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In vitro Hydroponic Studies on Root Characters for Drought Resistance Assessment in Rice

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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 four lines and ten testers and their 40 hybrids by subjecting to *in vitro* screening for root traits under controlled condition in order to use them in drought resistance breeding programmes. Observations were recorded on root length, shoot length, root dry weight, shoot dry weight and root: shoot ratio. Two genotypes *viz.* ,MAS 946 -1, MAS 26 among parents and 8 genotypes *viz.,* IR 58025 A x IR 65912 R, IR 68897 A x MAS 946-1, TNAU CMS 2A x Vandana, IR 68888 A x MAS 26, IR 68888 A x BI 33, IR 58025 A x IR 21567 R, IR 68897 A x Vandana and TNAU CMS 2A x MAS 26 among hybrids showed significantly superior mean values than grand mean for all the traits included in the study. Therefore, parental genotypes can be used as potential donors in drought resistance breeding program and identified outstanding hybrids may be suggested for commercial cultivation after the conduct of MLT and ART trials.

Key words: Rice, Root traits, Drought tolerance, *In-vitro* screening, Burette.

Rice (*Oryza sativa* L.) is the primary cereal crop in the world. It is the staple food for more than two third of the world's population (Dowling *et al.*, 1998).Although rice ranks second to wheat as the most extensively grown crop in the world, it is the most important food crop and the largest irrigated crop in the world (Roel *et al*., 1999). More than 75 per cent of the world's rice supply comes from 79 million ha of irrigated land in Asia. Thus, the present and future food security of Asia depends largely on the irrigated rice production system. This system is a major user of fresh water (Tabal *et al*., 2002). The available amount of water for irrigation, however, is increasingly getting scarce. Environmental factors that impose water-deficit stress, such as drought, salinity and temperature extremes, place major limits on plant productivity (Boyer, 1982). Meanwhile, rice is often considered as one of the most drought sensitive cultivated species. However, water deficit commonly occurs during the growing season, and the intensity of stress depends on the duration and frequency of water deficit.

Drought is a major constraint to rice production of rainfed and upland ecosystems. Developing improved drought resistant lines has been a major breeding objective in rainfed rice improvement programs under such environment. Choosing parents for crossing is one of the most important steps in a breeding program. No selection method can identify good cultivars, if the parents used in the program are not suitable. Breeders have different approaches to parental choice and have achieved success in different ways.

Although progress can be made by selection for yield in the target environments, using root traits that are associated with drought tolerance can hasten that progress. Root development has long been recognized as an important factor in determining the adaptability of a given plant species to varying water conditions. Root characteristics that are responsible for the adaptability to drought stress are root length, root thickness, and root: shoot ratio (Passioura, 1982). The selection for desirable root characteristics has been a major objective in breeding for drought resistant varieties of rice plant (O'Tool *et al*., 1980). The deep roots of rice plant help to explore different levels of soil moisture and root thickness may be important in water uptake and translocation as resistance to water flow may be less in thick roots. In addition, thick roots are able to penetrate deeper soil layers (Bashar, 1987). The varieties with high root : shoot ratio were more drought resistant (Yamauchi and Aragones, 1997).

In India, drought is a serious constraint on the productivity of main crops such as wheat and rice. It is known that drought inhibits root growth, dry matter production and severely reduces the yield and yield components. A number of morphological,

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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. 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.

Materials and Methods

The present investigation was conducted at Tissue Culture Laboratory, Agricultural College and Research Institute, Madurai, India during July – August 2012. The experimental materials consisted of four CMS lines *viz.,*IR 58025 A, IR 68897 A, TNAU CMS 2A and IR 68888 A; ten testers *viz.,* IR 60199 R, IR 65912 R, IR 21567 R, CB 87 R, MAS 946 -1, MAS 26, BI 33, KMP 148, BR 2655 and Vandana and their resultant 40 hybrids.

Evaluation of Parents and Hybrids by burette (controlled) method

Forty Hybrids and their parents were subjected to *in vitro* screening for root traits by keeping mature seeds in burettes as explants (Plate 1). The experiment was laid out in Completely Randomized Block Design (CRD) with two replications. Each genotype was accommodated in one burette. First, the burettes were fitted on the stands and filled with normal tap water. Two mature seeds from each genotype of all the sixteen parents were selected and tied by using cotton threads to hang on the mouth of the burette so that the seeds were immersed in the water. After germination, only one seedling was allowed to grow in one burette. The roots were allowed to grow vigorously towards water kept in the burette. The water level of root zone was maintained carefully by touching the root tips on the water surface, and were not allowed to dry. On fifteenth day after sowing, the seedlings were removed carefully from the burette and the root measurements *viz.,* root length, shoot length, root dry weight and shoot dry weight were recorded (Plate 2). The analysis of variance of CRBD for root traits were worked out as suggested by Panse and Sukhatme (1964).

Results and Discussion

For developing high yielding varieties and 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 off springs (Gilbert, 1958). So, the parents with significantly favourable mean performance over the grand mean for the root traits are preferred. The analysis of variance revealed significant differences among the parents and hybrids for all the root traits studied.

Table 1. Mean performance of parents for root traits under controlled conditions (burette method)

Parents	Root length (cm)	Shoot length (cm)	Root dry weight (g)	Shoot dry weight (g)	Root/shoot ratio
Lines					
IR 58025A	26.95	10.86*	0.006*	0.012	0.50*
IR 68897A	25.25	10.84*	0.004	0.012	034
TNAU CMS 2A	28.20*	13.45*	0.004	0.012	034
IR 68888 A	25.25	10.30*	0.004	0.012	034
Testers					
IR 60199 R	23.35	6.95	0.004	0.011	0.36
IR 65912 R	29.25*	13.30*	0.004	0.018*	0.22
IR 21567 R	32.00*	8.25	0.003	0.007	0.35
CB87R	11.45	7.35	0.003	0.011	0.270
MAS 946-1	36.00*	13.45*	0.008*	0.017*	0.47*
MAS 26	35.05*	13.00*	0.005*	0.014*	0.42*
BI 33	40.10*	13.55*	0.004	0.015*	0.26
KMP 148	18.65	10.10	0.004	0.013*	0.30
BR 2655	18.15	9.80	0.004	0.009	0.44*
Vandana	31.15*	9.80	0.005	0.012	0.41*
Grand mean	27.20	10.78	0.004	0.012	0.36
SEd	1.07	0.46	0.0008	0.001	0.018
CD (5%)	2.26	0.98	0.0016	0.003	0.036

*Significantly superior than general mean

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 includes, MAS 946 -1 and MAS 26 which possessed significantly favorable mean value for all the traits and BI 33 had significant mean value for root length, shoot length and shoot dry weight. This was followed by TNAU CMS 2 A, IR 65912 R,

Table 2. MeanPerformance of hybrids for root traits under controlled conditions (burette method)

Hybrids	Root length (cm)	Shoot length (cm)	Root dry weight (g)	Shoot dry weight (g)	Root/ shoot ratio
IR 58025 A x IR 60199 R	25.30	8.80	0.004	0.011	0.36
IR 58025 A x IR 65912 R	48.50*	10.86*	0.007*	0.014*	0.50*
IR 58025 A x IR 21567 R	35.30*	10.84*	0.006*	0.012*	0.50*
IR 58025 A x CB 87 R	22.30	8.80	0.003	0.006	0.50*
IR 58025 A x MAS 946 -1	29.30*	10.30	0.004	0.007	0.57*
IR 58025 A x MAS 26	28.30*	8.75	0.004	0.012*	0.33
IR 58025 A x BI 33	32.30*	9.40	0.004	0.007	0.57*
IR 58025 A x KMP 148	24.20	9.12	0.003	0.012*	0.25
IR 58025 A x BR 2655	24.30	13.30*	0.004	0.018*	0.22
IR 58025 A 2 x Vandana	26.30	6.95	0.004	0.011	0.36
IR 68897 A x IR 60199 R	19.80	8.25	0.003	0.012*	0.25
IR 68897 A x IR 65912 R	21.30	7.35	0.004	0.014*	0.28
IR 68897 A x IR 21567 R	22.60	13.00*	0.003	0.011	0.27
IR 68897 A x CB 87 R	23.20	9.80*	0.005*	0.011	0.45*
IR 68897 A x MAS 946 -1	42.30*	13.55*	0.008*	0.013*	0.61*
IR 68897 A x MAS 26	26.30	10.10	0.004	0.007	0.57*
IR 68897 A x BI 33	19.30	13.45*	0.004	0.012*	0.33
IR 68897 A x KMD 148	22.30	13.45*	0.004	0.012*	0.33
IR 68897 A x BR 2655	29.60*	9.80	0.0041	0.014*	0.29
IR 68897 A x Vandana	29.60*	11.23*	0.008*	0.013*	0.61*
TNAU CMS 2A x IR 60199 R	21.30	12.30*	0.001	0.012*	0.08
TNAU CMS 2A x IR 65912 R	20.60	8.25	0.004	0.014*	0.28
TNAU CMS 2A x IR 21567 R	32.30*	7.35	0.004	0.011	0.36
TNAU CMS 2A x CB 87 R	22.35	13.00*	0.003	0.012*	0.25
TNAU CMS 2A x MAS 946 -1	29.30*	9.80	0.004	0.012*	0.33
TNAU CMS 2A x MAS 26	32.30*	13.55*	0.008*	0.012*	0.66*
TNAU CMS 2A x BI 33	23.60	10.10	0.005*	0.006	0.83*
TNAU CMS 2A x KMP 148	22.55	10.86*	0.004	0.007	0.57*
TNAU CMS 2A x BR 2655	21.55	8.80	0.004	0.014*	0.28
TNAU CMS 2A x Vandana	45.60*	10.84*	0.008*	0.017*	0.47*
IR 68888A x IR 60199 R	26.30	10.30	0.004	0.012*	0.33
IR 68888A x IR 65912 R	24.55	8.75	0.002	0.013*	0.15
IR 68888A x IR 21567 R	22.60	9.40	0.003	0.012*	0.25
IR 68888A x CB 87 R	21.60	10.86*	0.003	0.011	0.27
IR 68888A x MAS 946 -1	26.30	9.80	0.004	0.015*	0.26
IR 68888A x MAS 26	49.30*	13.00*	0.007*	0.018*	0.39
IR 68888A x BI 33	46.30*	13.55*	0.008*	0.014*	0.57
IR 68888A x KMD 148	29.30*	10.10	0.002	0.013*	0.15
IR 68888A x BR 2655	31.30*	10.86*	0.004	0.011	0.36
IR 68888A x Vandana	29.30*	13.00*	0.003	0.012*	0.25
Grand mean	**28.1**	**10.53**	**0.0043**	**0.0119**	**0.38**
SEd	**1.84**	**0.48**	0.0008	0.001	0.018
CD (5%)	**1.68**	**0.96**	0.0016	0.003	0.036

*Significantly superior than general mean

which registered significantly superior mean performance for traits *viz.,* root length (20.60 cm) and shoot length (8.25 cm). Among the testers, MAS 946-1 and MAS 26 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, IR 58025 A x IR 65912 R, IR 68897 A x MAS 946-1, TNAU CMS 2A x Vandana, IR 68888 A x MAS 26, IR 68888 A x BI 33, IR 58025 A X IR 21567 R,IR 68897 A x Vandana and TNAU CMS 2A x MAS 26 had expressed significantly higher mean for all the traits under study. The hybrid IR 58025 A x MAS 946-1 had significant mean performance for root length(29.30 cm), shoot length (10.30 cm) and root: shoot ratio. Then next best hybrids were IR 68888 A x BR 2655 and IR 68888 A x Vandana for significantly high *per se* performance for root length and shoot length; hybrids TNAU CMS 2A x MAS 946-1 and IR 68888 A x KMP 148 showed significant root length and shoot dry weight and hybrids *viz*., IR 58025 A x MAS 946-1 and IR 58025 A x BI 33 recorded higher root length, shoot dry weight and root length and root: shoot ratio. Ganapathy *et al* . (2010) recorded significantly high mean value for root length, root volume, total number of roots, root thickness and root dry weight among parents and their hybrids for drought tolerance under controlled (PVC pipes) condition.

Simple effective method for early drought screening:

Drought tolerance screening under field condition involves lot of resources such as land and

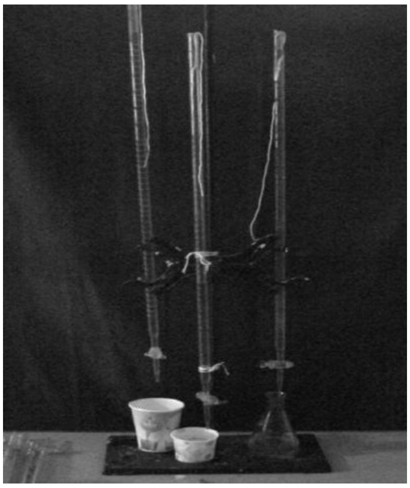

Plate 1.Evaluvation of parents and hybrids under controlled (bureete) condition

men power, besides the environmental influences also affect phenotypic expression of the genotype. The *in vitro* screening method through this sort of innovative hydroponic studies proves to be an ideal method to screen large set of genotypes with less effort and more accuracy with least environmental influences on genotypes. However, this experiment is to be additionally supported by field evaluation methods to validate drought resistant genotype (Kim *et al*., 2001). Field screening requires full season field data and it's not always convenient or efficient, hence, there is a need to have simple and effective early screening methods. Further, it has been proved to be very effective method for studying the effect of

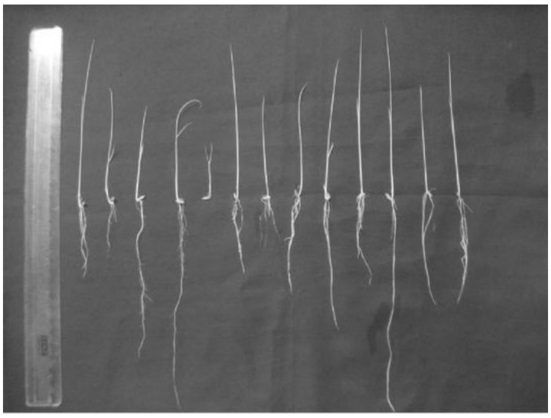

Plate 2. *In vitro* screening for root traits

root length, shoot length and root : shoot ratio of root growth characters. This study suggested the employment of this technique in rice for early drought screening in fast track programme.

The parents *viz.,* MAS 946-1 and MAS 26 can be regarded as drought resistant parental genotypes and hybrids; IR 58025 A x IR 65912 R, IR 68897 A x MAS 946-1, TNAU CMS 2A x Vandana, IR 68888 A x MAS 26, IR 68888 A x BI 33, IR 58025 A x IR 21567 R, IR 68897 A x Vandana and TNAU CMS 2A x MAS 26 as early drought tolerance based on various root characters *viz.,* root length, shoot length, root dry weight, shoot dry weight and root: shoot ratio since they express significantly higher mean performance over grand mean for these characters.

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