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EVALUATION OF SOME RICE GENOTYPES FOR INCIDENCE OF AFRICAN RICE GALL MIDGE AND ITS PARASITOID (*P. Diplosisae*)

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ABSTRACT

African rice gall midge (AfRGM), *Orseolia oryzivora* Harris and Gagne, is one of the major insect pests of lowland/irrigated rice and could result in considerable economic damage. Host plant resistance and biological control appear to be the most promising control measures adopted so far. Three major rice genotypes (*Oryza sativa*, *Oryza glaberrima* and interspecific rice, New Rice for Africa (NERICA)) are cultivated in Nigeria. In two consecutive years (2008/09), field experiments were conducted at two eco-sites, using the genotypes to determine their influence on the incidence of the gall midge and percentage parasitism by *Platygaster diplosisae*, Risbec (Diptera: Platygateridae), an endoparasitoid that has been identified as the most important natural enemy of AfRGM. The AfRGM tiller infestation and parasitism by the parasitoid were significantly influenced ($P < 0.05$) by the rice genotypes for the two locations and seasons. Tropical *Oryza glaberrima* (TOG) lines showed the highest level of resistance to AfRGM attacks. TOG 7106 gave the highest level of resistance among the TOG lines. The NERICA lines were moderately, resistant with WAS127-IDSA-2-WAS-1-1-1 showing the highest level of resistance across the sites; while the Sativa lines were virtually susceptible to the midge attack across locations and years. ITA 306 recorded the highest level of infestation by the gall midge. However, none of the varieties showed complete resistant to AfRGM attacks. The parasitism by the parasitoid took the same trends as recorded for the gall midge infestation. Thus, integration of midge tolerant varieties with natural enemy enhances AfRGM management.

Key Words: *Orseolia oryzivora, Platygaster diplosisae*

RÉSUMÉ

La cécidomyie africaine du riz (AfRGM), *Orseolia oryzivora* Harris and Gagne, est un des pestes importantes du riz irrigué des bas fonds et pourrait induire des dégats économiques. Il est récommandé d'introduire une plante hôte résistante et un control biologique comme mesure promettante de control de cette peste. Trois génotypes majeurs de riz (*Oryza sativa*, *Oryza glaberrima* et riz interspecifique, "New Rice for Africa" (NERICA) sont cultivés au Nigeria. Pendant deux années consécutives (2008/09), des essais en champs étaient conduits dans deux éco-sites, utilisant les génotypes pour déterminer leur influence sur l'incidence de la cécidomyie et le pourcentage du parasitisme par *Platygaster diplosisae*, Risbec (Diptera: Platygateridae), un endoparasito¿de identifié comme l'ennemie naturelle le plus important de AfRGM. L'infestation de tailles par l'AfRGM et le parasitisme par le parasitoïde étaient significativement influencés ($P \leq 0.05$) par les génotypes de riz pour les deux sites et saisons. Les lignées tropicales *Oryza glaberrima* (TOG) ont manifesté le niveau le plus élevé de résistance à l'attaque de l'AfRGM. TOG 7106 a induit le niveau le plus élevé de résistance parmi toutes les lignées TOG. Les lignées NERICA étaient modérément résistantes, seule WAS127-IDSA-2-WAS-1-1-1 montrant le niveau le plus élevé de résistance à travers les sites; pendant que les lignées sativa étaient virtuellement susceptibles à l'attaque de la cécidomyie à travers les sites et les années. ITA 306 a enregistré le niveau d'infestation le plus élevé face à l'attaque de la cécidomyie. Par ailleurs, aucune des variétés n'a montré une résistance complète aux attaques de l'AfRGM. Le parasitisme du parasitoïde a pris la même tendance que l'infestation de la cécidomyie. Ainsi, l'intégration des variétés tolérante à la cécidomyie avec des enemies naturelles améliore la gestion de l'AfRGM.

Mots Clés: *Orseolia oryzivora, Platygaster diplosisae*

INTRODUCTION

Rice has become the most popular food in Sub-Saharan Africa (Mohapatra, 2006; AfricaRice, 2008). Rice is now the main staple food for about 35 million people or 20% of the Nigerian population, and consumption is increasing faster than that of any other food crop in many countries in Africa (Kormawa *et al*., 2004; AfricaRice, 2005). The recurrent increases in rice prices both at local and international levels have, however, not affect rice consumption. Unfortunately, in Nigeria, rice is produced almost exclusively by small-scale farmers who have little or no hope of increasing their land-holding capacity in most of the African countries. Thus Africa is accounting for 32% of global rice importers in 2006 (Akinbile *et al*., 2007; AfricaRice, 2008). The increase in rice production observed in the recent years has been attributed to increase in area cropped to rice rather than quantitative increase (AfricaRice, 2007).

The production-consumption gap in this region is due to low yield of rice (AfricaRice, 2007). The low yield has been attributed to insect pest infestation, inferior quality of domestic rice vis-a-vis imported rice and poor agricultural systems (AfricaRice, 2007).

Insect pest is one of the major constraints in achieving the yield potentials of many varieties of rice. African rice gall midge, *Orseolia oryzivora* Harris and Gagn**é** (Diptera: Cecidomyiidae), appears to be the most serious insect pest of lowland and irrigated rice in the recent time (Williams *et al*., 1999, Ogah *et al.*, 2005, 2006; Nwilene *et al.*, 2006). *O. oryzivora* is an insect pest indigenous to Africa (Ukwungwu and Misari 1997; Harris *et al*., 1999). Since the establishment of its existence as a distinct species from the Asian rice gall midge *Orseolia oryzae* (Wood - Mason), its pest status and distribution has been on the increase. The status of AfRGM has changed in the recent years, from minor to major pest recorded in many African countries. AfRGM attacks rice at the vegetative stage and destroys the growing primordia, resulting in the formation of a tubular gall or onion shoot. Any tiller attacked is irreversibly damaged and does not produce any panicle. Losses caused by this pest have reached 80% and total crop failure is common in endemic areas (Heinrichs and Barrion, 2004).

The devastating outbreak of *O. oryzivora* and its response to changes and variation in agricultural systems, provided the basis for the adoption of control measures in its management (Ogah *et al.*, 2009). Unfortunately, most rice farmers have limited access to capital, and improved technologies (Nwilene *et al.*, 2008). Development and implementation of appropriate pest management approach in rice cultivation is, therefore, an absolute necessity.

Management of insect pests in Africa for the past 20 years has been dominated by the use of insecticide. However, considering the side effects of chemicals on the environment and on human health, concerted effects are being made to seek for alternative sources of control. In the past two decades, considerable efforts have been directed at integrating host plant resistance with biological agents (Omoloye and Fadina, 2003; Nwilene *et al.*, 2008). The use of biocontrol agents in conjunction with plant resistance may provide an equivalent level of control, with less adverse impact upon the environment than the use of chemicals (Nwilene *et al.*, 2008).

In Nigeria, three major rice genotypes are under cultivation, and diverse complexes of natural enemies of AfRGM have been identified that could reduce AfRGM infestation to tolerable levels (Ukwungwu and Misari, 1997; Ogah *et al.*, 2009). Among these is an endoparasitoid of the midge; *Platygaster diplosisae* Risbec (Diptera: Platygateridae) (Ogah *et al.*, 2009). The lack of information on integrating resistant varieties with biological agents could hinder the value of the compatible control measures against this pest.

Unfortunately, African rice gall midge responds differently to many rice varieties currently available to farmers in Nigeria. Identifying AfRGM responses and improving on varietal resistance appear to be one of the most promising options for managing AfRGM. This is because the Asian resistant varieties have been used with considerable success against the closely related gall midge, the Asian gall midge *Orseolia oryzae* (Wood-Mason).

Rice cultivars have different levels of either resistance or susceptible to pests. Varietal resistance to the gall midge was reported as early as 1920s in India for the Asian gall midge, and commercially high yielding resistant varieties have been produced for that species. However, in Africa, pure breeds with 100% resistant to AfRGM have not been identified (Omoloye and Vidal, 2007). AfricaRice's recent breakthrough in research led to the introduction of new genopype, New Rice for Africa (NERICA) into the Nigeria farming system in 2002. Hence, the present study assesses the reaction of the rice genotypes to gall midge attacks. Understanding the influence of rice varieties on the incidence of AfRGM and its parasitoid is a fundamental issue in IPM and is a practical concern with insects that could course economic damage. The role of parasitoids of AfRGM, particularly *P. diplosisae* has been described (Umeh and Joshi 1993; Ogah *et al*., 2009). The host plant can influence not only the ovipositional activity of AfRGM, but also that of the parasitoids.

MATERIALS AND METHODS

Experimental sites. Field experiments were conducted in two endemic areas in Nigeria for two consecutive years (2008/09). The two outbreak areas were in different agro-ecological zones in Nigeria, with different seasonal climatic patterns. All have recorded regular outbreak of *O. oryzivora* since the late 1980s. The two ecological zones were Ogidiga in south-eastern Nigeria, and Edozhigi in north-central Nigeria. Ogidiga is within the forest-savannah transition agro-ecological zone. It has a latitude 06^o 17' N, longitude 08^o 04' E, and altitude 104.40 m above sea level. Edozhigi is within the Guinea Savannah agro-ecological zone. It has a latitude 09^o 45' N, longitude 06^o 07' E, and altitude 50.57 m above sea level. Both sites have bimodal rainfall patterns with an average annual rainfall of about 1800-2200 mm and 900-1050 mm per *annum* for Ogidiga and Edozhigi, respectively. This is distributed between May and October of each season. The sites have average daily temperature that fluctuates between 20 and 35 ^{o}C, with an annual mean of 26.5 and 27.4 ^{o}C respectively. Their mean relative humidity ranges between 64 - 83 and 52 - 73% for Ogidiga and Edozhigi, respectively. Their soils were Utisol and Alfisol and slightly acidic with 4.5 to 4.9 and 5.5 to 6.3 acidity for Ogidiga and Edozhigi, respectively.

Field experiments. The rice varieties used for the experiments were obtained from Africa Rice Centre (AfricaRice) rice breeders in IITA, Ibadan. The varieties consisted of nine Sativa lines that appeared promising, nine *Oryza glaberrima* lines and nine newly bred lowland NERICA lines added to make a standard set of 27 varieties. The scientific names, origin and species of the genotypes are shown in Table 1.

The fields were laid out in randomised complete block design. All the varieties were transplanted at 2 seedlings per hill, after 21 days of seeding into 150 m^2 plots. Each variety occupied five rows transplanted at 20 x 20 cm inter and intra plant spacing. Dead rice seedlings were replaced at 7th and 14th day after transplanting. All the transplanting at each location was done during the middle of July of each season to coincide with the period of heavy AfRGM infestation. All the treatments were replicated three times. NPK fertiliser was basally applied at 80 kg ha^{-1} (15:15:15). That was followed by top dressing with nitrogen fertiliser. Nitrogen fertiliser in form of urea (80 kg ha^{-1}) was applied in 2 split doses, 50% top dressing 30 days after transplanting and 50% at booting stage of growth. No insecticide was applied to allow natural infestation of the field by both *O. oryzivora* and its parasitoid (*P. diplosisae*).

Data on *O. oryzivora* tiller infestation were collected at 42 and 63 days after transplanting from 20 hills randomly selected from each variety.

Screen house evaluation of the rice varieties. The twenty-seven varieties were seeded in seed

TABLE 1. The selected rice varieties used to access the incidence of *Orseolia oryzivora* and level of parasitism by its parasitoid, *Platygaster diplosisae* in Nigeria

Varieties	Species	Source of entry
WAS 186-B-8-B-1-WAS 2-WAS-1	Interspecific	AfricaRice
WAS 127-IDSA-2-WAS-1-1-1	Interspecific	AfricaRice
WAS 186-B-8-B-1-WAB-1-WAS-5	Interspecific	AfricaRice
WAS 186-B-8-B-1-WAB-1-WAS-3	Interspecific	AfricaRice
WAS 186-B-8-B-1-WAB-1-WAS-4	Interspecific	AfricaRice
WAS 127-IDSA-12-WAS-11-3-1	Interspecific	AfricaRice
WAS 127-IDSA-12-WAS-11-3-2	Interspecific	AfricaRice
WAS 186-B-8-B-WAB-1-WAS-2	Interspecific	AfricaRice
WAS 186-B-8-B-WAB-1-WAS-1	Interspecific	AfricaRice
TOG 7106	*Oryza glaberimma*	Mali
TOG 7206	*Oryza glaberimma*	Cote d' Ivoire
TOG 7442	*Oryza glaberimma*	Nigeria
TOG 5314,	*Oryza glaberimma*	Nigeria
TOG 5882,	*Oryza glaberimma*	Liberia
TOG 6309	*Oryza glaberimma*	Liberia
TOG 6270	*Oryza glaberimma*	Liberia
TOG 9066	*Oryza glaberimma*	Nigeria
TOG 6907	*Oryza glaberimma*	Siera Leone
BW 348-1	*Oryza sativa*	Seri lanka
CISADANE	*Oryza sativa*	Indonesia
AGHANI	*Oryza sativa*	India
T 1477	*Oryza sativa*	India
M BAHI-1	*Oryza sativa*	Benin Republic
JUMOBOR MANO	*Oryza sativa*	Benin Republic
TOS 8091	*Oryza sativa*	Tanzania
TOS 14519	*Oryza sativa*	Gambia
ITA 306	*Oryza sativa*	Nigeria

boxes (90 cm x 60 cm x 7 cm). The seedlings were planted in rows at one seedling per stand, spaced at 3 cm x 3 cm inter- and intra- plant spacing, with each variety occupying a row. Each line consisted of 20 seedlings per row. Dead rice seedlings were replaced at 7th day after planting. The treatments were replicated thrice. Each seed box with the seedlings was placed in an AfRGM mass culture cage in the screen house at 14 days after seeding with 30 females to 10 males, one-day-old *O. oryzivora* for 24 hr. Thereafter, the seed boxes containing the infested seedlings were each placed in another cage containing 30 females to 10 males of one day old *P. diplosisae* in the screen house for parasitism for another 24 hr. Then the boxes were sprayed with water at 2 hrs interval using Hills Master^R hand sprayer for 3 consecutive days to facilitate the entry and survival of the larvae in the rice culms, thereafter they were sprayed twice daily. Eighty kilogramme per hectare of 15:15:15 NPK fertiliser was applied basal. The setup was left in the screen house until galls started to appear. At gall appearance, records were taken on level of *O. oryzivora* infestation in relation to varieties. The level of parasitism was recorded by dissecting all the galls formed from each variety using SH-ZT binocular dissecting microscope with 100X magnifications.

Statistical analysis. Collected data were analysed using ANOVA (SAS, 2003). Then the varieties were categorised using Standard Evaluation System (SES) for rice against AfRGM as described by IRRI (2002) Table 2.

RESULTS

The damage ratings (% tiller infestation) recorded in the field on the different varieties of rice at the two sites, Edozhigi and Ogidiga, during 2008 and

TABLE 2. Standard Evaluation Systems for evaluating rice for resistance to AfRGM (IRRI 2002)

Scale	Percentage tiller infestation
Field test	
0	No damage
1	Less than 1 %
3	1 – 5 %
5	6 – 10 %
7	11 – 25 %
9	More than 25 %
Screen house test	
0	No damage
1	Less than 5 %
3	6 – 10 %
5	11 – 20 %
7	21 – 50
9	More than 50 %

Scale: 0 = Highly Resistant; 1 = Resistant; 3 = Moderately Resistant; 5 = Moderately susceptible; 7 = Susceptible; 9 Highly susceptible

2009 farming seasons are recorded in Table 3. The percentage infestation of *O. oryzivora* was found to have the same trends in the two locations, with few exceptions as indicated in the table. The indices of susceptibility (% tiller infestation) differed markedly among the varieties. The TOG lines showed the highest level of resistance to AfRGM attacks and differed significantly (P< 0.05) from other genotypes, followed by the NERICA lines, while the *Sativa* lines were virtually susceptible to AfRGM.

At Ogidiga, all the TOG lines were resistant with TOG 7106, showing the highest level of resistance across the years and sites, and TOG 6270 gave the least level of resistance. All the NERICA lines, were moderately resistant with WAS 127-IDSA-2-WAS-1-1-1 having the highest level of resistance and WAS 186-B-8-B-1-WAB-1-WAS-4 gave the least level of resistance for 2008 and 2009, respectively (Table 3). In the *Sativa* lines, virtually all the varieties were susceptible to AfRGM attack, however, TOS 14519 showed the highest level resistant and ITA 306 gave the least level of resistance.

At Edozhigi the trend was the same with TOG 7106 showing the highest level of resistance and TOG 6270 gave the least of resistance for 2008 and 2009, respectively. Among the NERICA lines, WAS 186-B-8-B-WAB-1-WAS-3 gave the highest level of resistance while WAS 186-B-8-B-WAB-1-WAS-2 gave the least level of resistance (Table 3). In the *Sativa* lines, the trend observed at Ogidiga site was observed with ITA 306 as the most susceptible variety across the sites, years and growing stages of rice.

At 42 days after transplanting, very low level of infestations were recorded in most varieties across the two locations and years. No significant differences in the percentage infestation were recorded among most rice varieties. However, as the crop aged, differences in the percentage infestation become apparent. At 63 DAT, very high level of infestation was recorded among the susceptible lines, which differed significantly (P< 0.05) from the tolerant and resistant varieties (Table 3).

The gall midge 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 0.1 to 26.4 with TOG 7106 as the highest resistance variety among the TOG lines and differed significantly (P< 0.05) from the NERICA lines. All the NERICA lines, except WAS 127-IDSA-2-WAS-1-1-1, were moderately susceptible (Table 4). WAS 127-IDSA-2-WAS-1-1-1 was moderately resistant and showed the highest level of resistance among the NERICA lines in the screen house. Seven out of the *Sativa* varieties were either highly susceptible or susceptible to gall midge infestation, while M Bahani and TOS 14519 showed resistant threats. ITA 306 still had the highest percentage tiller infestation level which differed significantly from the rest of the varieties.

Rice varieties and level of Parasitism by *diplosisae*. The percentage parasitism by *P. diplosisae* showed the same trend at both sites throughout the experimental periods. At Ogidiga, the percentage parasitism was highest with the *Sativa* lines, with the highest parasitism recorded on ITA 306, followed by the NERICA lines with the highest been recorded in WAS 127-IDSA-2-WAS-1-1-1; while the TOG lines showed the least level throughout the experimental years. The

TABLE 3. Mean percentage tiller infestation of rice by *O. oryzivora* at Ogidiga and Edozhigi at 63 DAT during 2008/09 farming seasons in Nigeria

Varieties	Ogidiga				Edozhigi			
	2008		2009		2008		2009	
	% infestation	SES rating	% infestation	SES rating	% infestation	SES rating	% infestation	SES rating
AGHANI	15.3	S	16.8	S	17.3	S	19.4	S
BW 348-1	27.9	HS	25.3	HS	34.3	HS	25.5	S
CISADANE	28.8	HS	26.7	HS	35.3	HS	25.3	S
ITA 306	31.1	HS	29.6	HS	40.2	HS	28.1	HS
J. MANO	19.5	S	17.8	S	23	S	28.1	HS
M. BAHANI	9.8	MS	7.2	MS	0.1	R	2.1	MR
TOS 14519	3.1	MR	5.8	MS	2	MR	0.8	R
TOS 8091	3.1	MR	3.8	MR	3.9	MR	6.3	MS
T 1477	3.4	MR	4.5	MR	5.9	MS	7.6	MS
TOG 5314	3.1	MR	4.4	MR	0.9	R	0.1	R
TOG 6270	1.4	MR	1.4	MR	3.6	MR	9.1	MS
TOG 6309	1.1	MR	1.2	MR	3.9	MR	8.2	MS
TOG 7106	0.4	MR	0	R	0.1	R	0.1	R
TOG 7206	0.5	MR	2.1	MR	0.1	R	0.1	R
TOG 7442	0.8	R	1	MR	0.1	R	0.5	R
TOG 9066	0.9	R	1.4	MR	0.1	R	0.3	R
TOG5882	0.6	R	0.7	R	0.1	R	0.6	R
TOG6907	1.6	MR	1.7	MR	0.1	R	0.2	R
WAS 127-IDSA-12-WAS-11-3-1	0.5	R	2.5	MR	3	MR	4.4	MR
WAS 186-B-8-B-WAB-1-WAS-1	3.7	MR	2.7	MR	3.1	MR	5.1	MS
WAS 186-B-8-B-1-WAB-1-WAS-3	3.8	MR	2.8	MR	3.5	MR	1.4	MR
WAS 127-IDSA-2-WAS-1-1-1	2.1	MR	2	MR	3.8	MR	3.4	MR
WAS 127-IDSA-12-WAS-11-3-2	4.7	MR	3.9	MR	6	MS	4.9	MR
WAS 186-B-8-B-WAB-1-WAS-2	3.6	MR	2.9	MR	7.2	MS	7.8	MS
WAS 186-B-8-B-1-WAS 2-WAS-1	4.6	MR	4.4	MR	8.2	MS	3.4	MR
WAS 186-B-8-B-1-WAB-1-WAS-4	4.5	MR	4.3	MR	8.2	MS	5.1	MS
WAS 186-B-8-B-1-WAB-1-WAS-5	4	MR	3.3	MR	6.2	MS	2.7	MR
F- LSD (P< 0.05)	1.9		1.3		2.5		2.1	

Scale: 0 = Highly resistant (HR), 1 = Resistant (R), 3 = Moderately tolerant (MT), 5 = Moderately susceptible (MS), 7 = Susceptible (S), 9 = Highly susceptible (HS)

TABLE 4. Mean percentage tiller Infestation of the rice varieties by *Orseolia oryzivora* in the screen house

Varieties	Percentage Infestation	Resistant ranking
AGHANI	7.39	MS
BW 348-1	17.28	S
CISADANE	21.69	S
ITA 306	26.44	HS
JUMOBOR MANO	15.14	S
M. BAHANI	1.78	MR
TOS 14519	2.08	MR
TOS 8091	13.53	S
T1477	15.25	S
TOG 5314	1.86	MR
TOG 6270	5.22	MR
TOG 6309	3.73	MR
TOG 7106	0.11	R
TOG 7206	0.48	R
TOG 7442	1.38	MR
TOG 9066	5.42	MS
TOG5882	0.50	R
TOG6907	0.16	R
WAS 127-IDSA-12-WAS-11-3-1	8.98	MS
WAS 186-B-8-B-WAB-1-WAS-1	8.86	MS
WAS-186-B—8-B-1-WAB-3	8.8	MS
WAS127-IDSA-2-WAS-1-1-1	4.5	MR
WAS127-IDSA-2-WAS-11-3-2	8.53	MS
WAS186-B-8- B-WAB-1-WAS-2	8.90	MS
WAS186-B-8-1-WAS2-WAS-1	9.81	MS
WAS186-B-8-B-1-WAB-1-WAS-4	8.91	MS
WAS186-B-8-B-1-WAB-1-WAS-5	9.90	MS
F- LSD (P< 0.05)	5.6	

Scale: 0= Highly resistant (HR), 1= Resistant (R), 3= Moderately tolerant (MT), 5=Moderately susceptible (MS), 7=Susceptible (S), 9=Highly susceptible (HS)

highest was recorded in TOG 6270 for 2008 and 2009, respectively (Table 5). At Edozhigi, the trend was the same across the varieties for 2008 and 2009, respectively. All the TOG lines were also parasitised with the exception of TOG 7106 and 7206 throughout the years.

In the screen house, the parasitism also varied with the rice varieties and ranged from 0.0 to 20.8 percent (Table 6). The parasitism took the same trend with the percentage infestation. The TOG varieties and NERICA lines were less parasitised by the parasitoid and differed significantly (P< 0.05) from the Sativa lines. Similarly, the Sativa lines had more parasitism with ITA 306 recording the highest level of parasitism.

The correlation between infestation and parasitism was positive and significant (r = 0.67, P < 0.05).

DISCUSSION

The low level of infestation observed at 42 DAT may be attributed to *O. oryzivora* population trend, which was still very low in the field. The low infestation observed may also be attributed to weather factors, which may have not been favourable to its survival. Practical experience and other research have previously established a link between the weather, especially raining pattern during the wet season and *O. oryzivora*

TABLE 5. Mean percentage parasitism by *P. diplosisae* at Ogidiga/Edozhigi during 2008/09 farming seasons in Nigeria

	Percentage parasitism			
	Ogidiga		Edozhigi	
Varieties	2008	2009	2008	2009
AGHANI	16.6	14.1	15.6	14.5
BW 348-1	22.0	17.3	19.8	9.3
CISADANE	24.5	16.6	19.7	19.1
ITA 306	25.4	25.1	23.7	21.9
JUMOBOR MANO	19.4	22.7	17.6	19.1
M BAHANI	0.0	4.3	17.1	17.9
TOS 14519	9.0	2.15	0.0	2.1
TOS 8091	20.1	22.5	23.9	14.9
T 1477	16.2	13.8	14.1	17.9
TOG 5314	2.2	0.0	5.2	8.6
TOG 6270	4.3	4.4	10.4	12.8
TOG 6309	0.0	0.0	11.2	9.0
TOG 7106	0.0	0.0	0.0	0.0
TOG 7206	0.0	0.0	0.0	0.0
TOG 7442	0.0	0.0	0.0	3.8
TOG 9066	0.0	0.0	6.15	6.2
TOG5882	0.0	0.0	3.6	0.0
TOG6907	0.0	0.0	5.7	5.7
WAS 127-IDSA-12-WAS-11-3-1	12.7	5.2	23.6	17.9
WAS 186-B-8-B-WAB-1-WAS-1	18.7	11.7	18.1	5.0
WAS-186-B—8-B-1-WAB-3	13.7	4.3	14.4	9.5
WAS127-IDSA-2-WAS-1-1-1	21.9	13.0	20.2	6.4
WAS127-IDSA-2-WAS-11-3-2	17.1	9.0	16.0	8.1
WAS186-B-8- B-WAB-1-WAS-2	13.8	9.3	18.5	10.9
WAS186-B-8-1-WAS2-WAS-1	13.5	14.2	13.8	12.0
WAS186-B-8-B-1-WAB-1-WAS-4	12.9	3.8	18.7	11.0
WAS186-B-8-B-1-WAB-1-WAS-5	18.7	11.5	14.4	14.2
F- LSD (P< 0.05)	7.3	6.7	9.1	7.0

rate of infestation and development (Umeh and Joshi 1993; Williams *et al.*, 1999; Ogah *et al.*, 2005). It has been reported that gall initiation that mostly takes place at this early vegetative stage of the rice growth stimulates tillering. Thus, when calculated in relation to tillers brought the percentage infestation very low. It also seemed that the ability to compensate, was induced by damage to the primary tillers; hence, compensation was higher in susceptible varieties, which suffered higher damage. However, the level of compensation by tillering rice varieties was independent of the degree of susceptibility to the gall midge. Earlier researchers like Israel *et al.* (1959) working with *Tryporyza incertulas* Wlk, however, found that there was a negative correlation between the number of tillers and percentage of infested tillers at the early seeding stage. They found that the micro-climatic conditions within the stem in the multi tillering varieties seemed to play an important part in reducing the infestation in these varieties at the early growth stages.

The TOG lines showed high levels of resistance to *O. oryzivora* and if adopted on large scale could suppress the pest (Table 3). This confirms the finding of Nwilene *et al.* (2002) that TOG lines showed the highest level of resistance to AfRGM among the rice varieties screened. The higher resistance of NERICA lines against AfRGM

TABLE 6. Mean percentage parasitism of *Orseolia oryzivora* by *Platygaster diplosisae* in the screen house

Varieties	% parasitism
AGHANI	9.5
BW 348-1	12.4
CISADANE	14.4
ITA 306	20.8
JUMOBOR MANO	14.8
M BAHANI	6.0
TOS 14519	1.3
TOS 8091	11.1
T1477	10.5
TOG 5314	2.6
TOG 6270	4.5
TOG 6309	1.8
TOG 7106	0.0
TOG 7206	0.2
TOG 7442	0.6
TOG 9066	1.3
TOG5882	0.3
TOG6907	1.3
WAS 127-IDSA-12-WAS-11-3-1	7.1
WAS 186-B-8-B-WAB-1-WAS-1	8.3
WAS-186-B—8-B-1-WAB-3	6.8
WAS127-IDSA-2-WAS-1-1-1	11.3
WAS127-IDSA-2-WAS-11-3-2	7.5
WAS186-B-8- B-WAB-1-WAS-2	8.2
WAS186-B-8-1-WAS2-WAS-1	8.5
WAS186-B-8-B-1-WAB-1-WAS-4	8.5
WAS186-B-8-B-1-WAB-1-WAS-5	8.4
F- LSD (P< 0.05)	4.8

to sativa may be attributed to its genetic inherent from the *O. glaberrima*. However, NERICA has a greater advantage over the TOG lines in terms of grain yield and quality. Consumer's preference for susceptible rice varieties continues to be an important factor in the prevalence of this pest. Similar observations have been recorded by Rajamani *et al.* (2004) for the Asian rice gall midge.

The differences in infestation between cropping seasons was probably related to the differences in weather factors. Rainfall was more intensive during the 2008 cropping season than 2009.

Among the various rice varieties used in the study in the two locations, the incidence of gall midge was maximum at Edozhigi (Table 3). Though it would be difficult to pin-point the reasons for its high incidence, factors like high mountains as barriers, sub-soil water availability, high humidity, presence of alkaline soils and application of large amount of fertilisers deserve consideration. Hidaka and Peries (1978) reported similar conditions existing in central plain of Thailand for the abundance of rice gall midge. A critical study of these factors existing at Edozhigi would throw light on the ecology of gall midge in other places. This is in line with WARDA (2000), which stated that multi-location trials in four countries have shown that varietal reactions to *O. oryzivora* are highly location specific and this has tremendous implications for *O. oryzivora* resistance screening and breeding.

The role of *P. diplosisae* as natural regulator of the *O. oryzivora* had been reported by several authors (Bâ 2003 and Williams *et al.*, 1999). The results and those of earlier studies (Ukwungwu and Misari, 1997) suggest that *P. diplosisae* is the only indigenous parasitoid with the potentials as natural bio-control agents of *O. oryzivora*. Umeh and Joshi (1993) reported that the decline in gall density observed as parasitism increases with resultant inverted sigmoid shaped curve could be attributed to the roles of the parasitoid.

The results of this study showcased synergistic effect of rice varieties and natural enemies in the management of AfRGM. Earlier researchers have reported the variety/location preferences and dominance of the parasitoid observed in this study. According to Umeh and Joshi (1993), *P. diplosisae* was the dominant parasitoid in Ogidiga. It was the first to establish in the field and maintained a higher percentage parasitism than any other parasitoid ever seen in the field throughout the season and across the years. The gregariousness of *P. diplosisae* and the exploitation of the host early in the season may be advantageous to this species as biological control agent of *O. oryzivora*. Also, the dominant of *P. oryzae* was reported in India (Joshi and Venugopal (1985), and in other Asian countries where *O. oryzae* is a pest (Hidaka *et al.*, 1988).

CONCLUSION

The infestation by African rice gall midge and parasitism by *Platygaster diplosisae* are dependent on rice varieties and are positively correlated. *Platygaster diplosisae* shows great promises as biological control agent for regulating damaging populations of African rice gall midge in Nigeria. Therefore, the integration of available gall midge-tolerant varieties must be pre-eminent in any IPM package developed for AfRGM in Nigeria, since it enhances the efficiency of indigenous natural enemies. Most importantly, smallholder farmers may have no difficulty in adopting this technology, since it is economical, environmentally sound and easy to practice instead of using expensive and dangerous chemicals in the management of AfRGM.

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