Indian J.Pl. Genet. Resources 7(1): 31-41, 1994

LOW PHOSPHORUS TOLERANT CULTURES IN UPLAND PADDY GERMPLASM AND THEIR UTILIZATION

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Four hundred and fifty germplasms collected from North-eastern Hill region were screened in phosphorus deficient soil for identification of tolerance to low phosphorus condition. Some of the promising lines (65) were evaluated again in hydroponics and a few tolerant lines (26) were further utilised in breeding programme. With these approaches tolerant varieties were identified from germplasm resources. While utilising a few elite lines in a systematic breeding programme undertaken for such stress condition, a few cultures (15) were developed which can be grown in different agro-ecological condition as biological amendment to boost up the productivity in problem soils.

Key words : Paddy germplasm, low phosphorus tolerant, utilization

Thousands of hectares of upland rice growing soils are acidic in nature. It is one of the major problems in upland and distributed universally (Garrity 1984). Acidic pH coupled with high amount of Fe and Al causes P-deficiency. The low pH in acidic soil limits the P-uptake for plants in unavailable form. In artificial phosphorus application, it gets fixed in the acidic soil in the presente of Al and Fe. Soil amendment is very costly as well as not a permanent solution. On the other hand, breeding for tolerance to low P-conditions is a practical solution (IRRI, 1975, 1976, 1978, 1979). Variation for tolerance/susceptibility has been reported earlier. An attempt was made to screen a few lines collected from predominantly red lateritic acid soil with low phosphorus condition of North eastern hill region of India. (Asthana and Majumder, 1981).

MATERIALS AND METHODS

Soil status: The experimental site for field screening of P-tolerant cultures, had red lateritic soils, pH 5.0 (soil : water, 1 : 2.5) available p-5ppm, organic matter 6.4 per cent exchangeable aluminium 0.25 meq/g, exchangeable iron-

45ppm., poor in available phosphorus status. The site is in upland terrace without water stagnation.

EXPERIMENT I : Four hundred and fifty rice germplasms collected from N.E. Hill areas, were screened in upland terrace, in the soil mentioned above. Seeds were drilled 5 cm apart in 2m row width, replicated two times in with and without phosphatic fertilizer (60 and 0 kg/ha P) application. Rasi, a low P-tolerant variety was taken as biological check. Observations were taken on height, days to flowering, ear bearing tillers (EBT), yield per plot and phenotypic index following IRRI standard evaluation system. P-uptake was measured in leaf samples collected at flowering stage (Yoshida *et al.*, 1976) and microchemical test for P-status in root was assessed taking a transverse cross section of root stained in a solution of ammonium molybdate in nitric acid. Grading for phosphores was done on the basis of intensity of yellow colour developed.

EXPERIMENT II : Sixty five varieties screened from initial screening trial in the P- deficient soil were included for hydroponic screening. Seeds were kept in the oven at 50°C for 5 days to avoid seed dormancy. Surface sterilisation of seeds was done by dipping in formaldehyde solution (16 ml/l) for 15 min. Seeds a soaking for sterilisation was followed by an incubation period for 43 hrs. Well germinated seeds (10 seeds / variety / replication) were placed in the styrofoam sheet to float on nutrient solution (Yoshida *et al.*, 1976). Culture solution was modified slightly for two treatments of P-availability 0.5 and 10 ppm. The critical pH 6.5 was maintained for P-availability with an adjustment daily with alkali or acid. Three seedlings/variety/replication were taken for screening and inserted in the Styrofoam sheet keeping in contact with the culture solution. Culture solution was changed as mentioned above. Records were taken at 30 days of plant growth for different plant characters such as plant height, tiller number, leaf area, root volume, shoot and root dry matter. Tolerance index was measured as P_1 P_2 x 100, where P_1 and P_2 are values at 0.5 and 10 ppm respectively. Statistical analysis was done in accordance with Gomezand Gomez (1976).

EXPERIMENT III : A few tolerant lines identified so far were crossed with high yielding IRRI varieties (IR 28, IR 29 and IR 30), DR 92 and Rasi, tolerant to low P-condition. Seventy lines developed (fixed) for such condition were evaluated in a trial conducted in the upland conditions with and without phosphatic fertilizer application (@ 0 and 60kg/ha phosphorus), alongwith a local (Ngoba) and improved (Rasi) biological check.

RESULTS AND DISCUSSION

EXPERIMENT I : Among the varieties (450) tested, 14 varieties were found to be quite tolerant to low phosphorus condition (Table 1). Excepting

Table 1. Performance of promising traditional rice germplasms in P- deficient soil

Culture	Height		Tolerance index	Days to flowering		EBT		Tolerance Index	Yield/plot(g)		Tolerance index	P-up take ppm	PI	MCT
	P_0	P60		P0	P60	P0	P60		P0	P_{60}				
Khaonowjoma	113	127	39	154	152	2.8	3.4	82	481	1256	38.8	6.8	3	M
Konoldhan	95	118	81	155	152	2.7	4.3	63	154	220	70.0	5.8	3	M
Maibiring	116	123	94	146	143	2.8	3.2	88	420	1416	29.7	6.9	3	M
Rasangtu	110	113	97	151	149	3.1	4.7	66	299	708	42.2	4.2	5	L
Khawji	114	120	95	155	153	2.5	3.1	81	437	1257	38.7	8.2	3	H
Emo Empo	120	180	92	153	151	2.7	3.1	87	470	1635	28.7	7.3	3	H
Millock 2	127	137	93	151	149	2.9	3.3	88	821	1451	56.6	5.6	3	M
Tura 80	113	127	89	153	151	3.1	4.8	65	248	1431	17.3	3.4	7	L
Khawant	115	139	83	154	154	2.1	4.1	51	459	1306	55.1	5.6	3	M
Chuksingpa	117	131	89	150	148	2.7	3.7	73	452	1613	28.0	6.6	3	H
IC 25692	108	130	83	153	151	1.8	2.9	62	450	1116	40.3	4.8	5	M
Ngoba	66	101	65	128	114	3.1	4.1	76	372	360	43.3	8.4	3	H
Asienkel	118	135	37	152	149	3.2	4.7	68	453	1163	39.0	9.6	3	H
IC 25696	124	135	92	149	147	2.6	3.8	68	467	1597	29.2	6.3	3	H
Rasi (Control)	60	81	74	97	97	2.2	3.2	69	370	880	42.0	7.3	3	H

PI - phenotypic index
MCT - Microchemical test (colour intensity, high - H, medium - M, Low - L).

$$\text{Tolerance index} = \frac{P_0 \text{ yield}}{P_{60} \text{ yield}} \times 10$$

Plot size = $5m^2$

varieties, **Khonoldhan** and **Rasangtu**, others were better yielder than control (**Rasi**) where phosphorus was withdrawn. Hillock 2 was the best followed by **Khawji, Khaonowjama**, Emo Empo, IC 25696, **Khawsant, Asenkel, Chuksingpa** and IC 25692. But when the individual varieties were compared with and without phosphorus **Konoldhan** and Hillock No.2 were found to be quite tolerant. In respect of P-up take ability **Asienkel, Ngoba, Khowji** and Emo Empo were found to be very efficient. Also the micro chemical test, taking a transverse section of culm staining with ammonium molybdate in nitric acid was found to be very reliable for screening the variety to P-tolerance. **Kasangtu, Khawji, Maibiring**, Hillock No. 2, Emo Empo and IC 25696 had maximum tolerance in respect of height when compared with and without p- level. Regarding EBT, Hillock No.2, **Maibiring**, Emo Empo, **Khawnowjoma** and **Khawji** showed enough tolerance.

Tolerance to low phosphorus condition might be due to efficient uptake and utilization of phosphorus (Majumder *et al.*, 1990 a, b, c). Good phenotypic index covering plant type and pest resistance indicated their profitable use as such or utilzation in breeding programme. Micro chemical test at flowering stage is assumed to be a quick and reliable test for screening varieties. These varieties were collected mainly from upland hill areas and their tolerance could be due to homeostatic effect.

EXPERIMENT II : On the basis of performance of a large number varieties tested initially in p-deficient soil, 65 varieties were picked up and tested in hydroponics in two p-level, 0.5 ppm (deficient) and 10 ppm (normal) respectively. Twenty six varieties enlisted in table 2 were found performing better in P-deficient condition. In respect of tolerance index calculated, **Pyat pyani, Khatu**, IC 25736 and **Changhoepal** for plant height; **Keturn, Changhoepal**, IC 25639, IC 25736, EC 25721, **Kerpu** and **Mirikrak** for tiller number; **Ketura, Changoepal, Changsan, Pyat pyani, Khaokha okenon**, Tura 680, IC 25696, IC 25687 and **Changat** for root volume; **pyat pyani**, ARC 7098, **Changsan** and **Changoepal** for shoot dry matter and pyat pyani, **Khatu**, IC 25736, **Chuksingpa**, IC 25721 and **Mirikrak** were found to be very promising.

Due to P-deficiency, leaf area was affected maximum followed by shoot dry matter, root volume, root dry matter, leaf number and plant height (Fig.1) among the characters studied. Higher coefficients of variation in some characters viz., indicates the scope of selection of some desirable types from the lot. Significant positive correlations were found (Table 3) between leaf area vs. tiller number, root volume, shoot dry matter and root dry matter; root volume vs. plant height, leaf area, shoot dry matter and root dry matter; shoot dry matter vs. plant height and root dry matter and root dry matter vs. plant height. This shows further, scope of indirect selection.

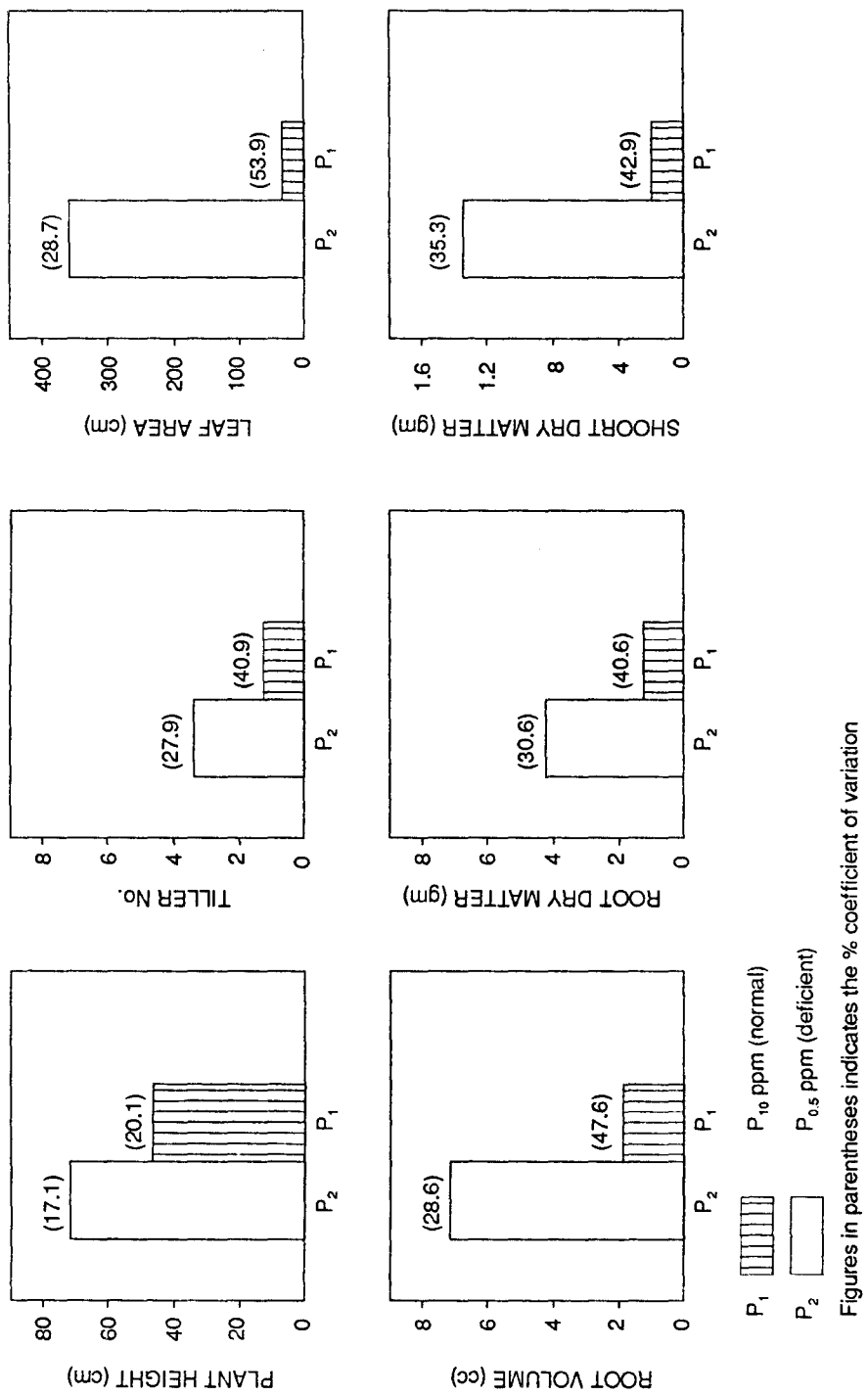

Fig. 1. Performance of traditional varieties in different phosphorus level (P_{10} ppm-normal)

Table 2. Performance of promising rice germplasms in hydroponics

Germplasm	Plant height (cm)			Tiller number			Leaf area cm^2			Root volume cc			Dry matter					
													Shoot (g)			Root (g)		
	T_1	T_2	TI	T_1	T_2	TI	T_1	T_2	TI	T_1	T_2	TI	T_1	T2	TI	T_1	T_2	TI
ARC 7098	39.2	72.5	43	1	3	33	17.3	270.6	6	1.2	6.1	20	0.33	0.94	35	0.08	0.28	29
Changsan	44.9	70.7	64	1	3	33	49.3	245.9	20	2.3	7.1	32	0.25	0.83	30	0.10	0.35	29
Changhoepal	49.5	67.5	73	3	5	60	101.7	470.3	22	2.4	7.8	31	0.36	1.22	30	0.13	0.33	39
Changat	45.8	88.7	52	1	3	33	28.3	391.4	7	2.0	5.0	40	0.18	1.56	12	0.07	0.35	20
Chuksingpa	48.5	80.5	60	1	3	33	39.2	320.0	12	2.2	6.4	34	0.23	1.13	20	0.16	0.39	41
IC 25637	43.6	73.9	59	1	3	33	29.1	412.0	7	3.0	7.6	40	0.21	1.55	14	0.07	0.39	18
IC 25689	44.2	70.0	63	1	2	50	26.7	233.8	11	2.9	8.2	35	0.18	1.14	16	0.07	0.29	24
IC 25694	44.3	69.0	65	1	3	33	26.7	343.7	8	1.3	13.0	10	0.12	1.73	7	0.07	0.50	14
IC 25696	47.2	78.8	60	1	3	33	21.5	303.9	7	2.0	5.0	40	0.19	1.09	17	0.11	0.35	31
IC 25736	46.0	62.6	74	1	2	50	28.0	183.2	15	1.9	5.2	37	0.23	1.12	21	0.14	0.27	52
IC 25721	34.9	58.0	60	1	2	50	19.3	131.2	15	1.2	4.4	27	0.13	0.57	23	0.08	0.20	40
Ketura	24.4	38.1	64	3	3	100	49.6	97.6	50	1.3	6.6	20	0.26	1.15	23	0.11	0.34	32
Khatu	47.0	62.0	76	1	3	33	26.7	323.7	8	1.2	6.1	20	0.32	1.19	27	0.12	0.23	52

(*Contd. from p. 36*)

Kerpu	37.0	59.7	62	1	2	50	22.3	155.9	14	1.7	7.8	22	0.15	0.71	21	0.07	0.27	26
Khaokha0-kenon	37.0	79.7	49	1	3	33	22.1	137.0	6	3.2	5.5	58	0.21	1.43	15	0.11	0.36	31
Local Ahu-A	49.1	71.8	68	1	3	33	31.2	394.2	13	1.6	7.3	22	0.36	1.65	22	0.14	0.41	34
Mirikrak	45.3	94.7	48	1	2	50	41.8	355.7	12	1.9	8.5	22	0.32	1.36	24	0.16	0.40	40
Mesong	46.7	69.0	68	1	3	38	26.6	254.5	11	0.9	5.8	16	0.20	1.01	20	0.95	0.25	32
Maikutsuk	34.1	70.2	49	1	4	25	22.2	390.0	6	1.1	5.6	20	0.28	1.25	22	0.08	0.67	12
Napgai	41.0	85.3	48	1	4	25	23.4	529.5	4	0.6	5.1	12	0.14	1.96	7	0.04	0.27	15
Pyatpyare	45.0	72.7	62	1	4	25	27.5	336	7	8	2.0	6.2	32	0.27	1.25	20	0.07	0.36
Pyatpyani	65.0	80.3	81	1	3	33	41.2	252.2	16	4.5	5.4	83	0.33	0.84	39	0.20	0.30	67
Phanlem	51.3	80.0	64	1	4	25	31.1	438.3	7	2.0	8.4	24	0.37	1.53	24	0.17	0.46	37
Ryllored-5	50.1	80.3	62	1	4	25	22.5	406.2	6	2.1	5.4	39	0.29	1.52	18	0.09	0.42	21
Tura 115	54.8	88.0	62	1	4	25	46.2	475.9	10	2.5	7.4	34	0.32	1.52	21	0.11	0.35	31
Tura 690	47.2	73.0	65	1	3	33	34.8	368.6	9	3.2	7.5	43	0.27	1.62	17	0.14	0.46	30

(T_1 and T_2, phosphorus treatment at 0.5 and 10 ppm respectively).

Table 4. Performance of breeding lines in P-deficient soil

Culture	Parentage	Days to flowering		Height		EBT		Yield/plot (g)		Tolerance index	PI score (0-9)
		P_0	P_{60}	P0	P60	P0	P60	P0	P60		
RCPU 101	(IR 28/Ngoba)/Ngoba	113	105	113	116	3.3	4.4	576	634	91	1
RCPU 103	(IR 28/Ngoba)/Ngoba	109	105	70	74	2.8	3.3	481	596	91	5
RCPU 105	(IR 28/Ngoba)/Ngoba	99	96	66	68	3.0	3.8	414	807	51	3
RCPU 107	IR 30 × Ngoba	100	92	111	114	4.4	5.0	403	618	65	5
RCPU 108	IR 30 × Ngoba	108	103	96	89	6.0	6.2	330	945	35	3
RCPU 109	IR 30 × Ngoba	110	103	87	89	5.8	6.1	840	878	96	1
RCPU 110	IR 30 × Ngoba	99	96	69	74	4.2	4.8	429	639	68	3
RCPU 111	IR 30 × Ngoba	118	111	62	68	4.4	4.5	368	960	38	5
RCPU 121	IR 29 × Ngoba	109	103	66	69	4.4	4.6	387	490	79	5
RCPU 123	IR 29 × Ngoba	109	102	81	94	3.4	4.6	567	600	94	1
RCPU 127	IR 29 × Mirikrak	108	103	78	81	3.9	5.0	352	370	95	5
RCPU 128	IR 29 × Mirikrak	104	99	66	69	3.2	4.9	357	439	81	3
RCPU 130	Mirikrak × Rasi	101	98	73	76	3.2	3.4	386	565	68	3
RCPU 131	(DR 92 × Mirikrak) × Ngoba	108	106	64	68	3.4	3.6	330	340	97	5
RCPU 132	(DR 92 × Mirikrak) × Ngoba	108	99	68	73	3.2	3.6	434	600	72	3
Ngoba (Local check)		122	119	36	39	4.8	5.2	405	700	58	1
Rasi (Improved check)		104	101	66	70	5.0	5.7	335	570	59	3

PI - Phenotypic index, Tolerance index (TI) = $\frac{\text{P yield}}{\text{60P yield}} \times 100$, Plot size 2.5 sqm.

Table 3. Estimation of correlation coefficients among plant characters under different p-level

	Plant height	Tiller No.	Leaf area	Root volume	Shoot volume
Tiller number	–0.238				
	(–0.231)				
Leaf area	0.333**	0.721**			
	(0.497)**	(0.517)**			
Root volume	0.552 **	0.088	0.446*'		
	(0.269)*	(0.180)	(0.415)*		
Shoot dry matter	0.596**	0.296*	0.694**	0.562**]	
	(0.512)**	(0.235)	(0.608)**	(0.528)**	
Root dry matter	0.579**	0.103	0.516**	0.676**	0.751**
	(0.394)**	(0.254)*	(0.559)**	(0.568)**	(0.634)**

Figures in parenthesis are p (10 ppm) and others P (0.5ppm).
* and **, significant at 5% and 1% respectively.

EXPERIMENT III : IR 28, IR 29, IR 30, and **Rasi** were identified as phosphorus tolerant varieties. Some of the elite and P-tolerant lines were crossed with IR 28, IR 29 and IR 30. Segregants in advancing generations (F_2 - F_6) were screened in P-deficient soil as mentioned earlier. Some of the materials fixed and found to be tolerant to low phosphorus. Materials in RCPU series, so obtained were given for yield trial in two treatments (phosphorus level 0 and 60), replicated three lines. Among the lines (70) tested, fifteen lines were found to be quite promising (Table 4). RCPU 131 had maximum tolerance followed by RCPU 109, RCPU 127, RCPU 123, RCPU 101, RCPU 128 and RCPU 103. These cultures showed good phenotypic index (PI) and significantly better yielder than both **Rasi** (improved check) and **Ngoba** (local check). Some of the promising germplasms were utilised in these breeding programmes and lines derived from the cross involving either **Ngoba** and **Mirikrak** as one of the parents were found to be promising. These elite lines can be used as biological amendment to increase the productivity in such problem soils.

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