Progress. Agric. 21(1 & 2): 31–38, 2010 ISSN 1017-8139

GENETIC ANALYSIS OF F_4 RICE LINES FOR SALT TOLERANCE AT THE REPRODUCTIVE STAGE

S. Akhtar, M. M. Islam[1]*, S. N. Begum[1], J. Halder[1], M. K. Alam and A. C. Manidas[1]
Department of Genetics and Plant Breeding, Bangladesh Agricultural University
Mymensingh-2202, Bangladesh

ABSTRACT

A total of 29 lines of F_4 population of rice along with their parents Binadhan-5 (high yielding and salt susceptible) and Harkuch (salt tolerant landrace) were evaluated for salt tolerance at the reproductive stage with EC 6 dS/m following IRRI standard protocol. High heritability coupled with high genetic advance was observed in plant height in salinized and non-salinized conditions. High heritability along with high genetic advance was also found in number of filled grains/plant in saline condition. These characters were under additive gene control and selection for salt tolerance might be effective. Number of filled grains/plant showed significant positive correlation with grain yield/plant. Path analysis revealed that number of filled grains/plant had positive and maximum direct effect on grain yield/plant. Therefore, number of filled grains/plant should be given the importance in selection of rice lines under saline condition.

Key Words: Rice, Reproductive stage, Salt tolerant, Variability, Correlation, Path coefficient

INTRODUCTION

Rice is the staple food crop in Bangladesh and one of the most important cereal crops throughout the world. Rice provides a major source of calories for the people. This staple food ranked first position by production (28,931 thousand metric tons) during the year 2007-08 (BBS, 2009) among all cereals in Bangladesh.

The demand for increased rice production is increasing to meet the needs of increasing world population. One of the alternatives is to cultivate rice on marginal lands with salt affected areas. Salinity is a serious and widespread agricultural problem. The total saline area in Bangladesh constitutes one third of the 9 million hectares of total national cultivated area (ABSPII, 2006). Among various strategies to overcome this problem, the possibility of selection and breeding for enhanced salinity tolerance in crop species has

---

[1] Plant Breeding Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh-2202, Bangladesh
* Correspondence (mirza_islam@yahoo.com)

received considerable attention as it is an economic and efficient alternative (Toenniessen, 1984; Ashraf *et al*., 2008 and Ashraf, 2009).

There are many reports on research for the salinity tolerance at the seedling stage in rice (Sabouri and Sabouri, 2009 and Mohammadi-Nejad *et al*., 2008) but very little attention has been given to the reproductive stage salinity tolerance (Sabouri and Biabani, 2009). The conventional methods of plant selection for salt tolerance are not easy because of large effects of the environment and low narrow sense heritability of salt tolerance (Gregorio, 1997). However, Salinity screening under controlled condition has the benefit of reduced environmental effects.

Yield is the complex end product of many factors which jointly or singly influence the seed yield. Rice yield is dependent on many important characters as well as on the environmental influence. For yield improvement it is essential to have knowledge on genetic variability of different characters. A survey of genetic variability with the help of suitable parameters such as genotypic co-efficient of variation, heritability, and genetic advance are necessary to start an efficient breeding programme (Mishra *et al.* 1998). The objectives of the present investigation were to find out and established suitable selection criteria for screening rice germplasms under salinized and nonsalinized condition at reproductive stage.

MATERIALS AND METHODS

This study was conducted in Plant Breeding Division at Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh 2202.

Plant materials

A cross was made between high yielding Binadhan-5 and salt tolerant landrace Harkuch and subsequently F_1, F_2 and F_3 were obtained. In this study, a total of 29 F_4 lines along with their parents (Binadhan-5 and Harkuch) were used.

Evaluation of rice germplasm at reproductive stage

The trial was conducted in randomized complete block design (RCBD) with three replications under salinized and nonsalinized conditions. Pregerminated seeds were sown in perforated glass fibre pots filled with fertilized soil and placed in the glass fibre tanks. Water level was maintained at 3 cm below the soil surface for 2 days. Five seeds of each genotype were sown in each pot and after establishment thinning was done keeping 3 seedlings per pot. Two weeks after seeding water level was raised to about 1-2 cm above the soil surface. When the seedlings were 21-day old, water was siphon out of the trays for 24 hrs followed by instantly prepared salinized water solution (up to EC 6 dS/m) by dissolving crude salt was added to the trays for salinized setup. Simultaneously, tap water was added to the trays for control setup (non-salinized condition). The EC of the salinized water was monitored every week and adjusted when necessary using crude salt and tap water.

Rice yield and yield component data were recorded at reproductive stage in both non-salinized and salinized conditions. Genotypic and phenotypic coefficients of variation and heritability in broad sense estimated as per Singh and Chaudhary (1985); Johnson *et al.* (1955); Hanson *et al.* (1956). Genetic advance in percent of mean was calculated by the formula of Comstock and Robinson (1952). The path and correlation analyses were conducted according to the procedure employed by Singh and Chaudhury (1985).

RESULTS AND DISCUSSION

Genetic variability of all the characters under saline and non-saline condition

Plant height showed moderate genotypic (17.00%) and phenotypic (18.99%) co-efficient of variation under salt stress condition. Moderate genotypic (15.30%) and phenotypic (17.03%) co-efficient of variation were also found in non-saline condition (Table 1). There was a little difference between genotypic and phenotypic co-efficient of variation, indicating minor influence of environment in the expression of this character in both conditions. Under salinized condition plant height showed high heritability (80.19%) coupled with high genetic advance (31.29%). High heritability (80.28%) coupled with high genetic advance (28.20%) was also found in non-salinized condition, suggesting the predominance of additive genes for controlling the plant height in rice. Shanthi and Singh (2001) observed little difference between phenotypic and genotypic coefficient of variations and high heritability coupled with high genetic advance.

Table 1. Genetic parameters of 29 F_4 lines along with their parents grown under saline and non-saline conditions

Characters	GCV%		PCV%		h^2_b%		GA%	
	Saline	Non-saline	Saline	Non-saline	Saline	Non-saline	Saline	Non-saline
Plant height	17.00	15.30	18.99	17.07	80.19	80.28	31.29	28.20
Days to maturity	4.89	4.71	5.97	5.44	67.00	74.87	8.16	8.30
No. of filled grains/plant	35.75	12.61	45.28	30.14	62.36	17.51	58.17	10.86
1000 grain wt.	8.27	10.39	9.86	11.29	70.40	84.67	14.21	19.63
Grain yield/plant	52.90	16.93	59.58	30.90	47.44	30.00	57.32	19.10

Note: GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation, h^2_b = Heritability and GA = Genetic advance

Days to maturity showed low genotypic (4.89%) and phenotypic (5.97%) co-efficient of variation under salinized condition. Low genotypic (4.71%) and phenotypic (5.44%) co-efficient of variation were also found in non-salinized condition (Table 1). Difference between genotypic and phenotypic co-efficient of variation was very low which indicated that environment had little influence on the expression of this character in rice. Similar findings were reported by Balan *et al.* (1999). Days to maturity showed high heritability coupled with low genetic advance under both salinized and non-salinized conditions.

This indicated that non additive gene effects were involved for phenotypic expression of this character. High heritability with low genetic advance was also reported by Gomathinayagam *et al.* (1990) for days to maturity. High heritability for days to maturity in rice was also reported by (Atwal and Singh, 2001).

Number of filled grains/plant showed high genotypic (35.75%) and phenotypic (45.28%) co-efficient of variation in saline condition but moderate genotypic (12.61%) and high phenotypic (30.14%) co-efficient of variation were found in non-salinized condition. A big difference between genotypic and phenotypic coefficient of variation was observed for this character. The expression of this character could be influence by the environment. High genotypic and phenotypic co-efficient of variation were supported by Sing and Chaudhury (1996) for this character. High heritability (62.36%) associated with high genetic advance (58.17%) was found for this character in saline condition but low heritability (17.51%) associated with moderate genetic advance (10.86%) was found in non-saline condition (Table1). High heritability associated with high genetic advance was found by Bidhan Roy *et al.* (2001).

1000-grain weight showed low genotypic (8.27%) and low phenotypic (9.86%) co-efficient of variation in saline condition but moderate genotypic (10.39%) and phenotypic (11.29%) co-efficient of variation was found in non-salinized condition (Table 1). The difference between genotypic and phenotypic co-efficient of variation was low, indicating the low environmental influence for this expression. Akanda *et al.* (1997) and Choudhury and Das (1997) reported similar findings. High heritability (70.40%) associated with moderate genetic advance (14.21%) was recorded in saline condition for 1000 grain weight. High heritability (84.67%) associated with moderate genetic advance (19.63%) was also recorded in non-saline condition. Paramavisan *et al.* (1995) found high heritability with high genetic advance for 1000-grain weight.

In salt stress Grain yield/plant showed high genotypic (52.90%) and phenotypic (59.58%) co-efficient of variation but in non-saline condition moderate genotypic (16.93%) and high phenotypic (30.90%) co-efficient of variation were found (Table 1). There was a large difference between phenotypic and genotypic co-efficient of variation indicating considerable environmental influence on this character. Choudhury and Das (1997) reported higher values of PCV and GCV for grain yield/plant. Moderate heritability (47.44%) associated with high genetic advance (57.32) in saline condition but in non-saline condition, low heritability (30%) associated with moderate genetic advance (19.10%) was found in this character. This result indicated that the importance of both additive genetic and non additive genetic effect for the control of this character. Kumar *et al.* (1998) and Shanthakumar *et al.* (1998) observed moderate heritability with high genetic advance in percent of mean for this character. High heritability with high genetic advance was observed by Chaudhury and Das (1998).

High heritability associated with high genetic advance for plant height revealed that selection for this trait will give positive response both in saline and non-saline conditions in rice. Number of filled grains/plant showed high heritability associated with high genetic advance and selection will be effective in saline condition.

Correlation study under salt stress

Among the characters number of filled grains/plant showed positive and highly significant correlation with yield/plant (Table 2). Positive and non-significant correlation was observed between number of filled grains/plant and 1000-grain weight. Biswas *et al.* (2000) obtained significant and negative correlation between filled grains/panicle and 1000-grain weight. Plant height showed negative non-significant correlation with days to maturity and positively non-significant correlation with number of filled grains/plant, 1000 grain weight and grain yield/plant. Iftekharuddaula *et al.* (2001) reported positive correlation of plant height with days to maturity and 1000-grain weight in modern rice varieties. Days to maturity showed positive and non-significant correlation with number of filled grains/plant, 1000-grain weight and grain yield/plant. 1000-grain weight showed non-significant positive correlation with grain yield/plant.

Table 2. Correlation coefficient among different yield component of 29 F_4 rice lines along with their parents under salt stress

Characters	Plant height	Days to maturity	No. of filled grains/plant	1000 grain wt.
Days to maturity	-0.068			
No. of filled grains/plant	0.081	0.239		
1000 grain wt.	0.028	0.304	0. 342	
Yield/plant	0.077	0.132	0.856**	0.296

** Significant at 0.01 level of probability

From this study, number of filled grains/plant was found positive and highly significant correlation with grain yield/plant, which indicated the importance of this trait for progeny selection under salt stress. Mehetre *et al.* (1994) observed that filled grains number/panicle and panicle length are the major characters contributing to grain yield under saline condition. Tao *et al.* (1992) assessed the breeding materials from salt tolerant deepwater rice genotypes in F_2 population and suggested that selection for filled grain number per panicle would be more efficient in improving grain yield of rice. Natarajan (2005) reported that selection for number of productive tillers, number of filled grains and 1000 grain weight would improve the seed yield in rice under saline environment.

Path analysis under salt stress

The direct and indirect effects of number of filled grains/plant were the highest and positive upon grain yield/plant, while, plant height, days to maturity and 1000 grain weight had negligible direct and indirect effects on grain yield/plant (Table 3). Hence, number of filled grains/plant could be considered to play a major role on determining grain yield/plant in rice under saline environment and direct selection through this trait would be effective. Nguyen (2001) reported the largest direct effect of filled grains/panicle, 1000-grain weight on yield. However, the residual effect was much higher (0.503) indicating that the four characters under this study contributed 49.66 percent of the total variability in grain yield/plant studied. Habib *et al.* (2005) observed a residual effect of 0.35 indicating 65% of the variability in grain yield. Higher residual effects towards grain yield in this study may be due to several of reasons such as causal factors (characters) not included in the analysis and sampling errors.

Table 3. Path coefficient analysis showing direct (bold) and indirect effects of four growth characters on grain yield of 29 F_4 rice lines along with their parents under salt stress

Characters	Plant height	Days to maturity	No. of filled grains/plant	1000 grain wt.	Grain yield/plant
Plant height	**0.0033**	-0.00023	0.00026	0.00009	0.077
Days to maturity	0.0061	**-0.0877**	-0.0210	-0.0263	0.132
No. of filled grains/plant	0.069	0.20892	**0.870**	0.2959	0.856**
1000 grain wt.	0.0009	0.009	0.001	**0.03**	0.296

** Significant at 0.01 level of probability, Residual effect, R = 0.503

The above findings with genetic variability, correlation and path coefficient analysis clearly indicated that the number of filled grains/plant is the determining trait for grain yield under salt stress and this trait can serve as indicator in selecting rice lines for salt tolerance.

REFERENCES

ABSPII (Agricultural Biotechnology Support Project II). 2006. Drought tolerant rice and salinity tolerance rice. Agricultural Biotechnology Support Project II- South Asia, 26 p.

Akanda, M. A. L., Alam, M. S. and Uddin, M. M. 1997. Genetic variability, correlation and path analysis in maize (*Zea mays* L.) inbreds. *Bangladesh J. Plant Breed. Genet*., 10(2): 57-61.

Ashraf, M. 2009. Biotechnological approach of improving plant salt tolerance using antioxidants as markers. *Biotech. Adv*., 27: 84-93.

Ashraf, M., Athar, H. R., Harris, P. J. C. and Kwon, T. R. 2008. Some prospective strategies for improving crop salt tolerance. *Adv. Agron*., 97: 45-110.

Atwal, D. S. and Singh, R. S. 2001. Genetic and variability and character association in semi dwarf indica rice. *Madras Agril. J*., 87(6): 183-191.

Balan, A., Muthiah, A. R. and Bhoopathi, M. R. 1999. Genetic variability, character association and path coefficient analysis in rainfed rice, under alkaline condition. *Madras Agril. J*., 86: 122-124.

BBS (Bangladesh Bureau of Statistics). Crop Statistics (Major Crops). 2009. Agriculture Wing. Bangladesh Bureau of statistics, Ministry of planning, Government of the People's Republic of Bangladesh, Dhaka. 54 p.

Bidhan, R., Hossain, M., Hossain, F. and Roy, B. 2001. Genetic variability in yield components of rice (Oryza sativa L.). *Ecology*., 19: 186-189.

Biswas, P. S. Bishwajit, P. and Dewan, S. B. A. 2000. Variability, character association and path analysis in rice (Oryza sativa L.). *Bangladesh J. Plant Breed. Genet*., 13: 19-25.

Choudhury, P. K. D. and Das, P. K. 1997. Genetic variability, correlation and path analysis in deep water rice. *J. Agril. Sci. Soc*., 10(1): 155-157.

Choudhury, P. K. D. and Das, P. K. 1998. Genetic variability, correlation and path analysis in deep water rice. *Ann. Agric. Res.*, 19(2): 120-124.

Comstock, R. E. and Robinson, H. F. 1952. Estimation of average dominance of genes. In Heterosis, Iowa State College Press, Ames., 494-556.

Gomathinayagam, P., Nataranjan, S. and Subramanian, M. 1990. Genetic Variability in drought tolerant genotypes in rice. *Oryza*, 27: 328-330.

Gregorio, G. B., 1997. Tagging salinity tolerance genes in rice using Amplified Fragment Length Polymorphism (AFLP). Ph. D. Thesis, University of the Philippines Los Baños. Laguna, Philippines. 118 p.

Habib, S. H., Bashar, M. K., Khalequzzaman, M., Ahmed, M. S. and Rashid, E. S. M. H. 2005. Genetic Analysis and Morpho-physiological Selection Criteria for Traditional Biroin Bangladesh Rice Germplasms. *J. Biol. Sci*., 5(3): 315-318.

Hanson, C. H., Robinson, H. F. and Comstock, R. E. 1956. Biometrics studies of yield in segregating population in Korean Iespedeza. *Agron. J.*, 48: 268-272.

Iftekharuddaula, K. M., Badshah, M. A., Hassan, M. S., Bashar, M. K. and Akter, K. 2001. Genetic variability, character association and path analysis of yield components in irrigated rice (Oryza sativa L.). *Bangladesh J. Plant Breed. Genet*., 14: 43-49.

Johnson, H. W., Robinson, H. F. and Comstock, R. E. 1955. Genotypic and Phenotypic correlations in soybean and their implications in selection. *Agron. J*., 47: 477-483.

Kumar, G. S., Mahadevappa, M. and Rudrradhya, M. 1998. Studies on genetic variability, correlation and path analysis in rice during winter across the locations. *Karnataka J. Agril. Sci.* 11(1): 73-77.

Mehetre, S. S., Mahajan, C. R., Patil, P. A., Lad, S. K. and Dhumal, P. M. 1994. Variability, heritability, correlation, path analysis and genetic divergence studies in upland rice. IRRN 19: 8.

Mishra, B., Singh, R. K. and Jetly, V. 1998. Inheritence pattern of salinity tolerance in rice. *J. Genet. Breed.*, 52(4) : 325-331.

Mohammadi-Nejad, G., Arzani, A., Rezai, A. M., Singh, R. K. and Gregorio, G. B. 2008. Assessment of rice genotypes for salt tolerance using microsatellite markers associated with the *saltol* QTL. *Afr. J. Biotech.*, 7(6): 730-736.

Natarajan, S. K., Ganapathy, M., Krishnakumar, S., Dhanalakshmi, R. and Saliha, B. 2005. Grouping of Rice Genotypes for Salinity Tolerance Based upon Grain Yield and Na: K Ratio under Coastal Environment. *Res. J. Agril. Biol. Sci*., 1(2): 162-165.

Nguyen, T. C., Nguyen, T. T. and Nguyen, T. L. 2001. Rice breeding for adverse soils and irrigated areas through diallel analysis. *Omonrice,* 9: 133-137.

Paramasivam, K., Giridharan, S. and Soundararaj, A. P. M. K. 1995. Genetic variability and character association of derived characteristics of rice genotypes. *Crop Res. Hisar*., 10(3): 285-290.

Sabouri, H. and Sabouri, A. 2009a. New evidence of QTLs attributed to salinity tolerance in rice. *Afr. J. Biotech.*, 7: 4376-4383.

Sabouri, H. and Biabani, A. 2009b. Toward the mapping of agronomic characters on a rice genetic map: Quantitative Trait Loci analysis under saline condition. Biotechnology, pp. 144-149.

Shanthi, P. and Singh, J. 2001. Variability in induced mutants of Mahsuri rice *(Oryza sativa L.)*. *Madras Agril. J.*, 88 (10-12): 707-709.

Shanthakumar, G., Mahadevappa, M. and Radraradhya, M. 1998. Variability, correlation and path analysis in rice (*Oryza sativa* L.) over seasons. *Karnataka J. Agril. Sci*., 11(1): 67-72.

Singh, S. and Chaudhury, B. S. 1996. Variability, heritability and genetic advance in cultivars of rice. *Crop Res. Hisar*., 12(2): 165-167.

Singh, R. K. and Chaudhary, B. D. 1985. Biometrical Methods in Quantitative Genetic Analysis. Kalyani PubL, New Delhi. pp. 38–54.

Tao, P. B., Truong, D. X., Buu, B. C. 1992. Assessment of breeding materials from salt tolerant deepwater rice in the Mekong Delta . *Omonrice*, 2: 56-63.

Toenniessen, G. H. 1984. Review of the world food situation and the role of salt-tolerant plants. In. *Salinity Tolerance in Plant-Strategies for crop improvement*. (Eds.): R. C. Staples and G. H. Toenniessen. pp. 399-413, John Wiley and Sons, New York.