Table 1. Average percentage infection of rice tungro bacilliform virus (RTBV) and rice tungro spherical virus (RTSV) in advanced breeding lines with different sources of resistance.

Cross	Resistant lines (no.)	Infection[a] (%)				
		BS	B	S	BB	SS
	1995 dry season[b]					
IR1561-228-3-3*3/*O. longistaminata*	16	8.3	57.2	2.0	65.5	10.3
IR1561-228-3-3*2/Utri Rajapan	15	14.8	72.7	0.2	87.5	15.0
IR1561-228-3-3*2/Utri Merah	10	8.6	56.1	2.1	64.7	10.7
IR1561-2I28-3-3*4/Utri Merah	10	5.7	53.1	1.7	58.8	7.4
IR1561-228-3-3*6/ARC11554	5	5.0	50.0	1.6	55.0	6.6
IR1561-228-3-3*4/Habiganj DW8	2	1.5	15.5	1.5	17.0	3.0
IR1561-228-3-3*6/Habiganj DW8	2	6.0	61.5	0.0	67.5	6.0
	1996 wet season					
IR1561-228-3-3*2/*O. longistaminata*	2	1.5	69.0	1.5	70.5	3.0
IR1561-228-3-3*3/*O. longistaminata*[c]	2	1.5	71.5	1.5	73.0	3.0
IR1561-228-3-3*2/*O. longistaminata*//IR24	2	1.5	82.5	0.0	84.0	1.5
IR1561-228-3-3*4/*O. longistaminata*//3*IR24	4	1.5	59.0	0.0	60.5	1.5
IR1561-228-3-3*2/Utri Merah[c]	3	1.0	30.0	0.0	31.0	1.0
IR1561-228-3-3*4/Utri Merah[c]	2	0.0	40.5	0.0	40.5	0.0
IR1561-228-3-3*2/Utri Merah//IR24	3	9.0	48.3	0.0	57.3	9.0
IR1561-228-3-3*6/ARC 11554[c]	5	2.4	43.6	0.6	46.0	3.0
IR1561-228-3-3*3/Habiganj DW8	1	3.0	47.0	0.0	50.0	3.0
IR1561-228-3-3*4/Habiganj DW8[c]	2	4.0	24.5	4.5	28.5	8.5
IR1561-228-3-3*6/Habiganj DW8	1	9.0	53.0	0.0	62.0	9.0
IR1561-228-3-3*3/Habiganj DW8//4*IR64	5	3.0	39.8	0.0	42.8	3.0
IR1561-228-3-3*2/Utri Rajapan[c]	2	5.0	77.5	0.0	82.5	5.0
IR1561-228-3-3*2/Utri Rajapan//IR24	3	1.0	68.7	0.0	69.7	1.0
IR1561-228-3-3/*O. rufipogon* (Acc. 105910)	1	0.0	76.0	0.0	76.0	0.0
IR1561-228-3-3/*O. rufipogon* (Acc. 105908)//IR24	5	0.0	69.4	0.0	69.4	0.0
IR24/*O. rufopogon* (Acc. 105910)//3*IR64	2	0.0	26.0	0.0	26.0	0.0
IR1561-228-3-3//IR42/*O. rufipogon* (unknown Acc. no.)	5	0.0	60.2	0.8	60.2	0.8

[a]Av of resistant lines. Infection of tungro viruses was assessed by enzyme-linked immunosorbent assay. BS = RTBV + RTSV, B = RTBV alone, S = RTSV alone, BB = total RTBV (BS + B), SS = total RTSV (BS + S). [b]Two inoculation trials conducted. Percentage infection is av of two trials. [c]Advanced progenies of breeding lines identified as resistant in 1995 dry season trial.

Table 2. Average percentage infection of rice tungro bacilliform virus (RTBV) and rice tungro spherical virus (RTSV) in advanced breeding lines inoculated in the greenhouse and subjected to natural infection in the field.

Cross	Lines tested[a] (no.)	Infection (%)[b]				
		BS	B	S	BB	SS
IR1561-228-3-3*3/*O. longistaminata*	4	18.8 (4.6)	55.3 (68.4)	2.8 (0.5)	74.1 (73.0)	21.6 (5.1)
IR1561-228-3-3*2/Utri Rajapan	4	32.6 (20.3)	52.8 (71.4)	4.5 (0.1)	85.4 (91.7)	37.1 (20.4)
IR1561-228-3-3*2/Utri Merah	4	5.7 (4.3)	43.0 (71.8)	3.2 (0.6)	48.7 (76.1)	8.9 (4.9)
IR1561-228-3-3*6/ARC11554	4	8.8 (2.8)	64.0 (59.2)	1.8 (0)	72.8 (62.0)	10.6 (2.8)
IR1561-228-3-3*6/Habiganj DW8	4	9.2 (5.0)	59.8 (47.4)	1.6 (0)	69.0 (52.4)	10.8 (5.0)

[a]Test lines were inoculated with RTBV + RTSV in the greenhouse at 7d after sowing (DAS) and transplanted in the field at 38 DAS. Values represent infection with tungro viruses at 69 DAS. Values in parentheses represent infection with tungro viruses at 38 DAS. [b]Infection of tungro viruses was assessed by enzyme-linked immunosorbent assay. BS = RTBV + RTSV, B = RTBV alone, S = RTSV alone, BB = total RTBV (BS + B), SS = total RTSV (BS + S).

Stress tolerance — adverse soils

Seasonal differences in iron toxicity tolerance of lowland rice cultivars

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Iron toxicity is a major stress and yield-reducing factor in irrigated and rainfed lowlands in West Africa. Varietal tolerance is the most practical and cost-effective means of reducing iron toxicity in iron-toxic soils. We have been evaluating lowland rice cultivars for iron toxicity tolerance at Korhogo, Côte d'Ivoire, a site with a consistent and high iron toxicity pressure on plants. Because irrigation water is available, it was possible to evaluate germplasm in both the wet and dry seasons.

We have observed that iron toxicity pressure is higher in the dry season than in the wet season at Korhogo. In the 1994 wet season (Jul-Nov 1994) and 1995 dry season (Dec 1994-Apr 1995), we evaluated the performance of 12 elite selections (based on evaluations made in 1992 and 1993). To determine the yield potential of these cultivars, they were also grown at Mbe, which provides a lower level of stress.

Experiments at both sites used a randomized complete block design with four replications. The plot size was 12 m^2 at Mbe and 24 m^2 at Korhogo. All plots received 20-36-36 kg NPK ha^{-1} as a basal application. A total of 80 kg N ha^{-1} was added to each plot. The soil at Mbe was an Alfisol (pH 6.2; organic carbon, 1.8%; extractable Fe, 93 mg kg^{-1}) with sandy clay-loam texture; the soil at Korhogo was an Ultisol (pH 5.7; organic carbon, 1.02%; extractable Fe, 154 mg kg^{-1}) with sandy loam texture.

The cultivars evaluated at Korhogo had large differences in yield during the wet and dry seasons (see table). Iron toxicity scores at Korhogo, based on bronzing symptoms on the rice plant

Performance of 12 lowland rice cultivars evaluated for grain yield (t ha^{-1}) and iron toxicity score (ITS) at sites with high iron toxicity (Korhogo) and low iron toxicity (Mbe), Côte d'Ivoire, 1994 wet season and 1995 dry season.

Cultivar	Korhogo				Mbe 1994 wet season
	1994 wet season		1994 dry season		
	Grain yield	ITS[a]	Grain yield	ITS	Grain yield
TOX3118-6-E2-3-2 (WITA 1)	6.7	1	5.0	2	7.6
CK4	6.1	1	5.0	2	8.3
CK73	4.9	2	4.9	3	4.2[b]
TOX3052-41-E1-2	6.3	1	4.8	3	8.1
TOX3100-32-2-3-5 (WITA 3)	4.3	3	4.7	3	7.8
TOX3050-46-E3-3	6.0	1	4.6	3	6.2
TOX3081-36-2-3	6.2	1	4.4	3	6.0
TOX3027-43-1-E3-1-1-1	5.5	2	4.1	5	7.5
TOX3093-35-2-3-3 (WITA 2)	4.8	2	3.7	5	7.6
Suakoko 8	3.7	2	3.3	3	5.3
Bouake 189	4.7	3	2.9	7	6.5
TOX 3069-66-2-1-6	4.2	5	2.8	7	7.7
LSD (0.05)	1.1		0.8		0.8

[a]Based on the *Standard evaluation system for rice* with a scale of 1-9, where 1 = growth and tillering nearly normal and 9 = almost all plants dead or dying. [b]Yield was low because of bird damage.

foliage, were higher (indicating higher iron toxicity) in the dry season than in the wet season. Iron toxicity in the growing season was not observed to any significant extent at Mbe and the rice plants grew normally there.

Seasonal differences in yield were larger for susceptible cultivars such as Bouake 189 and TOX 3069-66-2-1-6 than for iron-tolerant cultivars such as CK 4, Suakoko 8, and WITA 3. The yield potentials of cultivars CK 4, WITA 1, WITA 2, and WITA 3 were clearly expressed in the 1994 wet season experiment at Mbe (see table). The iron-toxicity susceptible cultivars Bouake 189 and TOX 3069-66-2-1-6 yielded 6.5 and 7.7 t ha^{-1}, respectively, at Mbe.

These results indicate that iron toxicity, coupled with dry-season environmental conditions at Korhogo, reduces the grain yield of both iron-toxicity-tolerant and -susceptible cultivars. The high temperatures in the dry season affect crop physiology, especially during grain maturity. High temperature may also enhance transpiration rates of rice plants, which could cause a higher uptake of iron. It is also known that in a growing medium where iron in solution is high (which is expected in the dry season because of the high prevailing temperatures), iron uptake increases with higher transpiration rates because of a passive uptake mechanism. In addition, water supplied by rainfall in the rainy season would dilute the iron in a soil solution and could provide some relief from iron toxicity. ■

Correlation of some varietal characteristics with grain yield and stress tolerance index under saline conditions

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Rice production in saline soils could be increased if salt-tolerant genotypes were developed, but progress toward combining superior tolerance with good yield potential is slow, largely because of the nonavailability of reliable and efficient selection criteria. Selecting directly for grain yield under saline conditions may be limited by the low heritability of observed variation and failure to distinguish between yield potential and capacity to cope with adverse stress factors.

We evaluated the correlation of 26 characteristics with grain yield and stress tolerance index (average grain yield under stress in relation to the corresponding controls taken as one) in rice under saline conditions to ascertain the role of these traits in indirect selection for yielding ability under these conditions and in measuring varietal ratings.

We studied 20 rice varieties under laboratory conditions and in the field. In petri dishes with NaCl at electrical conductivity of 12 dS m^{-1} (stress) and distilled water (0.02 dS m^{-1} as a control), 30 seeds of each genotype were placed in petri dishes with filter paper, with four replications. After 48 h, seed water uptake, peroxidase, catalase, alpha, beta, and total amylase isozyme activity in germinating seeds, seed respiration, and seed redox potential were evaluated. After 7 d, seed germination, seedling height, root length, fresh and dry weight of seedlings, leaf respiration, total water content, relative leaf water content, transpiration, sap cell concentration, proline content, and total chlorophyll content were measured. In the field, the genotypes were sown in specially designed 3 m × 3 m × 1 m test plots in saline soil (9 dS m^{-1}) and in nonstress productive soil over three seasons. The experiment was laid out in a randomized block design with four replications. Normal cultural practices were followed. We collected data on agronomic attributes (plant height, panicles plant^{-1}, panicle length and weight, filled grains panicle^{-1}, and grain yield) from 10 plants selected at random in each replication. We computed the correlation coefficient of all traits estimated.

Seed water uptake, peroxidase activity, seed germination, seedling height, root length, seedling dry weight, total water content, and