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

**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. In India, rice is cultivated on 44.00 million hectares with a production and productivity of 103.00 million tons and 2.34 t/ha. respectively (Viraktamath *et al* 2012). 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) (Singh *et al* 2011). 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.

**MATERIAL AND METHODS:-**

 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 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 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:

 Yij = m + Bi Ij + δij (i=1,2, …, t and j = 1, 2,…, s)

Where,

Yij =is the genotype mean of the ith genotype in jth environment,

m = is the mean of all the genotypes over all the environments.

Bi = is the regression coefficient of the ith genotype on the environmental index which

 measures the response of that variety to varying environments.

Ij =isthe 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 jth environment minus the grand mean. The computation of environmental index as bellow,

 [Ij = (Σi Yij / t) - (Σi Σj Yij / ts), with ΣjIj =0]

 Where, ΣjYij = Total of all the varieties at jth location,

 **t** = Number of varieties

 Σi Σj Yij = is the grant total and

 ts = Total number of observations.

δij = is the deviation from regression of the ith genotype atthe jth environment.

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

1. **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:

 **bi** = ΣjYij Ij / Σj I2j

 Where, ΣjYij Ij = is the sum of the products and

 Σj I2j  = is the sum of squares.

1. **Computation of mean square deviation (S-2d ) from linear regression** :

 **S-2d = (**Σj δij / s-2) – S2e / r

 Where, Σjδij = [ΣjY2ij  - Y2i / t] - (ΣjYij Ij )2 / Σj I2j

 **S2e** = is the estimates of pooled error and

 **r** = is the no. of replications.

1. **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 X 100

 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 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 (S2di = 0). OR in other words, an ideally stable genotype is one that, confirms high mean value (>gi), unit regression or linear response (bi=1) and no deviation from the linearity (S2di = 0). The estimates of mean performance (x), regression coefficient (bi) and deviation from regression ((S2di) 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/m2 and panicle length (cm). For days to 50% flowering the, general mean over three environment was 101.11 days. Out of 20 genotype 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 show 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/m2, genotype IET 21794 recorded highest mean grain yield (59.93q/ha) with very high sustainability index of 91.13 % followed by IET 22117 and IET 22095 indicating best performance of this genotype (Table-2). The best performance coupled with high value of sustainability index could be taken as the indication of close proximity between the best performance and the average 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.

1. Genotypes with high mean, bi = 1 with non significant s2d 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 s2d 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 s2d 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 s2d 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 /m2 based on the linear components (bi), non-linear response (S2di), high mean values and high sustainability index. 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/m2** | **Panicle length (cm)** | **Days to 50% flow.** |
| **Mean** | **bi** | **S-2di** | **Mean** | **bi** | **S-2di** | **Mean** | **bi** | **S-2di** | **Mean** | **bi** | **S-2di** | **Mean** | **bi** | **S-2di** |
| 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

 **Table: 2- Estimates of sustainability index of cane yield and its components in sugarcane.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Genotype** | **Grain yield (q/ha)** | **Plant height ( cm)** | **No. of panicles/m2** | **Panicle length (cm)** | **Days to 50 % flowering** |
| **Mean** | **YM** | **Õn** | **SI** | **Mean** | **YM** | **Õn** | **SI** | **Mean** | **YM** | **Õn** | **SI** | **Mean** | **YM** | **Õn** | **SI** | **Mean** | **YM** | **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 |