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Short Communication

Identification of rice (*Oryza sativa* L.) genotypes for aerobic condition under different water regimes

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Food security in India is challenged by increasing food demand and threatened by declining water availability. Even though rice (*Oryza sativa* L.) is an important grain crop in many parts of India, because of its water use, irrigated rice is being taken out of production in many areas. Savings in irrigation water and increase in water productivity would be possible, if rice is grown under aerobic soil conditions. However, a key component for the success of aerobic systems is developing appropriate cultivars. Keeping this in view, the present investigation was carried out to identify the suitable genotypes for aerobic condition based on physiological and root traits since these traits are essential for imparting tolerance to moisture stress.

Eighteen rice genotypes consisting of five drought tolerant varieties (MDU 5, PMK 2, PMK 3, IR 36 and TKM 9); three local land races (Norungan, Nootripathu, Varappukudanchan); two improved drought tolerant cultures (PM 01010, PM 01011), three Recombinant Inbred Lines (RIL 16 - CPMB ACM 04004, RIL 70 - CPMB ACM 04005, RIL 86 - CPMB ACM 04007), three New Plant Type lines (NPT 103 - IR 69020, NPT 105 - IR 71693, NPT 131 - IR 75268) and two varieties adapted for lowland irrigated condition (ASD 16, ADT 36) were raised under aerobic (non flooded) condition in RBD with three replications. Seeds were hand dibbled in the dry soil in the plots of 0.8 × 0.8 m adopting the spacing of 20 × 10 cm during summer (Apr-Aug) 2004. Drip irrigation system was used to generate three levels of water stress *viz.*, Low stress (80-100 % ASM), Medium stress (60-79% ASM) and High stress (50-59% ASM) based on Available Soil Moisture (ASM) by manipulating irrigation intervals and quantity of irrigation water. Eight traits including physiological and root characters were recorded in ten plants per replication and stress level. Physiological traits were recorded at active tillering stage and the plants were uprooted and the root traits were recorded at maturity.

The mean values and Co-efficient of variation (CV) percentage of the various traits studied under different water regimes are given in Table 1. The CV percentage was low for the trait DFF (0.92%) followed by RWC (2.06%), dry root weight (2.85%) and root length(3.82%) indicating least influence of environment on these characters (Table 1).

An understanding of physiological parameters conferring tolerance to moisture stress will help the breeders in the development of stress tolerant varieties. The water stress significantly lowered the RWC and LAI at vegetative stage. All the genotypes showed significant RWC except the NPT lines and lowland irrigated rice cultivars under low stress whereas the genotypes PM 01010, RIL 16 and RIL 86 recorded significant RWC under higher water stress. Singh *et al.* [1] reported that RWC is a reliable and simple screening technique for vegetative stage stress among the physiological traits. Similarly, significant LAI was recorded by Norungan, Nootripathu, Varappukudanchan, PM01011, RILs and NPT 103 under high stress.

Water deficit delayed flowering in all the cultivars. Among 18 genotypes studied, flowering was observed only in ten genotypes (Table 1) and the remaining genotypes *viz.*, IR 36, Nootripathu, RIL 86, NPT lines, ASD 16 and ADT 36 did not flower at all. The flowering delay between the low and high stress was maximum in PMK 3 (20 days) followed by TKM 9 (18 days) and PM 01011 (17 days) and minimum in RIL 16 (2 days). Delay in flowering and failure of flowering due to moisture deficit was earlier reported by Chandra Babu *et al.* [2]. Ravindra kumar and Robinson Kujur [3] suggested that flowering delay due to moisture stress is a strong indicator of drought susceptibility.

Studies on roots under moisture deficit condition revealed the possibility of enhancing the water availability through adaptation of better root system. The cultivars PMK 2, Norungan, Nootripathu, Varappukudanchan and

Table 1. Mean values of various traits studied under three different water regimes in rice

Genotypes	RWC (%)			LAI			Days to 50% flowering			Root length (cm)		
	LS	MS	HS	LS	MS	HS	LS	MS	HS	LS	MS	HS
MDU 5	76.54**	73.75**	53.75	0.08	0.05	0.04	86.67**	88.00**	92.00**	8.13	10.10	10.00
PMK 2	75.06**	69.49	56.29	0.15**	0.12	0.09	117.33	119.67	122.00	7.50	8.93	11.00**
PMK 3	77.44**	73.45**	55.26	0.12	0.08	0.13	97.00**	100.00**	117.00	8.00	9.03	9.93
IR 36	73.62**	68.13	60.23	0.05	0.07	0.11	-	-	-	9.50	8.47	5.77
TKM 9	79.17**	70.39	59.24	0.18**	0.11	0.09	97.00**	101.00**	114.67	13.07**	10.57**	6.10
Norungan	80.41**	72.18	63.85	0.22**	0.14	0.16**	113.00	117.67	120.00	6.50	10.13	15.33**
Nootripathu	81.82**	76.00**	69.87	0.25**	0.17**	0.15**	-	-	-	12.43**	13.43**	15.67**
Varappukudanchan	81.77**	71.40	62.82	0.20**	0.17**	0.20**	101.00**	114.00	116.67	11.87**	11.67**	12.57**
PM 01010	86.62**	84.85**	81.23**	0.14	0.12	0.14	96.67**	98.00**	102.00**	7.93	7.93	8.90
PM 01011	84.70**	79.16**	67.88	0.22**	0.19**	0.19**	97.33**	101.00**	114.33	11.20**	7.67	6.77
RIL 16	85.70**	84.58**	76.10**	0.19**	0.14	0.15**	121.33	121.67	123.00	11.99**	15.73**	16.87**
RIL 70	84.68**	80.51**	61.94	0.20**	0.18**	0.16**	116.67	117.67	121.67	9.03	12.37**	14.20**
RIL 86	84.29**	84.93**	78.23**	0.17**	0.15**	0.15**	-	-	-	9.17	11.51**	11.73**
NPT 103	70.96	69.84	64.05	0.13	0.13	0.19**	-	-	-	8.13	9.77	9.97
NPT 105	69.17	66.76	51.77	0.10	0.07	0.06	-	-	-	5.33	4.87	4.20
NPT 131	61.20	61.16	51.24	0.06	0.07	0.07	-	-	-	13.20**	14.23**	4.77
ASD 16	62.29	60.26	67.91	0.06	0.13	0.13	-	-	-	8.70	7.20	5.87
ADT 36	60.09	52.57	42.42	0.05	0.10	0.12	-	-	-	7.83	7.20	5.67
GM		69.98			0.13			114.33			9.70	
CD 5%		2.21			0.17			1.63			0.63	
1%		2.92			0.23			2.17			0.83	
CV (%)		2.06			8.68			0.92			3.82	

*Significance at 5 and 1% levels respectively; LS - Low stress, MS - Medium stress, HS - High stress

Genotypes	Root number			Dry root weight (g)			R/S ratio			Biomass yield (g)		
	LS	MS	HS	LS	MS	HS	LS	MS	HS	LS	MS	HS
MDU 5	109.33	106.00	119.67	0.82	1.22**	1.57**	0.18**	0.20**	0.21**	12.62**	9.34	8.04
PMK 2	109.33	177.67**	202.33**	0.90	1.27**	1.62**	0.10	0.19**	0.20**	16.07**	11.99	6.07
PMK 3	168.00**	177.33**	213.00**	0.85	1.12	1.45**	0.06	0.09	0.16**	15.07**	12.62**	11.08
IR 36	111.67	51.33	55.67	0.18	0.21	0.32	0.13*	0.05	0.04	6.76	4.63	3.67
TKM 9	168.67**	84.67	62.00	0.71	0.81	0.82	0.04	0.05	0.07	16.11**	8.00	4.45
Norungan	93.00	173.67**	187.67**	1.30**	1.30**	1.52**	0.12	0.19**	0.19**	18.59**	16.75**	15.27**
Nootripathu	131.33	131.67	174.67**	1.85**	2.50**	3.50**	0.13*	0.23**	0.26**	29.59**	20.17**	11.60
Varappukudanchan	138.33	136.67	182.00**	1.81**	2.45**	2.68**	0.11	0.20**	0.20**	32.51**	24.46**	20.47**
PM 01010	88.33	83.00	80.67	0.45	0.68	0.96	0.07	0.10	0.11	10.49	5.54	4.84
PM 01011	112.00	131.67	141.00	0.42	0.67	0.74	0.06	0.07	0.18**	11.65	5.88	4.54
RIL 16	98.33	93.67	203.33**	1.50**	1.53**	1.98**	0.11	0.13*	0.19**	26.94**	20.87**	13.27**
RIL 70	101.67	201.67**	205.33**	0.52	0.62	1.42**	0.05	0.09	0.12	14.36**	10.19	7.96
RIL 86	120.33	141.67*	188.00**	1.67**	1.79**	1.81**	0.17**	0.17**	0.18**	12.26	11.70	9.27
NPT 103	117.67	145.33**	136.67	1.68**	0.73	1.21**	0.09	0.09	0.08	9.87	8.11	7.36
NPT 105	171.33**	125.33	82.67	0.29	0.60	1.20**	0.04	0.05	0.06	8.16	6.18	5.09
NPT 131	179.00**	173.67**	237.67**	0.91	1.51**	1.73**	0.05	0.08	0.10	17.65**	13.08**	11.40
ASD 16	85.33	75.00	57.33	0.19	0.52	0.67	0.03	0.05	0.08	6.46	3.13	2.57
ADT 36	86.67	76.67	58.67	0.23	0.32	0.75	0.05	0.07	0.09	7.89	3.40	2.84
GM		130.84			1.13			0.114			11.48	
CD 5%		10.41			0.05			0.019			0.83	
1%		13.77			0.07			0.026			1.10	
CV(%)		4.73			2.85			11.28			4.56	

*Significance at 5 and 1% levels respectively; LS - Low stress, MS - Medium stress, HS - High stress

RILs registered significant root length under high stress level while Nootripathu, Varappukudanchan and RIL 16 recorded significant root length under all the three water regimes. ASD 16, ADT 36, IR 36 and NPT lines showed poor root length. As the drought stress enhanced, increase in root length observed in PMK 2, PMK 3, Norungan, Nootripathu, RIL 16, RIL 70, RIL 86 and NPT 103 suggested the tolerance of these genotypes to moisture stress. High variation was observed for root number. It ranged from 85.33 (ASD 16) to 179.00 (NPT 131) in low stress, 51.33(IR 36) to 201.67(RIL 70) in medium stress and 55.67 (IR 36) to 237.67 (NPT 131) in high stress. Root length and root number increased with the decrease of irrigation regimes and it was in conformity with the finding of Pradhan *et al.* [4]. Significant mean values were registered by the cultivars MDU 5, PMK 2, PMK 3, Norungan, Nootripathu, Varappukudanchan, RIL 16, RIL 86 for dry root weight and R/S ratio along with NPT lines and RIL 70 for dry root weight and PM 01011 for R/S ratio. Biomass yield was the only and best measure of plant production under stress [2]. All the genotypes except IR 36, PM 01010, PM 01011, RIL 86, NPT lines 103 and 105, ASD 16 and ADT 36 recorded significant mean values for biomass yield under low stress condition where as Norungan, Varappukudanchan and RIL 16 showed significant mean values for biomass yield under all the stress levels.

On the whole, better adaptability to moisture stress was exhibited by RIL 16, RIL 86, Norungan, Nootripathu, Varappukudanchan, since they recorded significant mean values for maximum characters under high stress. The genotypes MDU 5, PMK 2, PMK 3 and RIL 70 showed tolerance under medium stress where as the genotypes TKM 9 and PM 01011 were suitable for low stress. The low land irrigated rice cultivars ASD 16, ADT 36, IR 36, PM 01010 and the NPT lines were not suited for non-flooded (aerobic) condition.

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