International Scholars Journals

African Journal of Agriculture ISSN 2375-1134 Vol. 7 (1), pp. 001-006, January, 2020. Available online at www.internationalscholarsjournals.org © International Scholars Journals

Full Length Research Paper

Responses of *Oryza glaberrima* accessions to rice stresses and their morphological characteristics

Maji A. T.[1], Gana A. S.[2]* and Ukwungwu M. N.[1]

[1]National Cereals Research Institute Badeggi, Bida, Niger State, Nigeria.

[2]Department of Crop Production, Federal University of Technology, Minna, Niger State, Nigeria.

Accepted 12 September, 2019

Oryza glaberrima **accessions were characterized for their tolerance to drought, African rice gall midge, blast and some agronomic traits to source for donor resistant genes. The experiment was conducted at both Badeggi and Edozhigi. The blast and drought experiments were drilled in a single row of 70 cm each spaced 20 cm apart at Badeggi. While the African rice gall midge and morphological characterization experiments were conducted in a randomized complete block design replicated three times. Entries were planted in a single row of 5 m each in the replicate and spaced 20 x 20 cm. Result for African rice gall midge (AfRGM) at the two locations showed that there were resistant genes available in this population. 16% of the entries showed immune reaction (score 0) to the insect at Badeggi. At Edozhigi location none of the entries was immune or resistant, however 4% were moderately resistant (score 3). Result of drought screening showed that 27% of the entries showed resistant reaction at 32 days of water stress. Blast reaction at 5 weeks showed that none had resistant reaction to disease. The morphological description showed high variability among the entries. Therefore useful donor genes for drought and African rice gall midge could be made available in this population. TOG 6892 and 7270 could be selected for AfRGM, drought and early stage blast.**

Key words: *Oryza glaberrima* germplasm, resistance-rice-biotic, abiotic stresses.

INTRODUCTION

African rice, *Oryza glaberrima* is the second cultivated rice species and originated from West Africa sub-region (Grist, 1986). As its evolutionary center, the region also serves as its center of diversity for both cultivated and related wild species. Following the introduction of *Oryza sativa* from Asia and its wide acceptance, the African rice is being replaced in rice production fields. This constitutes a potential problem of genetic erosion. *O. sativa* is preferred to *O. glaberrima* because of higher grain yield, better grain qualities and wide adaptability to rice production ecologies and agronomic practices. However the *O. glaberrima* is generally adapted to rice biotic and abiotic production constraints of Africa (IRRI, 1976; Chang et al., 1977; Nq et al., 1991; Maji, 1994).

Attere and Fatokun (1993) and Paul et al. (1992) reported availability of immune lines for Rice Yellow Mottle virus in *O. glaberrima* and that no immune cultivars have been observed in *O. sativa*. Also Singh et al. (1996) and Williams et al. (1999) have also found high levels of resistance to African rice gall midge in *O. glaberrima* while no resistant lines have been identified in *O. sativa*. Realizing the genetic potential in *O. glaberrima,* both National and International Research Organizations working on rice are making efforts to utilized useful donor genes form *O. glaberrima* to be incorporated in the high yielding *O. sativa* cultivars which are often susceptible to several biotic and abiotic constraints of rice.

The success of gene introgression from the two species will essentially depend on the understanding of the different genetic markers existing within the *glaberrima* complex. Therefore this study was to identify donor genes for some rice stresses and agronomic adaptability of these materials to rice growing ecologies.

*Corresponding author. E-mail: andrewganasaba@yahoo.com. Tel: +234 8036373556.

Table 1. Scale used for scoring AfRGM.

SES score	Rate	Percent tiller infestation
0	Highly resistant (HR)	0
1	Resistant (R)	< 1
3	Moderately resistant (MR)	1 to 5
5	Moderately susceptible (MS)	6 to 10
7	Susceptible (S)	11 to 25
9	Highly susceptible (HS)	>25

Table 2. Drought score at vegetative stage.

Scale	Description	Rate
0	No symptoms	Highly resistant (HR)
1	Slight tip drying	Resistant (R)
3	Tip drying extended to ¼ length in most leaves	Moderately resistant (MR)
5	¼ to ½ of the leaves fully dried	Moderately susceptible (MS)
7	More than 2/3 of all leaves fully dried	Susceptible (S)
9	All plants apparently dead	Highly susceptible (HS)

Table 3. Scale used for scoring blast.

Scale	Description	Rate
0	No lesions observed	Highly resistant (HR)
1	Small brown specks of pin point size	Resistant (R)
3	Small roundish to slightly elongated, necrotic gray spots 1 to 2 mm.	Moderately resistant (MR)
5	Lesions 3 mm longer infecting up to 4 to 26% of the leaf area	Moderately susceptible (MS)
7	Lesions infecting 26 to 50% of the leaf area.	Susceptible (S)
9	More than 50% of the leaf area affected	Highly susceptible (HS)

MATERIALS AND METHODS

Seeds of the accessions were obtained from the West African Rice Association Development Rice germplasm unit. The materials were evaluated for drought tolerance in 2003, leaf blast and African rice gall midge (AfRGM) in 2004. The materials were also evaluated for some agronomic and grain characters at Edozhigi in 2004.

African rice Gall Midge screening

The screening was done at Badeggi (latitude 9° 045^{1}N and longitude 6° 07^1 E.) and Edozhigi (Latitude 9° 05^1 N and longitude 5° 50^{1}E). The entries were seeded in the nursery beds at both Badeggi and Edozhigi on 12/08/03 and 1/08/03 transplanted on 10/09/03 and 22/08/03 respectively. Each entry was transplanted in a single row of 5 m spaced 20 cm within rows. The gall midge score was taken at 63 days after transplanting (DAT). Galls were counted on ten hills per test entry. Percent tiller damage was calculated as per number of tiller infested by the insect over total number of tillers multiply by hundred (Table 1).

Drought screening

Drought screening was done in the dry season of 2003. Each entry was drilled in to a 70 cm row spaced 20 cm apart. Four checks with known reaction to drought were randomized between every 5 entries. The materials were watered for 21 days after seeding and water was withdrawn for another 32 days before drought tolerance was scored. The scores were based on standard evaluation system for rice (IRRI, 1996) (Table 2).

Blast screening

Blast screening was done in the rainy season of 2003. The blast innoculum was sought from the blasted leaves of Faro 52 collected from Edozhigi fields. They were crushed and filtered. The extract was used to spray both the spreader rows and the test entries two weeks after the test entries were seeded. The seeding was done on 8/09/03. Spreader rows surrounding the test entries along the edges were seeded on 22/08/03. This was made of mixture of FARO 52 and FARO 29 at the ratio of 1:1. The blast score was done at 3 and 5 weeks after inoculation (WAI) using standard evaluation system for rice. (Table 3).

Morphological characterization

Morphological characters were taken on plant height (PHT), total grain weight (TGW), panicle length (PL), grain number per panicle

(GNP), panicle branch per plant (PBP), panicle weight (PW), hundred grain weight (HGW), grain width (GW) and grain length (GL). Also grain color (GC), sterile lemma type (SLT) and presence of awns were taken.

RESULTS

Reaction of the entries to the three stresses is as shown in Table 4. The response of the entries to AfRGM at Edozhigi showed that most of the entries are at suscepti-ble level (percentage tiller infestation more than 11%). TOG 7594 (4.9%) and TOG 7420 (4.8%) were the only entries with moderate resistant genes. None of the ent-ries had highly resistant (score 0) or resistant (score 1) genes. Eleven entries had moderate susceptible reaction to the insect (tiller infestation of between 5 to 11%). Gall midge score at Badeggi showed that most entries were also susceptible. TOG 5292 was highly susceptible (per-centage tiller damage more than 25%). At Badeggi loca-tion unlike the Edozhigi, four entries were immune to the insect that is no gall in the test materials. They are TOG 6754, 6892, 7145 and 7270. Two other entries were also moderately resistant; they are TOG 6597 and CG 17.

Result of the drought score indicated that some entries showed resistant genes after 32 days of withdrawing water. Thirteen entries were resistant to drought (score rate of 1). These entries are TOG 5292, TOG 5278, TOG 5649, TOG 5687, TOG 5835, TOG 6582, TOG 6591, TOG 6594, TOG 6664, TOG 6668, TOG 6688, TOG 7391 and CG 17. Eight entries were susceptible to the stress while the others are between moderate suscepti-bility and moderate resistance. Reaction to blast taken at 3 and 5 weeks indicated various levels of infestation. At three weeks of score six entries were resistant, they are TOG 5378, 5687, 5885, 6080, 6674 and 6762. Most of the entries showed moderately resistant reaction at that date. At five weeks of score the level of susceptibility to the disease increased. None of the entries showed resis-tant genes at that rate. Only two entries were moderately resistant (TOG 6692 and 6762).

The results of the data obtained for the morphological description are shown in Table 5 Plant height ranged between 25 cm (TOG 5476) to 121 cm (TOG 5709). Mean height among the entries was 78.27 cm. There was a low coefficient of variability for plant height in this popu-lation. The highest grain weight was 24.1 g which was obtained by TOG 6754. TOG 6773 had the least grain weight. Mean value was 9.8 g. Panicle length ranges between 11 cm (TOG 6135) to 23.8 cm (TOG 5495). Panicle length has a high coefficient of variability of 29.19%. The mean value for panicle length was 18.1 cm. The highest grain number per panicle was TOG 5725 with a value of 94 while the lowest was TOG 5638 having a value of 19. The average is 55.62. Number of panicle branch per plant ranged from 4 (TOG 5429, 5650, 6135) to 30 (TOG 5681), with average of 10.31. For panicle weight the highest was 2.2g, which was obtained by TOG 5307 with a mean of 1.09g. Hundred grain weight ranged from 1.15 g (TOG 6689) to 3.14 g (TOG 5815). The mean value was 2.40 g. The data for grain width gave an aver-age of 1.63 mm. The highest value of 2.55 mm was obtained by TOG 6773 and the least value was from TOG 5495, 5953, 6570 and 6603 (1.52 mm).

The average length was 7.32 mm. CG 17 showed the longest grain length of 8.8 cm while TOG 5882 was the least with a value of 5.8. Twenty varieties were straw colored while 18 had black color grains. Only two varie-ties showed the presence of awns, these are TOG 6594 and 5681.

DISCUSSIONS

The number of tillers on percentage basis on which galls can be seen (percent tiller infestation) is commonly used as a measure of the level of midge infestation on the rice crop. High levels of infestation were recorded in this study. 16% of the varieties were immune at Badeggi while 4% were moderately resistant at Edozhigi. 65% were susceptible to highly susceptible at Edozhigi and 57% at Edozhigi. Resistant reaction to AfRGM among the *O. sativa* varieties has not been identified (Gana et al., 2002; Gana, 2006). Singh et al. (1996) and Williams et al. (1999) have identified high immunity levels in *O. glaberrima* as against none in *O. sativa.* These materials could be used as donor genes for hybridization programs. In drought studies leaf rolling, leaf tip burn, which is used to measure drought occurrence were used as an indica-tion of tolerance. 27% of the entries showed resistant reaction at 32 days of water stress. Only 16 % and 2% were susceptible and highly susceptible at that date.

Most lines were moderately resistant to moderately susceptible. Chen et al. (1993) in their screening of 2953 accessions of rice observed that 42 were highly resistant, 79 resistant, 1255 moderately resistant and 1733 suscep-tible to highly susceptible to drought. Gana (2006) obser-ved that most sativa lines screened were susceptible at 28 days of water stress. Therefore resistant traits for drought which could be used for hybridization programs and generate high heritability values is 27% in this population. The reaction of these experimental materials to blast is an indication of genes available to be used for the control of the disease. At 5 weeks, none of the varieties appeared to possess highly resistant or resistant reaction, that is, a score rate of 0 or 1. Which shows that major gene resistance for blast which has a high habita-bility value is absent in this population (WARDA, 1999). For hybridization programs, cultivars that are completely immune or highly resistant provide easy transfer of gene than cultivars with the value of 3 and above (WARDA, 1999). At score rate of 3 cultivars have resistant reactions that are durable since they contribute multiple genes that confer partial resistance to the host plant (Bonman et al., 1992).

Most entries had moderately susceptible reaction to the

Table 4. Reaction of the entries to the stresses and their level of resistance.

Varieties	AfRGM at Edozhigi (%)		AfRGM at Badeggi (%)		Drought score		Blast score at 3 weeks		Blast score at 5 weeks	
TOG 5282	34.8	HS	19.0	S	7	S	4	MS	4	MS
TOG 5292	22.3	S	34.6	HS	1	R	3	MR	5	MS
TOG 5307	19.6	S	22.3	S	7	S	4	MS	4	MS
TOG 5378	17.4	S	19.6	S	1	R	1	R	5	MS
TOG 5397	30.5	HS	17.4	S	5	MS	-	-	5	MS
TOG 5508	23.2	S	14.2	S	3	MR	6	S	6	S
TOG 5514	16.7	S	23.2	S	5	MS	3	MR	4	MS
TOG 5649	20.4	S	11.0	S	1	R	4	MS	5	MS
TOG 5660	17.0	S	20.4	S	3	MR	4	MS	5	MS
TOG 5687	9.2	MS	10.8	MS	1	R	1	R	4	MS
TOG 5709	5.4	MS	9.2	MS	3	MR	3	MR	4	MS
TOG 5747	24.7	S	20.0	S	3	MR	3	MR	4	MS
TOG 5775	16.1	S	24.7	S	7	S	5	MS	6	S
TOG 5835	13.2	S	8.7	MS	1	R	2	MR	4	MS
TOG 5885	8.8	MS	14.5	S	5	MS	1	R	4	MS
TOG 5963	13.6	S	-	-	5	MS	2	MR	4	MS
TOG 5976	9.3	MS	13.6	S	3	MR	2	MR	5	MS
TOG 6080	-	-	30.2	HS	7	S	1	R	4	MS
TOG 6220	14.9	S	-	-	7	S	3	MR	5	MS
TOG 6549	18.6	S	16.0	S	3	MR	2	MR	6	S
TOG 6582	30.4	HS	19.0	S	1	R	3	MR	5	MS
TOG 6584	15.5	S	30.4	HS	3	MR	3	MR	4	MS
TOG 6591	17.0	S	15.5	S	1	R	8	HS	4	MS
TOG 6594	4.5	MR	17.0	S	1	R	4	MS	6	S
TOG 6597	14.0	S	4.5	MR	5	MS	3	MR	4	MS
TOG 6639	18.5	S	25.7	HS	5	MS	3	MR	6	S
TOG 6655	8.3	MS	18.5	S	5	MS	3	MR	6	S
TOG 6664	7.8	MS	8.3	MS	1	R	3	MR	6	S
TOG 6668	13.3	S	7.8	MS	1	R	5	MS	8	HS
TOG 6674	10.6	MS	19.4	S	3	MS	1	R	6	S
TOG 6688	8.5	MS	16.7	S	1	R	3	MR	5	MS
TOG 6689	26.5	HS	8.5	MS	5	MS	2	MR	4	MS
TOG 6692	8.3	MS	26.5	HS	3	MR	2	MR	3	MR
TOG 6700	17.2	S	15.2	S	5	MS	3	MR	4	MS
TOG 6711	18.8	S	17.2	S	7	S	3	MR	5	MS
TOG 6754	18.1	S	0	HR	7	S	3	MR	5	MS
TOG 6762	20.6	S	18.1	S	3	MR	1	R	3	MR
TOG 6767	8.5	MS	20.6	S	5	MS	3	MR	4	MS
TOG 6773	-	-	8.5	MS	7	S	2	MR	4	MS
TOG 6892	15.3	S	0	HR	3	MR	2	MR	6	S
TOG 6927	15.4	S	15.3	S	3	MR	3	MR	5	MS
TOG 6943	22.6	S	15.4	S	9	HS	3	MR	5	MS
TOG 7145	12.2	S	0	HR	5	MS	4	MS	6	S
TOG 7270	16.7	S	0	HR	3	MR	3	MR	5	MS
TOG 7318	20.0	S	16.7	S	3	MR	4	MS	6	S
TOG 7391	10.3	MS	32.1	HS	1	R	2	MR	4	MS
TOG 7420	4.8	MR	-	-	3	MR	3	MR	6	S
CG 14	11.9	S	6.8	MS	3	MR	2	MR	4	MS
CG 17	23.5	S	2.19	MR	1	R	2	MR	6	S

Table 5. Morpho-physiological description of *Oryza glaberrima* germplasm at Edozhigi, Niger State.

Entries	PHT (cm)	TGW (g)	PL (cm)	GNP	PBP	PW (g)	HGW (g)	GC	SLT	Awn	GW (mm)	GL (mm)
TOG 5282	81	13	19	65	6	1.1	2.39	-	-	-	1.54	7
TOG 5292	66	12.8	19	57	5	0.95	2.95	Straw	Short	Absent	2.12	8.2
TOG 5307	110	13.4	23.1	77	22	2.2	2.82	Straw	Short	Absent	1.95	7.2
TOG 5378	106	12.8	20.2	56	10	1	2.6	Black	Short	Absent	1.53	7.6
TOG 5397	71	13.8	15.6	48	21	1.1	2.82	Straw	Short	Absent	1.93	7.2
TOG 5429	77	13.4	13.6	45	4	1.1	2.48	Black	Short	Absent	1.54	7.2
TOG 5457	78	13.3	17.7	67	9	1.5	2.41	Braw	Short	Absent	1.53	7
TOG 5473	93	8.5	21	37	17	0.5	2.69	Braw	Short	Absent	1.54	7.2
TOG 5474	69	9.6	15	41	10	0.97	2.96	-	-	-	1.75	8
TOG 5476	25	6.1	15.3	54	11	1.3	2.65	Black	Short	Absent	1.53	8
TOG 5484	76	5.3	17.6	56	12	1.3	2	Absent	Short	Straw	1.53	6.6
TOG 5491	75	13.4	18.2	39	19	0.85	2.66	Straw	Short	Absent	1.54	7.6
TOG 5495	78	12.1	23.8	74	7	1.4	2.21	Braw	Short	Absent	1.52	8.2
TOG 5533	85	20.3	20.7	71	17	1.2	2.25	Black	Short	Absent	1.53	7.4
TOG 5638	65	12.2	12.3	19	11	0.33	2.21	Braw	Short	Absent	1.53	7.2
TOG 5650	84	5.2	17.4	51	4	1.2	2.33	Black	Short	Absent	1.53	7.4
TOG 5685	100	10.8	18.8	57	12	0.8	2.31	-	-	-	1.53	8
TOG 5687	76	4.7	13	23	5	0.63	2.54	Straw	Medium	Absent	1.54	7.4
TOG 5709	121	7.5	21.9	53	10	2.1	2.12	-	-	-	1.53	7
TOG 5725	73	3.7	17.6	94	9	1.4	2.13	Straw	Short	Absent	1.53	7.4
TOG 5775	65	5.8	16.8	38	8	0.76	2.7	-	-	-	1.73	7.2
TOG 5815	75	11.2	18.2	43	7	0.45	3.14	-	-	-	1.73	8.6
TOG 5832	64	13.2	17.8	63	9	1.5	2.4	-	-	-	1.54	7
TOG 5835	94	10.2	17.1	41	7	0.7	1.97	Straw	Short	Absent	1.52	7.4
TOG 5882	71	6.2	20.2	69	27	1.1	2.06	Black	Short	Absent	1.73	5.8
TOG 5885	77	8.3	15.6	43	11	0.78	2.74	Straw	Short	Absent	1.53	7.8
TOG 5953	99	9.2	15.8	72	6	1.3	1.97	Straw	Short	Absent	1.52	8
TOG 5976	67	6	12.8	30	9	0.4	2.17	Black	Short	Absent	1.53	7.2
TOG 5979	65	4.2	18.4	52	11	1.4	2.18	Straw	Medium	Absent	1.54	7.4
TOG 6007	79	5.9	15.6	49	5	0.89	1.96	Black	Short	Absent	1.53	6
TOG 6135	60	4.9	11	22	4	0.5	2.4	-	-	-	1.53	7.2
TOG 6161	89	9.2	21	88	9	1.7	2.71	-	-	-	2.11	6.4
TOG 6570	75	10.4	12.5	27	12	0.45	2	Black	Short	Absent	1.52	6.8
TOG 6584	80	8.4	18.1	50	8	0.79	2.25	Straw	Medium	Absent	1.53	7.4
TOG 6591	75	11.3	18.8	61	6	1.4	2.12	-	-	-	1.52	6.6
TOG 6594	75	18	22.8	76	11	1.4	2.34	Straw	Short	Present	1.53	7.4
TOG 6597	92	13.3	23.6	93	9	1.9	2.18	-	-	-	1.53	7.4
TOG 6603	69	6.7	14.1	43	7	1.1	2.12	Black	Short	Absent	1.52	6.4
TOG 6639	70	12.2	16.4	50	15	1.2	2.27	Braw	Short	Absent	1.54	6.6
TOG 6655	85	14.4	18.9	60	7	1.3	3.06	Straw	Short	Absent	1.54	7.65
TOG 6668	80	10.5	20.3	62	13	0.84	2.3	Straw	Medium	Absent	1.53	7.4
TOG 6679	92	9.5	22.4	36	6	1	1.99	Straw	Short	Absent	1.53	6.8
TOG 6689	67	4.3	18.3	47	18	0.79	1.51	Black	Short	Absent	1.53	7.6
TOG 6693	54	5.8	16.6	35	9	0.56	2.24	Straw	Short	Absent	1.54	6.8
TOG 6711	70	10	18.5	75	5	0.99	2.78	Black	Short	Absent	1.95	7.4
TOG 6754	89	24.1	18.3	48	7	1.1	2.99	Straw	Medium	Absent	2.33	7
TOG 6762	93	10.4	20.5	66	7	1.9	2.48	Straw	Short	Absent	1.54	8.2
TOG 6767	74	11.9	20.4	75	10	1.4	2.45	Braw	Short	Absent	1.72	7
TOG 6773	83	2.6	21	69	16	1.3	2.58	Black	Short	Absent	2.55	8
TOG 7132	68	5.3	13.6	37	6	0.63	1.92	Black	Short	Absent	1.73	6.8

Table 5. Contd.

TOG 7190	70	6.4	20.5	62	6	1.5	2.99	Straw	Short	Absent	1.74	8.6
TOG 7270	94	11.6	19.4	46	7	1.5	2.44	Black	Short	Absent	1.54	6.6
TOG 7318	95	10.6	17.9	75	8	1.3	2.37	Straw	Short	Absent	1.53	8
TOG 7391	105	21.5	20.2	73	10	1.8	2.75	Black	Medium	Absent	1.54	7.2
TOG 7419	45	5.5	18.7	70	12	1.1	2.25	Black	Short	Absent	1.54	7.4
CG 17	69	5	18.5	69	9	1.5	2.19	-	-	-	1.54	8.8
CG 20	88	8.2	16.1	52	10	0.71	2.39	Braw	Short	Absent	1.53	6.6
TOG 5681	69	4.6	22.4	75	30	1.2	2.59	Black	Short	Present	1.68	7.2
Sum	4540	568.7	1049.9	3226	598	63.72	139	-	-	-	94.63	424.45
Mean	78.27	9.80	18.10	55.62	10.31	1..09	2.40	-	-	-	1.63	7.32
SD	15.76	4.48	3.00	17.40	5.42	0.44	0.34	-	-	-	0.21	0.61
Min	25	2.6	11	19	4	0.15	1.51	-	-	--	1.52	5.8
max	121	24.1	23.8	94	30	2.2	3.14	-	-	-	2.55	8.8
Var	248.51	20.10	9.02	302.83	29.44	0.19	0.11	-	-	-	0.04	0.38
CV	1.72	15.81	29.19	89.71	1.72	1.72	3.88	-	-	-	3.88	1.72

disease. Few entries showed some level of resistance across the stresses. TOG 5687 had resistant reaction to both drought and blast score at three weeks. Also TOG 6692 had moderate resistant reaction to drought and blast score at both dates. TOG 6892 and 7270 had highly resistant reactions to AfRGM at Badeggi and moderately resistant reactions to drought and blast at three weeks. TOG 7420 also sowed moderately resistant reactions to AfRGM at Edozhigi, drought score and blast at three weeks. These entries could be used for blast management and for hybridization programs.

Conclusion

This study provides the level of donor genes available to combat these stresses in farmer's field. *O. glaberrima* has been known to provide useful genes for most biotic and abiotic stresses of rice. When these genes are introgressed into the high yielding sativa varieties, the progenies will possess materials with improved yield and better resistant to pests and diseases.

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