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Genetic variability studies in sorghum (*Sorghum bicolor* (L.) Moench)

D Sravani Sandhya Nevedhitha, AW More, HV Kalpande, RR Dhutmal, JD Deshmukh, DK Zate, SG Shinde, AR Gaikwad, MP Wankhade and Shinde SL

D Sravani Sandhya Nevedhitha
Department of Genetics & Plant Breeding, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

AW More
Sorghum Research Station, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

HV Kalpande
Department of Genetics & Plant Breeding, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

RR Dhutmal
Seed Research Officer, STR & QSP Unit, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

JD Deshmukh
Department of Genetics & Plant Breeding, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

DK Zate
Department of Genetics & Plant Breeding, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

SG Shinde
Department of Genetics & Plant Breeding, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

AR Gaikwad
Department of Genetics & Plant Breeding, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

MP Wankhade
Seed Research Officer, STR & QSP Unit, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Shinde SL
Department of Genetics & Plant Breeding, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Corresponding Author:
D Sravani Sandhya Nevedhitha
Department of Genetics & Plant Breeding, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

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Abstract
The current study was carried out using twenty-two sorghum genotypes including five checks at Experimental farm, Genetics & Plant breeding department, College of Agriculture, VNMKV, Parbhani. The study was done during *Rabi* 2024-2025 using randomized block design (RBD) with two replications. A group of twenty-two genotypes were employed to assess genetic variability for yield as well as its contributing traits. A significant degree of variability was noted in yield components. Plant height (cm), brix reading and grain yield per plot (kg) had the highest GCV and PCV. While, moderate GCV and PCV was observed for stem girth (cm), number of leaves, leaf: stem ratio, fodder yield per plot (kg) and lowest GCV and PCV observed for days to 50% flowering. High heritability combined with high genetic advancement for plant height, number of leaves, leaf: stem ratio, stem girth, fodder yield per plot, brix reading and grain yield per plot. Hence, this insight indicates that these traits can be effectively employed in sorghum enhancement programs through selection method.

Keywords: Sorghum, analysis of variance, heritability, genetic variability, and genetic advance per mean

Introduction
Sorghum is among the fifth major cultivated crop species globally in terms of production and utilization. Globally, Sorghum produced about 52.8 MT during 2023-24. USA with ranks first followed by Nigeria with, Brazil with and India (USDA 2023). India ranked second in terms of area and fourth in terms of production globally during 2023-24 (USDA 2023). Majority of the sorghum was produced during *rabi* season. Maharashtra, ranks first in both area and production followed by Karnataka and Rajasthan (APEDA 2023-24).
Sorghum is cultivated in India during the monsoon as well as the post-monsoon seasons. *Rabi* sorghum, particularly is valued for its superior quality grain and is utilized as a vital feedstock for livestock, during droughts. Yet various aspects have influence over its productivity.
The degree of genetic variation has a significant impact on the possibility of improving any agricultural crop. The genotypic components, as a heritable component of total variability, impact the breeder's selection techniques for yield and component traits. Genetic variability for the agronomic characteristics is an important aspect of any breeding programmes for the gene pool development, and precise estimates of the heritability are required to establish an effective breeding programme. Therefore, the current study was conducted to estimate the genetic variability, heritability and genetic advance in *rabi* sorghum genotypes.

Materials and Methods
The experimental material included twenty-two genotypes of sorghum acquired from Experimental farm, Genetics & Plant breeding department, VNMKV Parbhani (Table 1) during *rabi* 2024 with 45 cm × 15 cm spacing and with plot size of 1.8 m × 4 m. On 21st October, 2024-25 the seeds were sown using Randomised Block Design (RBD) with two replications. From each genotype, five competitive plants were chosen randomly and observations are noted in each replication for eight grain yield and their contributing traits: days to 50% flowering, number of leaves, plant height (cm), leaf: stem ratio, brix reading,

stem girth (cm), fodder yield per plot (kg), grain yield per plot (kg).
Mean values of collected data was employed to analysis of variance (ANOVA) utilising Panse and Sukhatme (1985) [8] statistical analysis techniques. While, phenotypic coefficient of variance (PCV) and genotypic coefficient of variance (GCV) were determined according to Burton's (1952) [3] approach.
The formula provided by Johnson *et al*. (1955) [5] was used to estimate heritability (h^2) in the broad sense, genetic advance and genetic advance as percent mean for all characters.

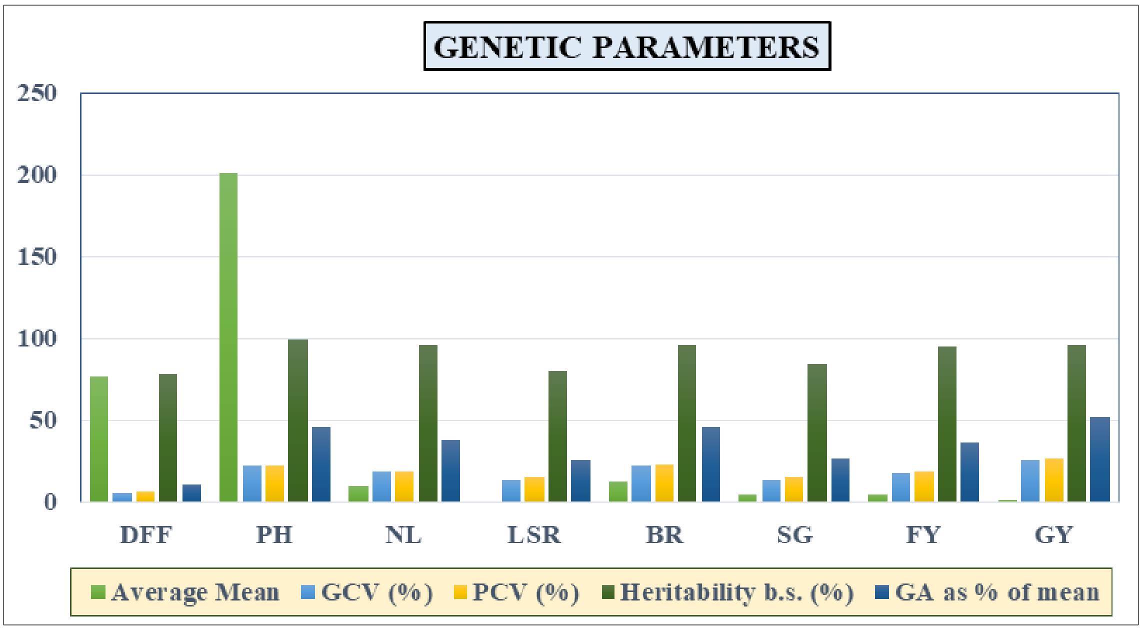
Results and Discussion

Analysis of variance showed that all the twenty-two genotypes varied considerably high for each of the eight characters including days to 50% flowering, plant height (cm), leaf: stem ratio, brix reading, stem girth (cm), fodder yield per plot (kg), number of leaves and grain yield per plot (kg) (Table 1).
For a plant breeding program to be successful, breeding material must have genetic variability. The magnitude of genetic variability in the plant population has a significant impact on the degree of selection. Estimates of mean value, genotypic and phenotypic coefficient of variation, heritability, genetic advance and genetic gain were used to evaluate this variability.
Estimation of PCV (%) and GCV (%) were acquired for various characters (Table 2, Fig. 1). Every trait has documented wide range of variance. A close relationship between GCV and PCV values for almost all the characters indicated that the environment had less impact on the characters expression. For all yield and yield contributing characters, phenotypic variance was greater than genotypic variance, suggesting that these traits are not significantly impacted by the environment. Grain yield per plot (kg) followed by the brix reading and plant height showed high PCV and GCV. The current results are in confirmation with those of Jain *et al*. (2009) [4], Kumar (2021) [7] and Khandebarad *et al*. (2022) [6]. While, traits such as number of leaves, leaf: stem ratio, brix reading, stem girth and fodder yield per plot recorded moderate PCV and GCV. The current findings are in confirmation with results of Singh *et al*. (2017) [10] and Santhosh and Pandey (2020) [9]. Whereas days to 50% flowering recorded lowest GCV and PCV Arunkumar (2013) [1] has previously been reported to have similar finding. This shows that genotypes under study differs less for days to 50% flowering, suggesting there is a little room for improving this.
High heritability combined with higher genetic advance suggests that additive gene action plays a role in both the expression and transmission of any trait, and selection may be effective in these circumstances.
The broad sense heritability estimate ranged from 78.53% to 99.44% (Table 3). The highest GAM was 52.65% recorded for grain yield per plot (kg). Higher heritability and greater genetic advance were observed in the current study for plant height, number of leaves, leaf: stem ratio, brix reading, stem girth, fodder yield per plot and grain yield per plot. However, for days to 50% flowering high heritability and moderate genetic advance were noted, suggesting that the environment has less of an impact and are governed by both additive as well as non-additive gene action. These results are consistent with the research findings of Jain *et al*. (2009) [4], Begum *et al*. (2023) [2] and Swaroop *et al*. (2024) [11].

Table 1: ANOVA for yield and its contributing traits

S. No.	Characters	Mean sum of squares		
		Replication (1 d.f)	Treatment (21 d.f)	Error (21 d.f)
1.	Days to 50% flowering	16.56	47.49**	5.71
2.	Plant height (cm)	48.2	4047.4**	11.3
3.	Number of leaves	0.20	7.758**	0.1569
4.	Leaf: stem ratio	0.0004	0.0018**	0.0001
5.	Brix reading	1.082	17.66**	0.322
6.	Stem girth (cm)	0.001	1.054**	0.085
7.	Fodder yield per plot (kg)	0.003	1.723**	0.043
8.	Grain yield per plot (kg)	0.0001	0.504**	0.009

**Significance at 1% level and *Significance at 5% level.



* DFF-Days to 50% flowering, PH-Plant height, NL-Number of leaves, LSR-Leaf: stem ratio, BR-Brix reading, SG-Stem girth, FY-Fodder yield, GY-Grain yield

Fig 1: Genetic parameters for yield and its contributing traits

Table 2: Genetic variability parameters studied for yield and its component traits.

S. No.	Characters	Range		Mean	Genotypic variance ($\sigma^2 g$)	Phenotypic variance ($\sigma^2 p$)	GCV (%)	PCV (%)	Heritability b.s. (%)	GA as% of mean
		Minimum	Maximum							
1.	Days to 50% flowering	66.50	85.00	76.84	20.89	26.60	5.94	6.71	78.53	10.85
2.	Plant height (cm)	83.50	253.60	201.53	2018.01	2029.35	22.28	22.35	99.44	45.78
3.	Number of leaves	7.00	13.00	10.38	3.80	3.95	18.77	19.15	96.04	37.89
4.	Leaf: stem ratio	0.12	0.29	0.20	0.0008	0.0010	13.95	15.59	80.00	25.69
5.	Brix reading	6.27	19.20	12.93	8.67	8.99	22.75	23.17	96.42	46.03
6.	Stem girth (cm)	2.8	6.4	4.96	0.48	0.57	14.01	15.20	84.94	26.60
7.	Fodder yield per plot (kg)	3.1	6.1	5.01	0.84	0.88	18.25	18.72	95.10	36.68
8.	Grain yield per plot (kg)	1.12	2.88	1.90	0.24	0.25	26.07	26.59	96.11	52.65

Conclusion

Furthermore, the characters plant height (cm), brix reading and grain yield per plot exhibited high estimates of PCV and GCV indicating significant variability among genotypes and a lower degree of environmental influence. Plant height, number of leaves, leaf: stem ratio, brix reading, stem girth, fodder yield per plot and grain yield per plot all showed higher heritability and higher genetic advancement. This suggests that these traits are controlled by additive gene action and hence direct selection for them will increase the grain yield through genetic improvement in sorghum.

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