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Genetic variability studies for yield and yield contributing traits in *Rabi* Colored pericarp sorghum (*Sorghum bicolor* L. Moench) in relation to Drought tolerance

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Abstract
Sorghum (*Sorghum bicolor* (L.) Moench)'s production and productivity is by far lower than its potential. Knowledge on the extent and pattern of genetic variability is prerequisite important for generating superior varieties of different objectives for sorghum improvement. Therefore, this research was conducted to quantify genetic variability, heritability, and genetic advance as percent of mean in colored pericarp sorghum for yield and yield contributing as well as moisture stress tolerating traits. In present study, analysis of variance shows that there is considerable difference between the genotypes for all the traits. The result of genetic parameters revealed that moderate to high PCV, GCV, high heritability accompanied with high genetic advance was recorded for the traits *viz.*, leaf area index, fodder yield and grain yield suggesting that the selection would be efficient for these characters to bring genetic enhancement in desired way.

Keywords: Colored pericarp sorghum, GCV, PCV, heritability, variability, genetic advance

Introduction
Sorghum bicolor commonly called sorghum and also known as *durra*, *jowar*, or *milo* is a grass species cultivated for its grain, which is used for food, both for humans and livestock, and for ethanol production. Sorghum is one of the important cereal crops in the world occupying fifth position after maize, rice, wheat and barley (FAOSTAT 2021) [7]. Sorghum is the staple food in the human diet especially for poor and most food insecure people living in semi-arid tropics (Tonapi *et al.* 2011) [20]. It is used as whole grain or processed into flour, it is gluten free and have essential nutrients (proteins, vitamins and minerals) and nutraceuticals (phenolics, antioxidants and cholesterol lowering waxes) (Assefa *et al.* 2018) [4].

Amidst rising agricultural expenditure, climate change and increasing demand of food supply, sorghum holds a great promise for food and nutritional security. Sorghum kernel color is the overall visual perception of the grain color as perceived by human naked eye. Sorghum kernel color is genetically controlled. The phenotypic pigments of sorghum pericarp and endosperm are determined by genotypic factors. Genetic factors control pericarp color, pericarp thickness, and secondary plant color (Dykes *et al.* 2009) [6]. The phenolic flavonoid pigments-anthocyanin and flavan-4-ols are located in the pericarp. These compounds are responsible for kernel color. The color of the sorghum grains varies from pale yellow through various shades of red and brown to deep purple and brown. Seed color ranges from shades of white to various shades of pink, orange, red and even brown, seed color occurs due to influences of pericarp thickness. Yellow pericarp color is not associated with yellow endosperm. Usually, red colored sorghum preferred in brewing industries. Whereas, flavanones which are loaded in yellow sorghum has somewhat higher total phenolic content than white sorghum. Due to existence of pigmented testa and high level of condensed tannins brown sorghum also known as tannin sorghum. Pericarp thickness, presence or absence of pigmented testa and endosperm color are some of the factors affecting sorghum kernel color (Shen *et al.* 2018 and Xiong *et al.* 2020) [15, 21].

The extent and nature of genetic variability, heritability, and genetic advance in the base population are the main factors that influence the improvement of sorghum quality and yield. For successful planning and executing of the breeding programme, knowledge regarding the genetic variability is very essential. For stabilizing the production of the crop growing under drought stress during post monsoon especially *rabi* sorghum, identification of the superior traits is essential. In order to increase the yield and drought tolerance among the genotypes identification of the essential traits, hybridization among these divergent sources and finally selection from the segregating generations is to be done. Among the various sorghum genotypes, variation due to drought tolerance was identified and some of the better adopted genotypes were also identified. The present study was undertaken with objective to estimate the genetic variability for the quantitative traits.

Material and Methods

The present investigation was undertaken to study genetic variability and character associated studies of twenty-seven genotypes of (*Sorghum bicolor* (L.) Moench) including three checks. Twenty-seven genotypes of colored pericarp sorghum including three checks were sown during *rabi* 2021-22 in Randomized Block Design with two replications. The experiment was conducted at research farm, Department of agricultural botany, VNMKV, Parbhani. All the recommended cultural practices and packages were applied for growing healthy and good crop, in each entry, five plants are randomly selected from each replication and following observations were recorded for seedling vigor, days to 50% flowering, days to physiological maturity, plant height, leaf area index, relative water content, SPAD chlorophyll meter reading, grain yield per plant and fodder yield per plant. The variability parameters were estimated as follows a range Panse and Sukhatme (1978) [11], co-efficient of variation was calculated by the formulae given by Burton (1952) [5], Heritability in broad sense and genetic advance were estimated by the following formula given by Johnson *et al.* (1955) [9] and Allard (1960) [1] respectively.

Results and Discussion

Current investigation was carried out to estimate several genetic parameters like estimation of variability *i.e.*, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, genetic advance (GA) and genetic advance as percentage of mean. Considerable genetic variability among 27 lines was observed for characters are presented in (Table 1) under study. Analysis of variance revealed significant differences. This indicated presence of considerable genetic variability between genotypes and there is ample scope for exploitation of all the above characters. These results are in agreement with Sanchez *et al*. who reported existence of significant differences among the treatments for the plant height and Amanullah *et al*. and Techale *et al*. who reported existence of significant differences among the treatments for the traits plant height and leaf area. Gebregergs *et al*. recorded significant differences for the traits; days to flowering, days to maturity, plant height, panicle length, total biomass, harvest index and grain yield. The result suggested that exploiting the wider genetic variability in the tested genotypes as source of breeding material for trait of interest improvement for different objectives could boost sorghum production and productivity. (Tariq *et al*. 2012) [18].

Genetic and Phenotypic coefficient of variation, Heritability and Genetic advance

The range of variation and the estimates of genetic parameters which include heritability in broad sense, genotypic and phenotypic coefficient of variation (GCV and PCV) and genetic advance are presented in (Table 2). Estimated variance components for the measured traits revealed that the PCV was higher in magnitude than the GCV, which implies that environmental effect influenced expression of the trait. The marked effect of environmental factors for the phenotype expression of genotypes was poor than the greater chance of improving these traits through selection depends on the output of phenotypes. However difference between them was not of high magnitude. High estimates of GCV and PCV were observed for seedling vigor (36.09, 46.32) followed by fodder yield per plant (30.82, 31.34), grain yield per plant (26.76, 29.55) and leaf area index (23.12, 23.35). The high values of GCV and PCV indicates that there was a chance of improvement of these traits through direct selection. While moderate to low estimates of GCV were observed for SPAD chlorophyll meter reading (14.40, 16.84), plant height (10.23, 10.43), relative water content (6.62, 7.05), days to 50% maturity (6.49, 7.65), days to physiological maturity (4.04, 4.64). These results were also supported by earlier workers Arunkumar *et al*. (2004) [2], Kusalkar *et al*. (2009) [10], Sonone *et al*. (2015) [16], Ranijth *et al*. (2016) [12], Rekha and Biradar *et al*. (2015) [13], Tafere mulaualem *et al*. (2018) [17].

Table 1: Anova

Source of Variation	df	Seedling Vigor	Days to 50% Flowering	Days to Physiological Maturity	Plant Height	Leaf Area Index	Relative Water Content	SPAD Chlorophyll Meter Reading	Fodder Yield per Plant	Grain Yield per Plant
Replication	1	0.07	26.74	32.67	85.63	0.00	0.11	1.13	100.86	2.76
Genotypes	26	1.09**	55.48**	60.91**	1093.91**	1.60**	60.61**	90.91**	1689.06**	291.55**
Error	26	0.27	9.05	8.36	20.66	0.02	3.77	14.10	27.94	28.82

Table 2: Genetic variability parameters for grain yield and its attributing traits in colored pericarp sorghum

Characters	Range		Grand Mean	Genotypic Variance	Phenotypic Variance	GCV	PCV	Heritability (bs)	Genetic Advance	Genetic Advance as Percent of Mean
	Minimum	Maximum								
Days to 50% Flowering	62	87	73.0	23.21	32.26	6.49	7.65	72.00	8.42	11.34
Days to Physiological Maturity	108	130	118.5	26.28	34.64	4.04	4.64	76.00	9.20	7.25
Plant Height	179.5	279	226.4	536.63	557.28	10.23	10.43	96.00	46.83	20.69
Leaf Area Index	2.8	6.5	3.9	0.79	0.81	23.12	23.35	98.00	1.82	47.15
Seedling Vigor	1	3	1.6	0.41	0.68	36.09	46.32	61.00	1.03	57.93
Relative Water Content	66.2	89.4	80.1	28.42	32.19	6.62	7.05	88.00	10.32	12.82
SPAD Chlorophyll Meter Reading	32.6	53.6	43.0	38.40	52.50	14.40	16.84	73.00	10.92	25.38
Fodder Yield per Plant	37.7	190.9	93.5	830.56	858.50	30.82	31.34	97.00	58.39	62.45
Grain Yield per Plant	20.9	68.6	42.8	131.37	160.18	26.76	29.55	82.00	21.38	49.92

The effectiveness of selection for any character depend not only the extent of genetic variability but also in the extent to which it will be transferred from one generation to the other generation. The genotypic and phenotypic coefficient of variation alone does not show the proportion of total heritable variation. The heritability and genetic advance as percent of mean estimates are better indicators in this respect. High value of heritability indicates that there is a favourable effect of environment and the traits were under genotypic control. For such characters selection could be easy and improvement is possible by using selective breeding methods for these traits. In the present study heritability ranged from 68 to 98%. High value of heritability in broad sense were observed for plant height, leaf area index, relative water content, fodder yield and grain yield.

Total heritable portion of variation cannot be indicated only by genotypic coefficient of variation. Effectiveness of the selection based on the phenotypic performance is indicated by the presence of high heritability but it does not indicate the genetic gain under selection. Thus it is necessary to estimate the genetic gain under selection *i.e.,* genetic advance. High heritability alone does not indicate the selection is effective; heritability estimates coupled with genetic advance are more useful in predicting the effectiveness of the selection. Selection is effective when there is high heritability coupled with high genetic advance as it indicates the presence of additive gene action whereas high heritability coupled with low genetic advance indicates presence of non-additive gene action thereby selection is ineffective. Genetic advance as per cent of mean ranges from 7.25 for days to physiological maturity to 62.45 for fodder yield. High heritability with high genetic advance indicates that most likely the heritability is due to additive gene effects and selection may be effective. The traits plant height, leaf area index, fodder yield and grain yield show high estimates of heritability accompanied with high genetic advance as percent of mean indicating additive gene action and thus selection for these traits in genetically diverse material would be effective for desired genetic improvement. Arunkumar *et al*. (2004) [3], Sonone *et al*. (2015) [16], Ranjith *et al*. (2015) [12], Rekha and Biradar *et al*. (2015) [13], supported the findings in the present investigation.

Conclusion
This research project revealed presence of large amount of scope for a breeder in selecting superior genotypes for yield improvement in *rabi* colored pericarp sorghum after studying character association as this study recorded presence of large amount of variation for various yield and yield contributing as well as drought stress conferring traits. Thus, the estimates of genetic parameters like PCV, GCV, heritability and genetic advance altogether it is evident that the traits *viz*., leaf area index, fodder yield and grain yield which show high value for PCV, GCV, heritability and genetic advance were considered most valuable and selection of these traits could be more effective for improving grain yield and tolerance against moisture stress in colored pericarp sorghum. Genotypes with these traits can be used for drought tolerance aspects and play a major role in breeding for abiotic stress tolerance *i.e*. for drought as well as advanced to next generation.

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