GENETIC VARIABILITY AND HERITABILITY ANALYSIS FOR YIELD AND MORPHOLOGICAL TRAITS IN SORGHUM (SORGHUM BICOLOR L. MOENCH) GENOTYPES

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ABSTRACT

Twenty four sorghum (Sorghum bicolor L. Moench) genotypes (SS 97-2 (S1), PARC-SS-1, No. 1500, No. 1692, T-3-DADU, 1572-T, S-98-6, SS-95-4, No. 1761, No. 1542, No. 1620, No. 1728, SP-1832, SS-97-10, SS 98-3, No.1828 (2001), F-9806, R-19, No. 1623, BR-123, PARC-SV-2, SS-95-RG, SS-95-RG and BMR-RED UNI) were evaluated for yield and various morphological traits to ascertain genetic variability, heritability and genetic advance at Arid Zone Research Institute, PARC, Dera Ismail Khan, Pakistan during 2013. The experiment was laid out in RCBD with three repeats. Each genotype was planted in 4 rows of 5 meter long keeping row to row distance of 50 cm. Data for days to 50 percent flowering, plant height, number of leaves per plant, leaf area index, days to maturity, 1000 grain weight, stalk yield and grain yield were recorded. Data for all traits were found significant which showed high level of variability in almost all the characters of sorghum which can be highly responsive to selection. The results further revealed that phenotypic co-efficient of variation were slightly higher in magnitude than respective genotypic co-efficient of variation in all characters studied. The higher genotypic and phenotypic variance components than the environmental variance estimates were found in case of days to 50 percent flowering, plant height, leaf area index, days to maturity, 1000 grain weight, stalk and grain yield. It showed that expression of these traits in sorghum population can be used further in breeding programme. The estimates of high heritability was linked with high genetic advance over mean for plant height, leaf area index and grain yield in sorghum genotypes indicating that selection based on these traits would be rewarding.

KEYWORDS: Sorghum bicolor; genotypes; genetic variability; heritability; agronomic characters, Pakistan.

INTRODUCTION

Sorghum (Sorghum bicolor L. Moench) is an important fodder crop of Pakistan. It provides bulk of raw materials for livestock, poultry and many other agro-based industries. However, it constitutes the staple food for

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masses in the world. Unlike other parts of country, sorghum is cultivated under Rod-kohi irrigation system through hill torrents in D.I Khan district of Khyber Pakhtoonkhwa. It grows well in rainfed areas. The yield level of sorghum at farmers field is quite low due to poor genetic makeup of existing land races. The only solution to overcome the lower stalk and grain yield is immediate replacement of old land races with new high yielding varieties. Newly developed varieties must possess wide range of adaptability alongwith some other desirable traits. Selection criterion for this purpose must be clearly defined keeping in view the demand of farmers.

The study of genetic variability is considered as one of the preconditions for development of new high yielding varieties. The phenotypic variability in a given environment can be measured easily, but it reflects the genetic as well as non-genetic influence on the phenotypic expression of traits (7). Godbharle et al. (8) concluded that genotypic variance was lower than the phenotypic variance for all the characters. They also pointed out that genetic factors are inferred from phenotypic observations, which are the results of interaction of genotypes and the environment. The emphasis given to phenotypic selection for the traits with high heritability coupled with high genetic advance will be effective for selecting the desirable genotypes (18). Naeem et al. (14) revealed significant variability in days to 50 percent flowering, plant height, fodder and grain yield in sorghum. While variation in leaf area and stem thickness was found to be non-significant due to genotypes. Amravati and Buldhana (4) recorded high phenotypic coefficient of variation (PCV) than genotypic coefficient of variation in most of the yield components. Abu and Yeye (1) reported that GCV estimates were lower than PCV estimates. Arun Kumar (5) and Bello et al. (7) observed high heritability coupled with high genetic advance for plant height, panicle length, fodder yield, total biomass, harvest index and grain yield per plant, indicating the preponderance of additive gene effect.

Studies of genetic variability in 30 sorghum land races under different environments showed significant variation in various morphological and yield traits (7). High estimates of broad sense heritability were found in yield and other yield related traits. Alhassan et al. (2) evaluated 20 sorghum genotypes and reported the significant genetic difference between lines in days to 50 percent flowering. They also reported higher estimates of heritability for maturity and grain yield. They also formed higher estimates of heritability and genetic advance for plant height and grain yield indicating that the traits were under influence of additive gene effect and selection based on phenotypic performance would be useful in breeding program.

Higher significant variations among the genotypes for various morphological and yield traits in sorghum has been reported by different workers (3, 9, 12, 13). High values for PCV and GCV were recorded for various yield and yield components. High heritability coupled with high genetic advance was observed for number of grains/panicle, plant height and grain yield/panicle. Warkad et al. (22) found significant genetic variability among sorghum genotypes for most of the agronomic traits. Naim et al. (15) and Puspitasari et al. (15) reported significant genetic variability of agronomic and grain quality traits such as plant height, number of leaves, stalk diameter, biomass weight, panicle length, grain yield per plant, 100 seed weight and gain yield in sorghum genotypes. Heritability in conjunction with genetic advance is more effective and reliable in predicting resultant effect of selection (10). It is apt to use broad sense heritability for prediction of selection response to the entire genotypic value which is transmitted to the progeny when any selection is advanced through selfing (20). The broad sense heritability of agronomic characters ranged from medium to high. Sweet sorghum population was highly variable for most of the morphological traits like days to 50 percent flowering, plant height, number of leaves, 1000 grain weight, grain yield and sugar content (19).

The main objective of the present study was to work out the enormity of genetic parameters variability among different sorghum lines and to select the most desirable lines either for stalk or grain yield and further evolution of new high yielding varieties.

**MATERIALS AND METHODS**

The trial comprising 24 local and exotic sorghum germplasm accessions (SS 97-2 (S1), PARC-SS-1, No. 1500, No. 1692, T-3-DADU, 1572-T, S-98-6, SS-95-4, No. 1761, No. 1542, No. 1620, No. 1728, SP-1832, SS-97-10, SS 98-3, No.1828 (2001), F-9806, R-19, No. 1623, BR-123, PARC-SV-2, SS-95-RG, SS-95-RG and BMR-RED UNI) was conducted at Arid Zone Research Institute, PARC, Dera Ismail Khan, Pakistan during 2013. The experiment was laid out in RCBD with three replications. Plot size comprising four rows 50 cm apart, five meters long (10 m²) was maintained for grass area, while middle two rows were taken into consideration for recording the data. All the recommended agronomic practices were carried out uniformly during the crop season. The crop was kept weeds free and also protected from insect pests. The data were recorded for various plant traits including days to 50 percent flowering, plant height, number of leaves per plant, leaf area index, days to maturity, 1000 seed weight and stalk and grain yield.
Analysis of variance (ANOVA) was carried out for all traits using computer’s software STATISTIX 8.1 for analysis of variance. The means of all the variables were separated to establish the level of significance through LSD at 0.05 percent level of probability (20). The genetic parameters viz. genotypic co-efficient of variation, (GCV), phenotypic co-efficient of variation, (PCV), heritability (h²) broad sense and genetic advance (GA) as percent of means at 1% standardized selection differential were calculated as proposed by different scientists (6, 10, 11).

RESULTS AND DISCUSSION

Days to 50 percent flowering

The analysis of variance (Table 3) revealed that disparity in days to 50 percent flowering in sorghum genotypes was highly significant. The flowering period ranged from 71 to 89.67 day. The lines No. 1620, No. 1542, SS-95-4, SS-95-RG and SP-1832 were found to be early availing 74.67, 74.33, 74, 73.67 and 71 days 50 percent flowering, respectively (Table 1). All these lines except A-23 were statistically uniform to lines R-19 T-3-DADU, F-9806, SS-97-10, PARC-SS-1, No. 1500 and No. 1692 which availed 77, 76.67, 76,75.76, 75.33, 75.33 and 75 days to 50 percent flowering respectively. The lines PARC-SV-2, SS 97-2 (S1), SS 98-3, SS-95-RG and No. 1761 were found late, consuming 89.67, 88.33, 87.67, 87.33 and 86.67 days respectively. All these lines were statistically at par with each other (Table-1). These results are in line with the findings of earlier scientists (2, 3, 4, 7, 9, 13, 14, 16) who also observed significant genetic diversity in days to flowering in sorghum genotypes.

Plant height

Height of plant was significantly affected due to variation in genetic makeup of sorghum genotypes (Table 3). Greater variation in plant height ranging from 141.67 to 423.67 cm was observed (Table 1). The maximum height was measured in line No.1761 which was tallest (423.67 cm) among 23 lines and produced more than one meter long stems and remained significantly taller than all the sorghum lines tested. It was followed by lines T-3-DADU (322.33 cm), BR-123 (313.67 cm), SS-95-RG (306 cm) (Table-1). The lines like SS 97-2 (S1), No. 1620, No. 1623, No. 1828 (2001), No. 1500, PARC-SV-2 and No. 1542 produced the plants with less than 200 cm (Table 1). The lines No. 1542 and PARC-SV-2 produced the short stature plant with height of only
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141.67 and 143.67 cm respectively. Several workers (2, 3, 4, 7, 9, 13, 14, 16, 22) had also got similar observations and showed significant genetic diversity in plant height in sorghum.

**Number of leaves per plant.**

The data (Table 1) revealed highly significant differences among the sorghum lines with respect to number of leaves per plant. The values ranged from 9 to 13 with an average of 11.17 leaves per plant. The line No. 1623 produced the highest 13 number of leaves and ranked first among 24 lines. It was however, statistically similar to eight other lines namely, BMR-RED UNI, T-3-DADU, SS-95-RG, S-98-6, No. 1828 (2001), SS-95-RG, No. 1728, and NO. 1500 (Table 1). These eight lines were also statistically at par with lines SS 98-3, R-19, SP-1832 and F-9806 each produced 11.33 leaves per plant. The rest of the lines showed poor performance with the least number of leaves (9) Bello *et al.* (7), Jain *et al.* (9) and Puspitasari *et al.* (16) also reported similar variability in number of leaves per plant in sorghum lines.

**Leaf area index**

Highly significant variation in leaf area index was found in different sorghum genotypes ranging from 303.77 to 725. The maximum leaf area index was observed in line No. 1761 (725) and remained significantly higher than all the genotypes (Table 1). The line S-98-6 ranked second by showing value of 634 followed by 1572-T. (627) and No. 1692 (61.7). All the lines were statistically uniform to each other. Similarly, the lines SS-95-RG, SS 97-2 (S1) and No. 1728 also showed high LAI with values of 585.73, 539.23 and 533.73, respectively (Table 1). The line No. 1620 showed lowest value of LAI (303.77) and remained statistically poor among all the lines studied. The lines SS 98-3, SP-1832, BMR-RED UNI, SS-97-10 and R-19 being poor in LAI were statistically at par with each other. Highly significant genetic variability in leaf area index was also measured by Bello *et al.* (7) Jain *et al.* (9) and Semi *et al.* (19). The results of Naim *et al.* (19) contradicted our findings which may be due to difference in environmental conditions and genotypes used.

**Days to maturity**

In present studies, highly significant variation in days taken to maturity was observed among various sorghum lines. The maturity period ranged from 102.33 to 120.67 days. The Lines SS-95-4, SS-97-10, PARC-SS-1, 1572-T and SS-95-RG were early in maturity availing 102.33,103, 103.67, 105 and
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105 days respectively (Table 1). All these lines were statistically comparable to each other. Similarly, the lines PARC-SV-2, SS-95-RG, SS 97-2 (S1), S-98-6, SS 98-3 and No. 1623 were found late in maturity (Table 1) were statistically similar to each other. Such types of variability in maturity have also been reported by earlier scientists (4, 7, 9, 13, 16, 22). In case of fodder yield early lines are more desirable as compared to normal and/or late varieties. Similarly, the normal maturing crops are usually considered ideal for grain yield. Delayed leaf senescence, or stay green in grain sorghum allows continued photosynthesis under drought conditions leading to normal grain filling and larger yields compared with senescent cultivars (19).

1000 grain weight

Grain size is an important yield component as it is directly proportional to seed yield. The selection based on size of seed may or may not be useful in getting higher grain yield depending upon the crop commodity. The genotypes with large seed size sometimes produces a few seeds while the small grain varieties produced higher number of seeds and ultimately higher yield. In our studies 1000 seed weight in different sorghum genotypes were significantly affected ranging from 16.33 to 28 grams (Table 1). The heaviest seeds (28 g per 1000 seed) were produced by lines SS 97-2 (S1) 3 and SS 97-2 (S1) followed by lines SP-1832, No. 1623 and SS-95-4 which in turn showed 25, 24, 23 gram respectively (Table 1). The smallest size grain were found in lines No. 1692, PARC-SV-2 and SS-95-RG (16.33 g) and remained statistically poor among all the sorghum genotypes under the investigation. Similar observations regarding variability in weight of grains in sorghum were also reported by earlier workers (3, 4, 7, 13, 16, 22).

Stalk yield

In present study the stalk yield in various sorghum lines remained highly significant (from 0.171 to 1.78 kg/plant Table 1). The highest stalk yield was obtained from lines No. 1623, SS-95-4, F-9806, T-3-DADU and PARC-SS-1 with yield of 1.780, 1.472, 1.300, 1.195 and 1.047 kg per plant, respectively. All these lines were significantly different from one another. The poorest stalk yield was shown by three similar lines viz; PARC-SV-2, BMR-RED UNI and R-19 (Table 1). The line producing highest stalk yield showed the highest number of leaves. Therefore, line No. 1623 may be further utilized for breeding high fodder yielding varieties. Similar findings regarding the variability in fodder yield in sorghum were reported by earlier scientists (13, 14, 16).

Grain yield

The variability in grain yield produced by different sorghum lines were found to be highly significant. The yield contributed by various lines ranged from 2.667 to 87.33 gram per plant. The highest value (87.33g/plant) was shown by lines SS 97-2 (S1). It remained significantly superior to all the lines. It was however, followed by the lines PARC-SS-1 (76.33 g) No. 1500 (73.67 g) and No. 1692 (76.33 g) (72.67 g) (Table 1). These lines were statistically at par with each other and significantly better than rest of 20 sorghum lines. The lines BMR-RED UNI remained shoddier by producing the least yield among the genotypes studied. The lines SS-95-RG, SS-95-RG, PARC-SV-2 and BR-123 also showed poor performance. The line SS 97-2 (S1) remained number one by producing the highest grain yield (Table 1). This line had also enjoyed maximum reproductive and grain formation period (33 days) from flowering up to maturity, therefore got maximum time to grain development. It was also found mediocre in case of plant height and number of leaves which is considered as an ideal plant type. The highest range of genetic variability in grain yield of sorghum genotypes similar to this study was also reported by earlier scientist (3, 4, 9, 13, 14, 15, 22).

Genotypic (GCV) and phenotypic (PCV) co-efficient of variation.

Results of variance components (Table 2) revealed that all the characters had higher genotypic and phenotypic variance suggesting that environmental influence was moderate for these traits as the experiment was managed under quite uniform input level to all the genotypes. The higher estimates of PCV and GCV were however obtained for plant height (27.60, 27.79), leaf area index (22.16, 22.83), stalk yield (67.20, 67.75) and grain yield (69.79, 86.68). It indicates that variation for these traits remarkably contributed towards the total variability.

<table>
<thead>
<tr>
<th>Characters</th>
<th>Mean</th>
<th>Range</th>
<th>GCV</th>
<th>PCV</th>
<th>Heritability (b.s.)</th>
<th>Genetic advance*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days to 5% flowering</td>
<td>79.71</td>
<td>71-89.67</td>
<td>6.87</td>
<td>7.35</td>
<td>0.87</td>
<td>13.48</td>
</tr>
<tr>
<td>Plant height (cm)</td>
<td>240.86</td>
<td>141.67-423.67</td>
<td>27.60</td>
<td>27.79</td>
<td>0.98</td>
<td>174.35</td>
</tr>
<tr>
<td>Number of leaves per plant</td>
<td>11.17</td>
<td>9-13</td>
<td>7.94</td>
<td>11.64</td>
<td>0.46</td>
<td>1.58</td>
</tr>
<tr>
<td>Leaf area Index</td>
<td>466.97</td>
<td>303.77-725</td>
<td>22.16</td>
<td>22.83</td>
<td>0.94</td>
<td>265.13</td>
</tr>
<tr>
<td>Days to maturity</td>
<td>112.28</td>
<td>102.33-129.67</td>
<td>5.50</td>
<td>5.78</td>
<td>0.90</td>
<td>15.51</td>
</tr>
<tr>
<td>1000 grain weight</td>
<td>20.36</td>
<td>16.33-28</td>
<td>16.65</td>
<td>16.75</td>
<td>0.98</td>
<td>8.90</td>
</tr>
<tr>
<td>Stalk yield per plant (g)</td>
<td>651.48</td>
<td>170.70-1780</td>
<td>67.20</td>
<td>67.75</td>
<td>0.98</td>
<td>1146.32</td>
</tr>
<tr>
<td>Grain yield per plant (g)</td>
<td>29.89</td>
<td>5.67-87.33</td>
<td>69.79</td>
<td>86.68</td>
<td>0.98</td>
<td>67.14</td>
</tr>
</tbody>
</table>

* = At 1% standardized selection deferential.
**Table 3.** Analysis of variance of mean squares of various sorghum genotypes as observed at Arid Zone Research Institute, PARC, Dera Ismail Khan.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>d.f.</th>
<th>Days to 50% flowering</th>
<th>Plant height</th>
<th>No. of leaves/plant</th>
<th>Leaf area index</th>
<th>Days to maturity</th>
<th>1000 seed weight</th>
<th>Stalk yield/plant (g)</th>
<th>Grain yield/plant (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replications</td>
<td>2</td>
<td>16.13</td>
<td>64.10</td>
<td>0.29167</td>
<td>605.20</td>
<td>39.847</td>
<td>15.0972</td>
<td>16.112</td>
<td>233.01</td>
</tr>
<tr>
<td>Genotypes</td>
<td>23</td>
<td>94.24***</td>
<td>13321.20***</td>
<td>3.275***</td>
<td>32775.5***</td>
<td>118.338***</td>
<td>34.63538***</td>
<td>578079***</td>
<td>1989.35***</td>
</tr>
<tr>
<td>Error</td>
<td>46</td>
<td>4.415</td>
<td>59.40</td>
<td>0.914</td>
<td>657.60</td>
<td>3.934</td>
<td>0.1262</td>
<td>3153</td>
<td>12.30</td>
</tr>
<tr>
<td>CV%</td>
<td></td>
<td>2.64</td>
<td>3.20</td>
<td>8.57</td>
<td>5.49</td>
<td>1.77</td>
<td>1.74</td>
<td>8.62</td>
<td>11.74</td>
</tr>
</tbody>
</table>

** = Significant at 0.01% level of probability.
This showed that genotypes have broad base genetic background as well as good potential that may respond positively to selection. These results are in conformity with early results (1, 4, 7). Moderate PCV and GCV values were observed for days to heading, number of leaves per plant, days to maturity and 1000 seed weight. These results are similar to those reported by earlier scientists (14, 19, 20) who also reported moderate PCV and GCV values for these traits. Higher estimates of PCV and GCV in these characters were reported by earlier scientist (4, 1, 8, 3, 13, 22).

**Heritability and genetic advance**

In present studies most of the traits showed higher estimates of broad sense heritability. The characters including; plant height, leaf area index, days to maturity, 1000 grain weight, stalk and grain yields exhibited very high heritability suggesting that simple selection would be sufficient for these traits for genetic improvement of desirable traits. But Johnsr et. al. (10) suggested that heritability values alone may not provide clear predictability of selection made. Therefore, heritability values along with estimates of genetic advance would be more reliable than heritability alone. The mere estimates of heritability only give the indication about the magnitude of inheritance of quantitative characters while genetic advance helps devise the selection procedure to be adopted in field crops. In our studies higher estimates of heritability coupled with high genetic advance over mean was obtained for the characters like, plant height, leaf area index, stalk and grain yield (Table 2). Therefore, it may be suggested that selection made via these characters would be more effective and reliable as these traits are predominantly controlled by additive gene action. The phenotypic selection of the traits with high heritability coupled with high genetic advance will be more rewarding for selecting of desirable genotypes (18). High heritability percentage reflects the large heritable variation which offers the possibility of improvement through selection as reported by different scientists (3, 5, 7, 8, 9, 13, 22) that high $h^2$ relationship was associated with high genetic advance for plant height, panicle length, fodder yield, total biomass, harvest index, stem girth and grain yield in sorghum.

The studies on genetic variability in sorghum revealed highly significant variation for all the traits studied. It suggested that genotypes have high level of variability. The results further revealed that PCV was slightly higher in magnitude than respective GCV. Therefore the environmental variance estimates were lower than both PCV and GCV for days to 50 percent flowering, plant height, leaf area index, days to maturity, 1000 grain weight,
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stall and grain yields which showed that such traits expression in sorghum population was genotype and can be exploited in breeding programs. The estimates of high heritability and high genetic advance over mean was observed for plant height, leaf area index and grain yield indicating that selection based on these traits would be stable and rewarding.

CONCLUSION

It is concluded that the line No. 1623 showed best performance by producing the higher stalk yield while SS 97-2 (S1) had proved its superiority and superseded all the sorghum lines by giving highest grain yield. It is, therefore, suggested these two lines may be considered for breeding fodder and grain purpose sorghum varieties, respectively. Similarly, the lines 1572-T, PARC-SS-1, No. 1500 and T-3-DADU which produced reasonable stalk as well as grain yield may be focused for breeding of dual purpose sorghum varieties.

REFERENCES


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