The Bioscan 8(2): 485-492, 2013
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

ANALYSIS OF QUANTITATIVE VARIATION AND SELECTION CRITERIA FOR YIELD IMPROVEMENT IN EXOTIC GERMPLASM OF UPLAND RICE (*ORYZA SATIVA* L.)

CHANDRA MOHAN SINGH*, G. SURESH BABU[1], BINOD KUMAR[2] AND SUHEL MEHANDI[3]
[1]Department of Genetics and Plant Breeding, Allahabad School of Agriculture,
Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad - 211 007, Uttar Pradesh, INDIA
[2]Department of Plant Breeding and Genetics,
Rajendra Agricultural University, Pusa (Samastipur) - 848 125, Bihar, INDIA
[3]Crop Improvement Division, Indian Institute of Pulse Research, Kalyanpur - 208 024, Kanpur, UP, INDIA
e-mail: cmsingh.gpb@gmail.com

KEY WORDS
Rice
Genetic parameters
Character association
Relative efficiency
Selection index
Selection criteria
Index score.

Received on :
15.10.2012

Accepted on :
09.03.2013

***Corresponding author**

ABSTRACT

The present experiment was conducted with 11 genotypes of upland rice during *Kharif* 2009 and 2010. Maximum genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) was observed only for number of spikelets per panicle, while plant height, flag leaf length, flag leaf width, panicle length, harvest index and grain yield per plant showed moderate GCV and PCV. High estimates of heritability coupled with high genetic advance as per cent of mean was observed for plant height, flag leaf length, flag leaf width, number of spikelets per panicle and grain yield per plant. Grain yield showed positive and significant correlation with plant height and panicle length at both genotypic level and phenotypic level. The expected genetic advance and relative efficiency of selection indices was ranged from 0.13 (Index III) – 33.23 per cent (Index XXI) and 4.20 ((Index III) – 1093.09 per cent (Index XXI), respectively. Two genotypes from index XXI and three genotypes from index XVI were isolated as diverse parent with Vandana and can be used in crossing programme to obtain the better heterotic cross combinations with high relative efficiency and good characters combination and may helpful to improve the grain yield in upland rice.

INTRODUCTION

Rice is one of the important food crops of the world. The production and productivity of rice is decreasing due to erratic climatic conditions. In such situation, upland rice may be a best option because it have ability to survive in water deficit condition. But the yield is very poor in upland rice. Therefore, need to increase the potential of yielding ability of the currently available upland rice varieties to meet the existing demand for rice by improvement of yield component traits and incorporation of important genes conferring resist to abiotic stresses (Atlin and Frey, 1990; Kanbar *et al.,* 2010) and earliness. Earliness is a best character for upland rice. That's why high yielding verities under irrigated condition with early and exra early duration may be shifted from irrigated condition to upland condition after incorporation of important traits from upland rice genotypes, which are necessary for survivability of rice under water deficit condition *i.e.* leaf rolling, cell membrane stability, deep root system, rapid vegetative growth to suppress the weeds, rapid recovering ability after water stress etc.

Yield is a complex polygenic trait and depends on the yield component traits. So, the improvement of these traits may help to improvement of grain yield. Development of high yielding verities requires the sufficient knowledge of existing variability with good transmitability and give the better scope of selection. The characters with high coefficient of variation and high heritability coupled with high genetic advance may be governed by additive genes and can be directly selected for improvement through simple plant selection. In contrast, the characters with low GCV, PCV, heritability and genetic advance may be used in heterosis breeding. Correlation coefficient analysis measures the degree and direction of relationship among the two traits. Correlation studies are the great value with yield for selecting the character played important role that influence the grain yield. The separate direct and indirect selection of trait may lead to negative or positive response in other trait (Ajibade and Morakinyo, 2000). Thus, selection of certain trait could depend on magnitude of relationship and their heritability estimates. In plant breeding, for yield improvement, breeders consider the several traits and their relationship as well as high heritability for the evaluation of cultivar. All the yield component traits not equally and highly contributed towards the grain yield. Thus, identification of a character combination may helpful to improve the grain yield. Construction of selection indices is a best method for quantitative integration of such information. Selection index is most widely used for selection of several traits at a time. Several researchers *viz.,* Akter *et al.* (2010), Kanbar *et al.* (2012) etc. used selection index and discriminant function analysis for improvement of rice. Plant breeders get more success using the index selection for incensing the expected genetic advance by using direct and indirect selection of the different trait (Smith *et al.,* 1981; Rabiei *et al.,* 2004; Weyhrich *et al.,* 2004). The extent of genetic diversity between parents has been proposed as a predictor of F_1 performance and magnitude of heterosis (Falconer and Mackay, 1996). So the crossing between diverse lines/varieties (based on index score) may give better heterotic cross combinations and helps to improve the grain yield in upland rice. Therefore, keeping the above facts under consideration the experiment was conducted (1) To access the genetic variability among the genotypes (2) To measure the relationship between grain yield and its component traits (3) To identify the most efficient character combination by discriminant function analysis (4) Construction of index score and identify the best lines/varieties for superior selection index and (5) To identify the diverse genotypes for upland rice improvement.

MATERIALS AND METHODS

Plant material and Experimental site

The experimental material consisting eleven entries (eight exotic lines and three checks) of upland rice genotypes *viz.,* IR 81423-B-B-111-3, IR 81421-B-B-25-4 IR 81413-B-B-75-3 IR 81063-B-94-4-3-1 IR 74371-54-1-1 IR 67017-124-2-4 IR 81413-B-B-75-4 IR 81429-B-31, Vandana, Annada and Govind. These entries were received from Department of Genetics and Plant Breeding, Allahabad School of Agriculture, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad and supplied by International Rice Research Institute, Philippines. The experiment was conducted at Field Experimentation Center, Department of Genetics and Plant Breeding, Allahabad School of Agriculture, SHIATS, Allahabad during *Kharif* 2009 and 2010. The experimental site is situated an elevation of 98 meter above from the sea level at 25.87ºN L and 81.25ºE L. This region is comes under southern UP and has subtropical climate with extreme summer and temperature reaches up to 48 to 50ºC.

Experimental Design, Data Recording and Data Analysis

The present experiment was performed in Randomized block design (RBD) with three replications. Five plants from each replication for each entries were selected at random and observations were recorded for the entire yield and its component traits except days to 50 per cent flowering. This was computed on plot basis. The mean data of two years was used for statistical analysis. The analysis of variance was carried out separately for each trait as per formula suggested by Panse and Sukhatme (1967), phenotypic and genotypic coefficient of variation by Burton (1952), heritability (Broad sense) and genetic advance as per cent of mean were estimated by the formula as suggested by Johanson *et al.* (1955). The phenotypic and genotypic correlations were calculated to determine the interrelationship between yield component traits with each other, as per the method of Al-Jibouri *et al.* (1958). The selection indices were constructed with various character combinations as per method of Smith (1936) and Hezal (1943). The expected genetic advance from selection indices was computed on the basis of model suggested by Smith (1936). The section indices are as follows:

Index I, II, III, IV, V – only one character (DFF, PH, NTP, NSP, GYP) considered for selection index.

Index VI, VII, VIII, IX – Two characters (DFF with PH, NTP, NSP and GYP) considered for selection index.

Index X, XI, XII – Three characters (DFF + PH with NTP, NSP and GYP) considered for selection index.

Index XIII, XIV – Four characters (DFF + PH + NTP with NSP and GYP) considered for selection index.

Index XV – Five characters (DFF + PH + NTP + NSP + GYP) considered for selection index.

Index XVI, XVII, XVIII – Two characters (PH with NTP, NSP and GYP) considered for selection index.

Index IX, XX – Three characters (PH + NTP with NSP and GYP) considered for selection index.

Index XXI – Four characters (PH + NTP + NSP + GYP) considered for selection index.

Index XXII, XXIII – Two characters (NTP with NSP and GYP) considered for selection index.

Index XXIV – Three characters (NTP +NSP + GYP) considered for selection index.

Index XXV – Two characters (NSP + GYP) considered for selection index.

RESULTS AND DISCUSSION

Pooled Analysis of Variance, Range and Mean

The pooled analysis of variance over year (*Kharif,* 2009-10), indicated the existence of significant differences among treatments for all the traits studied except number of productive tillers per plant (Table 1). The range and mean values for various quantitative traits are presented in Table 2. Days to 50 per cent flowering ranged from 72 days (Vandana) to 88 days (IR 67017-124-2-4) with grand mean 83 days. Plant height ranged from 69.67cm (Govind) to 114.28cm (Vandana) with grand mean 86.91cm. Number of productive tillers per plant ranged from 3 (Govind) to 5 tillers (IR 81429-B-31). Panicle length varied from 18.10cm (vandana) to 23.97cm (IR 81423-B-B-111-3). Number of spikelets per panicle ranged from 47 (IR 67017-124-2-4) to 112 (Vandana) and showed wide range of variability among all the characters studied. A range for harvest index and test weight varied from 38.00 (Govind) to 51.14 g. (IR 81423-B-B-111-3) and 18.03g (Vandana) to 23.18g (IR 81413-B-B-75-4), respectively. Grain yield per plant had considerable range of variation, the minimum and maximum were being recorded in IR 67017-124-2-4 (7.50g.) and Vandana (12.72g.), respectively. Results on range showed the maximum variability was present for number of spikelets per panicle among the genotypes used in this study and diverse genotypes/ varieties may be isolated for this character and used in crossing programme for improvement of upland rice. The non significant variability was found for number of productive tillers per plant because the upland rice genotypes had low tillering capacity and there is need to develop the lines/ varieties having high tillering capacity because this trait had positive significant role towards grain yield. Thus, these lines may crossed with other genotypes/ varieties that having high tillering capacity to get the herotic response for this trait and finally grain yield.

Genetic Parameters

The genetic parameters for various quantitative traits are presented in Table 2. The coefficient of variation measures the magnitude of variability present in population and depends on the heritable and non-heritable variation. In present investigation, the coefficient of variation indicated that the magnitude of PCV were slightly higher than the corresponding GCV for all the characters studied, indicated that these characters were less influenced by environment. The high GCV and PCV was observed only for one trait (Number of spikelets per panicle) while plant height, flag leaf length, flag leaf width, panicle length, harvest index and grain yield per plant showed moderate GCV and PCV. Higher GCV and PCV has earlier been reported by Singh *et al.* (2011). The high GCV and PCV value for this suggested the selection of these trait may be efficient for improvement of upland rice. Moderate GCV and PCV for grain yield per plant has earlier been reported by Rahman *et al.* (2012). The trait number of tillers per plant showed moderate PCV value but extent of GCV is low for this trait, indicated the higher effect of environment on this trait. Rest yield component traits *viz.,* days to 50 per cent flowering and test weight exhibited low GCV and PCV estimates indicated that it may be governed by non additive genes and recombination breeding may helpful for improvement of grain yield through selection of these traits. The low GCV and PCV values for days to 50 per cent flowering was also observed by several workers *viz.,* Anandrao *et al.* (2011), Paul *et al.* (2011), Singh *et al.* (2011) and Quatadah *et al.* (2012).

The estimates of heritability coupled with genetic advances are important preliminary steps of any breeding program and they provides information needed in designing the most effective breeding program and selection of most efficient trait(s). High heritability along with high genetic advance is an important factor for predicting the resultant effect for selecting the best trait. High heritability was recorded for days to 50 per cent flowering, plant height, flag leaf length, flag leaf width, number of spikelets per panicle and grain yield per plant (Prajapati *et al.,* 2011), while panicle length, harvest index and test weight showed moderate heritability estimates. Number of productive tillers per plant showed low heritability estimates. The high heritability of characters indicated selection for these characters should be fairly easy. This is because there would be close correspondence between the genotype and phenotype due to a relatively smaller contribution of the environment to the phenotype. Heritability estimates along with genetic gain are normally more helpful in predicting the gain under selection than heritability estimates alone (Johanson *et al.,* 1955). The most important function of the heritability in the genetic study of quantitative characters is its predictive role to indicate the reliability of the phenotypic value as a guide to breeding value (Dabholkar 1992; Falconer and Mackay 1996). The genotypic coefficient of variation along with heritability estimates provide reliable estimates of the amount of genetic advance to be expected through phenotypic selection (Burton, 1952). The estimates of genetic advance help in understanding the type of gene action involved in the expression of various polygenic traits. High values of genetic advance are indicative of additive gene action, whereas low values are indicative of non-additive gene action (Singh and Narayanan, 1993). Thus the heritability estimates will be reliable, if accompanied by high genetic advance. High estimates of heritability coupled with high genetic advance as per cent of mean was observed for plant height, flag leaf length, flag leaf width, number of spikelets per panicle and grain yield per plant, while days to 50 per cent flowering and test weight showed moderate heritability coupled with moderate genetic advance as per cent of mean. Similar finding has earlier been reported by Verma (2010). Number of productive tillers per plant showed low heritability coupled with low genetic advance as per cent of mean. High heritability coupled with low genetic advance indicates non-additive gene effects.

Association Analysis

Information regarding the nature and extent of association between component characters with grain yield per plant would be helpful to decide the major contribution towards grain yield. Yield is a complex polygenic trait for which direct selection may not effective always. So that nature and extent of association of component characters with grain yield and other component traits would be helpful in improvement of yield. The results on correlations revealed that genotypic correlation coefficient were higher than the corresponding phenotypic correlation coefficient, indicated the characters are governed by additive gene action and are useful in yield improvement. The association between yield and yield component traits are presented in Table 3. Grain yield is ultimate objective of any breeding programme. In this study, it showed positive and significant correlation with the yield component traits *viz.,* plant height and panicle length at both level, whereas in addition to these traits number of productive tillers per plant showed positive and significant correlation with seed yield per hill at genotypic level only. In general, plant height showed negative association with grain yield in rice but here in this study it showed positive association. It also significantly correlated with number of productive tillers per plant, flag leaf length and number of spikelets per panicle. Positive significant associations were obtained between grain yield and plant height may be due to tall lines generally excelled in their capacity to support kernel growth by stem reserve mobilization (Blum *et al.,* 1989). Therefore, selection for tall plants tends to increase grain yield per plant. Paul *et al.* (2011) also found positive correlation between grain yield and plant height. Yadav *et al.* (2011) found the positive correlation between number of tillers and panicle length with grain yield. Flag leaf length increases the rate of photosynthesis and dry matter accumulation and increase the biomass. Days to 50 per cent flowering showed negative and significant correlation with grain yield per plant. Similar finding has earlier been reported by Seyoum *et al.* (2012). Some researchers reported that traits of days to flowering and days to maturity had significant and positive correlation with grain yield, therefore varieties/ lines with longer flowering duration would have a better chance for fertilization of flowers and turning them to grain (Abdul *et al.,* 2011). Harvest index is very important parameter to improving the grain yield.

Days to 50 per cent flowering, flag leaf length and panicle length showed positive significant correlation with test weight. Days to 50 per cent flowering also showed positive correlation with flag leaf length, flag leaf width, panicle length and test weight. It is indicated that the late flowering genotypes had sufficient time for vegetative growth and they having god photosynthetic rate. The vigorous plants may produced panicles with good length, seed size and seed weight. But in upland rice there is need to develop the early maturing varieties with good grain yield and can be achieved by selecting the early duration rice varieties/ lines and improve the other major yield contributing traits. Thus these characters may be considered for improvement of grain yield in upland rice but simultaneous selection and improvement of various traits for yield is more difficult. Grain yield per plant showed maximum correlation coefficient value with number of spikelets per panicle. Ashfaq *et al.* (2012) also recorded the maximum correlation of grain yield with number of seeds per panicle. Earning maximum correlation coefficient in grain yield with number of spikelets per panicle is because it is assimilate supplier for the grains. Therefore, we can consider the positive and significant correlation of number of spikelets per panicle with grain yield per plant a natural thing. As a result, the more association of this trait with grain yield is observed due to the bigger sink plant would have for metabolic materials. The genotypic correlation value of number of productive tillers per plant with plant height was recorded more than one (1.066) but theoretically it is not possible. It may be due to sampling error. All the characters are not contributed highly towards grain yield and no single trait could be taken an adequate criterion for selection of yield. Therefore, we need to identify a character combination for yield improvement which having good genetic advance and relative efficiency and selection indices provide an useful method by making use of several traits for greater efficiency of selection for yield (Das *et al.*, 2001).

Genetic Advance, Relative Efficiency and Index Score

The relative effectiveness of different selection methods will depend on many factors. These include the breeding objectives, the type of material, the number and type of traits evaluated, relative importance of traits and the relationship among the traits (Chanyalew *et al.*, 2010). In present investigation selection indices were constructed on the basis of results on genotypic correlation coefficient. Grain yield and four other major yield contributing traits *viz.*, days to 50 per

Table 1: Pooled ANOVA for yield and its component traits in exotic rice genotypes over year (*Kharif* 2009-10)

SN	Traits	Mean sum of square Replication (d.f. = 2)	Treatment (d.f. = 10)	Error d.f. = 22)
1	Days to 50% flowering	4.46	69.74**	2.21
2	Plant height	11.32	571.73**	2.10
3	Number of panicles per plant	0.96	0.58	0.38
4	Flag leaf length	2.35	75.87**	0.98
5	Flag leaf width	0.01	0.08**	0.01
6	Panicle length	0.01	12.15**	1.09
7	Number of spikelets per panicle	16.81	1054.48**	7.96
8	Harvest index	28.42	111.56*	25.56
9	Test weight	0.47	6.55*	0.50
10	Grain yield per plant	0.51	7.14**	0.16

**and *significant at 0.01 and 0.05 level of significance. df = Degree of freedom

Table 2: Genetic parameters for twelve yield and its component traits in exotic rice genotypes

SN	Traits	Range Minimum	Maximum	Mean	Genetic parameters GCV (%)	PCV (%)	h^2 (bs)	GAM
1	Days to 50% flowering	72.5	88.33	83.32	5.70	5.97	91.08	11.20
2	Plant height	69.67	114.28	86.91	15.85	15.94	98.91	32.48
3	Number of productive tillers per plant	4.0	5.0	4.33	6.03	15.43	15.25	4.85
4	Flag leaf length	19.63	34.65	28.13	17.76	18.10	96.22	35.89
5	Flag leaf width	1.07	1.57	1.29	12.12	12.76	90.30	23.73
6	Panicle length	18.10	23.97	21.47	8.95	10.18	77.22	16.20
7	Number of spikelets per panicle	47.50	112.17	81.36	22.96	23.22	97.77	46.76
8	Harvest index	38.00	51.14	40.14	13.34	18.35	52.87	19.98
9	Test weight	18.03	23.18	20.99	6.77	7.56	80.11	12.48
10	Grain yield per plant	7.50	12.72	9.15	16.68	17.25	93.54	33.23

GCV = Genotypic Coefficient of Variation, PCV = Phenotypic Coefficient of Variation, h^2bs = Heritability in broad sense, GAM = Genetic Advance as per cent of Mean

Table 3: Phenotypic (Lower diagonal) and genotypic correlation (Upper diagonal) between seed yield and its component traits in exotic rice genotypes

SN	Character	DFF	PH	NTP	FLL	FLW	PL	NSP	HI	TW	GYP
1.	DFF	1.000	-0.450**	-0.397*	0.379*	0.372*	0.618**	-0.417*	0.203	0.833**	-0.497**
2.	PH	-0.430**	1.000	1.066*	0.375*	-0.263	0.039	0.596**	-0.422*	-0.265	0.543**
3	NPH	-0.090	0.447**	1.000	0.873**	-0.865**	-0.263	0.039	0.596**	-0.608**	0.457**
4	FLL	0.338*	0.367*	0.321	1.000	-0.192	0.372*	0.096	-0.032	0.487**	0.153
5	FLW	0.357*	-0.260	-0.259	-0.181	1.000	0.129	-0.461**	-0.237	0.041	-0.216
6	PL	0.534*	0.025	0.125	0.286	0.090	1.000	-0.259	0.468**	0.630**	-0.385*
7	NSP	-0.377*	0.583**	0.309	0.095	-0.426*	-0.205	1.000	-0.575**	-0.152	0.722**
8	HI	0.103	-0.313	-0.121	-0.054	-0.172	0.478**	-0.414	1.000	0.132	0.300
9	TW	0.718**	-0.246	-0.035	0.410*	0.085	0.557**	-0.122	0.167	1.000	-0.293
10	SYP	-0.450**	0.523**	0.165	0.151	-0.205	-0.329	0.691**	-0.221	-0.310	1.000

**and *significant at0.01 and 0.05 level of significance. DFF = Days to 50 per cent flowering, PH = Plant height, NTP = Number of productive tillers per plant, FLL = Flag leaf length, FLW = flag leaf width, PL = Panicle length, NSP = Number of spikelets per panicle, HI = Harvest index, TW = Test weight, GYP = Grain yield per plant.

Table 4: Expected genetic advance and relative efficiency of selection indices over direct selection for improvement of grain yield in exotic germplasm of upland rice

SN	Selection Index	Character combination	GA	RE
1	Index I	DFF	3.44	113.16
2	Index II	PH	9.88	325.00
3	Index III	NTP	0.13	4.20
4	Index IV	NSP	20.75	682.57
5	Index V	GYP	2.47	81.25
6	Index VI	DFF + PH	6.44	211.84
7	Index VII	DFF + NTP	3.31	108.88
8	Index VIII	DFF + NSP	17.31	559.21
9	Index IX	DFF + GYP	0.97	31.91
10	Index X	DFF + PH + NTP	6.57	216.12
11	Index XI	DFF + PH + NSP	27.19	894.41
12	Index XII	DFF + PH + GYP	8.91	293.09
13	Index XIII	DFF + PH + NTP + NSP	2.61	85.86
14	Index XIV	DFF + PH + NTP + GYP	9.04	297.37
15	Index XV	DFF + PH + NTP + NSP +GYP	29.80	980.26
16	Index XVI	PH + NTP	10.01	329.28
17	Index XVII	PH + NSP	30.63	1007.57
18	Index XVIII	PH + GYP	2.05	67.42
19	Index XIX	PH + NTP + NSP	30.15	991.78
20	Index XX	PH + NTP + GYP	12.48	410.53
21	Index XXI	PH + NTP + NSP + GYP	33.23	1093.09
22	Index XXII	NTP + NSP	20.89	687.17
23	Index XIII	NTP + GYP	2.61	85.86
24	Index XIV	NTP + NSP + GYP	23.51	773.36
25	Index XV	NSP + GYP	23.23	764.14

GA = Genetic Advance by Discrimant Function, RE = Relative Efficiency, DFF = Days to 50 per cent flowering, PH = Plant height, NTP = Number of productive tillers per plant, NSP = Number of spikelets per panicle, GYP = Grain yield per plant.

cent flowering, plant height, number of productive tillers per plant and number of spikelets per panicle showed positive and significant association with grain yield per plant and are used to construct the selection index. Several workers used various combinations for construction of selection index. Akhond *et al.* (1998) suggested that, for improvement of grain yield, selection could be made mainly on panicles per plant and grains per panicle. Bastia *et al.* (2008) also made the selection index with major yield contributing traits *viz.,* grain yield, panicle number, grain number, grain weight, fertility percentage, flag leaf area, plant height, panicle length, days to flowering and harvest index and found maximum efficiency for selection index having all characters. In present study, a total 25 selection indices along with genetic worth and relative efficiencies over straight selection are presented in Table 4 and index score for all the genotypes along with checks are presented in Table 5A and 5B. The expected genetic advance and relative efficiency of selection indices was ranged from 0.13 (Index III) to 33.23 per cent (Index XXI) and 4.20 (Index III) to 1093.09 per cent (Index XXI), respectively (Table 4). When we considered single trait as a selection criteria, then the number of spikelets per panicle showed maximum relative efficiency (Index IV). A plant breeder is always interested to have maximum genetic gain with incorporation of minimum characters in selection index. So results of present investigation indicated that, among the single character selection index number of spikelets per panicle is the key component to construct selection index in upland rice. Index score for index IV was ranged from 60.76 (IR 81423-B-B-111-3) to 109.93 (Vandana) and none of the genotype showed significant superiority over the best check Vandana, whereas five genotypes (IR 81413-B-B-75-3, IR 81063-B-94-4-3-1, IR 74371-54-1-1, IR 81413-B-B-75-4, IR 81429-B-31) showed superiority over Annada and six genotypes (IR 81421-B-B-25-4, IR 81413-B-B-75-3, IR 81063-B-94-4-3-1, IR 74371-54-1-1, IR 81413-B-B-75-4, IR 81429-B-31) over Govind. In two character combinations index XVII exhibited maximum expected genetic advance and relative efficiency followed by index XXI, XXII and VIII. Index score for index XVII was ranged from 179.19 (IR 81413-B-B-75-4) to 289.65 (Vandana) and three genotypes (IR 81421-B-B-25-4IR 81413-B-B-75-3, IR 81429-B-31) showed superiority over Annada and five genotypes (IR 81423-B-B-111-3, IR 81421-B-B-25-4, IR 81413-B-B-75-3, IR 81063-B-94-4-3-1, IR 81429-B-31) over Govind. In three character combination index XIX exhibited maximum expected genetic advance and relative efficiency followed by index XI and XXIV. In four character combination index XIV exhibited maximum expected genetic advance and relative efficiency. Index score for index XIV was ranged from 144.05 (Govind) to 181.37 (IR 81429-B-31) and one genotype (IR 81429-B-31) showed superiority over the best check Vandana, whereas all genotypes showed superiority over Annada and Govind. Similarly when all the five characters were taken at a time then the index XXI showed maximum expected genetic advance and relative efficiency (Fig. 1). Akter *et al.* (2010) used the characters spikelets per panicle, 1000-seed weight, tillers per plant and grain yield per plant to construct the selection index and found maximum genetic advance and relative efficiency for index having all character combination in study. Index score for index XXI was ranged from 129.78 (Govind) to 222.23 (Vandana) and none of the genotypes showed superiority over the best check Vandana, whereas six genotypes (IR 81421-B-B-25-4, IR 81413-B-B-75-3, IR 74371-54-1-1, IR 81413-B-B-75-4, IR 81429-B-31) showed superiority over Annada and seven genotypes (IR 81423-B-B-111-3, IR 81421-B-B-25-4, IR 81413-B-B-75-3, IR 74371-54-1-1, IR 81413-B-B-75-4, IR 81429-B-31) over Govind. The index XXI showed maximum genetic advance and relative efficiency among all the 25 indices. This index having five characters *viz.,* days to 50 per cent flowering, plant height, number of productive tillers per plant, number of spikelets per panicle and grain yield per plant and these characters may be used as a selection criteria for improvement of upland rice. Here in this study the maximum index score for index XXI was recorded for Vandana that means none of the genotype exhibited superiority over Vandana, when all the five traits considered simultaneously but many genotypes showed superiority over another two checks. That's why there is need to improve all the genotypes and it may be possible through improvement of major yield contributing traits based on correlation results and also by crossing between the diverse genotypes for this index because in this study maximum expected genetic advance and relative efficiency was exhibited by index XXI followed by index XVII, XIX (7 genotypes superior over Annanda and all the genotypes superior over Govind), XVI (5 genotypes superior over both checks) [Table 5 A and B]. The improvement of grain yield may possible by crossing between diverse genotypes for this index.

Identification of diverse genotypes/ varieties for yield

Table 5A: Index score for various indices in six exotic germplasm of upland rice

SN	Selection Index	IR 81423-B-B-111-3	IR 81421-B-B-25-4	IR 81413-B-B-75-3	IR 81063-B-94-4-3-1	IR 74371-54-1-1	IR 67017-124-2-4
1	Index I	77.96	77.03	77.03	75.80	79.36	82.15
2	Index II	70.84	73.11	77.21	70.42	60.30	71.40
3	Index III	2.56	2.67	2.67	2.56	3.09	2.88
4	Index IV	60.76	71.22	90.97	89.5	82.49	46.62
5	Index V	8.6	8.45	11.00	8.14	8.67	7.73
6	Index VI	148.80	151.13	154.24	146.21	139.65	153.55
7	Index VII	80.52	79.70	79.7	78.36	82.45	85.03
8	Index VIII	138.72	148.25	168.0	165.30	161.85	128.77
9	Index IX	86.56	85.48	88.03	83.94	88.03	89.88
10	Index X	151.36	153.38	156.91	148.77	142.74	156.43
11	Index XI	209.56	222.35	254.21	235.71	222.14	200.17
12	Index XII	157.40	159.58	165.24	154.35	148.32	161.28
13	Index XIII	212.12	224.6	247.88	288.27	170.52	136.5
14	Index XIV	159.96	161.83	167.91	156.91	151.41	164.16
15	Index XV	220.72	233.05	258.88	246.41	179.19	144.23
16	Index XVI	73.40	75.78	79.88	72.98	63.39	74.28
17	Index XVII	131.60	144.33	168.8	159.92	142.79	118.02
18	Index XVIII	79.44	81.56	88.21	78.56	68.97	79.13
19	Index XIX	134.16	147.0	170.85	162.48	145.88	120.90
20	Index XX	82.00	84.23	80.88	81.12	72.06	82.01
21	Index XXI	142.76	155.45	181.85	170.62	154.55	128.63
22	Index XXII	63.32	73.89	93.64	92.06	85.58	49.50
23	Index XIII	11.16	11.12	13.67	10.70	11.76	10.61
24	Index XIV	21.92	82.34	104.64	100.20	94.25	57.23
25	Index XV	69.36	79.67	101.97	97.64	91.16	54.35

DFF = Days to 50 per cent flowering, PH = Plant height, NTP = Number of productive tillers per plant, NSP = Number of spikelets per panicle, GYP = Grain yield per plant.

Table 5B: Index score for various indices in two exotic germplasm and three check varieties of upland rice

SN	Selection Index	IR 8141 3-B-B-7 5-4	IR 814 29-B-31	Vandana	Annanda	Govind
1	Index I	85.56	78.43	67.43	75.8	76.26
2	Index II	70.81	91.39	96.0	63.56	58.52
3	Index III	2.67	3.20	3.20	2.67	2.35
4	Index IV	93.91	92.78	109.93	77.26	61.74
5	Index V	10.79	8.89	13.10	8.99	7.37
6	Index VI	156.37	169.30	163.42	139.36	134.78
7	Index VII	88.23	81.63	70.63	78.47	78.61
8	Index VIII	179.47	171.20	177.36	153.06	144.0
9	Index IX	96.35	87.32	80.53	84.79	83.63
10	Index X	159.04	172.50	166.62	142.03	137.13
11	Index XI	250.28	262.07	273.35	216.62	196.52
12	Index XII	167.16	178.19	176.52	148.35	142.15
13	Index XIII	189.96	265.27	276.55	219.29	198.87
14	Index XIV	169.83	181.37	179.72	151.02	144.50
15	Index XV	200.75	274.16	289.65	228.28	206.24
16	Index XVI	73.48	94.59	99.20	66.23	60.87
17	Index XVII	164.72	184.16	205.93	140.82	120.26
18	Index XVIII	81.60	100.28	109.10	72.55	65.89
19	Index XIX	167.39	187.36	209.13	143.49	122.41
20	Index XX	84.27	103.48	112.30	75.22	68.24
21	Index XXI	178.18	196.25	222.23	152.48	129.78
22	Index XXII	96.58	95.97	113.13	79.93	64.09
23	Index XIII	13.46	12.09	16.30	11.66	9.72
24	Index XIV	107.37	104.86	126.23	88.92	71.46
25	Index XV	104.70	101.66	123.03	86.25	69.11

improvement based on index score

The production and productivity of upland rice is very due to non availability of high yielding varieties. It having low tillering ability due to direct seeding and also suppressed by weed. So we need to develop the high yielding varieties with good tillering ability and rapid growth nature with weed suppressing ability. The heterosis breeding may be a good option for this challenge (Srivastava, 2000). Duvick and Cassman (1999) suggested that the basic requirment of successful hybrid breeding programme is a sufficient magnitude of important traits and choice of suitable parents. So, need to identification of diverse genotypes/ varieties for best character combination may be giving the better heterotic response for yield improvement. Several workers *viz.*, Belaj *et al.* (2002), Rasul and Okubo (2002), Rajiv *et al.* (2010) suggested that genetic diversity is very important for exploitation of germplasm resources for yield improvement. Therefore, Four top most selection indices (>850 per cent relative efficiency) was used to identify the diverse genotypes and these genotypes may be involved in crossing programme for improvement of grain yield with high relative efficiency. Among these selection indices the best check Vandana had maximum index score for all these four selected selection indices. Vandana is well adopted upland rice variety in India and diverse from exotic lines in terms of yield and its component traits and also for geographical distibutation and adaptation. None of the genotype showed significant superiority over vandana. It means Vandana can be use as a parent for improvement of grain yield through these selection indices. None of the genotype showed more diversity (based on index score) with Vandana for selection index XIX and XVII, whereas two genotypes were inferior over all three checks and May diverse for index XXI. Similarly three genotypes showed inferiority over all three checks and may diverse for index XVI (Fig. 1). So the crossing between these selected genotypes with Vandana may gives better heterotic cross combinations with high relative efficiency and may having good characters *viz.*, days to 50 per cent flowering, plant height, number of productive tillers per plant, number of spikelets per panicle and grain yield per plant and may be helpful to improve the grain yield in upland

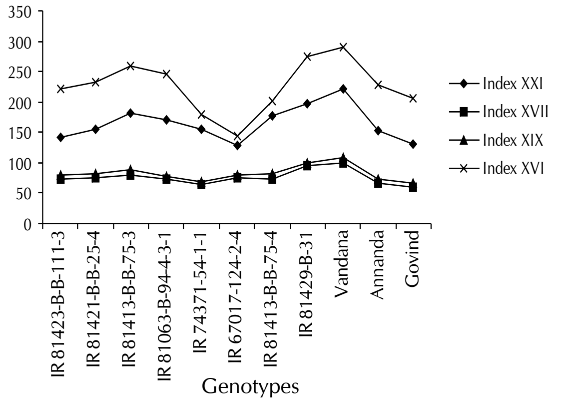

Figure 1: Graphical representation of various upland rice genotypes/ varieties for best four indices based on index score to identify the diverse genotypes having good index score with high relative efficiency

rice. Devi *et al.* (2013) also observed that the traits *viz.,* plant height, number of productive tillers per plant, number of spikelets per panicle are important selection parameters for improvement of grain yield.

Results of the present study indicated significant variation among the genotypes for most of the characters studied and selection would be effective for the characters *viz*., plant height, flag leaf length, flag leaf width and number of spikelets per panicle to increase the grain yield per plant as reflected by strong and positive correlation along with high heritability coupled with high genetic advance, whereas number of tillers also showed positive association with grain yield but low heritability and genetic advance. Among 25 selection indices index XXI exhibited maximum expected genetic advance and relative efficiency. Maximum index score for index XXI was recorded for Vandana and none of the genotype exhibited superiority over Vandana, simultaneously but six genotypes (IR 81421-B-B-25-4, IR 81413-B-B-75-3, IR 74371-54-1-1, IR 81413-B-B-75-4, IR 81429-B-31) showed superiority over another both checks (Annanda and Govind). Two genotypes (IR 81423-B-B-111-3 and IR 67017-124-2-4) from index XXI and three genotypes (IR 74371-54-1-1,IR 67017-124-2-4 and IR 81413-B-B-75-4) from index XVI were isolated as diverse parent with Vandana and may be used in crossing programme to obtain the better heterotic cross combinations with high relative efficiency and may helpful to improve the grain yield in upland rice.

AKNOWLEDGEMENT

The present research work was conducted at Field Experimentation Center, Department of GPB, SHIATS (Deemed to be University), Allahabad. The authors are highly thankful to Hon'ble Vice-Chancellor and Director Research, SHIATS, Allahabad to provide all the facilities for completion of this experiment.

REFERENCES

Abdul, F. R., Ramya, K. T., Chikkalingaiah, Ajay, B. C., Gireesh, C. and Kulkarni, R. S. 2011. Genetic variability, correlation and path coefficient analysis studies in rice (*Oryza sativa* L.) under alkaline soil condition. *El. J. Plant Breed.* **2(4):** 531-537.

Ajibade, S. R. and Morakinyo, J. A. 2000. Heritability and correlation studies in cowpea. *Niger. J. Sci.* **15**: 29-33.

Akhond, M. A. Y., Amiruzzaman, M., Bhuiyan, M. S. A., Uddin, M. N., Hoque, M. M. 1998. Genetic parameters and character association in grain sorghum. *Bangladesh J. Agril. Res.* **23**: 247-254.

Akter, S., Biswas, B. K., Azad, A. K., Hasanuzzaman, M. and Arifuzzaman, M. 2010. Correlation and discriminant function analysis of some selected characters in fine rice (*Oryza sativa* L.) available in Bangladesh. *Int. J. Sustain. Crop Prod.* **5(4):** 30-35.

Al jibouri, A. Miller, P. A. and Robinson, H. F. 1958. Genotype and environmental variation and correlation in an upland cotton crops of interspecific origin. *Agron. J.* **50**: 626- 636.

Anandrao, S. D., Singh, C. M., Suresh, B. G. and Lavanya, G. R. 2011. Evaluation of rice (Oryza sativa L.) hybrids for yield and yield component characters under North East Plain Zone. *The Allahabad Farmer*. **67(1):** 63-68.

Ashfaq, Md., Khan, A. S., Khan, S. H. U. and Ahmad, R. 2012. Association of various morphological traits with yield and genetic divergence in rice (*Oryza sativa* L.). *Int. J. Agril. Bio.* **14(1):** 55-62.

Atlin, G. N. and Frey, K. J. 1990. Selecting oat lines for yield in low-productivity environments. *Crop Sci.* **30**: 556-561.

Bastia, D., Mishra, T. K. and Das, S. R. 2008. Genetic variability and selection indices for grain yield in upland rice. *Oryza*. **45(1):** 72-75.

Belaj, A., Satovic, Z., Rallo, L. and Trujillo, I. 2002. Genetic diversity and relationship in olive germplasm collection as determined by RAPD. *Theor. Appl. Genet.* **5(4):** 638-644.

Blum, A., Golan, G., Mayer, J., Sinmena, B., Shpiler, L. and Burra, J. 1989. The drought response of landraces of wheat from the northern negev desert in Israel. *Euphytica*. **4**: 87-96.

Burton, G. W. 1952. Quantitative inheritance in pearl millet (*P. typhoides* L.). *Agron. J.* **50:** 503.

Chanyalew, S., Tefera, H. and Zelleke, H. 2010. Selection index for improving grain yield and related traits in Tef (*Eragrostis tef*). *Res. J. Agril. Biol. Sci*. **6(6):** 895-901.

Dabholkar, A. R. 1992. Elements of biometrical genetics. *Concept Publishing Company,* New Delhi, India.

Das, P. K., Chakraborty, S., Barman, B. and Sarmah, K. K. 2001. Genetic variation for harvest index, grain yield and yield components in boro rice. *Oryza*. **38(3 and 4):** 149-150.

Devi, B., Singh, C. M., Lal, G. M. and Yadav, P. 2013. Genetic architecture, interrelationship and path analysis for yield improvement in exotic rice. *Int. J. Agric. Env. Biotech*. **5(4):** 387-392.

Durick, D. N. and Cassman, K. G. 1999. Post green revolution trends in yield potential of temperature maize in North Central United States. *Crop Sci.* **39**: 1622-1630.

Falconer, D. S. and Mackay, T. F. C. 1996. Introduction to quantitative genetics. *4th Edn., Benjamin Cummings, England.*

Hezal, L. N. 1943. The genetic basis of constructing selection indices. *Genetics*. **28**: 476-479.

Johanson, H. W., Robinson, H. F. and Comstock, R. E. 1955. Estimates of genetic and environmental variability in Soyabean. *Agron. J.* **47(7):** 314-315.

Kanbar, A., Toorchi, M., Motohashi, T., Kondo, K. and Shashidhar, H. E. 2010. Evaluation of discriminant analysis in identification of deep and shallow rooted plants in early segregating generation of rice (*Oryza sativa* L.) using single tiller. *Aus. J. Basic Appl. Sci.* **4(8):** 3909-3916.

Ober, E. S., Le Bloa, M., Clark, C. J. A., Roya, A., Jaggard, K. W. and Pidgeon, J. D. 2005. Evaluation of physiological traits as indirect selection criteria for drought tolerance in sugarbeet. *Field Crop Res.* **91**: 231-249.

Panse, V. G. and Sukhatme, P. V. 1967. Genetics and qualitative characters in relation to plant breeding. *Indian J. Genet.* **17**: 312-328.

Paul, A., Suresh, B. G., Lavanya, G. R. and Singh. C. M. 2011. Variation and association among yield and yield components in upland rice (*Oryza sativa* L.). *Envir. Eco.* **29(2):** 690-695.

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

Quatadah, S. M., Singh, C. M., Babu, G. S. and Lavanya, G. R. 2012. Genetic variability studies in rice. *Environ. Ecol*. **30(3A):** 664-667.

Rabiei, B., Valizadeh, M., Ghareyazie, B. and Moghaddam, M. 2004. Evaluation of selection indices for improving rice grain shape. *Field Crops Res*. **89:** 359–367.

Rajiv, S., Thivendran, P. and Devanai, S. 2010. Genetic divergence of rice in some morphological and physiochemical response to drought stress. *Pertanika J. Trop. Agric. Sci.* **33(2):** 315-328.

Rahman, M. M., Syed, M. A., Adil, M., Ahmad, H. and and Rashid, M. M. 2012. Genetic Variability, correlation and path coefficient analysis of some physiological traits of transplanted aman rice (*Oryza sativa* L.). *Middle East J. Scientific Res*. **11(5):** 563-566.

Seyoum, M., Alamerew, S. and Bantte, K. 2012. Genetic variability, heritability, correlation coefficient and path analysis for yield and yield related traits in upland rice. *J. Plant Sci.* **7(1):** 13-22.

Singh, P. and Narayanan, S. S. 1993. Biometrical techniques in plant breeding. *Kalyani, Publishers New Delhi.*

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

Smith, H. F. 1936. A discriminant function for plant selection. *Ann. Eugen*. **7**: 240-250.

Smith, O. S., Hallauer, A. R. and Russel, W. A. 1981. Use of index selection in recurrent selection programs in maize. *Euphytica*. **20**: 611–618.

Srivastava, H. K. 2000. Nuclear control and mitochondrial transcript processing with Relevance to cytoplasmic male sterility in higher plants. *Crop. Sci.* **79(2):** 176-186.

Verma, U. 2010. Genetic diversity analysis in exotic rice germplasm. *M. Sc. Thesis. Deptt. GPB. SHIATS. Allahabad.*

Weyhrich, R. A., Lamkey, K. R. and Hallauer, A. R. 1998. Response to seven methods of recurrent selection in the BS11 maize population. *Crop Sci*. **38**: 308–321.

Yadav, S. K., Pandey, P., Kumar, B. and Suresh, B. G. 2011. Genetic Architecture, Inter-relationship and Selection Criteria for Yield Improvement in Rice (*Oryza sativa* L.). Pakistan *J. Bio. Sci.* **14**: 540-545.