

Research Article**Studies on root traits for drought tolerance in rice (*Oryza sativa* L.) under controlled (PVC pipes) condition**S₂Ganapathy, S. K Ganesh, P. Shanmugasundaram, and R. Chandra Babu**Abstract**

Rice (*Oryza sativa* L.) is the most important food crop of the world; but drought stress is a serious limiting factor to rice production and yield stability in rainfed areas. In order to design an efficient breeding program for synthesis of new varieties with virtues of drought tolerance and high yielding ability, it is necessary to identify potential parents that combine well for both yield and drought tolerance. Hence, the present investigation was undertaken to evaluate genetic potentiality of eight lines and five testers along with 40 hybrids were evaluated under PVC pipes (controlled) Condition for root traits in order to use them in drought resistance breeding programmes. The parents and hybrids were raised in PVC pipes, where the plants were subjected to drought for a period of 20 days during tillering stage starting on 60 days after sowing. Observations were recorded on seven important root traits viz., root length, root volume, root length density, total number of roots, root thickness, root dry weight and root:shoot ratio. Five genotypes viz., Norungan, CT 9993, Moroberekan, Nootripathu and MDU 5 showed significantly superior mean values than grand mean for most of the root traits included in the study. Therefore, these genotypes can be used as potential donors in drought resistance breeding programme. Among the hybrids, CT 9993 / ASD 18, Moroberekan / ASD 16, CT 9993 / IR 50, Moroberekan / Co 47, Noungan / ASD 16, Nootripathu / MDU and Nootripathu / CO 47 were identified as outstanding ones for improving drought tolerance as they registered significant higher mean value for majority of the root traits.

Key Words: rice, root traits, drought tolerance, PVC pipes

Introduction

Rice (*Oryza sativa* L.) is the most important food crop of the world; but drought stress is a serious limiting factor to rice production and yield stability in rainfed areas. Breeding for drought tolerance is a challenging task because of the complexity 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 (Fukai and Cooper, 1995; Nguyen *et al.*, 1997; Chapra and Sinha, 1998.). Root systems form one of the important components of drought resistance. 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 genotype with desirable root characters for drought tolerance.

Materials and Methods

The present investigation was conducted at Research Farm, Agricultural College and Research Institute, Madurai (latitude: 9.54' E; longitude: 78.8' N;

altitude: 147 m MSL) during *Kharif*, 2005. The experimental materials consisted of eight drought tolerant genotypes *viz.*, Norungan (L_1), Mattaikar (L_2), CT 9993 (L_3), Moroberekan (L_4), NPT 107 (L_5), CPMB ACM 03 015 (L_6), CPMB ACM 03 017 (L_7) and Nootripathu (L_8) (lines); five high yielding rice varieties *viz.*, MDU 5 (T_1), CO 47 (T_2), IR 50 (T_3), ASD 16 (T_4) and ASD 18 (T_5) (testers) and their resultant 40 hybrids. Crossing was carried out and sufficient F_1 seeds were obtained. Parents and their resultant 40 hybrids were sown in vertically standing PVC pipes of 1.0m long with a diameter of eight inches. The experiment was laid in Completely Randomized Design (CRD) with two replications. Each genotype was accommodated in one pipe. The pipes were filled with mixture of sandy clay loam and FYM in 1:4 proportion. Seeds were direct seeded in each PVC pipe. After germination, only one seedling was allowed to grow in one pipe. All the pipes were exposed to moisture stress by withholding irrigation for a period of 20 days during tillering stage starting on 60 days after sowing. On 80th day after sowing, the pipes were removed carefully and soaked in water overnight to loosen the soil. Next day, roots were cleaned and seven important root traits *viz.*, root length, root volume, root length density, total number of roots, root thickness, root dry weight and root:shoot ratio were recorded as follows:

Root length: Plant was uprooted by giving a deep dig near the base after watering and the maximum root length of the longest root was recorded in centimetre.

Root volume: Root volume was determined in 'cc' using water displacement method.

Root length density: Root length density was worked out.

Total number of roots: Total number of roots per plant at crown region were counted and recorded.

Root thickness: Root thickness was measured using screw gauge and recorded in 'mm'

Root dry weight: Roots of the plant was cut from the stem, dried moisture free in a hot air oven at 80°C for 48 hours (till attaining constant weight), weighed and recorded in gram.

Root : Shoot ratio: The root weight of plant was recorded as mentioned above. The shoot weight was recorded separately after drying the shoot portion in

hot air oven at 80°C for 48 hours till reaching constant weight. Root: Shoot ratio was worked out.

The analysis of variance of CRD for root traits were worked out as suggested by Panse and Sukhatme, 1964.

Results and Discussion

For developing high yielding varieties / hybrids through any breeding programme, the basic idea is the choice of parents. For choosing the parents, the phenotypic mean performance is taken as the sole criterion for the inception of the breeding programme. The parents with high mean performance would result in good performing offsprings (Gilbert, 1958 and Nadarajan, 1986). So, the parents with significantly favourable mean performance over the grand mean for the root traits. The analysis of variance revealed significant differences among the parents and hybrids for all the seven root traits studied.

In the present investigation, the mean performance of parents and their hybrids for different root traits were presented in Table 1 and 2 respectively. Several parents had significantly high *per se* performance for more than one character. This include, CT 9993(L_3) and Moroberekan (L_4) which possessed significantly favourable mean value for all the traits. This was followed by Norungan (L_1) and Nootripathu (L_8), which registered significantly superior mean performance for six traits each *viz.*, root length, root volume, root length density, total number of roots, root thickness and root dry weight. Among the testers, MDU 5 (T_1) had significantly superior mean performance for all the traits under study. Hence, these parents were adjudged as desirable ones for construction of drought tolerant varieties. Among the hybrids, CT 9993 / ASD 18 ($L_3 \times T_5$) and Moroberekan / ASD 16 ($L_4 \times T_4$) were expressed significantly higher mean for all the traits under study. Next best hybrid, CT 9993 / IR 50 ($L_3 \times T_3$), which also showed significantly high *per se* performance for all the traits, except root length density and another hybrid Moroberekan / Co 47 ($L_4 \times T_2$) also recorded significant greater mean performance for all the root traits under study except root thickness. The hybrids, Norungan / ASD 16 ($L_1 \times T_4$) and CT 9993 / MDU 5 ($L_3 \times T_1$), were also found to have significantly high mean value for five traits each. The former recorded significantly high mean value for root length, root volume, root thickness, root dry weight and root:shoot ratio, whereas in the latter case, significantly high mean

value for root length, root volume, total number of roots, root thickness and root dry weight. This was followed by the hybrids, Nootripathu / MDU 1 ($L_8 \times T_1$) and Nootripathu / CO 47 ($L_8 \times T_2$), which had significant higher mean values over the grand mean for five traits each. Hence, these hybrids were considered as outstanding ones for improving drought tolerance.

Considering all the root traits together, among the parents *viz.*, Nonungan, CT 9993, Moroberekan and MDU 5 can be regarded as drought resistant genotypes since they expressed significant greater mean performance over grand mean for most of the root traits. Among the hybrids, CT 9993 / ASD 18, Moroberekan / ASD 16, CT 9993 / IR 50, Moroberekan / Co 47, Nonungan / ASD 16, Nootripathu / MDU and Nootripathu / CO 47 were identified as outstanding ones for improving drought tolerance as they registered significant higher mean value for majority of the root traits included in the study.

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Table1. Mean performance of parents for different root traits under PVC pipes (controlled) condition

Parents	Root length (cm)	Root volume (cc)	Root length density (cm/cc)	Total no. of roots	Root thickness (mm)	Root dry weight (g)	Root: shoot ratio
Lines	69.42*	91.21*	0.75	138.50*	1.18*	21.65*	0.78
Norungan							
Mattikar	61.50	76.41	0.81	127.00	1.00	18.52	0.71
CT 9993	74.62*	94.32*	0.80	141.50*	1.22*	23.42*	0.91*
Moroberekan	70.15*	106.32*	0.66	153.50*	1.21*	22.38*	0.87*
NPT 107	57.65	66.54	0.85	121.00	1.01	17.56	0.82
ACM 03 015	64.52	78.32	0.82	126.50	1.06	18.31	0.76
ACM 03 017	69.00*	85.62	0.81	138.00*	1.16	22.04*	1.04*
Nootripathu	70.08*	92.02*	0.76	135.50	1.19*	20.05	0.82
G. Mean	67.02	84.63	0.80	135.07	1.11	20.48	0.83
Testers							
MDU 5	52.64*	53.42*	0.99	126.50*	0.91*	12.32*	0.62*
CO 47	41.51	41.24	1.01*	112.00	0.84	11.55	0.44
IR 50	38.50	34.26	1.12*	119.50	0.74	10.26	0.42
ASD 16	47.24*	51.12*	0.94	120.00	0.83	11.81	0.48
ASD 18	43.25	48.43	0.89	121.00	0.78	11.44	0.51
G. mean	44.83	45.69	0.99	120.40	0.81	11.44	0.48
SEd	0.84	2.07	0.05	1.37	0.03	0.41	0.018
CD (5%)	1.68	4.14	0.10	2.74	0.06	0.82	0.036

- Significantly superior than general mean

**Table 2. Mean performance of hybrids for different root traits under PVC Pipes (controlled) condition**

Hybrids	Root length (cm)	Root volume (cc)	Root length density (cm/cc)	Total no. of roots	Root thickness (mm)	Root dry weight (g)	Root: shoot ratio
L ₁ xT ₁	60.23	49.00	1.23*	116.50	0.86	17.20	0.71*
L ₁ xT ₂	67.58	50.00	1.35*	95.50	0.96	16.00	0.40
L ₁ xT ₃	55.31	44.00	1.26*	85.00	0.76	14.50	0.70*
L ₁ xT ₄	68.65*	84.50*	0.77	132.50*	1.26*	21.00*	0.43
L ₁ xT ₅	65.12	78.50*	0.83	134.00*	1.25*	16.00	0.68
L ₂ xT ₁	66.71	69.00	0.97	142.00*	1.12*	13.00	0.78*
L ₂ xT ₂	57.60	71.50	0.81	117.00	0.96	15.50	0.55
L ₂ xT ₃	45.15	82.00*	0.55	86.50	1.00	14.50	0.62
L ₂ xT ₄	61.22	71.00	0.86	132.50*	0.93	17.50	0.58
L ₂ xT ₅	67.14	55.50	1.21*	97.50	0.81	16.00	0.51
L ₃ xT ₁	72.13*	74.00*	0.97	142.00*	1.09	19.10*	0.95*
L ₃ xT ₂	75.58*	90.00*	0.84	121.50	1.40*	20.20*	0.51
L ₃ xT ₃	82.54*	91.50*	0.90	139.00*	1.20*	21.00*	0.94*
L ₃ xT ₄	74.35*	84.50*	0.88	116.00	1.33*	19.20*	0.75*
L ₃ xT ₅	84.55*	75.00*	1.13*	136.50*	1.16*	23.20*	0.82*
L ₄ xT ₁	77.65*	67.00	1.16*	132.50*	0.84	16.50	0.75*
L ₄ xT ₂	79.13*	71.70*	1.12*	140.00*	0.90	19.30*	0.71*
L ₄ xT ₃	73.52*	81.00*	0.91	138.00*	0.92	17.00	0.69
L ₄ xT ₄	80.75*	79.00*	1.08*	156.00*	1.33*	22.00*	0.81*
L ₄ xT ₅	73.27*	72.00*	1.02	148.00*	1.10*	18.00	0.75*
L ₅ xT ₁	58.56	64.00	0.92	135.00*	0.82	15.80	0.74*
L ₅ xT ₂	66.37	68.00	0.98	82.50	0.85	17.00	0.55
L ₅ xT ₃	53.25	41.00	1.30*	83.00	0.77	16.00	0.60
L ₅ xT ₄	65.25	52.50	1.24*	75.20	0.86	14.20	0.64
L ₅ xT ₅	50.14	37.50	1.34*	75.00	0.76	13.00	0.69
L ₆ xT ₁	61.57	54.00	1.14*	111.50	0.96	17.50	0.73*
L ₆ xT ₂	65.63	44.00	1.49*	89.00	0.86	16.00	0.58
L ₆ xT ₃	56.24	47.50	1.18*	76.50	0.82	15.70	0.53
L ₆ xT ₄	61.56	73.25*	0.84	89.00	0.93	17.30	0.52
L ₆ xT ₅	63.51	75.61*	0.84	142.00*	1.20	19.00*	0.60
L ₇ xT ₁	69.51*	86.40	0.80	151.00*	1.05	23.00*	1.12*
L ₇ xT ₂	64.12	45.50	1.41*	95.40	0.86	20.50*	0.91*
L ₇ xT ₃	62.61	44.00	1.34*	86.30	0.94	19.00*	0.80*
L ₇ xT ₄	64.21	60.00	1.07*	104.00	1.12*	16.00	0.73*
L ₇ xT ₅	65.26	72.00*	0.91	144.30*	1.15*	17.00	0.82*
L ₈ xT ₁	61.73	73.00*	0.85	131.00*	1.10*	19.00*	0.72*
L ₈ xT ₂	75.52*	78.50*	0.96	146.00*	1.18*	20.00*	0.51
L ₈ xT ₃	65.17	71.00	0.92	132.50*	1.05	14.50	0.43
L ₈ xT ₄	71.30*	90.20*	0.79	157.00*	1.31*	16.50	0.49
L ₈ xT ₅	73.54*	82.41*	0.89	142.00*	1.25*	16.00	0.64
GM	66.49	67.51	0.96	119.02	1.03	17.49	0.65
SE	0.84	2.07	0.05	1.37	0.03	0.41	0.018
CD (5%)	1.68	4.14	0.10	2.74	0.06	0.82	0.036

* Significantly superior than general mean