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G x E interactions, sustainability index and their comparison in rice (*Oryza sativa* L)

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Abstract
Twenty promising genotypes of non-aromatic rice (*Oryza sativa* L.) were evaluated for stability of grain yield in complete randomized block design during kharif 2010-2012, at Agricultural Research station, Ummedganj, Kota (Raj) under transplanted condition of South-Eastern Plane Zone of Rajasthan. The genotypic yield, regression coefficient (bi) and deviation from regression (S^2d) with sustainability index was used to identify the stability and adaptability of genotypes. Pooled analysis of variance showed highly significant differences among environments, genotypes and genotype x environment (G x E) interaction. Sufficient mean squares due to G x E interactions indicated that the genotypes interacted considerably with the environmental conditions. G x E (linear) components was highly significant showing the importance in expression of traits. The linear component was significant as against the nonlinear component (Pooled deviation), which revealed that a large portion of GxE interaction was accounted for by the linear regression through pooled deviation was significant. Over all mean performance and estimated stability parameters of grain yield, genotypes IET 21794, IET 22117, IET 22095, IET 22121 and IET 21515 were identified as superior which were well adapted to all the environments, stable with above average yielding ability or highest grain yield (59.93, 57.50, 57.17, 56.78 and 56.55 q/ha^{-1}, respectively) with non-significant bi and s^2d values coupled with high sustainability index. This showed that these varieties were better responsive to the favorable environments. Cultivars PR-113 and IR-64 (Checks) were good for low yielding environments (response to poor environment) and contradict with respect to the stability parameters and the sustainability index.

Keywords: Sustainability index, *Oryza sativa* L, South-Eastern Plane Zone

Introduction
Rice, *Oryza sativa* (2n = 24) is the second most important cereal and stable food for more than one third of the world's population. Adaptability to environmental fluctuations is very important for stabilization of crop production over both regions and years. Yield is a complex trait and is greatly influenced by environmental fluctuation; hence the selection for superior genotype based on yield *per se* at a single location in a year may not be very effective. Thus, varietal stability of paramount importance for stabilizing the production over regions and seasons as land holding in general of small size and farmers are resource poor. This lays a heavy emphasis on developing technologies while keeping to small farmer and sustainability of their resources as the first priority. In subsistence agricultural system, yield *per se* may be less important than reaching a certain yield level (Fox *et al*., 1997) [6].

Evaluation of genotypes for their consistency of performance under different environments is important in plant breeding programs. The occurrence of large genotype x environment (G x E) interaction posses a major problem of relating phenotypic performance to genetic constitution and makes it difficult to decide which genotypes should be selected. It is important to understand the nature of G x E interaction to make evaluation and the ultimately selection of the superior genotypes more effective. Bilbro and Roy (1976) [3] mentioned that, use of two additional parameters; adaptability and stability, in conjunction with yield would be of significant benefit in evaluation and characterization of advanced breeding material. The decision to reliant a genotype is usually make on basis of whether the genotype performance was satisfactory in comparison to performance of one or more standard cultivars over several crop seasons. Stability has been used by various researchers (Eberhart & Russell, 1966; Finley & Wilkinson, 1967; and Joshi *et al*., 2003) [4] to decide whether the performance of a genotype was satisfactory. Stability and adaptability studies are very useful for releasing a genotype for cultivation under wide as well as specific environments. There are many methods that can be utilized for stability and adaptability study.

In rice, phenotypic stability and sustainability has been studied by various workers (Koli *et al.* 2016, Panwar *et al.* 2008 and Umadevi *et al.* 2011 in rice) [10, 13]. However, information on use of sustainability index for assessment of varietal stability is lacking in rice. Hence, the present investigation was undertaken to determine the sustainability index of promising rice genotypes and were evaluated for three consecutive years (2010-2012).

Material and Methods

The experimental material consist of twenty promising genotypes of non-aromatic rice (*Oryza sativa* L.) namely, IET 22095, IET 22096, IET 22097, IET 22100, IET 222103, IET 22107, IET 22110, IET 22116, IET 22117, IET 22121, IET 22123, IET 22144, IET 21287, IET 21515, IET 21785, IET 21794 and four exiting checks (IR-64, PA-6201, PR 113 and Ratna) were evaluated at Agricultural Research Station, Ummedganj, Kota, Rajasthan in complete randomized block design with three replications with row to row spacing of 20 cm. and plant to plant distance of 10 cm. and recommended agronomic practices were followed . The data for grain yield was recorded on plot basis and estimated in q/ha. The three years data on each variety were used for estimation of stability parameters by using the Eberhart & Russell (1966) [4] model and sustainability index was estimated according to following formula used by other workers (Singh and Agarawal, 2003, Gangwar *et al*., 2004, Tuteja, 2006) [11, 7, 12].

Sustainability index (S.I.) = $(Y – Ón) / Y_M$ X 100

Where, Y = Average performance of a genotype, Ón = standard deviation and

$Y_{M =}$ Best performance of a genotype in any year.

The value of sustainability index were arbitrarily divided in to five group *viz*. very low (up to 60%), low (61– 70%), moderate (71-80%), high (81-90) and very high (above 90%)

The yield differences were found to be significant over years, indicating genetic difference among the varieties. For drawing meaningful interference, the yield (best performance) and sustainability index could be divided into four groups as follows;

The yield (best performance) and sustainability index could be divided into four groups as follows

Yield (Best Performance)	Sustainability index	Remarks
High	High	Desirable
High	Low	Location specific
Low	High	Undesirable
Low	Low	Undesirable

Results and Discussion

Pooled analysis of variance (Table 1) showed highly significant differences among cultivars for grain yield revealing the presence of sufficient variability in the materials. Significant mean squares due to genotype x environment interactions indicated differential response of genotypes in different environments. It means a particular variety may not exhibit the same phenotypic performance under different environments or different varieties may respond differently to a specific environment. Significant genotype interaction with environments was earlier reported by Panwar *et al.* 2008 [10] Ummadevi *et al*. 2011 [13] and Koli *et al* 2016 in rice and Koli *et al.* 2018 in sugarcane. Both linear and non-linear components of G x E interactions were also found significant for grain yield showing the importance of both linear (predictable) and non-linear (unpredictable) components in the expression of the traits. The linear component was significant as against the nonlinear components (Pooled deviation), which revealed that a large portion of G x E interaction was accounted for by linear regression although pooled deviation was significant. These results were in confirmation to those reported by Gourishanker *et al*. 2008 [8], Bhakta and Das (2008) [2] and Umadevi *et al.* 2011 [13] in rice.

Eberhart and Russell (1966) [4] 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.

1. 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.
2. 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.
3. Genotypes with low mean, bi<1 with non significant s^2d do not respond favourably to improved environmental conditions and hence, it could be regarded as specifically adapted to poor environments.
4. Genotypes with any bi value with significant s^2d are unstable.

In the present study, promising genotypes IET 21794, IET 22117, IET 22095 and IET 22121 were having high mean grain yield with bi =1.0 and non-significant s^2d = 0 (Table 2), indicated that these varieties were better responsive to all the environments and were considered as stable genotypes. IET 22107 & IET 22110 produced above average yield with nonsignificant unit regression value (-0.69) and deviation from regression (0), indicated below average stability, such genotypes tend to respond favourably to better environments but give poor yield in unfavourable environments. Hence, these genotypes were suitable for favorable environments. Varieties IR-64, IET 22116 having low mean value with nonsignificant s^2d value, indicated that genotype suitable for poor environment, whereas IET 22100 indicated low mean with significant bi and s^2d values, are unstable.

Sustainability index was also used to identify the stable genotypes. The average grain yield (Y_M), standard deviation (Ón) and sustainability index (SI%) of each genotype has been given in Table 3. High sustainability index (%) was estimated in case of IET 22107 (92.20) followed by IET 21794 (91.13), IET 22015 (90.88), and IET 22117 (90.59), whereas, moderate to lightly above moderate sustainability was observed in the check varieties, respectively.

The comparison of Eberhart & Russell (1966) [4] model with new model based on sustainability index (Table 4) revealed that IR-64 and PR 113 (checks) contradict with respect to the stability parameters and the sustainability index. According to Eberhart & Russell model of stability analysis, IET 22100 was unstable but it having high sustainability index.

In present study, Eberhart & Russell model was found to be more robust for predicting the stable genotypes. The stable genotype with respect to the seed yield under variable environments may be useful in breeding programme for evolving high yielding genotypes adapted in this zone. Genotypes IET 22107 and IET 21794 have sown stable performance under different environment by having above average seed yield, nonsignificant unit regression coefficient along with the nonsignificant variance due to deviation from regression. On the basis of these results, says that, these varieties are suitable for commercial cultivation in the Humid-South-Eastern plan Zone of Rajasthan.

Table 1: Pooled analysis of variance for grain yield (q/ha) of promising rice genotypes.

Sources	Degree of freedom	Mean squares
Genotype	19	97.7072**
Environ	2	39.1379**
G X E	38	15.8459**
E+(GXE)	40	5.6701*
E linear	1	1.3046
G X E linear	19	7.39816**
Pooled Deviation	20	4.2468**
Pooled Error	120	0.32021**

*, ** Significant against pooled deviation mean squares at 5% and 1%, respectively.

Table 2: Stability parameters for grain yield (q/ha) of promising rice genotypes.

Varieties	Mean grain yield (q/ha)	Regression coefficient (bi)	Deviation from regression (s^2d)
22095	57.17	-0.83	0.12
22096	51.15	-0.62	29.88**
22097	51.56	1.65	0.08
22100	47.75	6.24**	15.50**
22103	53.06	-0.39	0.10
22107	55.54	-0.69	0.17
22110	54.57	1.01	0.01
22116	51.35	-0.80	0.13
22117	57.50	1.03	0.02
22121	56.78	1.03	0.04
22123	55.51	4.84**	4.82*
22144	51.08	-0.60	0.05
21287	52.64	2.63	1.09
21515	56.55	-3.73	0.20
21785	55.52	1.62	0.11
21794	59.93	1.01	0.01
IR-64	52.34	0.84	9.55**
PA6201	54.30	1.58	4.13*
PR 113	46.62	1.89	0.14
Ratna	53.81	0.62	0.10
Mean	53.45		

*, ** Significant at 5% level of probability.

Table 3: Estimates of sustainability index for grain yield in promising rice genotypes.

Varieties	Mean grain yield (q/ha) Y	Standard deviation Ón	Best performance of a genotype in any year (Y_M)	Sustainability index (%)
22095	57.17	60.00	2.64	90.88
22096	51.15	57.92	4.13	81.19
22097	51.56	57.28	3.83	83.33
22100	47.75	59.74	6.19	69.58
22103	53.06	56.38	2.44	89.78
22107	55.54	58.15	1.92	92.20
22110	54.57	57.55	2.44	90.59
22116	51.35	56.25	3.25	85.50
22117	57.50	61.00	2.18	90.69
22121	56.78	63.83	3.41	83.61
22123	55.51	63.83	4.40	80.06
22144	51.08	55.21	2.54	87.92
21287	52.64	59.74	3.74	81.86
21515	56.55	63.83	5.29	80.31
21785	55.52	63.67	4.44	80.23
21794	59.93	63.30	2.24	91.13
IR-64	52.34	58.75	5.24	80.16
PA6201	54.30	63.83	5.32	76.73
PR 113	46.62	52.37	3.48	82.38
Ratna	53.81	58.77	2.65	87.05
Mean	53.45			

Table 4: Comparison between the Eberhart & Russell model and Sustainability Index.

Varieties/ Genotypes	Mean grain yield (q/ha) Y	Eberhart & Russell model			Sustainability index (%)	
		(bi)	**(s^2d)**	Rating	SI (%)	Rating
22095	57.17	-0.83	0.12	Stable	90.88	Very high
22096	51.15	-0.62	29.88	Un Stable	81.19	high
22097	51.56	1.65	0.08	Stable	83.33	high
22100	47.75	6.24	15.50	Un Stable	69.58	Low
22103	53.06	-0.39	0.10	Stable	89.78	high
22107	55.54	-0.69	0.17	Stable	92.20	Very high
22110	54.57	1.01	0.01	BAS	90.59	Very high
22116	51.35	-0.80	0.13	Stable	85.50	high
22117	57.50	1.03	0.02	BAS	90.69	Very high
22121	56.78	1.07	0.04	Unstable	83.61	high
22123	55.51	4.84	4.82	Unstable	80.00	Moderate
22144	51.08	-0.60	0.05	Stable	87.92	high
21287	52.64	2.63	1.09	Stable	81.86	high
21515	56.55	-3.73	0.20	Stable	80.31	Moderate
21785	55.52	1.62	0.11	Stable	80.23	Moderate
21794	59.93	1.01	0.01	Stable	91.13	Very high
IR-64	52.34	0.84	9.55	Un Stable	80.16	Moderate
PA6201	54.30	1.58	4.13	Un stable	76.73	Moderate
PR 113	46.62	1.89	0.14	Stable	82.38	high
Ratna	53.81	0.62	0.10	Stable	87.05	high
Mean	53.45					

[1]= below Average yield.

Table 6: Standard evaluation system develop for screening to resistance against stem borer and brown plant hopper.

	Stem Borer			**Brown plant hopper**	
Rating Score	**% head heart**	**% White ears**	**Remarks**	**No. of Hopper/ hill**	**Remark**
0	No damage	No damage	HR	Nil	HR
1	1-10	1-5	R	1-5	R
3	11-20	6-10	MR	5.1-10	MR
5	21-30	11-15	MS	10.1-20	MS
7	31-60	16-25	S	20.1-40	S
9	61-100	25-100	HS	>40	HS

Not: HR = Highly resistance, R = Resistant, MR = Moderately resistance, MS = Moderately Susceptible, S = Susceptible and HS = Highly susceptible.

References

1. Baber MA, Tariq MS, Ghulam A, Muhammad AH. Genotype x Environment interaction for seed yield in Kabuli chick pea (*Cicer arietinum*) genotypes developed through mutation breeding. Pak. J Bot. 2009; 41(4):1883-1890.
2. Bhakta N, Das SR. Phenotypic stability for grain yield in rice. *Oryza*. 2008; 45(1):105-119.
3. Bilbro JD, Ray LL. Environmental stability and adaption of several cotton cultivars. Crop Sci. 1976; 16:821-824.
4. Eberhart S, Russell WA. Stability parameters for comprising varieties. Crop Sci. 1966; 6:36-40.
5. Finley RW, Wilkinson GN. The analysis of adaption in plant breeding programme. Aust. J Agric. Res. 1963; 14:742-754.
6. Fox PN, Crossa J, Romagosa I. In (Kempton R A and P N Fox eds.) Statistical methods for Plant Variety Evaluation. Champion and Hall, London, 1997, 117-38.
7. Gangwar B, Katyal V, Anand KV. Stability and efficiency of cropping system in Chhattisgarh and Madhya Pradesh. Indian J Agril. Sci. 2004; 74:521-528.
8. Gouri Shankar V, Ansari NA, Ilias Ahmed M. Stability analysis using thermo-sensitive genic male sterility (TGMS) system in rice (*Oryza sativa* L.). Res. on crops. 2008; 9(1):141-146.
9. Nurmalina R. Analysis of sustainability index and status of rice availability system in several regions of Indonesia. Agro. Eco. J. 2008; 26(1):35-40.
10. Panwar LL, Joshi VN, Mashiat A. Genotypic x Environment interaction in scented rice. *Oryza*. 2008; 45(1):103-109.
11. Singh P, Agrawal K. Sustainability index as an aid determining genotypic stability in diploid cotton (*Gossypium arboretum*). J Cotton Res. Dev. 2003; 17(1):90-92.
12. Tuteja OP. Comparative studies on stability parameters and sustainability index for selecting stable genotypes in diploid cotton (*Gossypium hirsutum* L.). Indian J. Genet. 2006; 66(3):221-224
13. Umadevi M, Veerabadhiran P, Manonmani S. Stability analysis for grain yield and its components traits in rice (*Oryza sativa* L.). J of Rice Res. 2011; 3(1):10-12.