3.0	R
TOG 6270	5.1	MR	5.1	MR	8.9	MR	9.2	MR
TOG 6309	3.4	R	6.4	MR	11.4	MS	5.0	R
TOG 7106	1.4	R	2.0	R	3.1	R	3.0	R
TOG 7206	1.6	R	1.0	R	3.5	R	3.9	R
TOG 7442	1.8	R	1.7	R	4.3	R	4.1	R
TOG 9066	2.3	R	2.5	R	5.0	R	6.5	MR
TOG5882	2.2	R	2.3	R	6.6	MR	6.6	MR
TOG6907	2.4	R	3.1	R	4.0	R	5.4	MR
WAS 127-IDSA-12-WAS-11-3-1	3.1	R	3.8	R	6.1	MR	7.7	MR
WAS 186-B-8-B-WAB-1-WAS-1	6.4	MR	5.7	MR	9.6	MR	6.5	MR
WAS 186-B-8-B-1-WAB-1-WAS-3	6.8	MR	4.2	R	7.6	MR	7.1	MR
WAS 127-IDSA-2-WAS-1-1-1	4.7	R	8.9	MR	4.0	R	5.7	MR
WAS 127-IDSA-12-WAS-11-3-2	4.6	R	7.3	MR	7.3	MR	4.5	R
WAS 186-B-8-B-WAB-1-WAS-2	4.1	R	10.3	MS	8.0	MR	7.8	MR
WAS 186-B-8-B-1-WAS 2-WAS-1	5.8	MR	10.5	MS	12.2	MS	9.6	MR
WAS 186-B-8-B-1-WAB-1-WAS-4	8.1	MR	8.2	MR	12.8	MS	11.4	MS
WAS 186-B-8-B-1-WAB-1-WAS-5	8.2	MR	4.2	R	7.1	MR	6.3	MR
F-LSD (p<0.05)	1.2		1.9		5.1		4.3	

HR: Highly Resistant, R: Resistant, MR: Moderately Resistant, MS: Moderately Susceptible, S: Susceptible, HS: Highly Susceptible

Table 5: Percentage Infestation of the rice varieties by stem borers in the screen house

Varieties	Dead heart		White head	
	%Infestation	SES rating	% Infestation	SES rating
AGHANI 4.3	R	3.9	R	
BW 348-1 14.3	MR	13.1	MS	
CISADANE	18.1	MR	16.9	S
ITA 306 23.4	MS	22.1	S	
JUMOBOR MANO	12.2	MR	11.1	MS
M. BAHANI	1.2	R	0.8	R
TOS 14519	0.9	R	0.7	R
TOS 8091 10.5	MR	9.1	MR	
T1477 12.5	MR	10.0	MR	
TOG 5314	1.6	R	1.2	R
TOG 6270	2.2	R	1.2	R
TOG 6309	3.7	R	2.3	R
TOG 7106	0.2	HR	0.1	HR
TOG 7206	0.4	HR	0.8	R
TOG 7442	1.0	R	1.3	R
TOG 9066	2.2	R	1.4	R
TOG5882	0.5	R	0.8	R
TOG6907	0.6	R	1.1	R
WAS 127-IDSA-12-WAS-11-3-1	4.1	R	3.8	R
WAS 186-B-8-B-WAB-1-WAS-1	5.6	R	4.6	R
WAS-186-B--8-B-1-WAB-3	7.9	R	6.1	MR
WAS127-IDSA-2-WAS-1-1-1	11.6	MR	8.5	MR
WAS127-IDSA-2-WAS-11-3-2	5.3	R	4.5	R
WAS186-B-8-B-WAB-1-WAS-2	4.9	R	4.3	R
WAS186-B-8-1-WAS2-WAS-1	5.8	R	5.1	MR
WAS186-B-8-B-1-WAB-1-WAS-4	5.1	R	5.9	MR
WAS186-B-8-B-1-WAB-1-WAS-5	4.7	R	4.3	R
F-LSD (p<0.05)	1.1		0.9	

HR: Highly Resistant, R: Resistant, MR: Moderately Resistant, MS: Moderately Susceptible, S: Susceptible, HS: Highly Susceptible

Nwilene *et al.*¹⁸. According to them, *O. glaberrima* has the highest level of resistance to both biotic and abiotic factors among the rice genotypes grown in Africa. One of the major problems of low rice yield in Africa is the incidences of rice pest, in which stem borers have been implicated as a major factor. Similarly the less stem borers infestations recorded among the NERICA compare to the *O. sativa* lines have been reported by other researchers⁶. According to them NERICA lines have inherited the genetic characteristics of *O. glaberrima* that makes it to withstand most of the tropical stresses in the rice ecologies. To them the NERICA lines has the potential to with stand most of the tropical biotic factors compare to the sativa lines.

The differences in infestation levels recorded between both cropping seasons were probably related to the differences in weather factors. Rainfall was more intensive during the 2008-cropping season than 2009. Equally among the various rice varieties used in the study in the two locations, the incidence of stem borers were higher at Edozhigi than at Ogidiga site.

The positively correlation recorded between dead heart and white head across the sites implies that as the incidence of dead heart increased early in plant growth stage, the white head incidence equally increased at the heading stage.

Three borer species were recovered after field sampling from each genotype. The species were the *M. sepaaratella*, *C. zacconius* and *S. calamistis*. The percentage of each species recovered to the total population was 61.2, 53.3 and 5.9, respectively. Similar report has been reported by Akinsola¹⁹. Equally the presence of *Maliarpha* sp on tillers that appear to be normal observed in this study has been reported by Akinsola¹⁹. He reported *Maliarpha* as the major rice stem borer, making up about 70% of the borer population in most parts of Nigeria and because of their peculiar feeding habits, they do not show external signs of infestation.

CONCLUSION

The percentage dead heart and white head infestation were dependent on rice varieties and were positively correlated. NERICA genotype showed great promises in resisting rice pests and increased grain yield. Therefore the adoption of NERICA rice in integration with other available rice genotypes must be increased and sustained in Nigeria for enhanced rice protection and sustainable increased rice grain yield. Most importantly, smallholder farmers may have no difficulty adopting these varieties, since it is economical and distributed locally across the rice growing ecologies in Africa.

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