Madras Agric. J., 95 (7-12) : 315-319 July-December 2008
https://doi.org/10.29321/MAJ.10.100587

Identification of rice hybrids for aerobic condition based on physiological traits

K.AMUDHA AND K.THIYAGARAJAN
Department of Rice, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University,Coimbatore- 641 003, Tamil Nadu.

Abstract : An experiment was undertaken to identify rice hybrids for aerobic condition based on physiological and root characters associated with water stress tolerance in rice. Water deficit under aerobic condition decreased the releative water content of rice hybrids and increased the catalase activity for the maintenance of membrance structure and function. None of the hybrids showed desirable performance for all the traits. However, five hybrids *viz.*, IR 68885A / IR 73718-3-1-3-3, IR 67684A / CT-6510-24-1-2, IR 70369A / IR 73718-3-1-3-3, IR 70372A / PSBRC 80 and IR 70372A / IR 73718-3-1-3-3 recorded desirable mean values for maximum characters and exhibited better adaptability to aerobic conditions.

Key words : Rice hybrids, Physiological parameters, Aerobic condition

Introduction

Food security in Asia depends on irrigated rice ecosystem, which contributes about 75 per cent of the global rice production . However, the water use efficiency of rice is low and hence requires large amount of water. Savings in irrigation water and increase in water productivity is possible if rice is grown under aerobic conditions like an irrigated upland crop. For rice to succeed as an aerobic crop, it should tolerate intermittent water deficits and high soil impedance created due to aerobic conditions (Lafitte and Bennett, 2002). Therefore, any breeding programme towards the development of rice genotypes for aerobic environment must emphasize on the physiological and root traits associated with the water uptake, maintenance of plant water status and plant growth under water stress. Hybrid rice with its vigorous and more active root system tolerates moderate stresses caused due to limited irrigation water and therefore can be exploited under aerobic conditions .So far, there has been no major efforts on this front. Keeping this in view, the present investigation was carried out to identify suitable rice hybrids for aerobic condition based on characters associated with water stress tolerance.

Materials and Methods

An experiment was carried out with thirty rice hybrids under aerobic condition at Tamil Nadu Agricultural University, Coimbatore during *rabi*, 2005. The experimental material comprising of thirty rice hybrids were obtained by crossing six drought tolerant CGMS lines with five male parents (testers) in Line x Tester design. Well-preserved seeds from the thirty cross combinations were sown in raised nursery beds. Twenty-five days old seedlings were transplanted in the main field in a randomized block design (RBD) replicated twice adopting a spacing of 20 cm between rows and 10 cm between plants. Single seedling was transplanted per hill in

Table 1. Mean values of physiological and root traits of rice hybrids studied under aerobic condition

Hybrids	Days to 50 % flowering	Relative water content at flowering	Catalase at flowering (µg/g/ minute)	Membrane integrity (%of leakage) at flowering	Leaf rolling (secs.)	Transpiration rate at flowering (mmol/m²/sec)	Stomatal conductance at flowering (mmol/m²/sec)	Root length (cm)	Root dry weight (g)	Grain yield (g)
IR 67684A / PSBRC 80	90.50	81.50	18.94**	19.58	112.50	1.25	8.32**	19.83	2.99	12.27
IR 67684A / PSBRC 82	104.50	80.25	11.19	20.38	107.50	1.45	10.27	15.33	3.18	9.94
IR 67684A / CT-6510-24-1-2	87.50	84.50**	20.76**	18.52	282.50**	0.65**	8.43**	25.25**	2.24	19.56**
IR 67684A / IR 73005-23-1-3-3	91.00	76.00	5.30	19.80	76.25	1.00*	8.38**	19.75	3.16	8.88
IR 67684A / IR 73718-3-1-3-3	104.50	71.05	5.47	27.75	78.75	2.05	21.33	9.50	0.46	5.93
IR 68281A / PSBRC 80	91.50	77.25	22.19**	17.91**	186.25**	1.50	8.28**	19.95	3.05	11.43
IR 68281A / PSBRC 82	89.00	78.50	20.03**	17.60**	92.50	0.85**	10.25	18.90	0.94	11.01
IR 68281A / CT-6510-24-1-2	87.50	74.38	11.16	19.60	86.25	2.30	21.48	18.00	3.57**	14.63**
IR 68281A / IR 73005-23-1-3-3	92.00	81.00	19.25**	17.73**	98.00	1.06	8.09**	15.00	1.74	10.05
IR 68281A / IR 73718-3-1-3-3	95.50	83.00**	9.29	19.00	112.50	1.45	8.54**	16.57	3.00	15.45**
IR 68885A / PSBRC-80	91.00	78.83	19.50**	21.77	82.25	2.20	24.02	17.10	2.40	2.23
IR 68885A / PSBRC-82	92.00	80.98	20.82**	19.63	146.75	1.05	10.41	16.57	1.84	9.76
IR 68885A / CT-6510-24-1-2	83.00**	75.75	17.20	19.38	194.75**	1.35	10.26	13.00	1.13	10.91
IR 68885A / IR 73005-23-1-3-3	98.50	80.22	12.60	19.01	113.75	1.15	10.05	20.50**	3.87**	13.41
IR 68885A / IR 73718-3-1-3-3	81.50**	81.09	23.18**	15.36**	116.01	0.67**	7.81**	21.50**	3.82**	21.55**
IR 68887A / PSBRC 80	82.00**	81.33	5.25	20.00	194.75**	0.50**	8.16**	20.00*	2.89	9.69
IR 68887A / PSBRC 82	85.00**	77.25	19.44**	16.00**	193.50**	2.05	12.69	21.08**	2.33	12.05
IR 68887A / CT-6510-24-1-2	98.00	75.78	12.24	25.17	193.75**	2.15	10.53	20.08*	1.91	2.30
IR 68887A / IR 73005-23-1-3-3	88.50	79.40	20.22**	18.18*	103.75	1.45	8.34**	19.75	4.46**	15.74**
IR 68887A / IR 73718-3-1-3-3	90.50	78.00	11.92	21.00	62.50	0.85**	8.08**	20.68**	2.62	9.59
IR 70369A / PSBRC 80	89.50	78.98	20.04**	17.98**	180.00**	1.25	8.69**	19.07	3.41*	16.09**
IR 70369A / PSBRC 82	93.00	79.42	21.24**	16.74**	96.25	1.25	10.34	17.57	1.87	13.32
IR 70369A / CT-6510-24-1-2	88.00	74.44	17.13	20.81	285.00**	2.25	19.50	19.75	3.97**	5.34
IR 70369A / IR 73005-23-1-3-3	92.50	77.75	17.27*	19.46	68.75	0.75**	8.50**	20.32**	3.74**	13.95*
IR 70369A / IR 73718-3-1-3-3	86.00**	81.75	22.75**	17.06**	63.25	1.50	7.19**	21.00**	4.03**	19.45**
IR 70372A / PSBRC 80	89.50	83.00**	22.91**	17.18**	200.75**	0.57**	10.01*	16.43	4.10**	17.39**
IR 70372A / PSBRC 82	95.50	81.75	19.53**	18.00**	127.50	2.05	10.61	20.50**	2.60	12.95
IR 70372A / CT-6510-24-1-2	93.00	80.50	11.36	26.02	172.50**	1.09	10.35	20.00**	2.15	5.97
IR 70372A / IR 73005-23-1-3-3	108.50	78.00	12.99	20.63	152.50	1.33	8.01**	17.75	3.32*	12.84
IR 70372A / IR 73718-3-1-3-3	91.50	84.00**	22.52**	16.15**	128.00	1.50	8.08**	24.25**	4.08**	20.68**
Mean (Hybrids)	91.69	79.31	16.46	19.71	149.01	1.40	10.72	18.90	2.83	13.05
SEd	**1.54**	**1.24**	**0.58**	**0.69**	**2.89**	**0.19**	**0.49**	**0.62**	**0.30**	**0.53**
CD at 5 %	**4.20**	**2.46**	**0.9 6**	**1.23**	**8.72**	**0.38**	**0.71**	**1.09**	**0.44**	**0.82**
CD at 1 %	**5.02**	**3.27**	**1.29**	**1.64**	**9.60**	**0.50**	**1.09**	**1.42**	**0.72**	**1.18**

** Significant at 1% level. * Significant at 5% level.

single row of two-metre length (20 plants per row) in each replication. The transplanted crop was maintained under flooded condition (2-3 cm water layer) for 15 days to ease the establishment of the crop. Thereafter, aerobic condition was imposed by irrigating the crop up to field capacity after it has reached a certain lower threshold (*e.g.*, half way between field capacity and wilting point) as suggested by Bouman (2001). A total of 12 irrigations were given during the crop growth period. Every day soil samples were drawn and the soil moisture content was estimated using gravimetric method. Data were recorded in ten plants per replication. Physiological traits were recorded at flowering stage and plants were uprooted at maturity and root traits were recorded. For recording physiological traits like relative water content (Weatherly 1950), membrane integrity (per cent leakage) (Deshmukh *et. al.* 1991) and catalase activity (Deshmukh *et. al.* 1991) standard procedures were followed. Transpiration rate and stomatal conductance were measured in the fully expanded flag leaf using Steady State Porometer PMR 5. For recording leaf rolling, the leaf was cut near the base without ligules at the noon time (2-3 pm) and the time taken for the cut leaf to roll was noted with the help of stopwatch and expressed in seconds (Misra *et al.*, 2004).

Results and Discussion

The mean for various traits studied are given in (Table 1). Under aerobic condition, early maturing hybrids are desirable as they are more efficient in partitioning carbohydrate to the panicle and producing more yields per day (Lafitte and Bennett, 2002). Russo (2004) also found that early maturing cultivars were more adapted to aerobic conditions than late maturing ones and suggested earliness as a suitable criterion for selection of improved varieties. In the present study, five hybrids *viz.*, IR 68885A / CT-6510-24-1-2, IR 68885A / IR 73718-3-1-3-3, IR 68887A / PSBRC 80, IR 68887A / PSBRC 82 and IR 70369A / IR 73718-3-1-3-3 exhibited early flowering and were found suitable for aerobic conditions.

Maintenance of higher plant water status under drought plays a central role in stabilizing the various plant processes and yield (Kumar and Kajur 2003). Relative water content is one of the important measures which gives an idea of plant water status and therefore used as a most meaningful index for identifying genotypes with dehydration tolerance. In the present investigation, water stress significantly lowered the relative water content in the hybrids at flowering stage. However, the reduction was low in four hybrids namely IR 67684A / CT-6510-24-1-2, IR 70372A / IR 73718- 3-1-3-3, IR 68281A / IR 73718-3-1-3-3, and IR 70372A / PSBRC 80 indicating their tolerance to water stress. Tyagi *et al.* (1999) also observed higher relative water content in drought tolerant genotypes under water stress compared to susceptible genotypes.

With reference to catalase (an active oxygen species (AOS) scavenging enzyme under water stress) sixteen hybrids were identified to be superior. Higher catalase activity in these genotypes are suggestive of increase in the activity of free radical scavenging system leading to lower lipid peroxidation and maintenance of membrane structure contributing to drought tolerance (Chandrashekara Reddy *et al.*, 1998).

Maintenance of membrane integrity and function under water stress were used as measures of drought tolerance by Deshmukh *et al.* (1991). A total of twelve hybrids exhibiting significant mean values for catalase activity showed lesser percentage of leakage and were found to possess higher membrane integrity.

Among them, the hybrid IR 68885A / IR 73718-3-1-3-3 exhibited highest membrane integrity and were found to be highly suited for aerobic conditions. On the other hand, the hybrid IR 67684A / IR 73718-3-1-3-3 showed minimum membrane integrity under water stress. Lower membrane integrity or higher injury reflects the extent of lipid peroxidation which in turn is a consequence of higher oxidative stress due to water deficit (Leibler *et al.*, 1986).

The leaves of rice plant roll readily under water deficit and it has been used as an indicator of plant water status under stress (Courtois 2000). Ten hybrids involving aerobic rice cultures CT-6510-24-1-2 and PSBRC 80 as one of the parents exhibited small degree of leaf rolling under aerobic conditions. Fukai and Cooper (1990) reported that the cultivars with small degree of leaf rolling maintain high leaf water potential under stress. Therefore, these hybrids with minimum leaf rolling can be well exploited for the maintenance of high leaf water potential under water deficit conditions.

Low rate of transpiration and reduced stomatal conductance are considered advantageous under drought as they are associated with conservation of leaf moisture and maintenance of higher leaf water potential under water stress (Selvi *et al.* 2001). In the present study, six hybrids *viz.*, IR 67684A / CT-6510-24-1-2, IR 67684A / IR 73005-23-1-3-3, IR 68885A / IR 73718- 3-1-3-3, IR 68887A / PSBRC 80, IR 68887A / IR 73718-3-1-3-3 and IR 70369A / IR 73005-23-1-3-3 exhibited low transpiration rate and reduced stomatal conductance. Jalaluddin and Prize (1994) observed low stomatal conductance due to drought and suggested it as a result of partial closure of stomata and / or osmotic adjustment.

Deep rooting has been emphasized as an important adaptation to stress in rice (Nguyen *et al.*, 1997). Among the thirty hybrids, twelve hybrids had significant mean values for root length under aerobic conditions. Among them, the best five hybrids were IR 70372A / IR 73718-3-1-3-3, IR 67684A / CT-6510- 24-1-2, IR 68885A / IR 73718-3-1-3-3, IR 68887A / PSBRC 82, and IR 70369A / IR 73718-3-1-3-3. In aerobic systems, generally deep roots are required to penetrate through hard pan and fully explore the soil profile for effective absorption of water at deeper layers (Lafitte and Bennett, 2002). With respect to root dry weight, eleven hybrids exhibited significantly higher mean values. Among them, the best five hybrids were IR 70369A / IR 73718-3-1-3-3, IR 70372A / PSBRC 80, IR 70369A / CT-6510-24-1-2, IR 68887A / IR 73005-23-1-3-3 and IR 70372A / IR 73718-3-1-3-3. Sorte *et al.* (1992) reported that generally drought tolerant cultivar partitions its dry weight more in root for extracting more water from soil and had higher root dry weight under water stress than susceptible one.

Grain yield, an economic output of the plant was found to be significantly higher in nine hybrids under aerobic conditions. The hybrid IR 67684A / CT-6510-24-1-2 out yielded the other hybrid combinations by recording 19.78 g/plant, followed by the hybrids IR 70372A / IR 73718-3-1-3-3, IR 68885A / IR 73718-3-1-3-3, IR 70369A / IR 73718- 3-1-3-3 and IR 70372A / PSBRC 80.

In the present study none of the hybrids showed desirable performance for all the traits studied. However, five hybrids *viz.*, IR 68885A / IR 73718-3-1-3-3, IR 67684A / CT-6510- 24-1- 2, IR 70369A / IR 73718-3-1-3-3, IR 70372A / PSBRC 80 and IR 70372A / IR 73718-3-1-3-3 recorded desirable mean values for maximum number of characters and exhibited better adaptability to aerobic conditions. The hybrid rice seed production techniques of these hybrids have to be standardised for commercial exploitation .

References

Bouman, B.A.M. (2001). Water efficient management strategies in rice production. *Int. Rice Res. Notes*., **26(2)**: 17-22.

Chandrashekara Reddy, P., Vajranabhaian, S.N. and Udayakumar, M. (1998). Lipid peroxidation as a mechanism of stress tolerance in upland rice (*Oryza sativa* L.). *Calli. Indian. J. Plant Physiol*., **3(1)**: 68-70.

Courtois, B., McLaren, G., Sinha, P.K., Prasad, E., Yadav, R. and Shen, L. (2000). Mapping QTLs associated with drought avoidance in upland rice. *Mol. Breed*., **6**: 55-66.

Deshmukh, P.S., Sairam, R.F. and Shukla, D.S. (1991). Measurement of ion leakage as a screening technique for drought resistance in wheat genotypes. *Indian J. Plant Physiol.,* **34**: 89-91.

Jalaluddin, M.D. and Price, M. (1994). Photo-synthesis and stomatal conductance in rice as affected by drought stress. *Int. Rice Res. Notes*, **19**: 52-53.

Kumar, R. and Kajur, R. (2003). Role of secondary traits in improving the drought tolerance during flowering stage in rice. *Indian J. Plant Physiol.,* **8**: 236-240.

Lafitte, H.R. and Bennett, J. (2002). Requirements for aerobic rice : physiological and molecular considerations. In: Water Wise Rice Production. Proceedings of the International Workshop on Water-wise Rice Production, 8-11 April (Eds. Bouman, B.A.M., Hengsdijk H., Hardy, B., Bindraban, P.S., Twong, J.P. and Ladha, J.K.), IRRI, Los Banos, Philippines, pp.259-271.

Leibler, D.C., Kling, K.P.S. and Reed, D.J. (1986). Antioxidant protection of phospholipid bilayers by tocopherol. Control of tocopherol status and lipid peroxidation by ascorbic acid and glutathione. *J. Biol. Chem.,* **261**: 12114-12119.

Misra, B., Vijayakumar, C.H.M. and Voleti, S.R. (2004). Breeding for aerobic rice adapted to non-flooded irrigated conditions. In: Proc. Workshop on Resilient Crops for Water Limited Environments. Cuernavata, Mexico, pp.175-178.

Nguyen, H.T., Babu, R.C. and Blum, A. (1997). Breeding for drought resistance in rice: physiological and molecular considerations. *Crop Sci.,* **37**: 1426-1434.

Russo, S. (2004). Preliminary studies on rice varieties adaptability to aerobic irrigation, Cahiers options. *Mediterraneinnes*, **15**: 35-39.

Selvi, B., Rangasamy, P. and Nadarajan, N. (2001). Combining ability analysis for physiological traits in rice. *Oryza*, **38(1&2)**: 13-16.

Sorte, N.V., Deotale, R.D., Patankar, M.N., Narkhede, A.H., Golliwar, V.J. and Katole, B.D. (1992). Root and shoot physiology as influenced by short term water stress in upland paddy. *J. Soils and Crops,* **2(1)**: 86-91.

Tyagi, A., Kumar, N. and Sairam, S. (1999). Efficacy of RWC, membrane stability, osmotic potential, endogenous ABA and root biomass as indices for selection against water stress in rice. *Indian J. Plant Physiol.,* **4**: 302-306.

Weatherly, P.E. (1950). Studies in the water relations of the cotton plant. I. The field measurement of water deficits in leaves. *New Phytol.,* **49**: 81-97.