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SCREENING RICE GERMPLASM FROM NORTH EAST HILL REGION FOR TOLERANCE TO ALUMINIUM TOXICITY

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Aluminium toxicity is one of the most important factor among the edaphic stresses in the chemical environment in upland, lateritic soils. This study, helped in identification of 27 traditional varieties (15 from laboratory study and other 12 in phytotron study) tolerant to Al toxicity. The magnitude of affect due to Al was also recorded in different traits. These tolerant germplasm would be useful as such or in the breeding programme as donor parents.

Key words : Rice, germplasm, tolerance, Al. toxicity

In presence of heavy aluminium (Al) in the soil, phosphorus, even if present in sufficient quantity, becomes unavailable to the plant. Moreover Al impairs the intake of other essential ions and water by the plant (Foy, 1974). The toxicity due to Al is found in most of the crops growing in upland soil. One such area with problem soils in N.E. Hill region is also, a reservoir of large number of traditional varieties which, because of growing over the years, are likely to be adapted over such conditions. Hence, enough to search for a tolerant material in this germplasm, a screening programme was undertaken.

MATERIALS AND METHODS

A collection of 200 traditional varieties from Northeastern Hill region (Asthana and Majumder 1981) was screened for Al-toxicity in hydroponic condition. Seeds were kept in the oven at 50^{0}C for 5 days to avoid seed dormancy. Seed surface sterilisation was done by formaldehyde solution (16 ml/l) for 15 min. Seeds were soaked, followed by incubation for 48 hours. Well germinated seeds (10 seeds/ variety/ treatment/replication) were placed in the styrofoam sheet to float on nutrient solution (Yoshida, 1976) with and without Al, viz., two treatments - 0 and 30 ppm Aluminium (in the form of

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$AlCl_3$. $6H_2O$). A critical pH 4.0 was maintained, adjusting daily with alkali or acid in the nutrient solution to ensure Al availability to the plants. Biological checks (tolerant cultures - MW 10, Karyangya Gora etc.) were used to compare with varieties whose reaction were not known as well as for their screening. Culture solution was renewed after seven days. At fifteen days, observations were taken for shoot and root length, root volume, dry matter of shoot and root. Tolerance index was computed as $(Al_{30}/Al_0) \times 100$, where Al_0 and Al_{30} are magnitudes at 0 and 30 ppm respectively. The length of root deposite with Al was measured by haematoxylin staining technique which was adapted for routine screening of the varieties. Seedling grown in 30 ppm Al were transferred to water for 1 hr. followed by staining with haematoxylin, later on they were transferred in tray and covered with moistened paper. Observations were taken on staining due to Al diffusion in root portion as complete, partial and no staining.

In another experiment, 80 varieties were included in this screening programme. Seed treatment for breaking dormancy, surface sterilisation, incubation, placement in styrofoam sheet, treatments and after care in the experiment were similar as followed in the previous experiment. This experiment was conducted in phytotron, at IRRI (29/21°C, day and night temperature; 90% RH). Observations were taken on four characters as mentioned earlier excepting haematoxylin staining technique followed in earlier case.

RESULTS AND DISCUSSIONS

Out of the 200 traditional varieties from hilly areas of northeastern India screened in hydroponic conditions, 15 varieties were found to be most tolerant and 11 varieties were most susceptible (Table 1). The characters root length and total root mass were reported to be adversely affected by toxic Al concentration. Among the tolerant varieties Ngoba, Jorang, Changkohpal, IC 25688, IC 25727, Chamic, IC 25729, Hate Black Hull, Kohheng, IC 25697, and IC 25698 were found to be excellent as evident by minimum reduction of root growth and dry matter (score 1-5). In these varieties, Al diffusion was found to be absent or in other words Al ions were restricted at root tip or could not enter in the root, but IC 25697 and IC 25698 were the exceptions where Al diffusion was partial. So, latter two varieties escape somehow by any physiological means without much adverse effect. The varietal screening in hydroponic conditions was earlier advocated by Howeler and Cadavid (1976) and Tanaka and Navasero (1966) in rice.

On the contrary susceptible varieties had very poor root grwoth and dry matter turn over (score 7-9). Haematoxylin stain is bound with Al ions in the root and this showed the extent of Al deposite in the root (Marinez, 1976). Aluminium diffusion was recorded as mostly complete excepting a few remain

Table 1. Salient features of selected rice germplasm from N.E. Hill region for Aluminium tolerance

Accession Number	Culture	Place of collection	Tolerance index		Aluminium diffusion
			Root length	Dry-matter	
Most tolerant					+
2	Ngoba	Meghalaya	5	3	NS
198	Jorang	Arunachal Pradesh	5	1	NS
298	Changkohpal	Manipur	3	1	NS
128	IC 25688	Arunachal Pradesh	3	1	NS
167	IC 25727	Arunachal Pradesh	3	3	NS
94	Chamic	Arunachal Pradesh	1	1	NS
169	IC 25729	Arunachal Pradesh	5	1	NS
279	Eyroya (B)	Manipur	5	3	PS
276	Hate black hull	Manipur	1	3	NS
255	Kohheng	Manipur	5	1	NS
137	IC 25697	Arunachal Pradesh	3	3	PS
223	Boro	Arunachal Pradesh	5	3	PS
138	IC 25698	Arunachal Pradesh	1	5	PS
267	Kohn	Manipur	5	3	PS
259	Bangmai	Manipur	5	3	PS
Most Susceptible					+
81	Nemo (A)	Arunachal Pradesh	7	9	CS
65	Tura 299	Meghalaya	7	9	CS
217	Maidang Ahu	Arunachal Pradesh	7	9	CS
119	Champhal	Arunachal Pradesh	7	9	CS
140	IC 25700 (A)	Arunachal Pradesh	7	9	CS
108	Pangra Balongba	Arunachal Pradesh	9	9	CS
341	Yaribatsuk (A)	Nagaland	9	7	PS
266	Napdai Hangmeh	Manipur	7	9	CS
10	Nonglwai	Meghalaya	7	9	CS
40	Tura 212	Meghalaya	9	7	PS
198	Daro	Arunachal Pradesh	9	7	CS

NS = No staining, C = complete staining. P = Partial staining.

ing as partial. Such an extent of Al deposited in the root zone effected the intake of water and other essential ions or their free upward movement for physiological processes (Foy, 1974). Aluminium as such is not toxic to the plant but, it arrests the movement of useful ions for the plant, ultimately causes a poor growth of the plant. Besides a few most tolerant and susceptible varieties others were found to be intermediate type.

Table 2. Response of rice varieties to Aluminium toxicity

Character	Treatment	Parameter	
		Range	Mean
Shoot length	T_0	20.1 - 45.4	34.97
	T_{30}	18.6 - 44.1	33.25
Root length	T_0	9.5 - 20.6	14.61
	T_{30}	4.5 - 16.6	9.31
Tolerance index	-	29.2 - 95.3	63.24
Shoot length: Root length	T_0	1.57 - 3.85	2.47
	T_{30}	2.08 - 6.81	3.85
Shoot dry matter (A)	T_0	0.33 - 0.72	0.53
	T_{30}	0.25 - 0.70	0.45
Root dry matter (B)	T_0	0.11 - 0.32	0.22
	T_{30}	0.10 - 0.22	0.14
A : B	T_0	1.97 - 3.08	2.42
	T_{30}	2.09 - 5.02	3.33

T_0, T_{30} - Al treatment, 0 and 30 ppm respectively. Tolerance index $(T_{30}/T_0) \times 100$.

The significant difference in varietal means, particularly in root characters (Table 2) between the treatments (0 and 30 ppm) confirmed the effect of aluminium. The deleterious effect of toxic Al concentration was found to act on plant growth. However, phenotypic coefficients of variation (PCV) and genotypic coefficients of variation (GCV) (Table 3) varied in the array of varieties and higher magnitude of coefficients of variation was recorded for various characters which in turn, provided a scope to select tolerant genotypes. The varietal resistance to problem soils was earlier suggested by (Ponnamperuma, 1975) in rice. Among the characters studied root length, root and

shoot dry matter were highly affected and the plant height showed least effects. Negligible reduction was noticed in plant height (4.1 %) whereas tiller number, shoot dry matter and root dry matter reduced by 36.3, 15.1 and 36.4 per cent respectively (Fig. 1). The shoot-root ratio was found to decrease by 55.9 per cent might be due to the injury specially in the root parts which in turn affected the proportion of dry matter in those organs with a magnitude of 37.6 per cent. The variances due to treatment and varieties were found to be significant (Table 3) and thus confirmed the effect of Al on plant growth. However, the diversity in the varieties gives an opportunity to select the tolerant lines which was aimed at. Among the varieties studied **Ate local, Thlan-chhuah, Chao, Nikhunkati,** IC 25736, IC 25721, **Farmbuh, Changatpal, Mirikrak, Pyatpyani, Kohn** and **Changsan** were found to be quite tolerant as compared to the susceptible varieties like **changpalman, Napdai, Hangmeh, Mesong, kati,** IC 25704 and **Ryllored 5.**

Table 3. Analysis of variance

Source	DF	Characters			
		Shoot length	Root length	Shoot dry matter	Root dry matter
Replications (R)	1	9.59	0.14	0.0018	0.0057**
Al-treatment (T)	1	239.09**	2234.38**	0.3535**	0.4841**
Variety (V)	79	101.90**	27.30**	0.0336**	0.0039*
T x V	79	6.34	4.64	0.0059	0.0015
P C V		21.0	27.4	26.5	23.6
G C V		19.8	23.0	22.2	15.7

*, ** significant at 5% and 1% respectively

The estimation of correlation coefficients (Table 4) in those characters studied showed the associationship of shoot length vs. root length and shoot

Table 4. Estimation of correlation coefficients

Character		Shoot length	Root dry matter	Shoot dry matter
Root length	T_0	0.979**	0.972**	0.962**
	T_{30}	0.961**	0.280*	0.270*
Shoot dry matter	T_0	0.983**	0.993**	
	T_{30}	0.972*	0.944**	

*, ** Significant at 5% and 1% respectively
T_0 - Al, 0 ppm
T_{30} - Al, 30 ppm

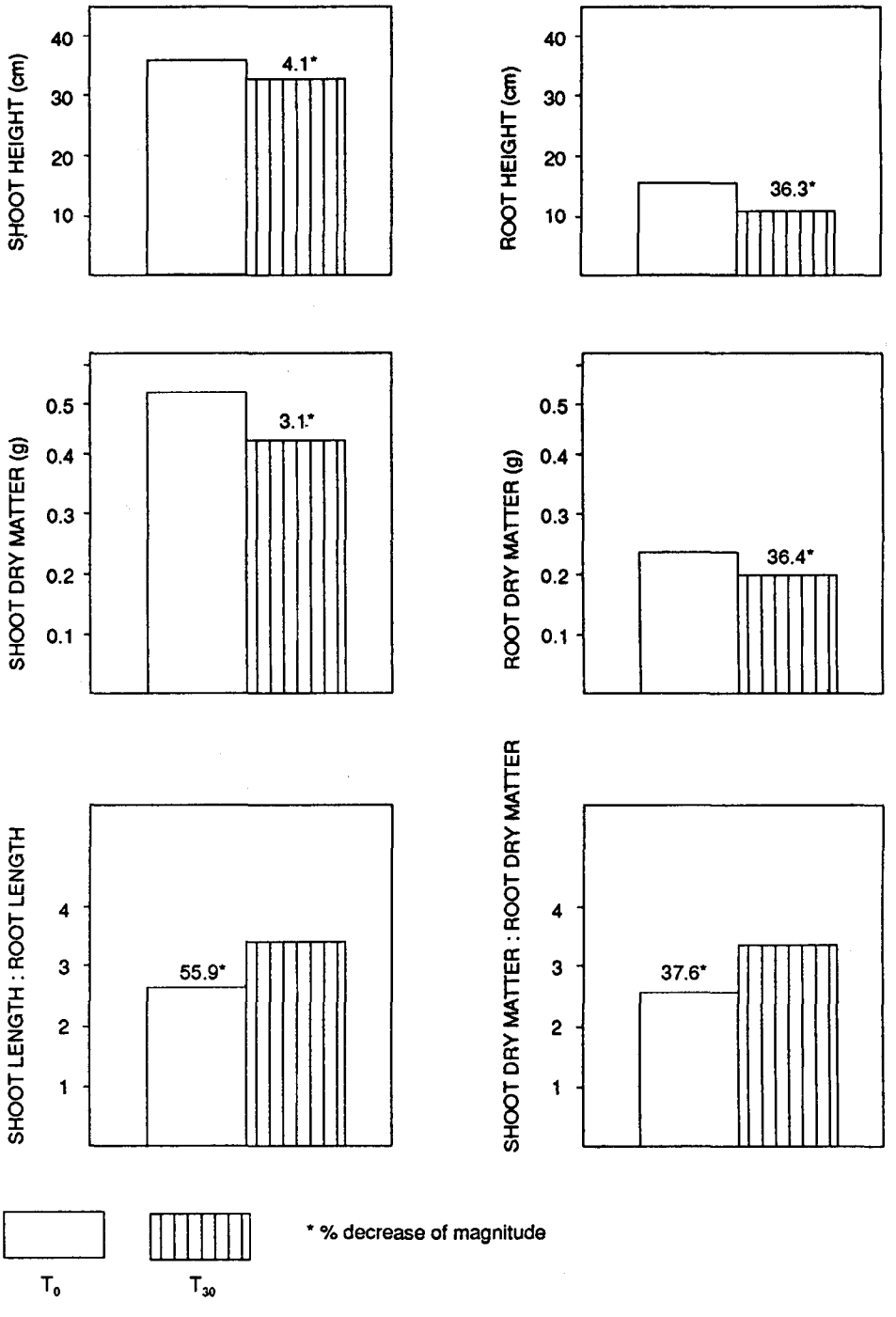

Fig. 1. Effect of Al concentration on morphological characters in rice (T_0, T_{30} - Al, 0 and 30 ppm respectively)

dry matter and root dry matter vs. shoot dry matter. Unlikely, correlation between root length vs. root dry matter and shoot dry matter varies considerably under different growth conditions mentioned above. This estimation makes an opportunity for indirect selection as well as judicious selection method. The correlation coefficients of root length vs. root dry matter and root length vs. shoot dry matter when compared in both the cases viz. T_0 (without Al ions) and T_{30} (with toxic Al ions), it was found that in the latter cases the magnitude is much lower than that found in without Aluminium treatments. This observation indicated that in toxic Al concentration both the characters were not proportionately affected unlike the other three correlation coefficients.

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