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# Study of genetic variability and heritability of yield and its components in forage sorghum (*Sorghum bicolor* L. Moench)

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**Abstract**
The present investigation was undertaken by using ten lines and four testers and their forty $F_1$ made with the parents of forage sorghum genotype of diverse origin, which were grown in a Completely Randomized Block Design (CRBD) with three replications during kharif season 2017 & 2018 were evaluated for eleven characters to study genetic variability, heritability and genetic advance. The 'analysis of variance' revealed highly significant differences among the genotypes for all the characters *i.e.* days to 50% flowering, plant height, leaf length, leaf breadth, internode length, stem girth, leaves per plant, leaf area, leaf stem ratio, total soluble solids and green fodder yield per plant, which indicated that wide spectrum of variability among the genotypes. The highest genotypic coefficient of variation (GCV) & phenotypic coefficient variation (PCV) was observed for leaf stem ratio, indicates that these attributes could be used as a selection for crop improvement. On the basis of high estimates of heritability coupled with high genetic advance was expressed as per cent of mean were observed for leaf breadth, leaf area, leaf stem ratio and green fodder yield per plant indicating a predominance of additive gene effects and possibilities of effective selection for the improvement of these characters.

**Keywords:** Forage sorghum, variability, GCV, PCV, heritability and genetic advance

## Introduction
Sorghum [*Sorghum bicolor* (L.) Moench] is one of the gifted genera among poaceae family in parts of the semi-arid tropics of the world and cultivated in areas considered to be too dry and hot for other cereals that provide food, feed, fodder and fuel to millions of poor farmer families and their livestock's (Doggett, 1988). It occupies fifth position among the cereals after wheat, rice, maize and barley in terms of production and acreage in overall world. In India, it covers about 5.14 million hectares with an annual grain production of 4.57 million tonnes and productivity of 889 Kg/hectare. The major sorghum growing states in our country are Maharashtra, Karnataka, Madhya Pradesh, Andhra Pradesh, Rajasthan, Tamil Nadu, Uttar Pradesh and Gujarat. In UP, it covers about 0.18 million hectares with an annual grain production of 0.18 million tonnes and productivity of 1000 Kg/hectare (Agriculture statistics at a glance, 2017). The fodder yield is primary traits targeted for improvement of dual-purpose sorghum productivity through exploration of heterosis. It has quick growth habit, quick recovery or regeneration after cutting or grazing and its ability to provide highly palatable and nutritious fodder for cattle (Padmashree *et al.*, 2014) [12]. Improvement of sorghum is much emphasized owing to its importance as food and fodder crop (Kalpande *et al.*, 2015) [8]. The estimates of genetic variability and heritability are of much value both for breeders and geneticists for determining an index of transmissibility of a trait from parents to offspring. Estimated of heritability in broad sense and genetic advance will help in knowing the nature of gene action affecting the concerned traits (Lush 1940, 1949 and Robinson *et al.*, 1949) [9, 10, 14]. High heritability coupled with high genetic advance estimated offers the most suitable condition for selection (Dhutmal *et al.*, 2014, Mallinath *et al.*, 2004) [3]. Keeping the above view in mind, this study was done with the objective to assess the Genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance of grain yield and its related components to select a more desired trait that may contribute for the improvement of forage sorghum.

## Material and Methods
### Field experiment and Plant material
The experimental material for the present investigation was generated by crossing ten diverse lines (Pusa Chari-6, Pusa Chari-9, Pusa Chari-23, Pusa Chari-615, UP Chari-2, Varsha,

HC-136, Rajasthan Chari-1, Pant Chari-7 and Pant Chari-8) and four testers (CSV-17, CSV-15, Pant Chari-2 and HJ-513) of forage sorghum were used as female and male respectively in a line x tester desion during *Kharif* 2017. Fourteen parents and their forty $F_{1's}$ were grown at Crop Research Centre, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut during *Kharif* 2018. The experimental material was planted in a Completely Randomized Block Design (CRBD) with three replications. Each of 40 $F_1$s was planted in five-meter long single row plot and the parents were planted in two rows. The rows were spaced 30 cm apart. The plant to plant distance was maintained at 10 cm by proper thinning. The border rows were also planted to neutralize the border effect. All the recommended cultural and plant protection practices were adopted for raising the crop.

**Observations recorded**

The data were recorded for eleven yield and its contributing characters *viz*. Days to 50% flowering, Plant height, Leaf breadth, Leaf length, Internode length, Stem girth, Leaves per plant, Leaf area, Leaf stem ratio, Total soluble solids and Green fodder.

**Statistical methods**

In this investigation line x tester mating design was followed and the mean value of the treatments for all the characters were subjected to analysis of variance (ANOVA) using the statistical analysis procedures of Panse and Sukhatme (1985). The phenotypic and genotypic variances were also estimated according to the method suggested by Burton (1952) [2]. Heritability ($h^2$) in broad sense for all characters was computed using the formula adopted by Lush (1940) [9]. Genetic gain for each character was computed using the formula by Johnson *et al*., (1955) [7].

**Results**

**Analysis of variance**

The 'analysis of variance' for the completely randomized block design was for all the eleven attributes for evaluating fifty-four treatments i.e. forty F1's, ten lines and four testers. The Mean square values due to treatments showed (table-1) highly significant differences among the used material for all the attributes namely, days to 50% flowering, plant height, leaf length, leaf breadth, internode length, stem girth, leaves per plant, leaf area, leaf stem ratio, total soluble solids and green fodder yield per plant, which indicated that the wide spectrum of variation among the genotypes.

**Estimates of variability parameters**

Estimates of variability parameters like; genotypic coefficient of variation, phenotypic coefficient of variation, heritability and expected genetic advance expressed as percentage of mean for all the traits are presented in table-2.

**Phenotypic coefficients of variation (PCV)**

High phenotypic coefficients of variation (more than 25%) observed for leaf stem ratio (33.26). Moderate percentage of phenotypic coefficients of variation (10-25%) was recorded for plant height (10.21), leaf length (11.13), leaf bredath (13.22), internode length (10.58), stem girth (13.70), leaves per plant (13.49), leaf area (19.12), total soluble solids (13.53) and green fodder yield (18.82) and exhibited low (<10%) phenotypic coefficients of variation for days to 50% flowering (8.86).

**Genotypic coefficient of variation (GCV)**

High genotypic coefficients of variation (more than 25%) revealed for leaf stem ratio (32.35). Moderate genotypic coefficients of variation (10-25%) reported for leaf breadth (12.15), stem girth (11.44), leaves per plant (11.06), leaf area (17.37), total soluble solids (10.98) and green fodder yield (16.92) whereas showed low genotypic coefficients of variation (<10%) for days to 50% flowering (7.43), plant height (8.70), leaf length (9.63) and internode length (9.28). In general, the value of genotypic coefficient of variance was lower than the respective phenotypic coefficient of variance.

**Heritability ($h^2$)**

High heritability (>60%) was noted for days to 50% flowering (70.34), plant height (72.65), leaf length (74.76), leaf breadth (84.44), internode length (76.90), stem girth (69.71), leaves per plant (67.21), leaf area (82.50), leaf stem ratio (94.63), total soluble solids (65.94) and green fodder yield per plant (80.83).

**Genetic advance (GA)**

Expected genetic advance expressed as percentage of mean was reported high (> 20%) for leaf breadth (22.99) leaf area (32.49), leaf stem ratio (64.83) and green fodder yield per plant (31.34). Moderate genetic advance as percentage of mean (10-20%) expressed for days to 50% flowering (12.84), plant height (15.27), leaf length (17.15), internode length (16.75), stem girth (19.67), leaves per plant (18.68) and total soluble solid (18.37).

**Discussion**

The present investigation entitled "Study of genetic variability and heritability for yield and its components in forage sorghum (*Sorghum bicolor* L. Moench)" was formulated to get the precise information of various metric traits like estimation of variability, heritability, genetic advance through line x tester analysis which may help in developing suitable breeding strategy for this crop improvement. One variety out of the parents *viz*., UP Chari-2 was used as check. According to Fisher (1918) [5], the continuous variation showed by quantitative characters with which most of the plant breeders have to deal with, includes the heritable and non-heritable components. The heritable component is the consequence of genotypes and the non-heritable part is mainly due to unknown environmental factors. expressed as per cent of mean were observed for leaf breadth, leaf area, leaf stem ratio and green fodder yield per plant Existence of genetic variability in the population provides ample opportunities for selection being effective. A thorough screening of the material studied under present investigation exhibited sufficient variability for all the eleven characters i.e. days to 50% flowering, plant height, leaf length, leaf breadth, internode length, stem girth, leaves per plant, leaf area, leaf stem ratio, total soluble solids and green fodder yield per plant which indicated that sufficient variability existed in the present set of material and further genetic analysis and study would be meaningful. High amount of genetic variability for many of these traits has also been reported earlier by Jain *et al.*, (2017) and Zinzala *et al.*, (2018) [17]. High phenotypic coefficients of variation (more than 25%) observed for leaf stem ratio (33.26). Moderate percentage of phenotypic coefficients of variation (10-25%) was recorded for plant height (10.21), leaf length (11.13), leaf bredath (13.22), internode length (10.58), stem girth (13.70), leaves per plant (13.49), leaf area (19.12), total soluble solids (13.53) and

green fodder yield (18.82) and exhibited low (<10%) phenotypic coefficients of variation for days to 50% flowering (8.86). High genotypic coefficients of variation (more than 25%) revealed for leaf stem ratio (32.35). Moderate genotypic coefficients of variation (10-25%) reported for leaf breadth (12.15), stem girth (11.44), leaves per plant (11.06), leaf area (17.37), total soluble solids (10.98) and green fodder yield (16.92) whereas showed low genotypic coefficients of variation (<10%) for days to 50% flowering (7.43), plant height (8.70), leaf length (9.63) and internode length (9.28). In general, the value of genotypic coefficient of variance was lower than the respective phenotypic coefficient of variance (table-2). Earlier researchers Vedansh *et al*., (2010) [16], Singh *et al.*, (2016) has reported similar findings with respect to phenotypic coefficient of variation and genotypic coefficient of variation. High heritability (>60%) was noted for days to 50% flowering (70.34), plant height (72.65), leaf length (74.76), leaf breadth (84.44), internode length (76.90), stem girth (69.71), leaves per plant (67.21), leaf area (82.50), leaf stem ratio (94.63), total soluble solids (65.94) and green fodder yield per plant (80.83). This indicates that lesser effect of environment on these traits. Therefore, the selection based on these traits might be effective in the improvement of this crop. High heritability estimates for these characters studied, have been reported earlier by Singh *et al*., (2016) [15], Jain *et al*., (2017), and Zinzala *et al*., (2018) [17]. Expected genetic advance expressed as percentage of mean was reported high (> 20%) for leaf breadth (22.99) leaf area (32.49), leaf stem ratio (64.83) and green fodder yield per plant (31.34). Hence these characters may be improved through hybridization followed by selection method. High heritability coupled with high genetic advance (table-2) was estimated for leaf breadth, leaf area, leaf stem ratio and green fodder yield per plant which indicated that these characters are governed by additive gene action. Direct selection of these characters will be effective and profitably for yield improvement. High heritability coupled with high genetic advance for some of these traits have also been reported earlier by Zinzala *et al.*, (2018) [17]. In the present study, broad sense heritability was computed which includes both additive and non-additive gene effects. Therefore, heritability estimates should be considered in conjugation with genetic advance. Based on this consideration, high heritability coupled with high genetic advance was estimated for leaf breadth, leaf area, leaf stem ratio and green fodder yield per plant which indicated that these yield components are governed by additive gene action.

**Table 1:** Analysis of variance for 11 characters in parents and their $F_1$ generation of forage sorghum**:**

| Source of variation | d.f. | Days to 50% flowering | Plant height (cm) | Leaf length (cm) | Leaf breadth (cm) | Internode length (cm) | Stem girth (mm) | Leaves per plant | Leaf area ($cm^2$) | Leaf stem ratio | Total soluble solids (%) | Green fodder yield (g/plant) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Replication | 2 | 83.07 | 605.56 | 4.98 | 0.31 | 0.85 | 0.02 | 0.71 | 32.13 | 0.03 | 0.06 | 22.01 |
| Treatment | 53 | 146.22** | 1994.07** | 160.43** | 2.15** | 9.28** | 14.06** | 8.25** | 11709.68** | 0.053** | 3.26** | 12678.15** |
| Error | 106 | 18.02 | 222.44 | 16.23 | 0.12 | 0.84 | 1.78 | 1.15 | 773.46 | 0.01 | 0.48 | 928.72 |

* Significant at 5% level, ** Significant at 1% level

**Table 2:** Mean performance and parameters of variability for various traits studied in forage sorghum

| Characters | Heritability (%) (broad sense) | Genetic advance | Genetic advance (as % of mean) | GCV (%) | PCV (%) |
|---|---|---|---|---|---|
| Days to 50% flowering | 70.34 | 11.29 | 12.84 | 7.43 | 8.86 |
| Plant height (cm) | 72.65 | 42.67 | 15.27 | 8.70 | 10.21 |
| Leaf length (cm) | 74.76 | 12.35 | 17.15 | 9.63 | 11.13 |
| Leaf breadth (cm) | 84.44 | 1.56 | 22.99 | 12.15 | 13.22 |
| Internode length (cm) | 76.90 | 3.03 | 16.75 | 9.28 | 10.58 |
| Stem girth (mm) | 69.71 | 3.48 | 19.67 | 11.44 | 13.70 |
| Leaves per plant | 67.21 | 2.60 | 18.68 | 11.06 | 13.49 |
| Leaf area ($cm^2$) | 82.50 | 112.97 | 32.49 | 17.37 | 19.12 |
| Leaf stem ratio | 94.63 | 0.27 | 64.83 | 32.35 | 33.26 |
| Total soluble solids (%) | 65.94 | 1.61 | 18.37 | 10.98 | 13.53 |
| Green fodder yield (g/plant) | 80.83 | 115.90 | 31.34 | 16.92 | 18.82 |

## Conclusion

In the present investigation which included ten lines and four testers and their forty $F_1$ of sorghum was carried out in order to study the nature and amount of variability, heritability and genetic advance for eleven yield and its component characters. The 'analysis of variance' among all genotypes showed a significant difference for all characters studied. The highest genotypic coefficient of variation (GCV) & phenotypic coefficient variation (PCV) was observed for a leaf stem ratio which indicates that scope of importance with respect to these characters through selection. On the basis of high estimates of heritability coupled with high genetic advance was expressed as per cent of mean were observed for leaf breadth, leaf area, leaf stem ratio and green fodder yield per plant indicating a predominance of additive gene effects and hence may prove useful for effective selection for the improvement of these characters.

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