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Research Article

Selection of stable genotype on the basis of stability performance and sustainability index in rice (*Oryza sativa* L.)

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Abstract
A comparative study on stability parameters and sustainability index for selecting stable genotypes of rice was carried out according to Eberhart and Russell Model. Stability analysis was carried out with twenty genotypes for grain yield and its contributing characters on three year data basis *viz.*, 2010, 2011 and 2012. Based on the linear component (bi), non-linear response (s^2di) and high mean performance (X), IET-21794 , IET-22110 and IET-22117 were found stable for grain yield (q/ha) , number of panicles /m^2 and panicle length (cm.) with high sustainability index of more than 90 % , indicated that these traits are least influenced by the environmental factors.

Key words
Genotype x environment interaction, regression coefficient, stability parameters, sustainability index and coarse rice

Introduction

Rice (*Oryza sativa* L.) is an important and stable food of almost half of the world. Rice is grown worldwide over an area of 154 million hectares with total production of 672 million tonnes. Among rice growing countries, India has largest area under rice in the world i.e., 36.9 million hectares and ranks second in production with 120.6 million tonnes (Savita *et al.,* 2015). Today, rice has special position as a source of providing over 75 % of Asian population and more than three billion of world populations meal, which represents 50 to 80 % of their daily Calorie intake. The world population will increase to over 4.6 billion by 2050, which demands more than 50 % of rice needs to be produced what is produced at present to cope with the growing population (Shreedhar *et al.,* 2011). Therefore, efforts were made to enhance rice productivity coupled with stability of performance under varying environments must receive top priority. India is largest rice growing country in the world; however its productivity per unit area is low. According to FAO, the productivity level of rice in India is very low (3.21 t/ha) as compared to the average productivity of the China (6.35 t/ha) and world (4.15 t/ha). The Agricultural Statistics of 2009 reveals the rice productivity of various states like, Punjab (4.022 t/ha), Andhra Pradesh (3.247 t/ha), Haryana (2.726 t/ha) and Uttar Pradesh (2.170 t/ha) (Koli *et al* 2014). The assessment of stability of a genotype under different environments is useful for recommending cultivars for known conditions of cultivation. The stability of varieties over wide range of environment with high yield potential is desirable; it has always been emphasized by breeders as base before releasing an ideal variety for commercial cultivation (Singh and Shukla 2001). Therefore a study was planned to evaluate and screen out the most stable and high yielding genotypes over environments.

Materials and method

The experimental material consisted of twenty genotypes of rice (including four checks varieties *viz.* IR-64, PA 6201, PR 113 and Ratna). These were grown under transplanted conditions in randomized block design with three replications during the three crop seasons of *kharif 2010*, 2011 & 2012 at Agricultural Research Station, Ummedganj, Kota. Each plot (5 x 2 =10 sqm.) consisted of rows spaced 20 cm apart and plant to plant distance was 10 cm. The cultural practices as per the recommended package of practices were followed to raise good crop. Observations on grain yield (q/ha), plant height (cm.), number of panicles per square meter, panicle length (cm.) and days to 50% flowering were recorded on ten randomly selected competitive plants. The days to 50 % flowering, days to 50 % maturity and grain yield (q./ha) were recorded on plot basis. The mean of pooled data were used to compute the stability analysis and stability parameters of varieties under different environments according to formulas used by Eberhart and Russell (1966). They used the following model to study the stability of genotypes/ varieties under different environments:

$Y_{ij} = m + B_i I_j + \delta_{ij}$ (i=1,2, …, t and j = 1, 2,…, s)
Where, Y_{ij} = is the genotype mean of the i^{th} genotype in jth environment, m = is the mean of all the genotypes over all the environments, B_i = is the regression coefficient of the i^{th} genotype on the environmental index which measures the response of that variety to varying environments, I_j = is the environmental index defined as the deviation of the mean of all the varieties at a given location from the overall mean. (or) obtained as the mean of all genotypes at the j^{th} environment minus the grand mean. The computation of environmental index as bellow,

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$[I_j = (\Sigma_i Y_{ij} / t) - (\Sigma_i \Sigma j Y_{ij} / ts), \quad \text{with} \quad \Sigma_j I_j = 0]$

Where, $\Sigma j Y_{ij}$ = Total of all the varieties at j^{th} location, t = Number of varieties, $\Sigma_i \Sigma j Y_{ij}$ = is the grant total and ts = Total number of observations, δ_{ij} = is the deviation from regression of the i^{th} genotype at the j^{th} environment.

Stability Parameters: Two Parameters of stability for an ideal variety are calculated.

Computation of regression coefficient (bi) = which is the regression of the performance of each variety under different environments on t5he environmental means over all the genotypes. This is estimated as follows:

$$\mathbf{bi} = \Sigma j Y_{ij} I_j / \Sigma_j I^2_j$$

Where, $\Sigma j Y_{ij} I_j$ = is the sum of the products and $\Sigma_j I^2_j$ = is the sum of squares.

Computation of mean square deviation (S^{-2}_d) from linear regression :

$$\mathbf{S^{-2}d} = (\Sigma_j \delta_{ij} / s\text{-}2) - S^2e / r$$

Where, $\Sigma j \delta_{ij} = [\Sigma j Y^2_{ij} - Y^2_i / t] - (\Sigma j Y_{ij} I_j)^2 / \Sigma_j I^2_j$

S^2e = is the estimates of pooled error and r = is the no. of replications.

Sustainability index: It was estimated according to following formula used by other workers (Gangwar *et al*., 2004 and Verma *et al* 2013).

Sustainability index = **(**Average performance of a genotype – Standard Deviation) / Best performance of a genotype in any year X 100

The value of sustainability index were arbitrarily divided in to five group *viz*. very low (up to 45%), low (46– 60 %), moderate (61-75%), high (76-90) and very high (above 90%).

Results and discussion

Pooled analysis of stability indicated that, genotype and environmental differed significantly for all the traits studied, indicating the presence of substantial variation among the genotypes over environments. As per Eberhart and Russell (1966), a variety / genotype is considered to be stable, if it shows high mean value (x) with unit regression coefficient or linear response (bi=1) and minimum deviation from the regression line ($S^2di = 0$). The estimates of mean performance (x), regression coefficient (bi) and deviation from regression ((S^2di) are presented in Table-1. The genotype IET 21794, IET 22117 and IET 22110 were found stable for grain yield (q/ha), number of panicles/m^2 and panicle length (cm). For days to 50% flowering the, general mean over three environment was 101.11 days. Out of 20 genotypes only two genotypes *viz.*, IET 21794 and IET 22110 have lower mean value than over all mean value. Earliness being a favorable trait, low mean is considered as desirable and also showed non-significant deviation from regression, which indicated that their performance for a given environment may be predicted and hence they are considered to be stable. Similar results reported earlier by Patel *et al* (2015), Wag mode and Mehta (2011), Mahalingam *et al* (2010) in rice.

The estimates of sustainability index and analysis of variance for grain yield and other related traits revealed significant genetic variability in the genotype under study. For grain yield and numbers of panicles/m^2, genotype IET 21794 has recorded highest mean grain yield (59.93q/ha) coupled with very high sustainability index of 91.13 % followed by IET 22117 and IET 22095 indicating best performance of these genotype (Table-2). The best performance coupled with high value of sustainability index could be taken as an indication of close proximity between the best performance and the stable performance over the years. For days to 50% flowering, IET 21785 recorded lowest mean value (98 days) with very high sustainability index of 94.97 % indicating better performance because early maturity is a desirable trait. Similar findings earlier reported by Koli and Prakash (2012) in rice.

Eberhart and Russell (1966) defined a stable genotype as the one which showed high mean yield, regression coefficient (bi) around unity and deviation from regression near to zero. Accordingly, the mean and deviation from regression of each variety were considered for stability and linear regression was used for testing the varietal response.

Genotypes with high mean, bi = 1 with non-significant s^2d are suitable for general adaption, *i.e.* suitable over all environmental conditions and they are considered as stable genotype.

Genotypes with high mean, bi >1 with non-significant s^2d are considered as below average in stability. Such genotypes tend to respond favourably to better environments but give poor yield in unfavourable environments. Hence, they are suitable for favorable environments.

Genotypes with low mean, bi<1 with non-significant s^2d do not respond favorably to improved environmental conditions and hence, it could be regarded as specifically adapted to poor environments.

Genotypes with any bi value with significant s^2d are unstable.

The comparative study of Eberhart & Russell model and sustainability index model indicated that, IET 21794, IET 22117 and IET 22110 were found stable for grain yield and no. panicles /m^2

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based on the linear components (bi), non-linear response (S^2di), high mean values and high sustainability index indicate genotypes suitable for favorable and poor environments also. These genotypes may be considered for cultivation and further improvement breeding programme.

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Table 1. Estimates of stability parameters of grain yield and its component traits in coarse rice genotypes

Genotype	Grain yield (q/ha)			Plant height (cm)			No. of panicles/m^2			Panicle length (cm)			Days to 50% flow.		
	Mean	bi	$S^{-2}di$	Mean	bi	$S^{-2}di$	Mean	bi	$S^{-2}di$	Mean	bi	$S^{-2}di$	Mean	bi	$S^{-2}di$
IET-22095	57.17	-0.83	0.12	105.11	0.90	0.20	267.78	0.82	-33.20	28.68	0.95	-0.10	100.89	1.023	-0.91
IET-22096	51.15	-0.62	9.88	107.69	19.90	12.80	240.89	9.61	59.50	27.79	1.72	5.30	99.83	1.524	2.44
IET-22097	51.56	1.65	0.08	108.20	17.30	1.40	257.22	13.25	1.90	28.95	-0.17	0.40	98.67	1.285	1.74
IET-22100	47.75	6.24	1.50	103.61	5.20	12.0	238.56	3.81	11.30	26.93	2.01	3.61	99.39	1.876	12.91
IET-22103	53.06	-0.39	0.10	101.43	33.10	11.70	277.44	4.45	28.90	25.70	1.05	3.90	97.28	1.264	8.11
IET-22107	55.54	-0.69	0.17	101.12	25.40	13.20	266.28	7.05	26.00	28.31	2.08	13.34	102.33	1.782	0.77
IET-22110	54.57	1.01	0.01	106.33	0.70	0.20	263.11	0.74	0.30	27.66	1.06	0.41	98.67	0.771	0.01
IET-22116	51.35	-0.80	0.13	109.77	0.00	66.10	247.44	-8.32	0.00	27.65	1.56	2.11	108.83	-0.009	3.22
IET-22117	57.50	1.03	0.02	104.44	0.50	0.10	268.67	0.75	0.00	27.67	1.02	0.00	101.22	0.653	0.60
IET-22121	56.78	2.70	5.94	104.60	5.60	4.10	261.22	12.38	10.30	27.01	0.48	1.11	102.28	1.332	5.71
IET-22123	55.51	4.84	4.82	100.39	0.80	0.60	260.72	-7.33	14.30	27.21	0.53	0.41	106.94	0.100	4.81
IET-22144	51.08	-0.60	0.05	103.56	50.90	17.20	260.33	-7.10	56.80	27.42	0.61	0.02	110.17	0.319	9.30
IET-21287	52.64	2.63	1.09	110.53	100.9	12.40	242.78	-4.88	97.30	26.21	1.45	1.12	98.78	1.234	1.70
IET-21515	56.55	-3.73	0.20	101.13	0.10	0.10	259.11	-7.81	30.40	27.31	1.73	0.84	99.83	1.204	0.51
IET-21785	55.52	1.62	0.11	100.44	2.50	0.10	265.89	-8.73	12.40	27.41	-0.08	4.80	97.72	0.236	0.21
IET-21794	59.93	1.01	0.01	103.56	0.80	0.00	275.22	0.92	0.00	28.22	1.01	0.04	99.89	0.894	0.02
IR-64	52.34	0.84	9.55	102.47	10.70	9.10	253.78	11.47	9.50	27.16	0.62	0.11	99.17	1.085	3.33
PA-6201	54.30	1.58	4.13	99.76	0.40	5.60	269.61	4.92	71.40	27.57	0.81	3.21	102.06	1.651	10.60
PR-113	46.62	1.89	0.14	102.07	0.10	4.90	263.67	-4.28	0.00	29.38	1.30	8.52	100.33	0.970	8.22
Ratna	53.81	0.62	0.10	108.37	41.10	6.10	258.56	-1.74	43.80	28.54	0.20	1.21	97.11	0.808	0.61
Pooled mean	53.73			104.22			259.91			27.64			101.01		
Stand. Error	1.45			2.18			5.82			1.12			1.39		

*= Significant at 0.05 probability, ** = Significant at 0.01 probability indicate level of significance in the table.

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Table 2. Sustainability index of grain yield and its attributes in coarse rice genotypes

Genotype	Grain yield (q/ha)				Plant height (cm)				No. of panicles/m^2				Panicle length (cm)				Days to 50 % flowering			
	Mean	Y_M	Õn	SI	Mean	Y_M	Õn	SI	Mean	Y_M	Õn	SI	Mean	Y_M	Õn	SI	Mean	Y_M	Õn	SI
IET-22095	57.17	60.00	2.64	90.88	105.11	115.00	4.43	87.55	267.78	285.00	10.38	90.32	28.68	32.10	1.53	28.68	100.89	105.00	3.76	92.51
IET-22096	51.15	57.92	4.13	81.19	107.69	113.00	4.26	91.53	240.89	275.00	21.46	79.79	27.79	31.00	2.41	27.79	99.83	106.00	5.11	89.36
IET-22097	51.56	57.28	3.83	83.33	108.20	119.00	4.66	87.01	257.22	300.00	22.78	78.15	28.95	30.20	0.91	28.95	98.67	102.00	4.30	92.52
IET-22100	47.75	59.74	6.19	69.58	103.61	110.00	3.56	90.95	238.56	285.00	24.94	74.95	26.93	30.40	2.66	26.93	99.39	106.00	6.58	87.56
IET-22103	53.06	56.38	2.44	89.78	101.43	108.00	4.67	89.59	277.44	301.00	15.57	87.00	25.70	28.90	1.78	25.70	97.28	105.00	4.74	88.13
IET-22107	55.54	58.15	1.92	92.20	101.12	107.00	4.42	90.37	266.28	310.00	33.04	75.24	28.31	33.60	3.30	28.31	102.33	107.00	5.92	90.11
IET-22110	54.57	57.55	2.44	90.59	106.33	111.00	3.57	92.58	263.11	285.00	14.18	87.34	27.66	29.80	1.51	27.66	98.67	103.00	3.39	92.50
IET-22116	51.35	56.25	3.25	85.50	109.77	116.00	5.58	89.81	247.44	273.00	13.65	85.64	27.65	31.60	2.15	27.65	108.83	112.00	1.58	95.76
IET-22117	57.50	61.00	2.18	90.69	104.44	110.00	4.56	90.81	268.67	284.00	8.66	91.55	27.67	29.80	1.44	27.67	101.22	107.00	4.09	90.78
IET-22121	56.78	63.83	3.41	83.61	104.60	109.00	4.48	91.85	261.22	294.00	22.74	81.12	27.01	29.30	1.01	27.01	102.28	107.00	4.84	91.06
IET-22123	55.51	63.83	4.40	80.06	100.39	102.00	1.98	96.48	260.72	315.00	23.75	75.23	27.21	29.20	1.20	27.21	106.94	110.00	2.16	95.26
IET-22144	51.08	55.21	2.54	87.92	103.56	115.00	8.24	82.88	260.33	280.00	13.50	88.15	27.42	29.60	1.40	26.58	110.17	115.00	2.67	93.48
IET-21287	52.64	59.74	3.74	81.86	110.53	121.00	6.79	85.74	242.78	273.00	14.67	83.56	26.21	28.00	1.76	26.21	98.78	103.00	4.29	91.73
IET-21515	56.55	63.83	5.29	80.31	101.13	105.00	1.86	94.55	259.11	285.00	15.86	85.35	27.31	29.80	2.14	27.31	99.83	105.00	4.08	91.20
IET-21785	55.52	63.67	4.44	80.23	100.44	104.00	2.04	94.62	265.89	290.00	14.35	86.74	27.41	29.60	1.53	27.41	97.72	100.00	2.75	94.97
IET-21794	59.93	63.30	2.24	91.13	103.56	108.00	2.78	93.31	275.22	290.00	11.40	90.97	28.22	30.20	1.48	28.22	99.89	106.00	3.72	90.72
IR-64	52.34	58.75	5.24	80.16	102.47	110.00	3.51	89.96	253.78	270.00	13.52	88.98	27.16	29.00	1.24	27.16	99.17	105.00	4.12	90.52
PA-6201	54.30	63.83	5.32	76.73	99.76	105.00	2.57	92.56	269.61	285.00	9.82	91.16	27.57	30.20	1.52	27.57	102.06	109.00	5.97	88.15
PR-113	46.62	52.37	3.48	82.38	102.07	106.00	2.74	93.70	263.67	287.00	14.76	86.73	29.38	33.20	2.37	29.38	100.33	106.00	4.03	90.85
Ratna	53.81	58.77	2.65	87.05	108.37	117.00	5.14	88.22	258.56	280.00	11.58	88.21	28.54	30.60	1.10	28.54	97.11	101.00	2.93	93.24

Y^m = Best performance of a genotype in any year. Ón = Standard deviation. SI = sustainability index