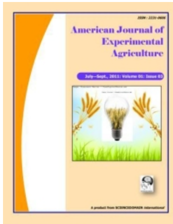

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Screening of Inter-Specific Rice Progeny Lines for African Rice Gall Midge (AfRGM) Resistance

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Authors' Contributions

M. Bashir performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author A.S. Gana and A.T. Maji managed the analyses of the study and literature searches and all the authors including A. A. Shaibu and E. K. Tsado went through the final manuscript.

Research Article

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ABSTRACT

Nine hundred and seventeen inter-specific rice lines were subjected to field screening for African Rice Midge Resistance in both Rainfed and Irrigated lowland ecologies at Badeggi and Edozhigi experimental fields respectively in 2009 cropping season, to determine the levels of African Rice Gall Midge (AfRGM) resistance in Bc_3F_3 inter-specific lines. The field was laid out in an Augmented Block Design, comprising of three blocks with 305 progenies in each block. The checks were randomized three times in each block. The result indicated that the progenies differ significantly in their resistance to AfRGM, four progenies were found to be resistance across the two locations. However, 7 out of the 146 progenies that have good phenotypic acceptability were resistant at Badeggi, while 5 out of 122 progenies with phenotypic acceptability were found resistant at Edozhigi location. Considering both resistance and phenotypic acceptability scores, only 16 progenies were selected for yield trial in both locations.

Keywords: Screening; inter-specific; progeny; gall midge; resistance.

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1. INTRODUCTION

Rice is the stable food for more than three billion people, which is over half of the world's population. It provides 27% of dietary energy and 20% of dietary protein in the developing world. Rice is cultivated in at least 114, mostly developing, countries and is the primary source of income and employment for more than 100 million households in Asia and Africa (FAO, 2004). Of the 840 million people suffering from chronic hunger, over 50% live in areas dependent on rice production (FAO, 2004). About 80% of the world's rice is produced on small farms, primarily to meet family needs, and poor rural farmers account for 80% of all rice producers (FAO, 2004). Less than 7% of the world's rice production is traded internationally (MacLean et al., 2002).

In West African sub-region, whereas the share of the traditional cereals mainly sorghum and millet consumed as food fell from 61% in early 1970 to 49% in the early 1990s and still tending down wards. The share of rice in cereals consumed as food has risen from 15% to 26% within the same period and is still increasing (Akpokdge et al., 2001). Going by the FAO (2000) projection of the West African-sub region rice consumption growth rate of 4.5% through the year 2000, the regional consumption of the staple in the first decade of the 21^{st} century is likely to increase by about 70%.

In Nigeria, rice as an important source of food and cash income to both the urban and rural dwellers of the population is steadily on the increase. WARDA (1996) reported that there has been a structural increase in rice consumption in the country averaging an annual growth rate of 7.7% from 2.1 million tons in 1992 to 2.8 million metric tons in 1996. There are numerous and diverse factors that limit rice production which depends on the agro-ecologies. Basically, they can be classified as abiotic, which include physio-climatic conditions such as drought, flood, soil fertility, nutrient deficiencies and toxicities, erosion etc; and the biotic, which include weeds, diseases, insects and various vertebrate animal pests particularly birds and rodents. In general, yield losses due to insect pests are difficult to quantify due to field and environmental factors and the role of natural enemies of insect pests. African Rice Gall Midge (AfRGM) has been reported to have caused over 80% losses on farmers' field in Abakaliki, Ebonyi state of Nigeria, (Ukwungwu et al., 1998). Yield loss assessments in field with up to 30% tiller infestation suggest that for each 1% increase in tiller infestation, a farmer can expect to lose 2-3% grain yield, (Nacro et al., 1996). Heavily infested fields may produce no grain at all (WARDA, 2000).

Therefore, there is the need to diversify the genetic base of improved rice varieties, and the first step towards this is to evaluate and characterize available rice germplasm or genotypes at the morphological levels. This trial is therefore conducted in order to screen the resistance ability of the B_3F_3 pedigree lines of the crosses made between FARO52, an improved *Oryza sativa* cultivar with Tog 7442 an *O. glaberrima* land race. The lines that are found to be resistance to pest will then be subjected to further yield trail in the subsequent year.

2. MATERIALS AND METHODS

The experiment was established in 2009 cropping season in two locations, namely National Cereals Research Institute experimental field at Badeggi and Edozhigi in Guinea Savannah agro-ecological zone, (Latitude 9°45'N Longitude 6°07'E and altitude 70.5 meters above sea level (msl) for Badeggi location and Latitude 9°45'N and Longitude 6°17'E altitude 50.57 meters above sea level (msl) for Edozhigi location respectively. The field was laid out using

Augmented Block Design (Federer, 1956). The experiment comprises of three blocks with 305 accessions in each block, local checks were randomized three times in a block after every 100 entries. One seedling was transplanted per hill with plot size of 5m long single row for each accession in the field. The fields were mechanically, ploughed, harrowed and leveled. The rice germplasm that was used in this study was lines from a single population of a cross between *O. glabberrima* (TOG 7442) and *O sativa,* FARO 52 (WITA 4). The F_1 was back crossed to WITA 4 to have BC_1-then back crossed to WITA 4 to get BC_2 which was back crossed to WITA 4 to get BC_3. The trial, consisting of 917 accessions and three different checks (FARO 37, FARO 52 and Tog 7442), were collected from National Cereals Research Institute rice breeding unit. The seeds were sowed on the nursery bed before they were transplanted at 21 days old with a spacing of 20 cm x 20 cm. Fertilizer application includes NPK 15:15:15 as basal application at the rate of 150 kg/ha during land preparation and urea that was applied is at the rate 50 kg /ha as top dressing first at tillering and second time at booting stage. Manual hand weeding was carried out at 21 and 42 Days after transplanting. Galls which are symptoms of insect damage or level of infestation were counted on all the twenty five plants in each row at 42 and 63 days after transplanting. The total number of tillers from each of the twenty five plants was also counted. Percentage hill and tiller infestations were computed using the following formula.

$$\text{Infested hill percentage} = \frac{\text{No of infested hills}}{\text{Total number of hill}} \times 100$$

$$\text{Infested tiller percentage} = \frac{\text{No of infested tillers}}{\text{Total number of tillers}} \times 100$$

Tiller damage levels were expressed as scores between the values of 0 and 9, according to standard evaluation system for rice (IRRI, 1986) as shown below.

Scores	**Percentage tiller damage**	**Rating (reaction)**
0	No damage	highly resistance or immune
1	Less than 1%	resistance
3	1-5%	moderately resistance
5	6-10%	moderately susceptible
7	11-25%	susceptible
9	Above 25%	highly susceptible

3. RESULTS

3.1 Reaction of Checks Entries to AfGRM Infestation

AfRGM infestations were generally high in 2009 wet season at both locations. Of the 3 check entries evaluated, Tog 7442 used as resistance check and donor of resistant gene, had scores of 0.78 and 13.83% tiller infestation at 42 DAT in Badeggi and Edozhigi respectively. The two other checks FARO 37 and FARO 52 (the recurrent parent of the progeny) showed susceptible reaction. Percent tiller damage at 63 DAT across the two locations showed no significant difference. Tog 7442 gave the least score of 32.66% as compared with FARO 52 and FARO 37 with scores of 47.8% and 41.7% respectively.

Hill infestation which is a measure of the spread of the insect in the field showed that, Tog 7442, had the least damage at 42 DAT with score of 5.9% at Badeggi and 6.0% at Edozhigi as compared to the susceptible checks FARO 37 (9.0%) and FARO 52 (22.0%). At 63 DAT, Tog 7442 showed the least significant damage of 96% compare with susceptible checks FARO 52 and FARO 37 with score of 99 and 98% respectively. The percent hill infestation in Edozhigi at 42 DAT and 63 DAT showed no significant difference.

Table 1. Mean AFGRI score of check entries at two periods and two locations

Check entry	Badeggi				Edozhigi			
	Tiller infestation		Hill infestation		Tiller infestation		Hill infestation	
	42 (DAT)	63 (DAT)	42 (DAT)	63 (DAT)	42 (DAT)	63 (DAT)	42 (DAT)	63 (DAT)
FARO 52	4.78	42.50	22.00	98.80	18.00	41.67	39.83	97.33
FARO 37	3.22	38.30	9.00	98.10	19.83	37.00	57.17	92.66
TOG 7442	0.78	37.30	5.89	96.00	13.83	26.00	32.66	90.5
CV%	101.2	16.3	103.8	2.2	34.5	40.8	48.3	14.3
LSD (0.05%)	2.95	N/S	12.75	2.19	N/S	N/S	N/S	N/S

DAT= Days after Transplanting, LSD = Least Significant Difference, CV = Coefficient of variation

3.2 Ranking of Rice Progenies to Different Gall Midge Reaction at 42 and 63 DAT

The result in the Table 2 shows that at 42 DAT in Badeggi, 103 progenies were found to be resistant with scores of less than 1%, 579 progenies were moderately resistant with scores of less than 3% and the remaining progenies were susceptible. In Edozhigi, 740 progenies were found to be susceptible with scores greater than 5%. It was observed that tiller % at 63 DAT across the two locations showed high susceptibility of 776 and 548 progenies in Badeggi and Edozhigi, respectively and only 15 and 21 progenies are found to be moderately resistant at Badeggi and Edozhigi.

Forty two (42) DAT hill damage assessment at Badeggi showed 261 progenies resistant, 496 were moderately resistant and 831 were highly susceptible with scores greater than 9%. This is in contrast to the scores at Edozhigi at 42 and 63 DAT with 605 and 768 progenies susceptible, respectively, and only 5 and 16 progenies are found to be resistant at 63 DAT across the two locations based on percent hill damage.

Table 2. Distribution of entries to different classes of Rice gall midge reaction on tiller and hill percentage at 42 and 63 DAT

SES	Badeggi				Edozhigi			
	Tiller infestation		Hill infestation		Tiller infestation		Hill infestation	
	42 DAT	63DAT	42 DAT	63DAT	42DAT	63DAT	42DAT	63DAT
0	-	-	-	-	-	-	-	-
1	103	-	261	5	4	-	-	16
3	579	15	538	-	20	21	2	-
5	142	11	76	-	92	15	-	3
7	87	115	42	56	698	215	229	127
9	6	776	-	856	102	666	686	772

0 = Immune, 1= Resistant, 3 = Moderately Resistant, 5 = Moderately Susceptible, 7 = Susceptible, 9 =Highly Susceptible. DAT= Days after Transplanting. SES = Standard Evaluation System

Table 3 shows that out of the 917 progenies evaluated, four resistant progenies across the two locations were FAROX 521-H559-1, FAROX 521-H880-1, FAROX 521-H521-1, FAROX 521-H688-1. Seven progenies were identified as resistant with good agronomic characteristics in Badeggi at 63 DAT namely FAROX 521-H686-1, FAROX 521-H878-1, FAROX 521-H433-1, FAROX 521-H473-1, FAROX 521-H493-1, FAROX 521-H558-1 and FAROX 521-H698-1. At Edozhigi five progenies that combine resistance and good agronomic traits were also selected. They are FAROX 521-E559-1, FAROX 521-E847-1, FAROX 521-E900-1, FAROX 521-E430-1 and FAROX521-E612-1. The 16 selected progenies based on the resistance and good agronomic characters with the three local checks FARO 37, FARO 52 and TOG 7442 will be evaluated for yield potential.

Table 3. Number of selected progenies based on resistance at 63 DAT and phenotypic acceptability at maturity

Class of selection	Badeggi	Edozhigi	
Phenotypic acceptability	**122**	**146**	
Resistance progenies @1%	254	187	
Resistance progenies common at the locations	4	4	= 4
Phenotypic acceptability + Resistance	7	5	= 12
Total for the resistance progenies			16

4. DISCUSSION

4.1 Reaction of *O. sativa* and *O. glaberrima* Checks to AfRGM at 42 and 63 DAT

Field Screening of parents at the two locations confirmed various reports on the high level of susceptibility to AfRGM in *O. sativa* as compared to *O. glaberrima* the indigenous African rice. Generally, there were high AfRGM infestations at the two locations. Thus, the least tiller damage recorded by *O. glaberrima* line was 0.78 and 13.85% at Badeggi and Edozhigi, repectively. This is in line with the findings of Singh et al. (1996) that some of the *O. glaberrima* lines such as Tog 7442 and Tog 7206 were immune to AfGM in Nigeria.

There is a close similarity in gall midge susceptibility of FARO 52 and FARO 37 with their tiller damage records of 4.78, 3.22% at Badeggi and 18.00 and 19.83% at Edozhigi respectively, at 42 DAT. This shows a high level of infestation at early stage in Edozhigi. Ukwungwu et al*.* (1998) recorded the highest tiller infestation of 5.7% in a field screening experiment for the Tog5860 at Okptumo as compared to 19.5% recorded on IITA 306 (FARO 37) in the same trial. Similarly, field evaluation of parents further confirmed that tiller damage percentage at 63 DAT across the two locations showed no significant difference; this might be due to high insect infestation.

Tog 7442 gave the least score of 26.0% as compared to FARO 37 and FARO 52 with scores of 41.67 and 37.00% respectively, Williams et al., 1999 also reported *O. glaberrima* lines to be susceptible in Burkina Faso and Mali, with Tog 7442 which is hardly infested in any field trial in Nigeria recording up to 10.75% tiller infestation.

4.2 Classification of Rice Progenies to Different Gall Midge damage sores at 42 and 63 DAT

Varietal resistance is a key component of integrated pest management (Singh et al., 1998), screening for host-plant resistance is ongoing in fields at hot-spot locations in Nigeria. Considerable diversity was observed in the reactions of 917 rice progenies to AfRGM at Badeggi and Edozhigi. The result revealed that at Badeggi, 103 progenies were identified to be resistant at 42 DAT with tiller damage scores less than1% and 579 were moderately resistant with scores less than 3%.This might be attributed to low gall midge infestation at the beginning of the season. Furthermore, at 63 DAT only15 progenies were found to be moderately resistant; this might be due high gall midge infestation at the peak of the season. This result is in line with the findings of Ukwungwu et al. (1992) who observed that, out of the lines screen under artificial infestation, only two lines, Agani and NAHTA 8 were moderately resistant.

At Edozhigi it was also revealed that, at 42 DAT, 4 progenies were found to be resistant with tiller damage scores less than 1% and 20 were moderately resistant at less than 3% tiller damage level. Also 21 progenies were found to be moderately resistant at 63 DAT. This agrees with the findings of Ukwungwu et al. (1991). Out of the lines he evaluated at Edozhigi only 32 lines had less than 5% tiller infestation.

5. CONCLUSION

Field screening at Badeggi and Edozhigi were conducted to identify African Rice Gall Midge resistant cultivars with good agronomic characteristics. The study discovered that out of the 917 progenies tested only 16 progenies were promising to be resistant to African rice gall midge. These lines should be evaluated further to identify materials for further genetic improvement work and release to the rice farmers in the region facing African rice Gall Midge challenges.

6. RECOMMENDATION

It is recommended that the rice lines from this study be evaluated in different environment in order test there genotype by environment interaction and identify their stability and response to African Rice Gall Midge.

COMPETING INTRESTS

Authors have declared that no competing interests exist.

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