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Effect of Intercropping Maize and Cassava with Upland NERICA Rice Varieties on Stemborer Attack in Southwest Nigeria

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ABSTRACT

Rice and maize intercrop is a common feature of traditional upland rice cultivation in Nigeria. Stemborer larvae cause significant yield loss in rice. The study aimed at identifying stemborer resistant status of upland NERICA rice varieties and evaluating the effectiveness of maize as a trap crop to protect upland NERICA rice varieties against stemborers. The resistance status of 7 NERICA rice and 2 other rice varieties to stemborer was evaluated in 2006 and 2007 under natural infestation maize and cassava intercropping systems in the humid forest zone of Nigeria. In 2006 study, NERICA1, NERICA2 and NERICA5 together with the resistant check LAC23 were classified as stemborer resistant (SBR) and NERICA3, NERICA4, NERICA6 and NERICA7 together with susceptible check OS6 were classified as stemborer susceptible (SBS). The SBR varieties (NERICA1 and NERICA2) from the 2006 study intercropped with maize and cassava in 2007 revealed the effectiveness of maize as a trap crop and cassava as a refuge for generalist predators against stemborer damage on upland rice. Maize appeared an effective trap crop for rice stemborers because there was a marked and significant reduction in the stemborer attack on rice in the NERICA rice/maize intercrops (GrB cluster) as compared to the NERICA rice monocrops (GrA cluster) and NERICA rice/cassava intercrops (GrA cluster). *Maliarpha separatella* Ragonot was the predominant stemborer species on rice followed by *Sesamia calamistis* Hampson. It was concluded that NERICA1 and NERICA2 could be recommended to farmers in stemborer prone areas and that maize was a suitable trap crop for managing rice stemborers.

Key words: Rice cultivation, natural infestation, trapping crops, generalist predators, yield losses

INTRODUCTION

Stemborers constitute the most widely distributed and injurious group of the insect pests of rice. They are key pests of rice in West Africa as they are in other rice-growing regions throughout the world (Heinrichs and Barrion, 2004). In fact, they have been implicated as the major constraint to rice production in West Africa (Heinrichs and Barrion, 2004). These stemborers comprise various species of lepidopterous moths and dipterous stalk-eyed, diopsis species (CABI, 2004). The visible

symptoms of stemborer damage vary with the growth stage at which plant infestation begins (Baloch *et al.*, 2004). Rice plants from seedling to maximum tillering stages that have been attacked at the base of the stem have deadhearts while plants that have started bearing panicles when they were attacked produce whitehead (IRRI, 2009b). Yield losses between 10-70% have been attributed to stemborers in cereal production in outbreak areas in sub-Saharan Africa (Pascal, 1998; Chabi-Olaye *et al.*, 2005a, b; Ateyim *et al.*, 2005; Setamou *et al.*, 2000). grain damage by total crop failure has also been reported in a few instances (Mulungu *et al.*, 2011; Khan *et al.*, 2003; Pascal, 1998). In addition, lepidopterous stemborers have been reported to predispose cereal crops such as maize to pre-and post-harvest infestations by storage beetles, infections by pathogens such as *Aspergillus flavus* Link and *Fusarium verticillioides* (Saccardo) Nirenberg and subsequent contamination by mycotoxins (Oparaeke and Kuhiep, 2006; Cardwell *et al.*, 1997; Setamou *et al.*, 2000).

Many strategies to reduce losses due to stemborers have been practiced. These include use of pesticides, varietal resistance/tolerance, biological control and cultural control measures through the biodiversity of plants. The use of synthetic insecticides can be environmentally disruptive and can result in the accumulation of residues in the harvested product (Dhuyo and Soomro, 2007; Pappas *et al.*, 2011). Also, the risks to health and the environment associated with the use of an insecticide mostly outweigh the benefits. Besides, because the larvae which cause the damage are concealed inside the plant stem, these pests can be very difficult to control with insecticides. Systemic insecticides which are translocated within the plant system would have been the only reliable form of chemical control for stemborers after the borers have entered the rice stem when it is generally too late to save/salvage (Dhyo and Soomro, 2008).

Major emphasis has been given in recent years to the use of habitat management techniques such as crop diversification as a control strategy (Songa *et al.*, 2007). Although this has for long been a prominent feature of small holder crop production in sub-Sahara Africa, its benefits are further promoted by the farmers' concerns. This will not only enhance farm productivity per unit land but also for ensuring security against the potential risk of monoculture alongside creating a platform for stabilizing the diversified needs of the farming households whose production (by its subsistence nature) is greatly influenced by the vagaries of nature (Tahir *et al.*, 2003; Tsubo *et al.*, 2003). Diversified cropping systems play many roles in the agro-ecosystem, such as protection of plants of individual crop species from their host-specific predators and disease organisms, greater competition towards weeds, improved product quality and reduced negative impact of arable crops on the environment. A considerable number of studies have shown that pest populations are higher, more frequent and cause greater yield losses in monocrops than in more diverse cropping systems (Rami *et al.*, 2002; Otway *et al.*, 2005). Also, many studies in tropical as well as temperate zones reported decreased pest densities in diversified cropping systems (Rami *et al.*, 2002; Thies and Tscharncke, 1999; Kruess and Tscharncke, 2000). The use of habitat management strategies with available natural resources such as wild hosts and non-host plants of stemborers against indigenous stemborer species, can increase the understanding of interactions between pests, their cultivated and wild hosts as well as their natural enemy fauna on both types of hosts plants (Khan *et al.*, 2000). However, farmers are mostly not aware of the beneficial effect that mixed cropping can have on pest infestations.

Most of the traditional *Oryza sativa* varieties grown in West Africa are highly susceptible to stemborer attack. Africa rice has generated several hundred NERICA lines, opening new gene pools and increasing the biodiversity of rice to farmers. The present study aimed at identifying stemborer

resistant status of upland NERICA rice varieties and evaluating the effectiveness of maize as a trap crop to protect upland NERICA rice varieties against stemborers. Maize and rice share some common stemborer species. There is also the need to assess if intercropping upland NERICA rice varieties with cassava can attract generalist predators such as spiders, cassava predatory phytoseiid mites, to reduce stem borer damage on rice plants.

MATERIALS AND METHODS

The study site: The field experiments were conducted under rainfed upland conditions in 2006 and 2007 at Ikenne, southwest Nigeria. The location is a 'hot-spot' for stemborers because maize is widely cultivated by farmers in the area. It lies between longitude 6° 32'N and 7° 97'N and latitude 2°67'E and 4°40'E. It has an average annual rainfall of 1480 mm and a monthly mean temperature range of 18-24°C during the rainy season and 30-35°C during the dry season. The rainfall pattern is bimodal and the vegetation type is humid forest. The soil type is a highly acidic ultisol with very low phosphorus content.

Rice varieties and experimental design: In 2006, the reaction of nine rice varieties (Table 1) to stemborer attack was evaluated under natural infestation at Ikenne. The seven NERICA rice varieties were selected because they were the first set of upland NERICA rice varieties released in Nigeria. The experimental design was Randomized Complete Block Design (RCBD) with three replications. There were 9 plots per replicate and each plot measured 2 by 3 m. In 2007 however, only two NERICA rice varieties (NERICAs 1 and 2) with the least level of stemborer infestation from the 2006 study and two control rice varieties were intercropped with maize and cassava (Table 2). There were a total of 14 plots per replicate and each plot measured 5 m by 5 m. The stemborer resistant maize variety, TZP-SR used was obtained from the International Institute of Tropical Agriculture (IITA) and the cassava was a local variety. In both years, rice seeds in the monocrops were directly sown at a spacing of 20 by 20 cm and seedlings later thinned to one per hole. The rice plots were separated by 40 cm alley from the maize. The plant spacing in the maize monocrops was 20 by 60 cm and seedlings later thinned to one per hole. The cassava stem cuttings were buried 10 cm into the ground at a spacing of 50 cm and later trimmed to one plant per hole. A basal fertilizer application of 30 kg ha⁻¹ each of N, P₂O₅ and K₂O was applied before planting followed by top dressings with 20 kg ha⁻¹ of N at the maximum tillering and early panicle initiation stages. Weeding was done at 21 and 42 Days after Sowing (DAS) and subsequently when necessary.

Table 1: Identity of rice varieties evaluated for stemborer attack under natural infestation at Ikenne Nigeria in 2006

S/N	Rice variety	Remark
1	OS 6	Susceptible check (SCK)
2	LAC 23	Resistant check (RCK)
3	NERICA 1	Test variety
4	NERICA 2	Test variety
5	NERICA 3	Test variety
6	NERICA 4	Test variety
7	NERICA 5	Test variety
8	NERICA 6	Test variety
9	NERICA 7	Test variety

Table 2: Identity of rice varieties with maize and cassava intercropped combinations evaluated for stemborer attack under natural infestation at Ikenne Nigeria in 2007

Rice variety	Intercrop	Intercropping combination
LAC 23 (RCK)	Cassava (local variety, SBR)	LAC 23/Cassava
	Maize (TZP-SR, SBR)	LAC 23/Maize
NERICA 1	Cassava (local variety SBR)	NERICA 1/Cassava
	Maize (TZP-SR, SBR)	NERICA 1/Maize
NERICA 2	Cassava (local variety SBR)	NERICA 2/Cassava
	Maize (TZP-SR, SBR)	NERICA 2/Maize
OS 6 (SCK)	Cassava (local variety SBR)	OS 6/Cassava
	Maize (TZP-SR, SBR)	OS 6/Maize

RCK: Resistant check, SCK: Susceptible check, TZP-SR: Maize variety name, SBR: Stemborer resistant

Assessment of stemborer damage: At 30 and 60 DAS, 20 hills were randomly selected per plot for assessing the intensity of stemborer damage (deadhearts). Scoring for whitehead was carried out at 90 DAS. The scoring and percentage plants with deadhearts and whiteheads were calculated as described in the standard evaluation system for rice stemborers (IRRI, 2009a).

Incidence and abundance of stemborer species: This was carried out following procedure adopted by Duale and Nwanze (1999). Twenty hills were randomly selected per plot and dissected in the laboratory for the species of the stemborer larvae and pupae present. The proportion of each species to the total number of hills was calculated. No insecticide was used in or near the experimental area throughout the study period.

Data analysis: Analysis of variance, mean comparison and unweighted pair group method arithmetic mean (UPGMA) principal component cluster analysis were carried out on % deadheart, % whitehead and % stemborer larvae and pupae (% *M. separata* and % *S. calamistis*) data using SAS statistical software (SAS Institute, 2002-2003).

RESULTS

The effect of intercropping maize with upland NERICA rice varieties on stemborer attack in southwest Nigeria has been evaluated. According to ANOVA results, the assessment of stemborer damage (% whitehead and % deadheart) among 7 NERICA rice varieties initially studied in 2006 was highly significant (1% level), meaning that all the 7 NERICA rice varieties were attacked but with different level of resistant status (Table 3). On the basis of ANOVA results, the assessment of stemborer damage (% whitehead, % deadheart, % *M. separata* and % *S. calamistis*) under maize and cassava intercropping condition with NERICA1 and NERICA2 rice varieties studied in 2007 was highly significant (1 and 5% levels), revealing that NERICA1 and NERICA2 rice varieties as well as their maize and cassava intercropping combinations were attacked but with different level of resistant status (Table 3). Besides, in the 2006 study ANOVA results also revealed significant interaction (1% level) between crop age (30 and 60 DAS) and stemborer attack, indicating that at different age the 7 NERICA rice varieties responded differently to stemborer attack (Table 4).

Table 3: Analysis of variance for % whitehead, % deadheart, % *Maliarpha separatella* and % *Sesamia calamistis* as measure for rice stemborer attack from 2006 and 2007 studies

Source	2006 study			2007 study				
	df	%WH F	%DH F	df	%M F	%S F	%WH F	%DH F
Rep	2	2.08ns	1.78ns	2	<1	1.13ns	7.28**	1.24ns
Variety	8	26.03**	55.93**	11	2.49*	3.54**	3.39**	8.55**
Error	16			22				
Total	26			35				

**Significant at 1% level; *Significant at 5% level; ns: Not significant. WH: Whitehead; DH: Deadheart; M: *Maliarpha separatella*; S: *Sesamia calamistis*

Table 4: Analysis of variance revealing the effect of crop age on rice stemborer attack from 2006 and 2007 studies

Source	%DH For 2006 study		%DH For 2007 study	
	df	F	df	F
Rep (R)	2	1.85ns	2	1.09ns
Treatment	17	29.85**	23	4.58**
Variety (V)	8	59.31**	11	8.44**
Crop age (A)	1	12.17**	1	1.84ns
VxA	8	2.59*	11	<1
Error	34		46	
Total	53		71	

**Significant at 1% level; *Significant at 5% level; ns: Not significant. WHWehead; DH: Deadheart

Table 5: Mean comparison for percentage stemborer damage (deadheart) of nine rice varieties relative to day after sowing without intercropping at Ikenne Nigeria in 2006 wet season.

Variety (V)	Deadheart for 2006 study (%)			
	Crop age (A)		V-Mean	Diff
30 DAS	60 DAS			
OS6	18.67 ^a	15.16 ^a	16.92	3.51*
LAC23	6.36 ^e	6.20 ^{ef}	6.28	0.16ns
NERICA1	4.81 ^e	5.20 ^{fg}	5.01	-0.39ns
NERICA2	5.63 ^e	4.45 ^g	5.04	1.18ns
NERICA3	11.37 ^b	9.64 ^{cd}	10.51	1.73ns
NERICA4	10.38 ^b	10.42 ^{bc}	10.4	-0.04ns
NERICA5	5.84 ^e	4.30 ^g	5.07	1.54ns
NERICA6	11.55 ^b	12.60 ^b	12.08	-1.05ns
NERICA7	12.27 ^b	7.80 ^{de}	10.04	4.47**
A-Mean	9.65	8.42	9.04	1.23

Means followed by the same letter are not significantly different at $p < 0.05$ Fisher's least significant difference, **Significant at 1% level, *Significant at 5% level, ns: Not significant, DAS: Day after sowing.

Besides, in the 2007 study ANOVA results revealed no significant interaction between crop age (30 and 60 DAS) and stemborer attack, indicating that at different age under maize and cassava

intercropping conditions NERICA1 and NERICA2 rice varieties responded in the same way to stemborer attack in contrary to 2006 study without intercropping (Table 4). The percentage stemborer damage on the 7 NERICA rice varieties at 30 and 60 DAS was between 4.81 to 12.27% and 4.3 to 12.6%, respectively (Table 5). The percentage stemborer damage on the NERICA1 and NERICA2 rice varieties and their maize and cassava intercrops at 30 and 60 DAS was between 7.34 to 21.22% and 8.32 to 30.15% respectively (Table 6). The mean stemborer damage in terms of % whitehead and % deadheart among the 7 NERICA rice varieties was between 5.35 to 14.5 and % 5.01 to 12.06%), respectively (Table 7). The mean stemborer damage in terms of % *M. separatella*, % *S. calamistis*, % whitehead and % deadheart, among NERICA1 and NERICA 2 rice varieties and their maize and cassava intercrops was between 58.85 to 85.6%, 14.41 to 41.15%, 4.47 to 8.67% and 15.66 to 51.37%, respectively (Table 8).

The classification of the levels of resistance of the 7 NERICA rice varieties to stemborer damage according to cluster dendrogram was as follows: NERICA1, NERICA2 and NERICA5 together with the resistant check (RCK) LAC23 were classified as stemborer resistant (SBR) and NERICA3, NERICA4, NERICA6 and NERICA7 together with susceptible check (SCK) OS6 were classified as stemborer susceptible (SBS) (Fig. 1). Consequently on the basis of SBR classification, NERICA1 and NERICA2 emerged as the best in terms of stemborer resistance among the 7 NERICA rice varieties studied in 2006 and were used in maize and cassava intercropping study in 2007 to further confirm their resistance status under intercropping condition.

According to principal component cluster dendrogram, the classification of the effects and levels of resistance of NERICA1 and NERICA 2 rice varieties and their maize and cassava intercrops to stemborer damage revealed three major groups (GrA, GrB and GrC) (Fig. 2). GrA was made up of stemborer resistant (SBR) varieties and their cassava intercrop only (NERICA1, NERICA1/Cassava,

Table 6: Mean comparison for percentage stemborer damage (deadheart) of four rice varieties relative to day after sowing with intercropping at Ikenne Nigeria in 2007 wet season

Deadheart for 2007 study (%)				

Crop age (A)				

Variety/intercrop (V)	30 DAS	60 DAS	V-Mean	Diff
LAC23	17.98 ^{ab}	22.62 ^{ab}	20.30 ^{abc}	-4.63ns
LAC23/Cassava	16.73 ^{ab}	15.22 ^{bcd}	15.98 ^{bc}	1.52ns
LAC23/Maize	7.88 ^{cd}	6.60 ^e	7.24 ^e	1.28ns
NERICA1	21.22 ^a	30.15 ^a	25.68 ^a	-8.93ns
NERICA1/Cassava	17.85 ^{ab}	16.95 ^{bc}	17.40 ^{bc}	0.90ns
NERICA1/Maize	8.60 ^{cd}	10.87 ^{cde}	9.73 ^{de}	-2.27ns
NERICA2	17.83 ^{ab}	20.30 ^{ab}	19.07 ^{abc}	-2.47ns
NERICA2/Cassava	10.26 ^{bcd}	18.45 ^{bc}	14.35 ^{cd}	-8.19*
NERICA2/Maize	7.34 ^d	8.32 ^{de}	7.83 ^e	-0.98ns
OS6	25.39 ^a	21.52 ^{ab}	23.45 ^{ab}	3.87ns
OS6/Cassava	15.58 ^{abc}	19.13 ^{abc}	17.36 ^{bc}	-3.55ns
OS6/Maize	15.30 ^{abc}	12.48 ^{b-e}	13.89 ^d	2.82ns
A-Mean	15.16	16.88	16.02	-1.72ns

Means followed by the same letter are not significantly different at p<0.05 Fisher's least significant difference, *Significant at 5% level, ns: Not significant; DAS: Day after sowing

Table 7: Mean comparison for percentage stemborer damage (whitehead and deadheart) of nine rice varieties without intercropping at Ikenne Nigeria in 2006 wet season

2006 study				
Variety	%Whitehead		%Deadheart	
	Ranks	Means	Ranks	Means
OS6	9	16.40 ^f	9	16.92 ^d
LAC23	4	10.50 ^{c,d}	4	6.28 ^a
NERICA1	2	7.90 ^b	1	5.01 ^a
NERICA2	5	11.30 ^{c,d}	2	5.04 ^a
NERICA3	6	12.30 ^{d,e}	7	10.51 ^{b,c}
NERICA4	8	14.90 ^f	6	10.40 ^{b,c}
NERICA5	1	5.35 ^a	3	5.07 ^a
NERICA6	3	9.57 ^{b,f}	8	12.08 ^c
NERICA7	7	14.50 ^{e,f}	5	10.04 ^b
Mean		11.41		9.04

Means followed by the same letter are not significantly different at $p < 0.05$ Fisher's Least Significant Difference; DAS = day after sowing

Table 8: Mean comparison for percentage stemborer damage of four rice varieties with intercropping at Ikenne Nigeria in 2007 wet season

2007 Study								
Variety/Intercrop	% <i>M. separatella</i>		% <i>S. calamistis</i>		% Whitehead		% Deadheart	
	Ranks	Means	Ranks	Means	Ranks	Means	Ranks	Means
LAC23	11	93.22 ^c	2	6.78 ^a	9	8.62 ^{b,c,d}	10	40.60 ^{c,d,e}
LAC23/Cassava	7	80.63 ^{abc}	6	20.36 ^{abc}	8	8.55 ^{b,c,d}	6	31.95 ^{c,d}
LAC23/Maize	6	68.30 ^{abc}	8	31.70 ^{bc}	5	6.67 ^{abc}	1	14.48 ^a
NERICA1	10	85.60 ^{bc}	3	14.41 ^{ab}	2	5.10 ^{ab}	12	51.37 ^c
NERICA1/Cassava	5	68.14 ^{abc}	7	31.19 ^{bc}	3	5.98 ^{abc}	8	34.80 ^{c,d}
NERICA1/Maize	1	58.85 ^a	12	41.15 ^c	1	4.47 ^a	3	19.47 ^{ab}
NERICA2	9	84.12 ^{abc}	4	15.88 ^{ab}	6	6.90 ^{abc}	9	38.13 ^{c,d,e}
NERICA2/Cassava	3	65.59 ^{ab}	10	34.41 ^{bc}	10	8.67 ^{b,c,d}	5	28.71 ^{b,c}
NERICA2/Maize	4	67.71 ^{ab}	9	32.29 ^{bc}	4	6.12 ^{abc}	2	15.66 ^a
OS6	12	94.05 ^c	1	5.95 ^a	12	13.45 ^d	11	46.91 ^{d,e}
OS6/Cassava	2	64.92 ^{ab}	11	35.08 ^{bc}	11	10.35 ^{c,d}	7	34.72 ^{c,d}
OS6/Maize	8	82.34 ^{abc}	5	17.66 ^{abc}	7	7.72 ^{abc}	4	27.78 ^{b,c}
Mean		76.12		23.91		7.72		32.05

Means followed by the same letter are not significantly different at $p < 0.05$ Fisher's least significant difference

NERICA2, NERICA2/Cassava, LAC23 and LAC23/Cassava), GrB formed maize intercrop only of SBR varieties (NERICA1/Maize, NERICA2/Maize and LAC23/Maize) while *GrC* constituted the stemborer susceptible (SBS) variety and its maize and cassava intercrops (OS6, OS6/Maize and OS6/Cassava) (Fig. 2). The basis of GrA cluster in terms of stemborer resistance revealed that both NERICA1 and NERICA2 monocrops and their cassava intercrops showed similar response to stemborer damage, whereas GrB cluster revealed both NERICA1 and NERICA2 monocrops and

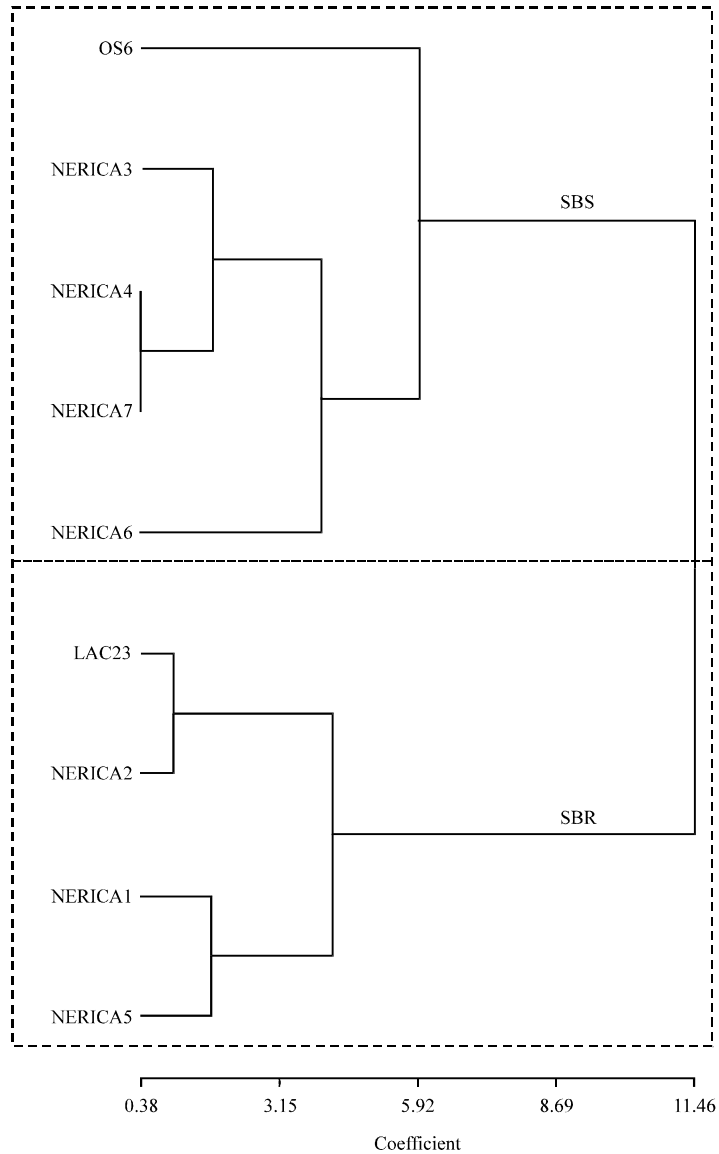


Fig. 1: Unweighted pair group method arithmetic mean (UPGMA) principal component cluster showing stemborer resistance status of 7 NERICA rice and 2 other rice varieties in 2006 study

their maize intercrops have different response to stemborer damage. Therefore, the resistance status of NERICA1 and NERICA2 was further enhanced under maize intercropping condition as critically revealed by GrB cluster (Fig. 2).

DISCUSSION

The current trend in global agriculture which is to search for a highly productive, sustainable and environmentally friendly cropping system has resulted in the renewed interest in cropping systems research (Crews and Peoples, 2004). Two hypotheses, the trap crop and natural enemy hypotheses, postulated by Shelton and Badenes-Perez (2006) were the objectives for the cropping

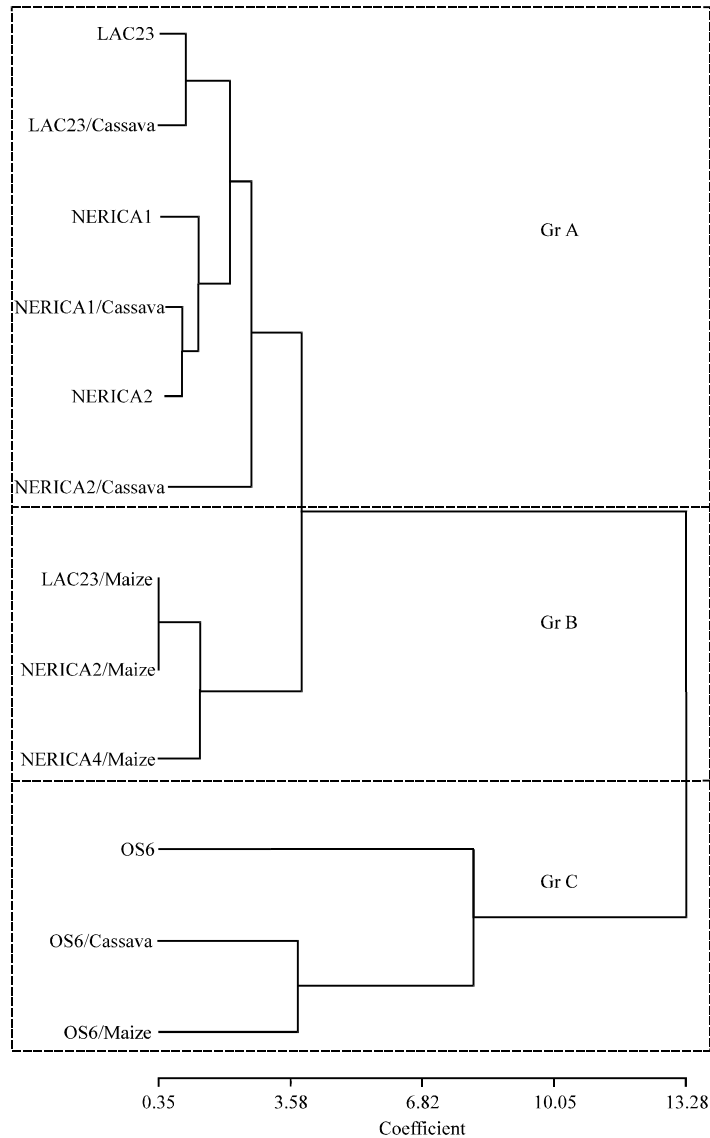


Fig. 2: Unweighted pair group method arithmetic mean (UPGMA) principal component cluster showing the effect of rice/maize intercropping on NERICA stemborer attack in 2007 study

patterns used in the present study. Trap cropping as a control strategy exploits the insects' preference for certain plant species or growth stages of a plant by attracting the pest species away from a nearby main crop (Shelton and Badenes-Perez, 2006). Recent studies in West Africa showed that mixed cropping involving maize and non-host plants such as legumes or cassava, reduced borer infestations by up to 80% (Schulthess *et al.*, 2004; Chabi-Olaye *et al.*, 2005b). Maize was included in the present study to assess its effectiveness as a trap crop for the rice stemborers. The results obtained in the present study indicated that maize diverted some of the stemborers from attacking upland NERICA 1 and NERICA 2 rice varieties under maize intercropping condition as critically revealed by GrB cluster. In the present study, results further points to maize as an effective trap crop for rice stemborers because there was a marked and significant reduction in the stemborer attack on the rice in the NERICA rice/maize intercrops (GrB cluster) as compared to the

NERICA rice monocrops (GrA cluster) and NERICA rice/cassava intercrops (GrA cluster). The reason for the preference could not be farfetched. The sturdier and fuller stems of maize as compared to rice which has a thin and hollow stem could be the reason for the preference for maize as this would provide more readily available food to the stemborer larvae (Heinrichs and Barrion, 2004).

The inclusion of cassava in the study was to observe if it would attract predators such as spiders, cassava predatory phytoseiid mites, etc. and also to observe if the afore-mentioned might have some foraging activity on the stemborers. Results obtained however from the rice/cassava intercrops did not prove this as NERICA rice monocrops and NERICA rice/cassava intercrops formed the same GrA cluster. The reason for this result could be that the cassava variety used for the study does not naturally harbour predators such as spiders and phytoseiid mites and as well does not provide food to the stemborer larvae.

Of the stemborer species that attack cereals in West Africa, four are of major importance on rice which includes the dipterous stalk-eyed fly (*Diopsis longicornis* Macquart), lepidopterous white stemborer (*M. separatella*), striped stemborer (*Chilo zacconius* Bleszynski) and the pink stemborer (*S. calamistis*) (Rami *et al.*, 2002; Nwilene *et al.*, 2008). Two of the afore-mentioned stemborer species, *M. separatella* and *S. calamistis* were observed in the present study to infest upland rice at Ikenne with the population of *M. separatella* being higher than that of *S. calamistis*. Previous studies at M'be, Côte d'Ivoire have shown that *M. separatella* was the most abundant stemborer species in the drought-prone upland and lowland rice ecosystems based on tiller dissections (Heinrichs and Barrion, 2004). In another study carried out at the vegetative, booting and flowering (ripening) stages of rice growth on farmers' fields in Côte d'Ivoire, *M. separatella* was also found to be more abundant than *S. calamistis* at the three stages of the rice growth cycle (Heinrichs and Barrion, 2004). The percent stemborer composition of *C. zacconius*, *M. separatella* and *S. calamistis* in upland and irrigated rice ecosystems in Ibadan, Nigeria revealed *M. separatella* as predominating in both ecosystems (Nwilene *et al.*, 2008). The higher population of *M. separatella* notwithstanding, its feeding damage is unique as it seldom causes deadhearts and whiteheads because of its habit of dwelling at the lower internodes (Heinrichs and Barrion, 2004). This possibly suggests that most of the stemborer damage reported on rice in this study could be attributed to *S. calamistis* since its feeding damage readily results in deadhearts and whiteheads. The population of *S. calamistis* was generally higher in the NERICA rice/maize intercrops than NERICA rice monocrops and the NERICA rice/cassava intercrop suggesting a preference of *S. calamistis* for maize. Linnet and Adele (2001) reported populations of *S. calamistis* to be highest in the upland rice fields near maize, as maize is the preferred host plant. In a study by Songa *et al.* (2007) on the role of intercropping different cereal species in controlling maize stemborers in Kenya, a high infestation of *S. calamistis* was reported not only on monocropped millet but also in maize/millet intercrop. It was observed that *S. calamistis* was predominant on the interspecific NERICA rice varieties while *M. separatella* was predominant on the *O. sativa* varieties (LAC 23 and OS 6). This could also suggest a preference of *S. calamistis* for the interspecific NERICA rice varieties.

CONCLUSION

The NERICA rice varieties are becoming increasingly popular especially amongst farmers for their yield advantage over their *O. glaberrima* and *O. sativa* parents through their superior weed competitiveness, drought tolerance, higher yielding potentials and pest and disease resistance. Of

the upland NERICAs screened in the present studies, NERICAs 1 and 2 stood out as stemborer resistant varieties. They have therefore, proved to be potentially good varieties in stemborer prone areas and as resistant checks in stemborer studies. Also, the importance of intercropping and diversified cropping systems has been discussed and can not be ignored. Apart from its advantages in insect pest control, diversified cropping systems is also helpful for farmers that have limited access to land and inputs such as fertilizer. In the control of rice stemborers, diversified cropping systems involving maize can be an effective tool against stemborer attack.

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