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VARIATION STUDIES ON SEEDLING STAGE ROOT SYSTEM IN RICE LANDRACES

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Abstract

Roots are the principal plant organ for nutrient and water uptake. Root traits are found to be critical for increasing yield under soil-related stresses. The present study was conducted with the objective of assessing the presence of genetic variability for root traits in 51 rice landraces. Observations were recorded on length of root (cm), number of lateral roots and number of leaves. PCV was a little higher than GCV which indicated the influence of environment in each trait. Length of root and number of lateral roots recorded high PCV, GCV, heritability and genetic advance indicating the presence of high variability among the rice landraces and these traits can be improved through direct selection. Based on relative magnitude of D^2 estimates rice landraces were grouped into six clusters. Maximum genetic divergence was observed between cluster IV and V. On the basis of cluster mean values, cluster IV was superior for root length and cluster III for number of lateral roots. Landraces *Sigapu kavuni, Navaraa, Rasakedam, Milagu samba* and *Pisini* can be used as parents in future breeding programmes to improve root system. The knowledge on rice root systems can be used to elucidate the role of roots for improvements in drought resistance.

Key words: Root development, landraces, variability, genetic diversity.

Introduction

Climate change poses serious problems of declining water tables, unpredictable growing environments and increased food demand which necessitates the development of crop varieties adaptable to adverse environments. Drought is one of the major abiotic stress, affecting rice production in rainfed ecosystem (Bimpong *et al*., 2011). Rice landraces are widely grown under rainfed lowland conditions by farmers and are adapted to local environments (Zeven, 1998). These landraces may serve as a valuable source of breeding for drought resistance due to their superior root traits.

Among the various mechanisms of drought resistance, root is closely associated with drought avoidance (Dixit *et al*., 2014). The contribution of root characters on grain yield under stress condition is more important than well-watered condition. Under low moisture stress condition maximum root length and root number improves panicle length and grain yield (Kanbar *et al*., 2009). Root length and lateral roots are important components of root architecture as they increase the root biomass and enable plants to absorb more water and nutrients from the soil (Meng *et al*., 2019). Hence, the present study was formulated to evaluate the variability and diversity of traits related to root system development in rice landraces at seedling stage.

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Materials and Methods

The present investigation was carried out in Anbil Dharmalingam Agricultural College and Research Institute, TNAU, Trichy using 51 rice landraces collected from various places near Trichy. Landraces were grown in raised nursery bed in three replications following randomized block design. Thirty days after sowing five seedlings from each genotype in a replication were used to explore the root growth in rice landraces. The whole root system was pulled out from the soil with minimum damage and disturbance and washed in water to remove the soil. Observations were recorded on length of root (cm), number of lateral roots and number of leaves in a seedling. The recorded data were subjected to analysis of variance according to the method recommended by Panse and Sukhatme, (1967). Phenotypic and genotypic coefficients of variation were computed as suggested by

Burton, (1952). Heritability on broad sense was calculated as per the formula given by Allard, (1960). Genetic advance was worked out using the formula suggested by Johnson *et al.*, (1955). The analysis of divergence was carried out by Mahalanobis D^2 statistic, (1936).

Results and Discussion

The results of ANOVA revealed that the mean sum of squares due to genotypes were highly significant for root traits (Table 1). This indicated that the genotypes were having inherent genetic variances among themselves with respect to the characters studied. Extensive root growth is important for plant survival in complex soil conditions (Dorlodot *et al.*, 2007).

Among the 51 rice landraces studied, 20 landraces exhibited significantly high root length with a mean value of 7.87 cm (Table 2). Landrace *Sigappu kavuni* had the highest root length (13.85 cm) followed by *Navaraa* (13.33 cm), *Karung kuruvai* (12.6 cm) and *Poongar* (12.42 cm). The lowest root length was recorded by *Salem samba* (2.55 cm). Plants having deeper root system at early stage colonize a large soil volume and improve the water uptake from the lower layers and help to maintain a good plant water potential which has been reported to have a positive effect on yield under stress (Mambani and Lal, 1983).

Lateral roots plays a major role in water uptake particularly under drought conditions (Wang *et al*., 2009). A significantly high number of lateral roots was recorded by 14 landraces. Number of lateral roots had a mean value of 3.87. *Rasakedam* had more number of lateral roots (20.90) followed by *Navaraa* (18.65), *Pisini* (17.70) and *Milagu samba* (17.65). *Mysore malli* had less number of lateral roots (7.75). Thus, landraces with deeper roots and more number of lateral roots at early stages may be used in breeding programmes for improvement of drought tolerance.

A mean value of 3.87 was recorded by the trait number of leaves and nine landraces had significantly more number of leaves. The highest value was recorded by *Rasakedam* (5.00) and lowest value was recorded by *Kandasali* (2.40).

Narrow difference was observed between the

Table 1: ANOVA of rice landraces in 30 day old seedling.

Source	df	Mean squares		
		Length of root	Number of lateral roots	Number of leaves
Genotype	50	11.7739**	14.5330**	0.6551**
Replication	2	4.2989	17.0479	0.5515
Error	100	0.0381	0.2396	0.0497

Table 2: Mean performance of rice landraces in 30 day old seedling.

S. No.	Landrace	Length of root	No. of lateral roots	No. of leaves
1	Vaadan samba	10.50**	13.65	4.50**
2	Jeeraga samba	8.52**	10.70	3.90
3	Bhavani	5.05	9.60	3.65
4	Rajamannar	7.10	15.05**	4.10
5	Kaalanamak	9.05**	8.20	4.00
6	Poongar	12.42**	11.20	3.95
7	Sangilikar	5.05	13.25	3.95
8	Kuruvai samba	9.78**	9.50	4.00
9	Kuliyadichan	5.46	12.00	3.65
10	Kothamalli samba	6.39	14.00*	4.80**
11	Milagu samba	7.95	17.65**	3.20
12	Ilupaipoo samba	4.85	9.35	3.35
13	Bommi	7.41	9.65	3.85
14	Kichili samba	5.30	12.90	3.20
15	Palkuda vazhai	9.97**	11.45	4.20
16	Chinna	8.96**	10.75	3.55
17	Karung kuruvai	12.60**	11.23	4.05
18	Thooyamalli	7.97	13.60	4.00
19	Salem samba	8.74**	14.00*	4.40*
20	Sembuli samba	6.42	10.40	2.90
21	Thengapoo samba	8.05	12.38	3.60
22	Garudan samba	6.05	11.37	3.15
23	Kottara samba	5.73	11.00	3.10
24	Kaatu ponni	10.95**	13.60	4.00
25	Sigapu kavuni	13.85**	10.80	3.20
26	Kandasali	8.80**	13.20	2.40
27	Kaalajeera	11.35**	13.45	3.10
28	Ottadam	8.07	13.55	3.55
29	Navaraa	13.33**	18.65**	3.20
30	Samba mosanam	8.70**	16.00**	4.00
31	Singinikar	5.81	17.45**	3.35
32	Kaatuyanam	9.85**	14.24**	4.05
33	Vaalan	7.70	15.75**	3.55
34	Kaatu vanibam	7.25	9.70	3.65
35	Manjal ponni	5.20	12.54	3.55
36	Swarnamughi	8.90**	14.29**	4.15
37	Swarna masoori	8.50**	14.30**	3.65
38	Perungkar	6.60	11.23	3.05
39	Pisini	3.20	17.70**	4.40*
40	Vaal sigapu	11.06**	13.50	4.15
41	Karuvachi	3.74	13.75	4.10
42	Kaliyan samba	7.66	12.55	4.75**
43	Kallurundai	9.49**	14.50**	4.55**
44	Rajamudi	6.27	14.39**	4.75**
45	Mapillai samba	5.95	12.50	4.50**
46	Karupu kavuni	6.00	10.15	4.00
47	Mysore malli	6.50	7.75	4.00
48	Karuthakar	5.34	10.60	4.60**
49	Koombalai	5.80	11.75	4.20
50	Rasakedam	7.82	20.90**	5.00**
51	Kochin samba	8.50**	15.00**	4.95**

*Significant at 5% level; **Significant at 1% level

Table 3: Variability parameters among rice landraces in 30 day old seedling.

S. No.	Characters	Mean	Minimum	Maximum	PCV	GCV	h^2	GAM
1	Length of root	7.87	3.20	13.85	30.87	30.77	99.35	63.19
2	Number of lateral roots	12.88	7.75	20.90	21.11	20.76	96.76	42.07
3	Number of leaves	3.87	2.40	5.00	15.33	14.21	85.90	27.13

Table 4: Distribution of rice landraces into clusters.

Clusters	No. of geno types	Name of the genotypes
I	22	Kaatu ponni, Vaal sigapu, Vaadan samba, Kaalajeera, Kaatuyanam, Palkuda vazhai, Kallurundai, Poongar, Karung kuruvai, Swarnamughi, Kuruvai samba, Chinna, Kandasali, Salem samba, Swarna masoori, Samba mosanam, Jeeraga samba, Kochin samba, Ottadam, Thengaipoo samba, Thooyamalli, Kaalanamak
II	24	Kothamalli samba, Rajamudi, Mapillai samba, Koombalai, Kuliyadichan, Rajamannar, Sangilikar, Kaliyan samba, Manjal ponni, Garudan samba, Karupu kavuni, Kichili samba, Kottara samba, Perungkar, Karuthakar, Sembuli samba, Kaatu vanibam, Ilupaipoosamba, Bommi, Bhavani, Singinikar, Vaalan, Mysore malli, Karuvachi
III	2	Milagu samba, Rasakedam
IV	1	Sigapu kavuni
V	1	Pisini
VI	1	Navaraa

Table 5: Intra and inter cluster distances of various clusters.

Cluster no.	I	II	III	IV	V	VI
I	**152.13**	487.74	365.38	639.55	1316.89	780.96
II		**119.16**	444.32	1850.80	420.82	1990.25
III			**83.99**	1333.59	693.46	940.71
IV				**0**	3463.67	319.97
V					**0**	3143.21
VI						**0**

Table 6: Cluster mean values of root traits in rice landraces.

Cluster	Root length	Number of lateral roots	Number of leaves
I	9.58	12.83	3.94
II	6.02	12.03	3.82
III	7.89	19.28	4.10
IV	13.85	10.80	3.20
V	3.20	17.70	4.40
VI	13.33	18.65	3.20

magnitude of PCV and GCV which indicates less environmental influence and greater role of genetic factors in the expression of these characters. The magnitude of phenotypic coefficient of variation was high for length of root and number of lateral roots while it was moderate for number of leaves (Table 3). High genotypic coefficient of variation was recorded by length of root and number of lateral roots. Moderate genotypic coefficient of variation was recorded by the trait number of leaves. Therefore, these characters are likely to allow reasonable scope for improvement through selection.

Heritability and genetic advance estimates were high for all the traits for length of root, number of lateral roots and number of leaves. It indicates the predominance of additive gene action for the expression of these traits. Hence selection of these characters would be effective in rice landraces.

Fifty one rice landraces were grouped into six clusters using Mahalanobis D^2 analysis. Cluster II was largest with 24 rice landraces followed by cluster I with 22 rice landraces (Table 4). Clusters IV, V and VI were solitary with one rice landrace. The highest intra cluster distance was exhibited by cluster I (152.13) followed by cluster II (119.16) indicating that the genotypes within these clusters were more diverse (Table 5). Cluster IV and V recorded maximum inter cluster distance (3463.67) followed by cluster V and VI (3143.21). While the lowest inter cluster distance was observed between cluster IV and VI (319.97). Thus, crossing *Pisini* (cluster V) with *Sigapu kavuni* (cluster IV) and *Navaraa* (cluster VI) would create more variability in segregating population.

Sigapu kavuni in cluster IV had maximum root length (13.85 cm) followed by *Navaraa* in cluster VI (13.33). The genotypes with deep coarse roots has high ability for branching and soil penetration which helps in avoiding drought induced stress by extracting water from deep soil layers (Samson *et al*., 2002). More number of lateral roots was observed in *Milagu samba* and *Rasakedam* of cluster III (19.28) followed by *Navaraa* in cluster VI (18.65). *Pisini* in cluster V recorded more number of leaves (4.40) followed by *Milagu samba* and *Rasakedam* in cluster III (4.10). Hence, based on mean performance *Navaraa* in cluster VI could be useful to improve the traits root length and number of lateral roots (Table 6). Maximum contribution towards divergence

Table 7: Contribution of different traits towards genetic divergence.

S. No.	Traits	Times ranked first	Contribution (%)
1	Length of root	871	68.31
2	Number of lateral roots	273	21.41
3	Number of leaves	131	10.27

(Table 7) was made by root length (68.31) followed by number of lateral roots (21.41) and number of leaves (10.27).

Active root system improves grain yield by enhancing the water and nutrient uptake (King *et al*., 2003). The identified rice landraces *Sigapu kavuni, Navaraa, Rasakedam, Milagu samba* and *Pisini* can be utilized in breeding crops with improved root system at early establishment to enhance productivity under water deficit condition which minimize the negative impact of abiotic stresses and may be further evaluated at different growth stages to determine the genetic and physiological basis of rooting traits.

References

Allard, R.W. (1961). Principles of plant breeding. *Soil Science.*, **91(6):** 414.

Bimpong, I.K., R. Serraj, J.H. Chin, J. Ramos, E.M. Mendoza, J.E. Hernandez, M.S. Mendioro and D.S. Brar (2011). Identification of QTLs for drought-related traits in alien introgression lines derived from crosses of rice (*Oryza sativa* cv. IR64) × *O. glaberrima* under lowland moisture stress. *Journal of Plant Biology.*, **54(4):** 237-250.

Burton, G.W. (1952). August. Qualitative inheritance in grasses. Vol. 1. In *Proceedings of the 6th International Grassland Congress, Pennsylvania State College,* 17-23.

Dixit, S., A. Singh and A. Kumar (2014). Rice breeding for high grain yield under drought: a strategic solution to a complex problem. *International Journal of Agronomy.*, 2014.

de Dorlodot, S., B. Forster, L. Pages, A. Price, R. Tuberosa and X. Draye (2007). Root system architecture: opportunities and constraints for genetic improvement of crops. *Trends in plant science.*, **12(10):** 474-481.

Johnson, H.W., H.F. Robinson and R. Comstock (1955). Estimates of genetic and environmental variability in soybeans 1. *Agronomy journal.*, **47(7):** 314-318.

Kanbar, A., M. Toorchi and H.E. Shashidhar (2009). Relationship between root and yield morphological characters in rainfed low land rice (*Oryza sativa* L.). *Cereal Research Communications.*, **37(2):** 261-268.

King, J., A. Gay, R. Sylvester-Bradley, I. Bingham, J. Foulkes, P. Gregory and D. Robinson (2003). Modelling cereal root systems for water and nitrogen capture: towards an economic optimum. *Annals of botany.*, **91(3):** 383-390.

Mahalanobis, P.C. (1936). Mahalanobis distance. In Proceedings National Institute of Science of India, **49(2):** 234-256.

Mambani, B. and R. Lal (1983). Response of upland rice varieties to drought stress: I. Relation between root system development and leaf water potential. *Plant and Soil.*, 59-72.

Meng, F., D. Xiang, J. Zhu, Y. Li and C. Mao (2019). Molecular mechanisms of root development in rice. *Rice.*, **12(1):** 1-10.

Panse, V.G. and P.V. Sukhatme (1967). Statistical methods for agricultural workers. *Indian Council for Agricultural Research.* New Delhi, Indlca.

Samson, B.K., M. Hasan and L.J. Wade (2002). Penetration of hardpans by rice lines in the rainfed lowlands. *Field Crops Research.*, **76:** 175-188.

Wang, H., J. Siopongco, L.J. Wade and A. Yamauchi (2009). Fractal analysis on root systems of rice plants in response to drought stress. *Environmental and Experimental Botany.*, **65(2-3):** 338-344.

Zeven, A.C. (1998). Landraces: a review of definitions and classifications. *Euphytica.*, **104(2):** 127-139.