Stability Analysis for Yield and Component Traits in Sorghum [Sorghum bicolor (L.) Moench.]

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A B S T R A C T

Stability analysis were carried out for grain yield and component traits using one hundred fifty accessions of sorghum during Kharif, 2013, 2014 and 2015 under rainfed condition at ICAR-CAZRI, Regional Research Station, Pali. Mean squares for genotype, environments and genotype x environment interaction were significant for almost all the studied characters. Genotype GPU-4 for grain yield/ plant, earliness, maturity and leaf area and GPU-8 for grain yield/ plant, fodder weight/ plant and dry weight/ plant exhibited high per se performance, non-significant $S^2_{di}$ and regression coefficient around unity. They were considered stable for these characters. EJ-34 showed good performance for grain yield, maturity and peduncle width under unfavorable environment and IS-6953 and GPU-14 was suitable for grain yield, earliness and peduncle width under favorable environment.

Keywords: grain yield/ plant, fodder weight/ plant, Genotype GPU-4

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Introduction

Sorghum [Sorghum bicolor (L.) Moench] is the most important dry land cereal crop grown for food, feed and fodder in India. It is genetically suited to hot and dry agro-ecologies with frequent drought, where it is difficult to grow other crops (Jain et al., 2010). Sorghum is preferred over maize in kharif season because of its high tolerance to various stresses and its superiority to pearl millet in having lower oxalate and fiber content. Sorghum stover is valued over all other sources of fodder (paddy straw, pearl millet straw and wheat straw). The grain-purpose types are grown during both the rainy (kharif, about 3.0 million ha) and the post-rainy seasons (rabi, about 4.2 million ha). In addition to these, forage and dual-purpose (grain and fodder) type of sorghum are cultivated mainly in the north-western, central and also other parts of the country. Sorghum is usually grown on marginal lands with low fertility, no or limited irrigation and with high
levels of biotic and abiotic yield limiting factors. Under such conditions, farmers rely mostly on in-built resistance and yield stability of the cultivar. Increasing the productivity of dry land cereals is one of several strategies that will improve global food security (Stewart and Lal, 2018). Assessment of stability and adaptability of a genotype to varied environments is useful for identifying and recommending genotypes for known conditions of cultivation and is a requirement in breeding programmes. Stability of trait expression can be understood by partitioning the genotype × environment (G × E) interaction into linear trends and a departure from linear called residual (Eberhart and Russell 1966). The present study was carried out to evaluate a set of dual-purpose sorghum genotypes for their grain and fodder yield stability across kharif sorghum growing regions, and to identify stable and highly adaptable genotypes for wider cultivation and to use in future breeding programmes.

Materials and Methods

One hundred fifty sorghum accessions collected from Directorate of sorghum, Hyderabad, Sorghum Research Station, Dessa, SDAU, and NAU, Surat, Gujarat, Rajasthan College of Agriculture, Udaipur and farmer field of Rajasthan were used for present study. These accessions were evaluated under rainfed condition at ICAR-CAZRI, Regional Research Station, Pali, Marwar (25°46’N, 73°50’E; 225 masl) Rajasthan during Kharif-2013, 2014 and 2015 in a Randomized Block Design (RBD) with three replications. The experimental soil was fine sandy clay loam in texture, mixed hyper thermic belonging to the family Lithic calcioorthids having shallow depth of 25-45 cm and underlying dense layer of murrum (highly calcareous weathered granite fragments coated with lime) up to 10-15 m depth. The soil of the experimental farm was moderately saline with pH 8.2 and contains low organic carbon 0.37%. Nutrient profile of soil contains 215 kg ha⁻¹ available N, 11.3 kg ha⁻¹Olesn’s extractable P and 225 kg ha⁻¹ available K at the time of sowing. The experiment unit was a single row plot of 3.5 m long, spaced 0.5 m apart. The standard agronomic practices were followed throughout the period of crop growth. The observations were based on the five randomly selected plants from each genotype and replication for different agromorphological traits i.e. plant height, number of leaves, leaf area, peduncle length, peduncle width, fodder weight/plant, dry weight/plant, 1000 seed weight and grain yield/plant. The observation for days to 50% flowering and days to maturity was recorded on the plot basis. Statistical analysis for stability was performed according to Eberhart and Russell (1966) method.

Results and Discussion

The Analysis of Variance for stability revealed that mean squares due to genotypes were significant for all the characters which showed the presence of variability among all the genotypes under investigation. The mean squares due to environments (Linear) were significant for all the characters except 1000 seed weight. The mean squares due to genotype x environment were significant for all the characters except days to 50% flowering, leaf area and 1000 seed weight. Pooled deviation differs significantly for all the above characters except number of leaves, peduncle length, peduncle width and 1000 seed weight (Table 1). These results corroborated with the findings of Kenga et al. (2003), Das and Prabhakar (2003), Khandelwal et al. (2005), Kale (2012) and Jadhav and Deshmukh (2017). A perusal of stability parameters for grain yield per plant indicated that out of one hundred fifty accessions, thirty four accessions exhibited higher mean value for grain yield per plant than population mean. All these accessions
also exhibited non-significant $S^2 di$, indicating their predictable performance. Out of the thirty four accessions, seven accessions viz., EJ-34, ES-7, IS-20582, IS-11497, EJ-18, Gundari and GPP-8 were good performer for unfavorable environment i.e. bi less than 1 (bi<1). EJ-34 also exhibited stable performance for maturity and peduncle width for unfavorable or unpredictable environmental conditions. Out of the thirty four accessions, four accessions viz., E-4, EB-22, GPU-4 and GPU-8 were average performer i.e. bi around unity (bi=1). These accessions therefore can be considered as suitable and will provide stable performance under different environmental conditions for higher grain yield per plant. With respect to component traits, two accessions out of above four accessions, exhibited higher per se performance, non-significant $S^2 di$ and regression coefficient around unity for grain yield as well as earliness, maturity and leaf area (GPU-4) while GPU-8 also showed stable performance for fodder weight/ plant and dry weight/ plant. Among the thirty four accessions, twenty three accessions viz., EJ-38, IS-14008, IS-6953, CSV-22, E-47, ES-5, IS-15664, SMU-1, IS-13974, SPV-1822, GPU-1, GPU-2, GPU-3, GPU-14, GPU-17, EJ-17, EJ-55, EG-48, EG-1, GJ 40, GPP6, GPP19 and GPP-22 were good performer for predictable or favorable environment i.e. bi more than 1 (bi>1). IS-6953 and GPU-14 also expressed stable performance for earliness and peduncle width for favorable environment (Table 2).

Similar results have been reported in the past by other workers, Madhusudhana et al. (2003), Khandelwal et al. (2005), Ezzat et al. (2010), Glazy et al. (2012), Anarase et al. (2016) and Patel et al. (2019). In case of fodder yield per plant, out of the twenty seven accessions, three accessions viz., EJ-34, E-4 and GPU-2 were good performer for unfavorable environment i.e. bi less than 1 (bi<1). Four accessions viz., SMU-1, IS-11497, SPV-1822 and GPU-1 were average performer i.e. bi around unity (bi=1). These accessions therefore can be considered as suitable for varying environments. Among the twenty seven accessions, six accessions viz., IS-6953, IS-15664, IS-13974, GPU-4, GPU-17 and GJ 40 were good performer for predictable or favorable environment i.e. bi more than 1 (bi>1) (Table 3). Similar results have been reported by other workers, Prabhakar et al. (2010), Umakanth et al. (2012), Vange et al. (2014), Girish et al. (2016) and Sissoko et al. (2018). A perusal of stability parameters for dry fodder yield per plant indicated that out of twenty six accessions, ten accessions exhibited higher mean value for dry fodder yield per plant than population mean.

All these accessions also exhibited non-significant $S^2 di$, indicating their predictable performance. Out of the ten accessions, only one genotype namely, IS-14008 was good performer for unfavorable environment i.e. bi less than 1 (bi<1). Out of the ten accessions, two accessions viz., IS-11497 and GPU-2 were average performer i.e. bi around unity (bi=1). These accessions therefore can be considered as suitable and will provide stable performance under different environmental conditions for higher grain yield per plant. Among the ten accessions, seven accessions viz., IS-6953, IS-20582, SMU-1, GPU-1, GPU-4, GPU-8 and Gundari were good performer for predictable or favorable environment i.e. bi more than 1 (bi>1) (Table 4).

Similar results have been reported in the past by other workers Glazy et al. (2012), Anarase et al. (2016) and Patel et al. (2019). Nevertheless, experiment has resulted into identification of certain accessions yielding higher than checks and having stable performance over environments.
Table 1 Pooled ANOVA for grain yield and its components in sorghum.

| Source of variation | d.f. | Days to 50% flowering | Days to maturity | Plant height | Number of leaves | Leaf area | Peduncle length | Peduncle width | Fodder weight/plant | Dry weight/plant | 1000 Seed Weight | Grain yield/plant |
|---------------------|------|-----------------------|-----------------|--------------|------------------|----------|-----------------|---------------|-------------------|-----------------|-----------------|------------------|
| Replication         | 6    | 0.566                 | 5.057           | 535.443**    | 4.926**          | 1563.884 | 5.308**         | 1.512**       | 642.325           | 44.857          | 2.933*          | 40.608           |
| Genotypes (G)       | 149  | 190.577**             | 130.386**       | 3265.757*    | 6.188**          | 14671.38*| 101.769**       | 10.531**      | 7420.370**        | 938.737**       | 46.119*         | 130.540**        |
| Env. + (G x E)      | 300  | 19.054                | 48.828**        | 595.100**    | 3.395*           | 2074.521 | 5.092**         | 1.655**       | 3828.859**        | 680.990**       | 0.806           | 12.535           |
| Environments (E)    | 2    | 1254.710**            | 5233.076*       | 47730.210**  | 397.244*         | 82758.72*| 191.485**       | 68.850**      | 395789.6          | 63547.900*      | 2.382           | 54.2             |
| Genotypes x Env. (E)| 298  | 10.761                | 14.034**        | 278.757**    | 0.751**          | 1533.016 | 3.841**         | 1.204**       | 1198.250**        | 259.065**       | 0.795           | 12.255*          |
| Environments (Linear) | 1   | 2509.420**            | 10466.150**     | 95460.430**  | 794.488*         | 165517.4*| 382.969**       | 134.699*      | 791579.3**        | 127095.8**      | 4.763           | 108.401*         |
| Genotypes x Env. (Linear) | 149 | 4.629                 | 20.793**        | 463.432**    | 1.291**          | 1205.168 | 7.592**         | 2.373**       | 2053.102**        | 438.276**       | 0.269           | 3.496            |
| Pooled deviation    | 150  | 16.780**              | 7.266**         | 93.455**     | 0.21             | 1848.458*| 0.089           | 0.036         | 341.109**         | 79.321**        | 1.313           | 20.874**         |
| Pooled error        | 894  | 0.841                 | 0.976           | 55.084       | 0.313            | 258.503  | 0.438           | 0.187         | 97.543            | 26.647          | 1.079           | 3.808            |
| Total               | 449  | 75.974                | 75.893          | 1481.354     | 4.322            | 6254.77  | 37.174          | 4.6           | 5020.797          | 766.523         | 15.843          | 51.695           |

*, ** Significant at 5% and 1% level of significance, respectively.
Table 2 Abstract table of promising and stable accessions for grain yield per plant in sorghum

| Genotypes | Mean  | bi   | S²di |
|-----------|-------|------|------|
| EJ-38     | 17.06 | 1.35 | 3.7  |
| EJ-34     | 23.38 | 0.56 | 4.69 |
| E-4       | 17.17 | 1.17 | -224 |
| ES-7      | 19.7  | 0.64 | 1.49 |
| IS-14008  | 19.7  | 3.46 | 3.52 |
| EB-22     | 16.3  | 0.99 | -1.92|
| IS-6953   | 24.5  | 2.51 | -3.9 |
| CSV-22    | 13.32 | 2.79 | 2.75 |
| E-47      | 22.03 | 3.94 | -0.71|
| ES-5      | 22.37 | 4.19 | -0.87|
| IS-20582  | 14.32 | 0.7  | 2.15 |
| IS-15664  | 15.97 | 3.16 | 3.87 |
| SMU-1     | 13.43 | 2.88 | 7.52 |
| IS-11497  | 16.6  | 0.7  | 1.8  |
| IS-13974  | 14.71 | 1.53 | -2.59|
| SPV-1822  | 13.5  | 1.97 | 1.48 |
| GPU-1     | 14.6  | 1.74 | -2.41|
| GPU-2     | 15.11 | 1.32**| -4.05|
| GPU-3     | 16.5  | 1.3  | -3.58|
| GPU-4     | 23.44 | 1.11 | -3.32|
| GPU-8     | 22.78 | 1.09 | -2.53|
| GPU-14    | 24.3  | 2.74 | -3.77|
| GPU-17    | 24.23 | 2.81 | -3.95|
| EJ-17     | 17.79 | 2.97 | 5.13 |
| EJ-18     | 12.77 | 0.71 | -0.81|
| EJ-55     | 19.68 | 2.23 | -2.6 |
| EG-48     | 20.08 | 2    | -3.14|
| EG-1      | 18.39 | 3.1  | 3.57 |
| Gundari   | 14.27 | 0.52 | -3.25|
| GJ-40     | 24.51 | 2.37 | -0.98|
| GPP-6     | 15.98 | 2.52 | 7.09 |
| GPP-8     | 20.91 | 0.03 | 4.89 |
| GPP-19    | 17.39 | 1.42 | -3.86|
| GPP-22    | 15.8  | 2.54 | 7.43 |

*, ** Significant at 5% and 1% level of significance, respectively.
Table 3 Abstract table of promising and stable accessions for fodder yield per plant in sorghum

| Genotypes | Mean | bi | S²di |
|-----------|------|----|------|
| EJ-38     | 165.2| 0.73 | 24.29 |
| EJ-34     | 108.8| 0.14 | -26.51 |
| E-4       | 166.9| 0.36 | 248.44 |
| ES-7      | 148  | 0.87 | -100.22 |
| EB-22     | 130.4| 1.13 | 118.55 |
| IS-6953   | 255.9| 1.45 | -57.32 |
| IS-20582  | 152.4| 1.26 | -93.75 |
| IS-15664  | 173.5| 1.7  | 103.48 |
| SMU-1     | 184.5| 0.85 | 84.96 |
| IS-11497  | 271.2| 0.91 | -99.16 |
| IS-13974  | 188.5| 2.13 | -17.52 |
| SPV-1822  | 167.1| 0.97 | 10.93 |
| GPU-1     | 194.5| 0.94 | -86.34 |
| GPU-2     | 201.7| 0.7  | 485.81 |
| GPU-4     | 177.3| 1.29 | -26.47 |
| GPU-17    | 172.3| 1.81 | 206.72 |
| EJ-17     | 146.4| 1.07 | -83.24 |
| EJ-18     | 138.1| 1.79 | 103.59 |
| EJ-55     | 101.9| 0.8  | -90.61 |
| EG-48     | 141  | 1.04 | -8.44 |
| EG-1      | 123.9| 0.91*| -101.12 |
| Gundari   | 158.7| 1.04 | -98.68 |
| GJ-40     | 220.5| 1.56 | -46.77 |
| GPP-6     | 133.7| 0.93*| -101 |
| GPP-8     | 86.07| 0.61 | -96.06 |
| GPP-19    | 108.3| 0.88 | -45.59 |
| GPP-22    | 106  | 0.66 | -74.71 |

*, ** Significant at 5% and 1% level of significance, respectively.
**Table.4** Abstract table of promising and stable accessions for dry fodder yield per plant in sorghum

| Genotypes | Mean  | bi  | S²di |
|-----------|-------|-----|------|
| EJ-34     | 37.378| 0.13| 21.77|
| E-4       | 56.156| 0.44| -22.47|
| ES-7      | 47.444| 0.6*| -26.66|
| IS-14008  | 81.022| 0.81| 61.94|
| EB-22     | 43.5  | 0.84| -13.78|
| IS-6953   | 95.256| 2.17*| -21.9|
| ES-5      | 50.8  | 0.93| -10.38|
| IS-20582  | 59.8  | 1.41| 2.6|
| IS-15664  | 50.689| 0.68| -3.94|
| SMU-1     | 71.567| 1.75| 60.31|
| IS-11497  | 99.511| 1.15| 16.83|
| SPV-1822  | 42.189| 0.34| 26.83|
| GPU-1     | 69.522| 1.58| -16.44|
| GPU-2     | 65.589| 0.94| -2439|
| GPU-4     | 67.378| 1.76| 14.74|
| GPU-8     | 113.989| 1.31*| -26.41|
| GPU-14    | 51.944| 0.72| 54.18|
| EJ-18     | 52.544| 1.85| 66.18|
| EJ-55     | 32.833| 0.76| -16.4|
| EG-48     | 50.922| 0.98| -13.8|
| EG-1      | 42.922| 0.98| -24.66|
| Gundari   | 67.889| 1.26*| -26.6|
| GPP-6     | 41.811| 0.31| -3.34|
| GPP-8     | 33.944| 0.57*| -26.01|
| GPP-19    | 39.889| 0.77| -22.34|
| GPP-22    | 36.011| 0.38| -18.25|

* *, ** Significant at 5% and 1% level of significance, respectively.

The stable genotypes across the environment may be used in future breeding programme further development of stable varieties. While the genotypes which performed well under unfavorable and favorable environment may play a role in the development of variety for the respective environments.

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