INHERITANCE OF TOLERANCE TO IRON TOXICITY IN TWO RICE CULTIVARS*

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The primary objective of the study was to determine if the genes for resistance to Fe toxicity in Suakoko 8, a tolerant cultivar, and those in Gissi 27, a highly tolerant cultivar, are different or allelic. Determining the mode of inheritance of tolerance to Fe toxicity was the secondary objective. The reactions of the F_1 and F_2 populations and their parents were determined under Fe toxic field conditions using 0–9 scores. Lines scoring 0-4 were classified as tolerant and those scoring 5–9 as susceptible. It was found that tolerance in Suakoko 8 is controlled by a dominant gene and in Gissi 27 by a recessive gene.

There are many inland swamps and valleys in West Africa where Fe toxicity is a great problem for rice production. Tolerant varieties have been identified for these conditions, examples being Suakoko 8 and Gissi 27 in Liberia. Many new tolerant lines have also been identified in Liberia (1) and Nigeria (3, 6). However, there are not many reports on the inheritance of tolerance to the toxicity problem, especially in Africa. The only published study found (5) concerns the F_3 families of a cross of MRC 172–9 and LAC 23, which is an upland variety; it was found that the expression of tolerance to Fe toxicity at the maximum tillering stage is probably controlled by three genes. Two appeared to be dominant and complementary in action, but the third gene was inhibitory over them. The study concluded that, in the absence of inhibitory genes at the maximum tillering stage, the trait should behave as dominant and should show 9:7 segregation in the F_2; the author of the study stated, however, that this hypothesis needed confirmation, and that investigation of the segregation behavior of more crosses was necessary.

In order to make more rapid progress in the development of improved tolerance to Fe toxicity combined with good agronomic traits, it is essential to have more genetic knowledge of the plants, such as the identification of new genes for resistance, the mode of inheritance of different tolerant cultivars, the number of genes responsible, and the linkages between some traits and Fe tolerance. As more tolerant genes are identified, the faster the development of tolerant varieties will be, since many of the genes will be incorporated systematically in our breeding work as has been done for pest resistance (2).

Therefore, the main objectives of the present study were to determine the mode of inheritance of tolerance to Fe toxicity in two tolerant cultivars and to determine the allelic relationships of these genes.

MATERIALS AND METHODS

Four cultivars — Gissi 27, Suakoko 8, IR5, and IR26 — were crossed in various combinations in late 1983. The F_1 seeds were raised under nontoxic soil conditions, and 4-week-old seedlings were transplanted into a moderately toxic soil. The female parents were also grown under the same field conditions. The female parents were used to distinguish self from true crosses within the F_1 plants. The field was continuously flooded, and Fe toxicity scores based on leaf symptoms and plant vigor were made on all of the plants. The scores of 0–9 based on the Standard Evaluation System for Rice (4) were taken at 4, 6, and 10 weeks after transplanting (WAT).

Seeds harvested from true F_1 plants were sown in 1984 in nontoxic soil and transplanted into toxic soil when the seedlings were about 4 weeks old. Toxicity scores were taken as done for the F_1 plants at 2, 4, 6, 8, and 10 WAT. The scores of 8 WAT were used in the genetic analyses based on our previous studies (unpublished data) that the reaction at 8 WAT is the most reliable.

Plants with scores of 0–4 were regarded as tolerant and those with 5–9 as susceptible. Susceptible (IR26) and resistant (Suakoko 8) checks were grown perpendicular to the plots to indicate whether or not there was sufficient or too high a level of toxicity in any given row. Any row with IR26 growing luxuriously (or Suakoko 8 with a score of 8–9) was discarded or the plants close to them were disregarded. This meant either that there was insufficient stress or that the stress was too high and might have been due to other factors (when Suakoko 8 scored 8–9).

Some of the crosses, e.g., Gissi 27/Suakoko 8, IR5/Gissi 27, were not analyzed in this study due to either high level of rat damage or high day length sensitivity.

RESULTS

Inheritance of tolerance

Table 1 shows the reactions of the four cultivars and those of the F_1's to the moderately Fe toxic conditions. All the F_1 plants were tolerant or highly tolerant.

The analyses of the F_2 plants from the crosses of IR26/Suakoko 8 and IR5/Suakoko 8 did not fit any of the F_2 ratios expected (Table 2). The calculated χ^2's for 1:3, 1:15, 55:9, or 37:27 were highly significant, indicating no goodness of fit. On the other hand, F_2 plants from a cross of Gissi 27/IR5 produced 295 tolerant plants and 922 susceptible plants. A good fit was obtained for a 1:3 ratio. This indicates that only one recessive gene confers tolerance in Gissi 27.

Allele tests

Suakoko 8 and Gissi 27 are both tolerant cultivars. The F_1 plants, as expected, were highly tolerant. However, the F_2 populations produced 407 plants that were tolerant and 1,771 that were susceptible, or a ratio of 3:13 tolerant to susceptible. This indicates that two genes—one recessive and one dominant—segregated in this cross. Since Gissi 27 has a recessive gene, Suakoko 8 must have a dominant gene. The data further show that these genes are independent.

DISCUSSION AND CONCLUSION

In general, it is important to note that conclusions made from this type of study can be affected by the level of Fe toxicity, age of the plants, the susceptible and resistant checks, the uniformity of the soil, other soil mineral deficiencies and toxicity, and the diseases and insects that may affect the number of plants classified as tolerant or susceptible. Therefore, there is a need for further studies with these and other crosses. The development of repeatable screening conditions is also essential.

There are two different genes that control Fe tolerance in Suakoko 8 and Gissi 27. Suakoko 8 has a dominant gene while Gissi 27 has a recessive gene for tolerance to Fe toxicity. The practical importance of this finding is that a cross of the two cultivars should produce lines that combine the two genes for tolerance, barring the presence of modifying or inhibitory genes, and that such lines should be more tolerant than either of the parents.

Table 1. **Means of Fe toxicity scores on F_1's grown under moderate Fe toxic conditions in Suakoko, Liberia, 1984.**

F_1 and parents	Fe toxicity scores (WAT)[a]			F_1 plants (no.)	Level of resistance or susceptibility
	4	6	10		
IR26/Suakoko 8	2.6	1.6	1.6	9	highly tolerant
IR26	6.0	8.0	9.0		highly susceptible
Gissi 27/Suakoko 8	3.7	1.5	1.8	6	highly tolerant
Gissi 27	2.5	1.0	1.0		highly tolerant
IR5/Gissi 27	3.8	1.9	2.2	13	moderately tolerant
IR5	4.9	2.0	3.8		moderately tolerant
IR5/Suakoko 8	4.2	3.3	3.3	13	moderately tolerant
IR5	2.0	2.0	4.0		moderately tolerant
Suakoko 8/Gissi 27	1.8	1.5	1.7	19	highly tolerant
Suakoko 8	0.5	1.0	20		tolerant
Gissi 27/IR5	2.1	1.6	1.6	14	highly tolerant
Gissi 27	2.0	2.0	2.0		tolerant

[a]WAT = weeks after transplanting.

Table 2. **Reactions to Fe toxicity in F_1 and F_2 rice populations from crosses of four cultivars scored at 8 weeks after transplanting at Suakoko, Liberia.**

Cross	F_1 reaction	F_1 plants (no.)		F_1 plants (%)		χ^2 (df = 1)	
		Toler-ant	Suscep-tible	Toler-ant	Suscep-tible	3:13	1:3
Suakoko 8/Gissi 27	highly tolerant	407	1771	18.67	81.31	0.0023	
IR26/Suakoko8	tolerant	115	1084	9.59	90.41		
IR5/Suakoko8	tolerant	229	121	65.43	34.57		
Gissi 27/IR5	tolerant	295	922	24.24	75.76		0.3355

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