SELECTION INDEX IN RAINFED UPLAND RICE (*Oryza sativa* L.)

ABSTRACT

The present investigation was conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, Thiruvananthapuram during the period from May, 2014 to July, 2016. Twenty diverse rice genotypes were screened for drought tolerance. Screening was carried out in the target environment *i. e.* upland virippu. Morphological characters of the genotypes were studied. A selection index was developed for identifying the best six parents combining yield and drought tolerance. Twenty upland rice genotypes were assessed for study of genetic variability and construction of selectionindices for enhancing selection efficiency. The indices were worked out on the basis of yield and eight component characters *viz.*, panicle length, number of spikelets panicle^{-1}, number of filled grains panicle^{-1}, grain weight panicle^{-1}, 1000 grain weight, straw yield plant^{-1}, harvest index and biological yield plant^{-1} having high significant genotypic correlation with grain yield. Among the twenty genotypes Vaishak ranked first with the highest index value followed by Thottacheera, Kalladiaryan, Vyttila 6, Harsha and Swarnaprabha.The varieties with least index value were Uma, Aathira and Kanchana.The highest index value showing first six parents were considered for hybridization program for the development of drought tolerant variety.

Key words: Rainfed upland rice, Mean values, Selection index

INTRODUCTION

Rice (*Oryza sativa* L.) is the staple food of more than half of the world human population (Gross and Zhao, 2013). It has the evolutionary particularity of being semi-aquatic. So irrigated or lowland rice is the most common ecosystem, comprising 55% of the global rice area and accounting for 75% of global rice production (Khush, 2005). Acute water scarcity which is on the increase has threatened this ecosystem making a switchover to upland rice ecosystem essential. Upland rice encompasses 12% of global rice production area and is generally the lowest yielding ecosystem.

Selection index method which combines information on all the high heritability traits associated with yield in a linear regression model can be used in selection process. The selection based on such an index is more efficient than selecting individually for the various traits (Islam *et al*., 2017). Selection index can be constructed based on several analyses, such as correlation analysis, path coefficient analysis and principal component analysis. Correlation and path coefficient analysis simultaneously can effectively explain the correlation among traits and the influence of a trait directly and indirectly to the dependent trait (Samonte *et al*., 2013). The coefficients when combined with economic weights for trait values can make a new selection index formula that can be used to rank the lines' performance (Jolliffe, 2002; Sabouri *et al*., 2008). The superiority of selection based on index increases with an increase in the number of traits under selection (Raghuwanshi*et al*., 2016). Patil and Lekha Rani (2015)reported that characters such as biologicalyield per plant, harvest index and filled spikelets per panicleshowed significant positive effect on grain yield per plant underdirect seeded rainfed upland rice ecosystems. Significantnegative association was observed between days to 50%flowering and grain yield indicating the preference for shortduration types in drought situations. They observed that Vaishak(PTB 60), Kalladiaryan and Vyttila 6 recordedhighest yield under natural drought condition.Patil*et al*. 2016 also reported that biological yield was the major contributor in termsof direct effect and indirect effects on grain yield per plant atgenotypic level so that this trait should be consideredwhen breeding programs for higher grain yield in rice are to beplanned. The objective of the research was to obtain superior parents for hybridization programmebased on selection index.

MATERIALS AND METHODS

The present investigation was conducted in the Department of Plant Breeding and Genetics, College of Agriculture, Vellayani, Thiruvananthapuram, Kerala, India during the period from May, 2014 to July, 2016.

In the present study, twenty diverse rice genotypes were screened for drought tolerance. Screening was carried out in the target environment *i. e.* upland virippu. Morphological characters of the genotypes were studied. A selection index was developed for identifying the best six parents combining yield and drought tolerance.

Performance of rice genotypes for drought tolerance under upland condition

Twenty diverse rice genotypes including traditional upland varieties recommended for uplands and popular high yielding varieties were screened for drought tolerance under upland conditions. Morphological observations were taken at appropriate plant growth stages following the Standard Evaluation System for Rice (IRRI, 1996). The screening of genotypes was done as per the protocols of DRR (Directorate of Rice Research, 2012).

Layout

Design:	RBD
Treatment:	20
Replication:	3
Plot size:	2 x 5 m^2
Spacing:	20 x 15 cm
Season:	Upland virippu

Genotypes selected for study

The genotypes selected for study were Katta Modan (PTB 28), Karutha Modan (PTB 29), Chuvanna Modan (PTB 30), Vyttila 2, Vyttila 6, Jyothi (PTB 39), Swarnaprabha (PTB 43), Kanchana (PTB 50), Aathira (PTB 51), Aiswarya (PTB 52), Harsha (PTB 55), Vaishak (PTB 60), Kanakom (MO 11), Uma (MO 16), Prathyasha (MO 21), Parambuvattan, Arimodan, Kalladiaryan, Karuthadukkan and Thottacheera.

Selection index for identification of best parents (Singh and Chaudhary, 1985)

General selection index was proposed by Hanson and Johnson in 1957.This is a modification of the scheme of Smith (1936). In this model the weightsfor various traits are based on the average statistics for several populations. Thegeneral form of selection index is given below

$I = b_1X_1+b_2X_2+b_3X_3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. .b_nX_n$

Where,

X_1, X_2, X_3 and X_4 represent the phenotypic values of the character number1, 2, 3 and n respectively and b_1, b_2, b_3 and b_n are the corresponding weights.The b values are calculated from series of simultaneous equationsinvolving the appropriate phenotypic and genotypic variances and co-variances.The b values are worked out separately for various selection indices involvingsingle, double, triple and multiple traits. The simultaneous equations are solvedby elimination process and b values are obtained. The following simultaneousequations could be set with the help of appropriate variances and co-variances ofthese traits.

$b_1w_{11}+b_2w_{12}+b_3w_{13}=g_1y$

$b_1 w_{12}+b_2w_{22}+b_3w_{33}=g_2y$

$b_1w_{13}+b_2w_{23}+b_3w_{23}=g_3y$

Where, b_1, b_2, b_3 are weighing coefficients, w_{11}, w_{22},w_{33} are phenotypic variances of character number 1,2 and 3 respectively; w_{12}, w_{13} and w_{23} are phenotypic co-variances between characters 1-2,1-3 and 2-3 respectively. g_1y,g_2y and g_3y are genotypic co variances between characters 1, 2 and 3 with dependent trait that is yield.

RESULT AND DISCUSSION

The results revealed a wide range of variability among the genotypes for most of the traits studied. The range and analysis of variance indicated potential genetic variability and diversity in the material under consideration. These results indicated better scope for genetic improvement through conventional breeding.The results revealed a wide range of variability among the genotypes for most of the traits studied. The range and analysis of variance indicated potential genetic variability and diversity in the material under consideration. These results indicated better scope for genetic improvement through conventional breeding. The early flowering and maturing genotypes were Karutha Modan, Arimodan and Harsha. Earliness in flowering is important because a close association between this trait and drought tolerance was observed in upland evaluation of parents (Laffitte and Curtosis, 2002). The late flowering and maturing genotypes were Uma, Aathira and Kanakom. The range in number of productive tillers plant^{-1} was from 3.4 to 6.96 with variety Kanakom recording the lowest value and varietyVyttila 2 recording the highest value (Table 1). The higher the number of productive tillers the greater is the yield. Similar results were reported by Valarmathi and Leenakumary (1998) that grain yield increased when number of productive tillers increased. They also observed a reduction in time to maturity in rice cultivars under upland situation compared to lowland transplanted condition.

The range for plant height was from 73.06 to139.13 cm with variety Chuvanna Modan being the tallest and variety Kanchana being the shortest. In general, moisture stress resulted in reduced plant height and the susceptible types were more sensitive to height reduction than the rice varieties specifically suited for uplands (Salisbarry and Ross,1992). The variety Swarnaprabha had the highest harvest index of 41.74. Shanmugasundaram *et al*. (2002) suggested that while selecting superior genotypes for cultivation under rainfed situations, harvest index and straw yield are important.

The variety Vaishak showed the highest mean of 11.66g for the trait grain yield plant^{-1}. Vaishak had appreciably high harvest index also. This is in line with the reports of Atlin*et al.* (2008) that grain yield under moisture stress is a function of biomass production and harvest index. The variety Uma which is very popular in Kerala in terms of performance and yield showed good performance during vegetative stage. The variety being late maturing and since a dry spell in kharif 2014 unfortunately coincided exactly with the early reproductive phase of this strictly rainfed upland crop, performance was severely affected. Uma scored lowest number of filled grains panicle^{-1}, grain weight panicle^{-1}, 1000 grain weight, grain yield plant^{-1}, biological yield plant^{-1}, harvest index and highest spikelet sterility. This is supported by Liu *et al.* (1993) and Wopereis*et al.* (1996) who observed that water stress at booting and heading to flowering stages reduced the number of filled grains panicle^{-1}, 1000 grain weight and grain yield plant^{-1} and increased spikelet sterility.

The variety Kalladiaryan had the lowest spikelet sterility and the highest grain weight panicle^{-1}, 1000 grain weight, straw yield plant^{-1} and biological yield. Adequate number of fertile grains panicle^{-1} and heavy grains are important traits, which should be considered in selection for high yield (Prasad *et al.*, 2001; Sürek and Beser, 2003). These results showed that increasing the number of spikelets panicle^{-1} does not always result in higher grain yield, but with increased filled grains percentage it increases yield. The highest yielding genotypes were Vaishak, Kalladiaryan and Vyttila 6 with grain yields of 11.66, 10.7 and 9.72 g per plant respectively and filled grains per panicle of 63.17, 61.87 and 68.94 respectively. Similar

Table 1. Mean performance for 13 characters in 20 rice varieties under rainfed upland condition

Sl. No	Name of variety	Days to 50% flowering	Number of productive tillers plant^{-1}	Plant height at tip of leaf (cm)	Plant height at maturity (cm)	Panicle length (cm)	Number of spikelets panicles^{-1}	Number of filled grains panicle^{-1}	Spikelet sterility (%)	Grain weight panicle^{-1} (g)	1000 Grain weight (g)	Grain yield plant^{-1} (g)	Straw yield plant^{-1} (g)	Biological yield plant^{-1} (g)	Harvest Index (%)
		X_1	X_2	X_3	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}
1	Katta Modan (PTB28)	91.67	4.24	97.00	82.33	17.43	53.16	40.08	24.51	0.62	15.20	2.57	5.07	11.80	21.47
2	Karutha Modan (PTB29)	80.67	4.58	119.71	104.81	16.72	54.31	47.90	11.81	1.21	22.97	7.33	13.23	21.93	33.21
3	Chuvanna Modan (PTB 30)	92.67	5.49	114.80	139.13	16.29	47.95	36.14	24.65	0.97	24.47	5.73	12.22	18.73	30.43
4	Vyttila 2	105.67	6.97	147.47	138.73	21.18	85.72	24.14	71.82	1.04	23.20	6.55	11.64	18.84	34.81
5	Vyttila 6	101.67	3.78	102.47	93.60	18.91	74.83	68.94	15.96	1.60	24.63	9.73	13.33	23.67	41.03
6	Jyothi (PTB 39)	95.33	4.59	72.07	74.80	16.56	55.41	40.30	27.29	0.72	18.67	2.97	12.04	17.00	17.48
7	Swarnaprabha (PTB 43)	100.67	4.36	116.87	120.13	21.53	85.52	60.94	28.72	1.42	23.57	9.07	12.06	21.67	41.74
8	Kanchana (PTB 50)	94.67	3.66	74.67	73.07	15.63	41.85	36.43	12.93	0.66	18.23	2.50	7.72	11.00	22.59
9	Aathira (PTB 51)	106.00	4.11	109.33	97.07	18.13	49.74	34.18	31.27	0.59	16.17	1.58	8.00	13.53	11.70
10	Aiswarya (PTB 52)	97.67	4.98	99.87	94.80	14.85	64.31	29.17	54.65	0.49	16.77	2.77	7.67	12.49	21.71
11	Harsha (PTB 55)	84.67	4.87	82.13	79.33	16.20	54.61	31.82	45.00	0.88	26.73	4.67	11.20	16.47	28.41
12	Vaishak (PTB 60)	91.00	4.58	121.87	115.47	20.84	75.60	63.17	16.45	1.53	24.23	11.67	17.16	29.47	39.16
13	Kanakom (MO 11)	106.00	3.40	88.33	89.00	15.86	64.59	29.00	55.11	0.54	18.07	1.27	12.01	14.00	8.99
14	Uma (MO 16)	109.00	5.22	80.33	77.67	15.90	56.88	11.69	78.11	0.21	17.60	0.51	5.96	8.52	5.79
15	Prathyasha (MO 21)	98.67	5.02	97.80	95.73	18.52	53.01	37.19	29.86	0.86	23.07	4.60	9.80	15.00	30.76
16	Arimodan	83.67	6.16	112.67	99.20	17.82	46.90	30.97	38.35	0.73	23.53	5.00	10.59	18.00	27.72
17	Kalladiaryan	88.33	5.98	114.93	108.13	20.56	65.43	61.87	3.50	1.67	27.13	10.70	19.00	33.00	32.38
18	Karuthadukkan	95.00	5.73	120.60	114.67	17.16	62.64	41.35	33.97	0.90	21.59	5.67	9.01	16.47	34.20
19	Parambuvattan	92.33	4.13	110.93	101.20	18.57	60.04	38.49	35.86	0.79	20.43	3.50	6.54	11.36	30.78
20	Thottacheera	87.00	4.93	141.80	131.67	20.13	64.80	55.16	14.87	1.42	26.60	7.27	10.00	19.33	37.57
	General mean	95.11	4.83	106.28	101.52	17.93	60.86	40.94	32.73	0.94	21.64	5.28	10.71	17.6	27.59
	CD (0.05)	2.18	0.57	3.04	2.60	1.73	3.14	3.29	2.94	0.15	1.76	1.67	1.83	2.87	4.60

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findings were reported by Cruz and O’Toole (1984) and Pantuwan*et al.*, 2002 that in rice, during drought situations a lot of factors cause spikelet sterility which eventually result in yield reduction.

SELECTION INDEX

Discriminant function technique was adopted for the construction of a selection index using grain yield and component characters. The selection indices for the twenty genotypes are given in Table 2. The indices were worked out on the basis of yield and eight component characters *viz.*, panicle length, number of spikelets panicle^{-1}, number of filled grains panicle^{-1}, grain weight panicle^{-1}, 1000 grain weight, straw yield plant^{-1}, harvest index and biological yield plant^{-1} having high significant genotypic correlation with grain yield. Among the twentygenotypes Vaishak ranked first with the highest index value followed by Thottacheera, Kalladiaryan, Vyttila 6, Harsha and Swarnaprabha. The genotypes with least index value were Uma, Aathira and Kanchana.

The use of selection index offers ample scope for the breeder for effective selection based on component characters rather than direct selection based on yield alone. Superior genotypes can be selected from a collection of germplasm using a selection index employing the discriminant function for characters with favourable association.

Table 2. Index scores according to morphological traits in 20 rice varieties in rainfed upland rice

Sl.No.	Name of variety	Index score
1	Kattamodan (PTB28)	137.7965 (16)
2	Karutha Modan (PTB29)	183.3884 (8)
3	Chuvanna Modan (PTB 30)	157.9608 (12)
4	Vyttila 2	189.4600 (7)
5	**Vyttila 6**	**227.2757 (4)**
6	Jyothi (PTB 39)	146.3599 (13)
7	**Swarnaprabha (PTB 43)**	**189.4619 (6)**
8	Kanchana (PTB 50)	127.7195 (18)
9	Aathira (PTB 51)	120.9686 (19)
10	Aiswarya (PTB 52)	139.6101 (15)
11	**Harsha (PTB 55)**	**204.5798 (5)**
12	**Vaishak (PTB 60)**	**240.8918 (1)**
13	Kanakom (MO 11)	129.1689 (17)
14	Uma (MO 16)	90.7445 (20)
15	Prathyasha (MO 21)	158.5236 (11)
16	Arimodan	145.3451 (14)
17	**Kalladiaryan**	**238.2462 (3)**
18	Karuthadukkan	175.1748 (9)
19	Parambuvattan	158.6314 (10)
20	**Thottacheera**	**238.3552 (2)**

The selection indices were worked out for the twenty genotypes on the basis of yield and eight component characters *viz*., panicle length, number of spikelets panicle^{-1}, grain weight panicle^{-1}, 1000 grain weight, straw yield plant^{-1}, biological yield plant^{-1} and harvest index. The genotypes with high index score in the varieties such as Vaishak (240.8918), Thottacheera (238.3552), Kalladiaryan(238.2462), Vyttila 6(227.2757), Harsha(204.5798), and Swarnaprabha(189**.**4619) were selected as parents for hybridization programme based on the selection index developed. The use of selection index was important for selecting best genotypes from a group of varieties was confirmed by Singh *et al.* 2013 and he observed that the relative efficiency of selection indices ranged from 0.13 to 33.23 per cent in upland rice.

CONCLUSION:

It is concluded that among the twenty genotypes Vaishak ranked first with the highest index value followed by Thottacheera, Kalladiaryan, Vyttila 6, Harsha and Swarnaprabha.The genotypes with least index value were Uma, Aathira and Kanchana. The highest index value showing first six parents were considered for hybridization program for the development of drought tolerant varieties.

REFERENCES

Atlin, G.N., Venuprasad, R., Bernier, J., Zhao, D., Virk, P., and Kumar, A. 2008. Rice germplasm development for drought-prone environments: progress made in breeding and genetic analysis at the International Rice Research Institute (IRRI). In: Serraj, R., Bennett, J., Hardy, B. (Eds.), *Drought Frontiers in Rice: Crop Improvement for Increased Rainfed Production.* International Rice Research Institute/World Scientific, Los Banos, Philippines/Singapore: 35–59.

Cruz, R.T. and O'Toole, J.C. 1984. Dry land rice response to an irrigation gradient at flowering stage. *Agronomy Journal***76**: 178-183.

DRR [Directorate of Rice Research]. 2012. Rice Knowledge Management Portal[on line]. Available:http://www.rkmp.co.in. [07 Oct.2012].

Gross, B. L., and Zhao, Z. 2013. Archaeological and genetic insights into the origins of domesticated rice. *Proceedings of the National Academy of Sciences*6190–6197.

Hanson, W.D and Johnson, H.W.1957. Methods of calculating and evaluating ageneral selection index obtained by pooling information from two or moreexperiments.*Genetics***42**:421-432.

IRRI [International Rice Research Institute]. 1996. *Standard Evaluation Systemfor Rice* (4th Ed.). International Rice Testing Programme, Los Banos,Philippines, 52 p.

Islam M.A, Kayess M.O, Hasanuzzaman M, Rahman M.W, Uddin M.J, Zaman MR 2017. Selection index for genetic improvement of wheat (*Triticum aestivum* L.). *Journal of Chemical Biological Physical Sciences* **7**(1): 1-8.

Jolliffe I.T 2002. Principal Component Analysis (2th ed). Springer-Verlag. New York.

Khush, G. S. 2005. What will it take to feed 5.0 million rice consumers in 2030? *Plant Molecular Biology***35**: 25-34.

Lafitte, H.R and Courtois, B. 2002. Interpreting cultivar x Environment Interactions for yield in upland rice: Assigning value to drought adaptive traits. *Crop Science***42**:1409-1420.

Liu, B.G., Li, C.M., ren, C.F., Cai, C.F., Yang, Q.L., and Chen, X.W. 1993. A study of the physiological basis for upland culture of paddy rice. *Journal of Southwest Agricultural University* **15**: 477-482.

Pantuwan, G., Fukai, S., Cooper, M., Rajatasereekul, S., and O'Toole, J.C. 2002, Yield response of rice (*Oryza sativa* L.) genotypes to drought under rainfed lowland. III. Plant factors contributing to drought resistance. *FieldCropsRes*earch**73**(2-3):181-200.

Patil KrantikumarH.and Lekha Rani, C.2015.Genetic variability and character association in rainfed upland rice (*Oryza sativa* L). *The Ecoscan***9** (3 and 4):911-915.

Patil Krantikumar.H., Lekha Rani,C., Leenakumary, S., Roy, S., Vijayaraghavakumar and Jayalekshmy, V.G.2016. Path analysis in rainfed upland rice under natural stress. *International Journal of Scientific Research* **5**(5): 237-239.

Prasad, P.V.V., Craufurd, P.Q., Kakani, V.G. Wheeler, T.R. and Boote, K.J. 2001. Influence of temperature during pre- and postanthesis stages of floral development on fruit-set and pollen germination in peanut. *Functional Plant Biology* **28**:233–240.

Raghuwanshi S.S, Kachadia V.H, Vachhani J.H, Jivani L.L, Malav A.K, Shakti Singh Bhati S.S (2016). Selection indices in groundnut (*Arachis hypogaea* L.). *Electronic Journal of Plant Breeding* 140-144.

Sabouri H, Rabiei B, Fazlalipour M (2008). Use of selection indices based on multivariate analysis for improving grain yield in rice. *Rice Sci*ence **15**(4): 303–310.

Salisbury, B. and Ross, W. 1992. Plant physiology.4thedition, Wadsworth, Belmont, California 580-585.

Samonte SOPB, Tabien RE, Wilson LT (2013). Parental selection in rice cultivar improvement. *Rice Sci*ence **20**(1): 45–51.

Shanmugasundaram, P., Chandrababu, R., Chezhian, P., Thiruvengadam, V., Manikanda Boopathi, N., Chandrakala, R., and Sadasivam, S. 2002. Genetic evaluation of double haploid population of rice under water stress in field condition. In: An International workshop on Progress toward developing resilient crops for drought prone areas. 27–30 May, 2002, IRRI, Los Banos, Philppines: 144–145.

Singh, C. M., Babu, G.S., Kumar, B., and Mehandi, Suhel 2013. Analysis of quantitative variation and selection criteria for yield improvement in exotic germplasm of upland rice (*oryza sativa* L.). *The Bioscan***8** (2):485-492.

Singh, R. K. and Chaudhary, B. D. 1985. *Biometrical Methods in QuantitativeGenetic Analysis.* Kalyani publishers, New Delhi, pp. 178-185.

Smith, H.F. 1936. A discriminant function of plant selection. *Annals of Eugenics***7**:240-250.

Surek, H. and Beser, N. 2003. Correlation and path coefficient analysis for some yield related traits in rice (*Oryza sativa.* L) under thrace condition. *TurkishJournalof Agriculture* 27:77-83.

Valarmathi, G. and Leenakumary, S. 1998. Performance analysis of high yielding rice varieties of Kerala under direct seeded and transplanted conditions. *Crop Research* **16** (2):284-286.

Wopereis, M. C. S., Kropff, M. J., Maligaya, A. R., and Tuong, T. P. 1996. Drought-stress responses of two lowland rice cultivars to soil water status. *Field Crops Research***46**: 21–39.