Electronic Journal of Plant Breeding, 6(1): 191-195 (Mar 2015)
ISSN 0975-928X

Research Note

Genetic evaluation of rice genotypes for zinc deficiency tolerance and yield traits under aerobic condition in rice

J.Vanitha, R.Usha Kumari, K.Amudha and S.Robin
Department of Plant Breeding and Genetics,
Agricultural College and Research Institute,
Madurai - 625104, Tamil Nadu.
Email: vanithajrm@gmail.com

(Received: 09 Oct 2014; Accepted: 09 APR 2015)

Abstract
Sixty rice genotypes were screened for zinc deficiency tolerance and yield traits under aerobic condition at Paddy Breeding Station, TNAU, and Coimbatore during *Rabi,* 2013-14. Nine rice genotypes with increased yield have been identified as suitable entries for zinc deficiency tolerance under aerobic cultivation. Genetic parameters estimated showed that the highest GCV and PCV were observed for zinc score, plot yield, plant harvest index and vegetative vigour. Also, high heritability accompanied by high genetic advance as per cent of mean was observed for zinc score, plant height, plant harvest index, 100 grain weight and plot yield. Therefore, selection for any one of the above characters would bring in simultaneous improvement of other characters and ultimately improving the grain yield.

Keywords
Rice, Aerobic, zinc deficiency tolerance, genetic variability.

Rice, the staple food of the country is cultivated predominantly under irrigated conditions. Being an extravagant consumer of water, rice uses around 5000 litres of fresh water to produce 1kg of rice (Bouman, 2009). The increase in depletion of fresh water resources is a major threat to the traditional way of rice cultivation. To combat this problem water-saving rice production system like, aerobic rice cultivation is being popularized to obtain optimum yield with less water consumption. Aerobic rice is a production system under which input responsive rice varieties with aerobic adaptation are grown in non-puddled and non-saturated soils (Bouman et al., 2002). To obtain high grain yield under aerobic method of cultivation, there is a need to develop new rice varieties which are drought tolerant and better nutrient absorbers especially micro nutrients like zinc for the fact that zinc becomes unavailable due to positive soil redox potential (Gao *et al.*,2012). So, genetic improvement of rice genotypes for zinc deficiency tolerance and better yield traits under aerobic condition is essential to exploit the water saving potential of aerobic condition.

Genetic improvement for quantitative traits can be achieved through a clear understanding of the nature and amount of variability present in the genetic stocks and the extent to which the desirable traits are heritable. Since, variability is a prerequisite for any selection programme, it is essential to detect and document the amount of variation available existing in the population. Genetic parameters such as genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) are useful in detecting the amount of variability present in the germplasm. Heritability coupled with high genetic advance would be more useful tool in predicting the resultant effect in selection of the best genotypes for yield and its attributing traits. It helps in determining the influence of environment on the genotypic expression and reliability of characters.

Sixty genotypes comprising of upland and lowland cultures of rice were raised under aerobic condition at Paddy Breeding Station, TNAU, Coimbatore during *Rabi,* 2013-14. Each entry was directly sown in a plot size of 3.6 m x 0.8 m by adopting a spacing of 20 cmx20 cm. The entries were replicated twice in randomized block design. Single seedling per hill was maintained. The crop was irrigated everyday till establishment and thereafter the crop was irrigated once in 4-5 days (when hairline crack occurs). Genotypes exhibited zinc deficiency symptom six to eight weeks after sowing. This is because under aerobic condition due to the changes in the physical and chemical properties of the soil, zinc becomes unavailable to the plants. Genotypes were visually scored for tolerance/ susceptibility based on 1-9 scale (Table 1) for zinc deficiency. At maturity, data on yield and yield components were recorded in five randomly tagged plants in each genotype per replication.

Data were recorded on 11 agronomic characters *viz.*, vegetative vigour, zinc score, SPAD value, plant height at maturity (cm), days to 50% flowering (days after sowing), panicle length (cm), productive tillers(nos.), 100-grain weight (g), panicle harvest index, harvest index and plot yield (g).

Panicle Harvest Index was calculated as the ratio of grain weight to the total weight of a single panicle and expressed as percentage

$$Panicle\ Harvest\ Index = \frac{Grain\ wieght\ of\ a\ panicle\ (g)}{total\ weight\ of\ a\ panicle\ (g)} x\ 100$$

Analysis of variance was carried out as suggested by Panse and Sukhatme (1961). GCV and PCV were calculated using the formula suggested by Burton (1953). The heritability estimate in the broad sense was calculated by the method proposed by Lush (1949). The mean, GCV, PCV, heritability (broad sense) and GA as percentage of mean worked out for 11 characters and presented in Table 2.

Mean performance: In any breeding programme, the mean performance is the foremost criteria in selection of genotypes. Out of sixty entries evaluated, genotypes *viz.*, CB-06-803, CB- 00-11-4, CB-00-11-21, CB-00-11-22, CB-06-803-2, CB-00-15-23 and CB-08-709-2 exhibited a zinc score of 1.0 and were found to be tolerant to zinc deficiency whereas genotypes *viz.*,CB-07-701-262, CB-07-701-264, CB-07-701-268, CB-07-701-218, CB-00-11-7, CB-00-11-23, CB-00-755-2,PSBRC 83 and CO51 exhibited a zinc score of 7.0 and were found to be susceptible to zinc deficiency. Genotypes CB-00-11-22, CB-00-11-21, CB- 00-11-4 and CB-07-701-218 flowered earlier under aerobic condition and possessed lengthy panicles. CB-06-803-2 recorded highest mean value of 94.51% for panicle harvest index while CB-09-512 recorded highest mean value of 35.91% for plant harvest index. With respect to grain yield the foremost trait, CB-06-803, CB-08-702, CB-08 701, CB-07-701-230, CB-00-11-21, CB-00-11-22, ANNA-4, APO and CB-06-803-2, recorded significantly superior plot yield (Table 3). Among them, CB-06-803-2 recorded highest plot yield of 1.88 kg followed by CB-00-11-21 with a plot yield of 1.72 kg. Both the genotypes recorded lowest zinc score and had high mean value for panicle harvest index and plant harvest index and therefore can be utilized directly under aerobic condition or used as donor for the genetic improvement of rice genotypes for aerobic condition.

Genetic variability in any crop is pre-requisite for selection of superior genotypes over the existing cultivars. Variance analysis for all the characters revealed significant variation among the genotypes studied (Table 2). All characters showed low genotypic coefficient of variation than phenotypic coefficient of variation indicating the influence of environment on these traits. Similar findings were earlier reported by Devi *et al*. (2006), Prajapati *et al*. (2011). PCV ranged from 7.02 % (days to 50 % flowering) to 66.62 % (plot yield). GCV ranged from 5.95 % (productive tillers) to 41.34 % (zinc score). GCV and PCV was low (<10%) for days to 50 per cent flowering and SPAD value. Similar findings of low GCV were reported for days to 50 per cent flowering by Mazida *et al*. (2013). Vegetative vigour, zinc score, productive tillers, plant harvest index and plot yield recorded high PCV (> 20%) values. This was in conformity with the findings of Kundu *et al*. (2008) for grain yield and total number of productive tillers. Moderate PCV (10-20%) values noticed for plant height, panicle length, 100 grain weight and panicle harvest index. GCV values were high (> 20%) for the characters vegetative vigour, zinc score, plant harvest index and plot yield. Moderate GCV (10-20%) values were noticed for plant height, panicle length and 100 grain weight. Low GCV was exhibited for panicle harvest index and productive tillers. These results indicated that sufficient level of variability was observed for most of the traits in genotypes studied.

Heritability value alone may mislead during selection. Therefore, heritability and genetic advance together should be taken into consideration for selection (Johnson *et al*., 1955). The range of heritability (in broad sense) was from 7.93 % (productive tillers) to 97.73 % (days to 50 per cent flowering). High heritability and high genetic advance as percentage of mean were recorded for the traits zinc score, plant height, plant harvest index, 100-grain weight and plot yield. High heritability and high genetic advance as percentage of mean indicates the presence of additive gene action. Directional selection for these traits would be more effective for desired genetic improvement. Similar findings were reported for plant height by Krishna and Hittalmani (2009); for harvest index and yield by Singh *et al.*,(2011). High heritability and moderate genetic advance were observed for SPAD value and days to 50 per cent flowering. Moderate heritability and high genetic advance as a percentage of mean was observed for vegetative vigour. Moderate heritability and moderate genetic advance as a percentage of mean was observed for panicle length and panicle harvest index. Low heritability and low genetic advance was recorded for productive tillers. This indicated that this trait was highly influenced by environment. From the foregoing discussion, it may be concluded that directional selection would be effective for the traits that have high heritability and genetic advance as percent of mean *viz*., zinc score, plant height, plant harvest index, 100-grain weight and plot yield.

Skewness and kurtosis: Skewness and kurtosis were studied for 11 characters. Among the traits studied, positive skewness was observed for vegetative vigour, plant height, plant harvest index and panicle length. Negative skewness was observed for SPAD value, days to 50% flowering and panicle harvest index. Hence, directional selection could be made for panicle harvest index. In case of kurtosis, the characters plant height, panicle harvest index and plant harvest index recorded lepto kurtic nature. Due to narrow variability, selection may not improve the *per se* performance for these traits. The trait vegetative vigour, zinc score, days to 50% flowering, panicle length, productive tillers, 100-grain weight and plot yield had platy kurtic nature. Due to wider variability, directional selection could be made to improve the *per se* performance of these traits.

Genetic evaluation of rice genotypes under aerobic conditions revealed that traits *viz.*, zinc score, plant height, plant harvest index, 100-grain weight and plot yield had high heritability and genetic advance as per cent of mean. In the selection of genotypes, maximum importance should be given to these traits in order to obtain higher grain yield in rice under aerobic conditions. The results also suggested that all rice genotypes are not suitable for aerobic method of cultivation and genotypes which are able to acclimatize to aerobic condition and record high yield like CB-00-11-21 and CB -06- 803- 2 may be well utilized in the genetic improvement programmes for aerobic conditions.

References

Burton, G.W. and Dewane, E.M. 1953. Estimating heritability in tall fescue (*Festuca circulinaccae*) from replicated clonal material. *Agrono.* J., 45: 478–481.

Bouman, B.A.M., Wang, H.Q., Yang, X.G., Zhao, J.F. and Wang, C.G. 2002. Aerobic rice (Han Dao): a new way of growing rice in water-short areas. In: Proceedings of the 12th International Soil Conservation Organization Conference, 26–31 May 2002, Beijing, China. Tsinghua University Press, pp. 175–181.

Bouman, B. 2009. How much does rice use?. *Rice today*, January-March: 28-29.

Devi, S.L., Raina, F.A., Pandey, M.K. and Cole, C.R. 2006. Genetic parameters of variation for grain yield and its components in rice. *Crop Res*., 32(1): 69-71.

Gao, X., Ellis, H., TjeerdJan, S., Cynthia, A., Chunqin, G.Z. and Zhang, F. 2012. Improving zinc bioavailability in transition from flooded to aerobic rice. Agron. Sustain. Dev. 32:465–478.

Johnson, H.W., Robinson H. F. and Comstock R.E. 1955 . Estimation of genetic and environmental variability in soybean. *Agron. J.,* 47: 314-318.

Krishna, T.V. and Hittalmani, S. 2009. Response of yield and related traits in a recombinant inbred line population at reproductive stage moisture stress in rice. *Bull. Biol. Sci.,* 7(3): 165-177.

Kundu, A., Senapati, B.K., Bakshi, A. and Mandal, G.S. 2008. Genetic variability of panicle characters in tall indica aman rice. *Oryza*, 45(4): 320-323.

Lush, J.L. 1949. Heritability of Quantitative Characters In Farm Animals. *Hereditas*, 35: 356 - 375

Mazida, M.S., Rafii, M.F., Hanafi, M.M., Rahim, H.A., Shabanimofrad, M., Latif, M.A. 2013. Agromorphological characterization and assessment of variability, heritability, genetic advance and divergence in bacterial blight resistant rice genotypes. *South African J. Bot.,* 86: 15–22.

Panse, V.G. and Sukhatme, P.V. 1967. Statistical methods for Agriculture workers. Indian council of Agriculture, New Delhi.

Prajapati, M., Singh, C.M., Suresh, B.G., Lavanya, G.R. and Jadhav, P. 2011. Genetic parameters for grain yield and its component characters in rice. *Electron. J. Pl. Breed.*, 2(2): 235-238.

Singh, S.K., Chandra M.S. and Lal G. M. 2011. Assessment of genetic variability for yield and its component characters in rice (*Oryza sativa* L.). *Res. in Plant Biol.*, 1(4): 73-76,

Tuong, T. P. and Bouman B.A.M. 2002. Rice production in water-scarce environments. Proceedings of theWater Productivity Workshop, 12-14 November 2001, Colombo, Sri Lanka. International Water Management Institute.

Table 1. Scale for Zinc Deficiency

Scale	Description
1	Growth and tillering nearly normal; healthy
2	Growth and tillering nearly normal; basal leaves slightly discolored
3	Stunting slight, tillering decreased, some basal leaves brown or yellow
5	Growth and tillering severely retarded, about half of all leaves brown or yellow
7	Growth and tillering ceases, most leaves brown or yellow
9	Almost all plants dead or dying

Electronic Journal of Plant Breeding, 6(1): 191-195 (Mar 2015)
ISSN 0975-928X

Table 2. Range, variability, skewness and kurtosis of 60 genotypes for various characters

CHARACTERS	Max	Min	Mean	GCV(%)	PCV(%)	h^2(%)	GA(%) of mean	Skewness		Kurtosis	
Vegetative vigour	6.00	1.00	2.33	38.67	66.62	33.69	46.23	0.98	**	0.52	**
Zinc score	7.00	1.00	4.33	41.34	42.20	95.95	83.42	-0.04		-0.96	**
SPAD value	36.40	24.50	30.90	8.58	8.95	91.89	16.94	-0.12	**	-0.11	
Days to 50% flowering (days after sowing)	93.00	65.50	83.81	6.94	7.02	97.73	14.12	-1.10	**	0.82	**
Plant height at maturity (cm)	103.50	55.00	69.91	15.49	16.83	84.7	29.37	1.23	**	1.31	**
Panicle length (cm)	23.50	13.50	17.16	11.02	14.83	55.21	16.86	0.91	**	0.82	**
Productive tillers(nos.)	25.00	12.67	18.64	5.95	21.15	7.93	3.45	0.06		-0.77	**
100-grain weight (g)	2.93	1.42	2.17	12.63	14.48	76.10	22.69	0.02		0.89	**
Panicle harvest index	94.51	49.18	79.86	7.89	10.56	55.85	12.15	-1.35	**	3.80	**
Plant harvest index	35.91	12.72	21.04	20.99	23.01	83.26	39.46	0.67	**	1.19	**
Plot yield (g)	1.88	0.42	1.13	27.74	28.23	96.54	56.14	-0.05		-0.85	**

*,** significant at 5 % and 1% levels, respectively.

Table 3. Mean performance of superior genotypes

Genotypes	Vegetative vigour	Zinc score	SPAD Value	Days to 50% flowering	Plant height (cm)	Panicle length (cm)	Productive tillers	100-grain weight (g)	Panicle Harvest Index (%)	Plant harvest index	Plot Yield (kg)
CB-06-803	3	1	34.97	86	75.67	21	13.83	2.21	90.64	25.91	1.50
CB-08-702	2	2	32.34	86	89.17	23.33	17	2.25	78.30	15.90	1.64
CB-08-701	1	3	32.50	88	74.50	19.33	20.17	2.08	84.42	27.26	1.56
CB-07-701-230	2	3	30.66	85.50	68.17	16	15	2.45	81.41	20.97	1.67
CB-00-11-21	1	1	31.60	71.50	103.50	20.73	15	2.61	82.50	20	1.72
CB-00-11-22	1	1	30.23	65.50	97.83	22.84	16.67	2.57	88.81	22.71	1.59
ANNA-4	1	3	32.69	85	76.50	19	16.33	2.45	76.14	20.27	1.58
Apo	3	3	31.55	88	91.34	21.50	16.17	2.01	83.28	18.15	1.74
CB-06-803-2	1	1	32.50	84	71.17	16.33	23.83	2.17	94.51	23.63	1.88