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Response of Environment and Stability on Grain Yield in Promising Genotypes of Rice (*Oryza sativa* L.)

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A B S T R A C T

The present investigation was determining the response of environment and stable genotypes across the environments. Ten promising genotypes of rice were evaluated for their adaptability in respect of grain yield for three years 2014-2016. The stability parameters were estimated by using the method of Eberhart and Russell 1966. Table 1 showed highly significant yield differences among the genotypes, environment and GxE interaction. The general mean (X), regression coefficient (bi) and deviation from regression (S^2di) were considered as stability parameters. Variety P 2511, P 1121, Pratap 1 and promising genotype IET 21960 were found stable or better responsive in general adaptation but the genotype IET 21593 showed below average stability and found suitable for favorable environment, whereas the genotype IET 21959, IET 22290 & P-1460 were found unstable. Therefore these genotypes which are general in adaptation may be commercially cultivated over a wide range of environments.

Introduction

The yield stability performance is one of the most desirable properties of genotypes to be released as a variety for commercial cultivation. The genotypes that are adapted throughout a reasonable large geographical area and that show some degree of stability from year to year is a major problem facing plant breeders. As a result, several methods of measuring and describing genotypic response across environments have been developed and utilized. For this purpose multilocation trials, over a number of year are conducted. Sometimes unilocation trials can also serve the purpose provided different environment (Mosavi *et al.*, 2013). Varietal adaptability to environmental fluctuations is very important for stabilization of crop production over both regions and years. An information on genotype x environment interaction leads to successful evaluation of stable genotype which could be used general cultivation (Koli *et al.*, 2018). 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 (Koli and Prakash, 2012).

Stability has been used by various researchers (Eberhart and Russell, 1966; Finley and Wilkinson, 1967) to decide whether the performance of a genotype was satisfactory. Stability and adaptability studies very useful for releasing a genotype for cultivation under wide as well as specific environments. However, this information is lacking in rice, hence the present investigation was undertaken to determine the environmental response and stability analysis, adaptability and sustainability index of five release varieties and some promising genotypes of rice.

Materials and Methods

The material for present investigation was consisted of five released variety of rice (P-1121, P-2511, P 1460, Taraori basmati and Pratap-1 along with five promising genotypes viz., IET 21953, IET 21959, IET 21960, IET 22289 and IET 22290. These genotypes were laid out in randomized block design with three replications with row to row spacing of 20 cm and plant to plant distance of 10 cm in each environment during three years (2014 to 2016) at Agricultural Research Station, Ummedganj, Kota, to determine the environment response and stability. All the cultural practices were adopted during the entire cropping season to ensure a good crop. 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 and Russell (1966) model and sustainability index was estimated according to following formula used by other workers (Singh and Agarawal, 2003; Gangwar *et al.*, 2004; Tuteja, 2006).

Sustainability index (S.I.) = $(Y - Ón) / Y_M \times 100$

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;

Results and Discussion

Pooled analysis of variance (Table 1) showed highly significant differences for genotypes, environment and G x E interactions. 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 genotypic interaction was earlier reported by Panwar *et al.,* (2008) Ummadevi *et al.,* (2011) and Koli *et al.,* (2016) and (2018) in rice. 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 Koli *et al.*, (2018), Panwar *et al.*, (2008) and Umadevi *et al.*, (2011) in rice.

The mean performance, regression coefficient (bi) and mean square deviation from regression (S^2d) were presented in Table 2. Data revealed that variety P-1121, P-2511, Pratap-1 and promising genotype IET 21960 have high mean values, regression coefficient close to unity (bi =1) and least square deviation (S^2d =0) for grain yield, indicated that these varieties were better responsive to all the environments and were considered as stable genotypes. The promising genotype IET 21953 and IET 22289 produced above average yield with non-significant unit regression value and deviation from regression (0), indicated below average stability, such genotypes tend to respond favorably to better environments but give poor yield in unfavorable environments. Hence, these genotypes were suitable for favorable environments. Whereas the variety P 1460 and promising genotypes IET 22959 and IET 22290 indicated low mean with significant bi and S^2d values, are unstable.

Eberhart and Russell (1966) also 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 favorably to better environments but give poor yield in unfavorable environments. Hence, they are suitable for favorable environments.

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

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

Sources	Degree of freedom	Mean squares
Genotype	9	123.3744**
Environ	2	41.3182**
G X E	18	4.1687**
E+(GXE)	20	2.6279*
E linear	1	1.3772**
G X E linear	9	4.5309**
Pooled Deviation	10	1.0402**
Pooled Error	60	0.06109**

*, ** 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/ Genotypes	Mean grain yield (q/ha)	Regression coefficient (bi)	Deviation from regression (s^2d)
IET 21953	46.15	0.652	-0.8
IET 21959	45.41	3.918**	4.1**
IET 21960	46.37	1.00	0.5
IET 22289	45.92	0.753	0.2
IET 22290	44.79	4.988**	1.6*
P 1121	47.24	1.076	0.0
P 1460	44.77	2.898*	1.6*
Taraori Basmati	36.00	2.732*	0.6
P-2511	48.27	1.018	0.3
Pratap-1	49.97	0.964	0.4
Mean	45.48		

*, ** 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 (%)
IET 21953	46.15	1.436	49.55	90.24
IET 21959	45.41	2.941	50.53	84.06
IET 21960	46.37	1.603	48.88	91.59
IET 22289	45.92	3.624	48.00	88.11
IET 22290	44.79	3.729	48.54	84.59
P 1121	47.24	1.422	49.11	93.29
P 1460	44.77	3.269	49.87	83.22
Taraori Basmati	36.00	3.801	41.22	78.11
P-2511	48.27	1.627	51.00	91.45
Pratap-1	49.97	1.149	51.20	95.36
Mean	45.48			

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

Varieties/ Genotypes	Mean grain yield (q/ha) Y	Eberhart and Russell model			Sustainability index (%)	
		(bi)	(s^2d)	Rating	SI (%)	Rating
IET 21953	46.15	0.652	-0.8	Stable	90.24	high
IET 21959	45.41	3.918**	4.1**	Un Stable	84.06	high
IET 21960	46.37	1.00	0.5	Stable	91.59	Very high
IET 22289	45.92	0.753	0.2	Stable[-1]	88.11	high
IET 22290	44.79	4.988**	1.6*	Un Stable	84.59	high
P 1121	47.24	1.076	0.0	Stable	93.29	Very high
P 1460	44.77	2.898*	1.6*	Un Stable	83.22	high
Taraori Basmati	36.00	2.732*	0.6	Un Stable	78.11	Moderate
P-2511	48.27	1.018	0.3	Stable	91.45	Very high
Pratap-1	49.97	0.964	0.4	Stable	95.36	Very high
Mean	45.48					

[1]= below Average yield.

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.

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. Very high sustainability index (%) was observed in Pratap-1(95.33) followed by P 1121 (93.29), IET 21960 (91.45) and P 2511 (91.4). Whereas, moderate to high sustainability was observed in rest of all.

The comparison of Eberhart and Russell (1966) model with new model based on sustainability index (Table 4) revealed that IET 22289 contradict with respect to the stability parameters and the sustainability index. According to Eberhart and Russell model of stability analysis IET 21959, IET 22290, P-1460 and Taraori basmati were found as unstable but it having moderate to high sustainability index.

In the present study, Eberhart and Russell model was found to be more robust for predicting the stable genotype. 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. Rice varieties P 1121, P 2511 and Pratap-1 and promising genotype IET 21953 and IET 21960 have sown stable performance under different environment by having above average seed yield, non-significant unit regression coefficient along with the non-significant variance due to deviation from regression. On the basis of these results, says that, these varieties/ genotypes are suitable for commercial cultivation over a wide range of environment.

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