



## An antixenosis component of rice resistance to African rice gall midge, *Orseolia oryzivora*

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The African rice gall midge (AfRGM) *Orseolia oryzivora* Harris and Gagné is a pest of rainfed and irrigated lowland rice in sub-Saharan Africa. Several management strategies have been proposed to manage the pest (Nwilene et al 2002). Of these, host-plant resistance is the most farmer-friendly pest control option. Considerable progress has been made in screening and breeding for host-plant resistance to AfRGM, but little or no attention has been paid to identifying and understanding the mechanisms associated with resistance (Omoloye 1998). The morphological characteristics of the plant are a key component of host-plant resistance to insects (Heinrichs 1992). This is a property that enables a plant to avoid economic injury from insect feeding. Many morphological features of plants such as leaf hair, surface wax, tissue thickness, and allelochemical content (Khan and Saxena 1985, Saxena and Okech 1985, Omoloye 1998) have been associated with nonpreference of plants for feeding and oviposition by insect herbivores. The chemical stimuli emitted by the rice varieties guide the gall midge to its host (Heinrichs and Pathak 1981). This paper reports on the extent and nature of antixenosis in diverse rice genotypes to AfRGM.

Studies were conducted in 2000 on four susceptible *Oryza sativa* varieties (Cisadane, BW348-1, T1477, Aganni); one interspecific progeny (WAB450-1-B-P181-22-1-HB); three resistant *O. glaberrima* (TOG 7106, TOG 6346, TOG 7206); one moderately resistant traditional *O. sativa* (TOS 14519); and two check varieties, NHTA 8 (resistant check) and ITA 306 (susceptible check), under artificial infestation in a paddy screenhouse at WARDA/IITA, Ibadan, Nigeria. The levels of resistance and susceptibility of the rice varieties to AfRGM were measured in terms of percentage of tillers with galls (Nwilene et al 2002) and scored according to the *Standard evaluation system for rice* (IRRI 1996). Each variety was tested in three replications in a randomized complete block design, each replication consisting of 125 plants. Test entries were transplanted from the field nursery at 21 d after sowing with two seedlings per hill. Individual whorls of the central four rows in each block were artificially infested with four neonate larvae at 25–30 d after transplanting (DAT). The plants were sprayed lightly with water just before the larvae were introduced, and every 2 h thereafter to maximize larval survival and to facilitate the speed of larval movement and gall

formation. Rice varieties with a high transpiration rate may be preferred for oviposition by AfRGM, and there may be genotypic differences in surface wetness of the central shoot leaf between resistant and susceptible genotypes. Leaf surface wetness (LSW) was evaluated on seedlings at 35 DAT between 0630 and 0830 by excising the central unfolded leaf and spreading it under a binocular microscope. It was assessed on a 0 to 3 scale (0 = leaves absolutely dry, no water droplets at all; 1 = few water drops on leaves; 2 = leaves with a moderate number of water droplets but not thoroughly wet; and 3 = leaves thoroughly covered with water droplets). Fertilizer (16-16-16 kg NPK) was added at the rate of 60 kg N ha<sup>-1</sup> at transplanting and urea at 15 kg N ha<sup>-1</sup> 40–45 d after weeding. Damage was recorded by counting the total number of tillers with galls and the total number of tillers at 70 DAT from a sample of 20 hills of each variety per replication. The following morphological traits were determined: (1) eggs laid—number of eggs laid on five leaves per variety were counted under an Olympus stereo microscope at 45 DAT; (2) trichome density—number of trichomes on the upper and lower leaf segments approximately 5 mm × 5 mm of five leaves per variety were counted under an Olympus stereo microscope at 35 DAT; (3) internode elongation; (4) stem diameter—10 tillers per variety were measured in cm at 45 DAT; and (5) rate of adult emergence—exit holes or pupal skins in 20 plants were counted after artificial infestation per variety. Data on percentage tiller infestation (total tillers with galls divided by total number of tillers) and morphological traits were subjected to correlation analysis and analysis of variance (SAS 2002-03) and, when significant, means were separated using Tukey's studentized range test. Data on agronomic characteristics (yield) were subjected to multiple logistic regression.

Of the 11 rice varieties evaluated, the resistant *O. glaberrima* varieties were not preferred by the gall midge females and were not damaged under artificial conditions (see table). Nonpreference for oviposition by gall midge females is one of the antixenotic components of resistance. More eggs were laid on the susceptible *O. sativa* varieties than on the resistant ones (*O. glaberrima*). The number of eggs laid on *O. sativa* varieties was positively associated with gall midge damage ( $R = 0.84$ ,  $P < 0.001$ ) and it was found that the presence of moisture on the unexpanded central whorl leaf of seedlings was an important

**Traits associated with resistance in rice varieties to the AfRGM under artificial infestation, 2000 wet season, Ibadan, Nigeria.<sup>a</sup>**

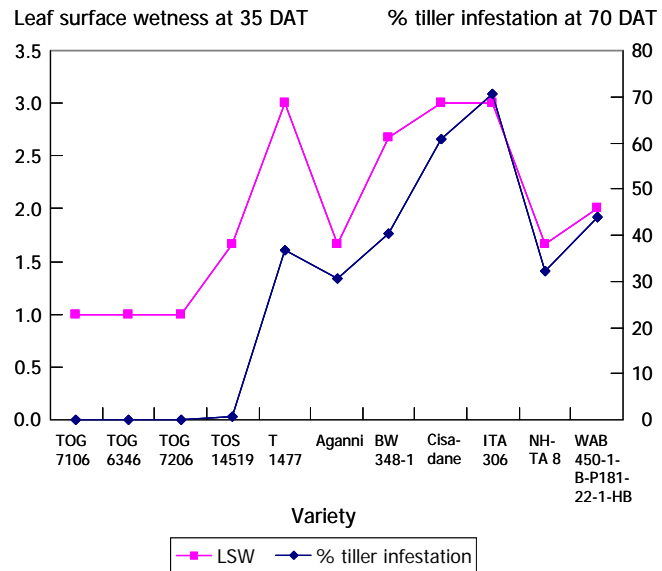
Variety	Tiller infestation at 70 DAT (%)	Eggs/five leaves at 45 DAT (no.)	Trichomes on abaxial leaves (5 mm <sup>2</sup> ) at 35 DAT (no.)	Trichomes on adaxial leaves (5 mm <sup>2</sup> ) at 35 DAT (no.)	Internode elongation (cm)	Stem diameter (cm)	Exit holes/rate of adult emergence/pupal skins at 70 DAT	Yield of infested plots (kg ha <sup>-1</sup> )	Yield of noninfested plots (kg ha <sup>-1</sup> )
TOG 7106	0.0 d	2.0 c	0.0 e	0.0 e	4.6 bcd	0.6 a	0.0 c	1,013.1 ab	1,274.3 e
TOG 6346	0.0 d	1.7 c	0.0 e	0.0 e	5.8 ab	0.6 a	0.0 c	1,244.1 ab	1,330.5 e
TOG 7206	0.0 d	1.7 c	0.0 e	0.0 e	5.4 abc	0.5 a	0.0 c	1,380.3 ab	1,463.3 e
TOS 14519	0.7 d	3.7 c	34.0 d	36.3 d	5.5 abc	0.6 a	33.3 bc	2,714.0 a	3,937.9 bcd
T 1477	36.7 bc	4.3 c	41.3 bc	43.7 bc	5.8 ab	0.5 a	95.8 a	1,197.5 ab	2,685.1 cde
Aganni	30.8 c	4.3 c	44.7 ab	45. bc	6.7 a	0.6 a	82.5 ab	1,285.5 ab	1,633.4 e
BW 348-I	40.6 bc	8.0 abc	45.0 ab	47.3 ab	5.5 abc	0.6 a	91.8 a	1,160.2 ab	4,440.2 abc
Cisadane	60.8 a	11.7 ab	41.7 bc	43.0 bc	3.4 cd	0.5 a	87.9 ab	1,934.8 ab	6,536.8 a
ITA 306	70.7 a	14.7 a	48.7 a	50.7 a	3.1 d	0.5 a	94.0 a	1,931.5 ab	5,567.2 ab
NHTA 8	32.5 bc	5.3 bc	49.7 a	52.3 a	7.4 a	0.5 a	81.7 ab	794.4 b	1,506.8 e
WAB 450-I-B-PI81-22-I-HB	44.0 b	8.0 abc	38.0 cd	40.3 cd	4.3 bcd	0.5 a	86.5 ab	902.4 b	2,263.5 de
F value	97.37	8.38	218.07	387.10	8.50	1.36	12.83	2.48	16.23
Probability	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.26	<0.0001	0.04	<0.0001
R2	0.98	0.83	0.99	0.99	0.84	0.45	0.88	0.59	0.91
CV (%)	14.24	39.52	7.05	5.28	13.61	8.83	31.23	41.13	24.72

<sup>a</sup>Means (untransformed) within a column followed by the same letter are not significantly different at  $P > 0.05$ ; Tukey's studentized range test.

factor related to susceptibility to AfRGM ( $R = 0.73$ ,  $P < 0.001$ ) (see figure). Moisture on this leaf was different from dew on expanded leaves or rainwater within the whorl, which can easily be dislodged by gentle tapping. The density of trichomes on the upper and undersurface of leaves was not associated with resistance to AfRGM. The resistant varieties (with few or no galls) had zero trichomes, whereas the susceptible varieties (with more galls) had more trichomes. Stem diameter and leaf length were negatively associated with the number of eggs laid and gall midge damage.

Longer internode elongation was associated with AfRGM resistance ( $R = -0.42$ ,  $P < 0.014$ ). The *O. sativa* varieties with shorter internodes were more heavily damaged than those with longer ones. The number of eggs laid and percentage tiller infestation on *O. sativa* varieties were positively associated with the rate of adult emergence or exit holes ( $R = 0.83$ ,  $P < 0.001$ ). This implies that the *O. sativa* varieties did not inhibit oviposition by the midges and did not also adversely affect gall midge development and emergence. No gall midge flies emerged from the tillers of *O. glaberrima* varieties, indicating that the resistant *O. glaberrima* varieties not only inhibit oviposition but also adversely affect gall midge development and emergence. The biochemicals present in the resistant *O. glaberrima* varieties play a vital role in the antiobiosis mechanism. Grain yield under infested and noninfested conditions was used as a measure of the tolerance mechanism. There was a significant difference in yields of *O. sativa* varieties under infested and noninfested conditions. The logistic regression using eggs laid, internode elongation, and leaf surface wetness as factors showed strong association with probability of infestation, which contributed to the difference in yields of rice varieties under infested and noninfested conditions (Wald chi-square = 4.45,  $P < 0.035$ ).

The results suggest that internode elongation and rate of exit holes/adult emergence are associated with resistance to AfRGM. The presence of trichomes on the leaves is not associated with resistance. However, there is a need to determine antibiotic and other morphological traits in rice varieties related to AfRGM resistance. Also, it is necessary to confirm the results obtained above under field conditions at "hotspot" locations.



**Relationship between leaf surface wetness of various rice genotypes and damage by gall midge.**

## References

- Heinrichs EA. 1992. Rice insects: the role of host plant resistance in integrated management systems. *Kor. J. Appl. Entomol.* 31(3):256-275.
- Heinrichs EA, Pathak PK. 1981. Resistance to the rice gall midge, *Orseolia oryzae*, in rice. *Insect Sci. Appl.* 1:123-132.
- IRRI (International Rice Research Institute). 1996. Standard evaluation system for rice. 4<sup>th</sup> ed. Los Baños (Philippines): IRRI.
- Khan ZR, Saxena RC. 1985. Effect of steam distillate extract of a resistant rice variety on feeding behaviour of *Nephotettix virescens* (Homoptera: Cicadellidae). *J. Econ. Entomol.* 78:562-566.
- Nwilene FE, Williams CT, Ukwungwu MN, Dakouo D, Nacro S, Hamadoun A, Kamara SI, Okhidievbie O, Abamu FJ, Adam A. 2002. Reactions of differential rice genotypes to African rice gall midge in West Africa. *Int. J. Pest Manage.* 48(3):195-201.
- Omoloye AA. 1998. Mechanisms of resistance in rice cultivars to the African rice gall midge, *Orseolia oryzivora* Harris and Gagné in Ibadan, Nigeria. PhD thesis, University of Ibadan, Nigeria.
- SAS Institute Inc. 2002-03. SAS online help: SAS 9.1 help and documentation. Cary, NC: SAS Institute Inc.
- Saxena RC, Okech SH. 1985. Role of plant volatiles in resistance of selected rice varieties to brown planthopper, *Nilaparvata lugens* (Stål) (Homoptera: Delphacidae). *J. Chem. Ecol.* 11:1601-1616.