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Research Note

Studies on root traits for drought tolerance in aerobic rice (*Oryza sativa* L.) using polythene bags

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Abstract
The present investigation was carried out under aerobic condition to evaluate twenty five genotypes for drought tolerance potentiality conferred by root traits. To study the root related traits in the field conditions will be the difficult task as well as the accuracy will not be there to overcoming these problems.The root studies were done in PVC pipes as well as in polythene bags. The genotypes were raised in polythene bags, from which the following observations were recorded on eight important root traits *viz.*, root length, root number at 15,30 and 45 cm, root volume, root density, root thickness, root weight. Six genotypes *viz*., PMK 4, MAS 946, Annada, KMP 175, PMK 2 and Vandana showed significantly superior mean values for most of the root traits included in the study. Therefore, these genotypes can be used as potential donors in drought resistance breeding programme.

Key words
Aerobic rice, root traits, drought tolerance, polythene bags

Rice (*Oryza sativa* L.) is the staple food of more than three billion people in the world; but drought stress is a serious limiting factor to rice production and yield stability in rainfed areas. Normally breeding for drought tolerance is a challenging task because of the complexicity of the component traits, screening technique, environmental factors and their interaction. A number of morphological, physiological and phenological traits have been reported to improve the performance of rice challenged by drought. Adaptive mechanisms of plants in response to drought have been reported by several scientists (Chopra and Sinha, 1998). Root systems form one of the important components of drought resistance and it is normally evaluated under aerobic condition. Aerobic rice production system is the one where in which input responsive rice varieties are grown in non-puddled and non-saturated soils (Bouman *et al.*, 2002). To obtain high grain yield under aerobic method of cultivation, there is a need to develop new rice varieties which are having drought tolerant and it's conferred by root morphological and physiological characters. To study the root related traits in the field conditions will be the difficult task as well as the accuracy will not be there to overcome these problems. The root studies were done in PVC pipes (Kanbar *et al*. 2009; Ganapathy *et al*. 2010) as well as in polythene bags. Among the root morphological traits, root length and root thickness are found to be associated with drought resistance in upland condition. Increased root thickness improves drought resistance as the roots are capable of increasing root length density and water uptake by producing more and larger root branches. Under rainfed lowland condition, greater root length density below 30/20cm and moisture stress induced dynamic response in the 10-30 cm soil layer were found to be associated with drought resistance (Ingram *et al*., 1994). Selection and breeding for desirable root characteristics associated with drought resistance have been practiced in rice (Chang *et al*., 1972). Keeping these considerations in view, an attempt was made in the present study with the objectives of screening rice genotypes with desirable root characters for drought tolerance.

The present investigation was carried out at the Department of Plant Breeding and Genetics, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, a tail end region of Cauvery Delta Zone during *kharif* 2014.Twenty five genotypes comprising of 13 varieties / advanced breeding lines developed for irrigated (lowland and flooded) rice system,4 varieties developed for rainfed (lowland) rice system, 2 varieties developed for (rainfed) upland rice system and 6 varieties / advanced breeding lines developed for aerobic rice system utilized as experimental materials for the present study.

The polythene bags of 25 micron thickness having a length of 75 cm and 25 cm diameter were used. The experiment was laid in Randomized Block Design (RBD) with three replications. Each genotype was accommodated in two bags in each replication. The polythene bags were filled up to 65 cm with a mixture of sandy clay loam and FYM in 4:1 proportion as suggested by Kanbar *et al*. (2009) and Ganapathy *et al*. (2010). Two seeds were direct seeded in each poly bag and after germination, only one seedling was allowed to grow in each bag. The soil of polythene bags was initially soaked with water for facilitating

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germination and thereafter aerobic condition was maintained in bags by giving irrigations using rose cane as and when necessary without allowing water stagnation. Necessary drainage holes were provided in the bags to avoid dampness. The soil in the bags was fertilized according to the recommended package of practices. On 80th day after sowing, polythene bags were carefully removed and soaked in water overnight to loosen the soil. Next day, roots were thoroughly washed with water and then used for observing following root characters.

Root length (RL): The maximum length of the longest root was measured and expressed in centimeter.

Root number at 15 cm (RN_{15}): Number of roots per plant from crown region up to the depth of 15 centimeter were counted and recorded.

Root number at 30 cm (RN_{30}): Number of roots per plant from crown region up to the depth of 30 centimeter was counted and recorded.

Root number at 45 cm (RN_{45}): Number of roots per plant from crown region up to the depth of 45 centimeter were counted and recorded.

Root volume (RV): Root volume was determined by water displacement method in which the roots were immersed in measuring cylinder with a known volume of water and the change in level of water was measured as the volume of the roots and expressed in cubic centimeter.

Root density (RD): Root density was worked out by dividing the root length with root volume and expressed as cm/cm^3.

Root thickness (RT): Thickness of the root at the center of crown region was measured using screw gauge and recorded in millimeter.

Root weight (RW): Roots of the plant was cut from the stem, washed thoroughly in water to remove the adhered soil and then dried moisture free in hot air oven at 80^{0}C for 48 hours. The dry weight of the root of the selected plant was recorded and expressed in grams.

Observations recorded for eight root characters on selected plants in twenty five genotypes were analyzed statistically by adopting the standard methods suggested by Panse and Sukhatme (1967).

Analysis of variance for all the twenty three characters studied was found to be significant. The results of the mean performance of the twenty five genotypes for the eight characters studied are presented character wise in table 1. Among the twenty five genotypes studied, twelve genotypes produced significantly higher root length. Twelve genotypes recorded significantly higher root number at 15 cm. root number at 30 cm were recorded significantly higher values for eight genotypes. Fourteen genotypes registered significantly higher root number at 45 cm. significantly higher root volume was found in five genotypes. Three genotypes alone recorded significantly higher root density. Eight genotypes had significantly higher root thickness. High significant values for root weight were found in eight genotypes.

The main criteria considered by the breeders while evaluating the genotypes is the mean / *per se* performance. In the present study also, the twenty five genotypes were evaluated for their mean values for the eight characters under study. Regarding root traits, six genotypes *viz*., PMK 4, MAS 946, Annada, KMP 175, PMK 2 and Vandana had higher mean values for six out of eight traits studied *viz*., root length, root number at 15, 30 and 45 cm, root thickness and root weight. In addition, PMK 4 and MAS 946 recorded higher mean for one more root trait, PMK 4 for root density and MAS 946 for root volume. Hence, these varieties could be adjudged as most promising and suitable for aerobic rice cultivation. These six genotypes were selected as they have drought tolerance due to better expression for many root traits. These six genotypes identified in the present study may be utilized either directly for aerobic cultivation or used as parents in the future aerobic rice breeding programme. Among the above six genotypes selected for aerobic cultivation in the present study, MAS 946 and KMP 175 were specifically evolved for aerobic condition through a planned recombination breeding programme by combining desirable high yielding features with root features conferring drought tolerance using high yielding irrigated rice genotypes and drought tolerant upland / rain fed genotypes as parents. Babu *et al*. (2011), Desai *et al*. (2011), Murthy *et al*. (2011) and Kumar *et al*. (2014) also observed superior performance of MAS 946 when tested along with other genotypes under aerobic system.

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Table 1. Mean performance of root characters

Sl. No.	Genotypes	RL (cm)	RN_{15}	RN_{30}	RN_{45}	RV (cm^3)	RD (cm/cm^3)	RT (mm)	RW (g)
1	ADT 37	33.25	74.33	25.00	21.33*	23.33	1.44	1.21	9.00
2	ADT 43	33.50	75.33	16.33	0.00	19.67	1.72	1.18	9.33
3	ADT 45	31.60	79.33	30.33	0.00	19.33	1.65	1.19	7.00
4	ADT 46	31.83	74.67	15.33	13.67	18.00	1.78	1.18	9.00
5	ADT 47	36.30	80.67	19.00	7.33	25.33	1.44	1.19	11.00
6	ADT 48	30.98	72.67	18.33	14.33	18.00	1.74	1.19	9.00
7	CO 47	37.28	78.67	26.00	15.33	14.00	2.70*	1.19	7.00
8	CB 06563	37.00	74.67	29.67	26.33*	20.67	1.82	1.19	9.00
9	CB 06803	37.65	86.00	28.33	25.67*	25.33	1.51	1.21	11.67
10	ASD 16	36.00	85.67	41.00*	24.00*	26.00*	1.40	1.22	10.00
11	ASD 20	36.80	84.33	28.00	0.00	16.00	2.38	1.20	7.33
12	IR 36	34.30	79.00	32.00	0.00	21.33	1.63	1.20	8.67
13	IR 72	31.18	85.33	31.33	0.00	14.67	2.26	1.18	9.33
14	PMK 2	52.45*	113.67*	31.00	12.67	19.00	2.81*	1.27*	**22.00***
15	PMK 3	53.05*	111.33*	31.33	30.67*	22.83	2.33	1.26*	11.00
16	PMK 4	**55.40***	116.33*	42.00*	30.00*	19.33	**2.95***	1.27*	16.00*
17	RMD 1	53.95*	113.67*	**78.67***	18.67	**34.00***	1.59	1.22	17.00*
18	Vandana	47.90*	115.67*	29.00	22.67*	20.33	2.37	1.21	8.67
19	Annada	50.20*	115.33*	42.67*	27.00*	21.00	2.42	1.23*	16.00*
20	CR 2996-1-14	52.70*	124.67*	51.33*	**33.67***	24.00	2.20	1.26*	16.33*
21	CR 3001-5-5-2	48.12*	**126.33***	55.67*	25.33*	32.00*	1.51	1.26*	13.00
22	CR 3001-5-5-14	52.15*	119.33*	47.00*	27.33*	25.33	2.08	1.22	14.00
23	KMP 153	51.97*	109.67*	33.33	32.00*	24.67	2.13	1.20	16.67*
24	KMP 175	52.50*	117.33*	28.00	27.67*	32.00*	1.64	**1.28***	17.00*
25	MAS 946	53.67*	124.33*	36.00*	28.00*	30.00*	1.79	1.24*	16.00*
	Grand mean	**42.87**	**97.53**	**32.59**	**18.63**	**22.65**	**1.97**	**1.22**	**12.04**
	SE	1.03	3.05	1.22	1.06	1.37	0.24	0.01	1.54
	CD at 5 per cent	2.06	6.12	2.45	2.13	2.75	0.49	0.01	3.10

*Significant at 5 per cent level Bold values indicate maximum values