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Genetic variability studies for morpho-physiological traits in relation to drought tolerance in *rabi* sorghum (*Sorghum bicolor* L. Moench)

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Abstract
The studies pertaining to the genetic variability present in a crop species were useful for effective selection. Crop improvement through breeding studies mostly depends on the presence of desirable variation as well as the amount of that variation which is heritable. Therefore the primary requirement for initiating any breeding program for crop improvement is the knowledge pertaining to genetic variability, heritability and genetic advance. The genetic variability study carried out for yield and yield contributing traits in thirty seven genotypes of *rabi* sorghum with three checks namely M 35-1, Phule Suchitra and CSV-22-R at Sorghum Research Station, V.N.M.K.V., Parbhani during *rabi* 2019. The objective of this investigation is to estimate the genetic variability for the quantitative traits. A randomized block design was used with three replications and these treatments were evaluated and data pertaining to eight traits was recorded. This investigation revealed presence of highly significant differences among the genotypes indicating presence of large amount of variability in all the eight characters studied. Current study indicated presence of higher estimates of phenotypic coefficient of variation (PCV) for all the traits when compared to genotypic coefficient of variation (GCV) and these estimates are of lower magnitude. Among the forty genotypes studied VJV 107, VJV 106, PEC 30, RSV 1921, RSV 1945 and RSV 1984 recorded better performance and these are considered as the superior genotypes. Higher estimates of GCV and PCV recorded for the traits like third leaf area, flag leaf area, SPAD chlorophyll meter reading at 50 percent flowering, SPAD chlorophyll meter reading at physiological maturity, relative water content whereas high heritability coupled with moderate to high genetic advance is observed for traits like third leaf area, flag leaf area, SPAD chlorophyll meter reading at 50 percent flowering, SPAD chlorophyll meter reading at physiological maturity, relative water content.

Keywords: Genetic variability, heritability, PCV, GCV, genetic advance

Introduction
Sorghum (*Sorghum bicolor* L. Moench) is one of the important cereal crop in the world occupying fifth position after maize, rice, wheat and barley [1]. Sorghum is the staple food in the human diet especially for poor and most food insecure people living in semi-arid tropics [2]. 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) [3]. Rabi sorghum occupies large area mainly in the states of Maharashtra, Karnataka and Andhra Pradesh with an average productivity of 819 kg/ha (Low). Rabi sorghum area is consistent over many years and it is an important component of dry land economy irrespective of its low productivity. The reasons for low productivity include biotic and abiotic stresses [4]. The major abiotic stress limiting crop growth is Drought. As the climate is changing frequently, water availability to the crop is becoming very essential to meet the production needs *Sorghum bicolor* is one of C4 cereal which is highly suited for the drought environment mainly due to its morphological and anatomical characteristics such as thick leaf wax, deep root system and physiological responses such as osmotic adjustment, stay green, quiescence [5]. C4 photosynthetic pathway in sorghum allows it to grow in high temperature, high light intensity and low water availability and it is highly efficient in fixing carbon dioxide [6]. Sorghum as a staple food in the world, improving the crop is a key to ensure food security to the increasing population [7]. Even though sorghum is considered as drought tolerant crop, growth and yield reduction occurs due to water stress. Identification of the traits (especially morphological and physiological) related to drought stress given higher importance in drought related studies [8]. At both pre and post flowering stages sorghum is effected by water stress.

Due to post flowering drought *rabi* sorghum is highly effected and it shows highly variable and low productivity. Even though it is one of the highly valued crop due to its good grain quality [9]. For reducing the risk due to post flowering drought superior genotypes are required. This in turn requires the identification of traits (cost effective and easily measurable) related to terminal drought tolerance [10]. Among the various sorghum genotypes, variation to drought tolerance is identified and some of the better adopted genotypes are also identified [8]. For stabilizing the production of the crop growing under drought stress during post monsoon especially *rabi* sorghum, identification of the superior traits is essential. For successful planning and executing of the breeding programme, knowledge regarding the genetic variability is very 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 [11]. The present study was undertaken with objective to estimate the genetic variability for the quantitative traits.

Materials and Methods

Experimental material for the proposed work consists of 37 drought tolerant sorghum genotypes received from IIMR, Hyderabad along with three checks namely, M-35-1, CSV 22R and Phule Suchitra. These genotypes were evaluated using randomized block design with three replications during *rabi* 2019. The data pertaining to leaf area (cm2/plant), leaf area index (%), flag leaf area (cm2), relative water content (%) at boot stage, SPAD chlorophyll meter reading at 50% flowering and at physiological maturity, stay green score (1- 9 scale) at 50% flowering and physiological maturity were recorded and used for analysis of variance [12]. Further statistical analysis was carried out using mean values (Table 2) for all the eleven traits under consideration.

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 percent of mean. Combined ANOVA of the current investigation is furnished under the following Table 1, for the forty genotypes. The data shown presence of highly significant differences among the genotypes indicating presence of large amount of variability in all the eleven characters studied. These results are in agreement with Amanullah *et al.* (2007) [14], Pawar (2007) [26] who reported existence of significant differences among the treatments for the traits leaf area and relative water content respectively, Rajarajan *et al.* (2016) [27] for the traits relative water content and SPAD chlorophyll meter reading.

In the current investigation wide range of variability exhibited by various traits related to drought tolerance like third leaf area (198.2 to 341.3), flag leaf area (135.7 to 268.1), relative water content at boot stage (54.9 to 92.3), SPAD chlorophyll meter reading at 50% flowering (34.3 to 60.23) and SPAD chlorophyll meter reading at physiological maturity (32.6 to 58.5), stay green score at physiological maturity (3 to 7), leaf area index (2.54 to 6.85) and stay green score at 50% flowering (1 to 2.67). These results are in agreement with Ali *et al.* (2009b) [13] who reported existence of wide range of variability for relative water content and others.

Genotypic and phenotypic variance

Current investigation exhibited slightly higher phenotypic variance when compared to genotypic variance and these differences are of lower magnitude. These results were presented in the table 3. Higher values of genotypic and phenotypic variances recorded for the traits like third leaf area, flag leaf area, SPAD chlorophyll meter reading at 50 percent flowering, SPAD chlorophyll meter reading at physiological maturity and relative water content. Similar results reported by Ali *et al.* (2009a) [13] for the trait flag leaf area, Rajarajan *et al.* (2016) [27] for the traits relative water content and SPAD chlorophyll meter reading and Singh *et al.* (2019) [30] for leaf area.

Genotypic and phenotypic coefficient of variation

Current study indicated presence of higher estimates of phenotypic coefficient of variation for all the traits when compared to genotypic coefficient of variation and these estimates are of lower magnitude. These results were presented in the table 3. Moderate to higher estimates of phenotypic and genotypic coefficient of variation observed for traits third leaf area, flag leaf area, leaf area index, relative water content. Similar results recorded by Veerabadhiran and Kennedy (2001) [34], Date (2002) [19], Kumar and Sahib (2003) [24], Arunkumar *et al.* (2004) [17], Ali *et al.* (2009b) [13], Kusalkar *et al.* (2009) [25], Arunkumar (2013) [16], Chittapur and Biradar (2015) [18], Tesfamichael *et al.* (2015) [33], Dhutmal *et al.* (2015a) [20], Khandelwal *et al.* (2015) [23], El-salam & Hovny (2018) [21], Singh *et al.* (2019) [30], Gebregergs and Mekbib (2020) [22].

Heritability and genetic advance

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.

In current investigation heritability varied from 22.84 to 98.68 and genetic advance varied from 0.22 to 86.2. High heritability coupled with moderate to high genetic advance is observed for traits like third leaf area, flag leaf area, SPAD chlorophyll meter reading at 50 percent flowering, SPAD chlorophyll meter reading at physiological maturity, relative water content which indicates presence of additive gene action and selection for these traits is effective. These results are in agreement with Ambekar *et al.* (2000) [15], Date (2002) [19], Kumar and Sahib (2003) [24], Tariq *et al.* (2012) [31] and Chittapur and Biradar (2015) [18], El-salam & Hovny (2018) [21], Singh *et al.* (2019) [30], Gebregergs and Mekbib (2020) [22].

High heritability coupled with low genetic advance is observed for trait leaf area index which indicates presence of non-additive gene action and selection for this trait is ineffective. These results are in agreement with Dhutmal *et al*. (2015a) [20]. Finally, it is evident that in *rabi* sorghum for the improvement of grain yield all the estimates of genetic parameters i.e., genotypic coefficient of variation, phenotypic coefficient of variation, heritability and genetic advance should have higher values.

Table 1: Analysis of variance for eight characters of *rabi* sorghum

Sr. No.	Sources of variation	Degrees of freedom	Third leaf area (cm2/ plant)	Flag leaf area (cm2)	Leaf area index (%)	SCMR at 50% flowering	SCMR at Physiological maturity	Relative water content (%) at boot stage	Stay green score at 50 percent flowering	Stay green score at physiological maturity
1.	Replication	2	2.541	0.686	0.168	0.595	3.004	3.019	0.475	0.7
2.	Treatment	39	5486.066**	1609.01**	2.868**	90.403**	58.418**	220.578**	0.376**	3.28**
3.	Error	78	14.828	2.622	0.031	18.316	5.638	4.233	0.261	0.238

**Significant at 1 percent level.

Table 2: The mean performances of eight characters studied in *rabi* sorghum

Sr. No.	Genotypes	Third leaf area (cm2/plant)	Flag leaf area (cm2)	Leaf area Index (%)	SCMR at 50% flowering	SCMR at Physiological maturity	Relative water content (%) at boot stage	Stay green score at 50 percent flowering	Stay green score at physiological maturity
1	RSV 1837	278.11	195.32	3.43	46.27	44.47	68.51	1.67	4
2	RSV 1921	261.59	182.18	3.46	39.27	57.93	84	1.67	4
3	RSV 1945	290.9	190.29	3.69	50.14	34.9	69.71	1.33	5.67
4	RSV 1984	238.7	140.38	3.6	39.3	47	71.06	1.33	4.33
5	RSV 1988	288.88	189.14	3.6	53.97	53.2	75.93	1.33	6
6	RSV 2124	290.63	195.32	3.18	52.6	55	92.31	1.33	6.33
7	RSV 2197	288.41	183.73	3.55	44	38.03	70.33	1.67	6.33
8	RSV 2209	305.33	217.54	3.63	55.9	54.33	70.8	1.67	6.67
9	RSV 2234	198.2	135.67	5.83	42.43	52.9	74.27	1.67	5
10	RSV 2252	261.64	179.28	3.27	47.67	42.47	72.68	1.67	4.33
11	VJV 106	317.25	239.71	4.64	57.33	56	68.57	1	5.33
12	VJV 107	321.56	242.63	4.76	56	61.5	69.82	1	5.33
13	VJV 108	275.54	242.94	2.81	49.57	42.5	80.59	1.33	4.67
14	VJV 109	336.56	187	6.85	38.7	34.83	62.18	1	5.67
15	VJV 110	278.17	191.06	3.36	47.73	46.9	71.92	1.33	4.33
16	VJV 111	236.4	183.82	3.23	42.67	39.53	69.52	2.67	4.67
17	VJV 112	281.76	235.74	3.1	48.82	47.93	69.97	1	5.67
18	VJV 113	244.92	183.12	3.78	45.72	45	60.76	1.67	7
19	VJV 114	255.16	189.66	3.11	47.33	48.03	59.52	1.33	5.67
20	VJV 115	270.52	147.81	3.76	44.73	43.27	58.9	1.33	4.67
21	CRS 69	240.57	268.13	3.35	36.9	44.3	69.7	2	4.67
22	CRS 70	241.98	164.47	3.36	41	47.67	72	1	4.33
23	CRS 71	281.12	204.5	3.64	47.87	45.8	63.63	1	4.67
24	CRS 72	244.78	205.46	3.89	51.8	37.4	68.86	1.33	4.67
25	CRS 73	242.2	207.51	3.15	44.7	32.6	62.52	1	6
26	CRS 74	266.79	156.65	3.51	45.33	43.5	70.45	1	4.67
27	EP 85	296.68	162.63	3.71	54.67	49.53	69.6	1.33	4.33
28	EP 89	338.82	199.08	3.55	48.9	43.4	75.48	1.33	3.67
29	EP 94	209.52	151.31	2.73	49.9	47.83	71.01	1.33	4.67
30	EP 98	243.9	175.72	2.54	45.6	40.6	82	1.67	4.33
31	PEC 15	268.48	141.16	3.31	43.27	58.93	76.44	1	4.33
32	PEC 23	247.65	243.48	2.9	39.67	41.67	54.9	2	5
33	PEC 30	341.25	178.1	3.04	46.37	46.17	74.9	2	4.67
34	PVRL16-2	283.06	135.66	3.96	34.3	55.33	73.26	2	4.67
35	PVR 16-3	247.77	231.3	2.91	59.63	42.33	70.95	1.67	5.33
36	PVR 947	266.99	245.18	2.93	57.77	47.67	61.2	1.33	5.67
37	PVR 950	274.51	180.49	3.47	60.23	49.33	76.65	1.67	6.67
38	M 35-1 (C)	242.4	160.47	3.04	52.63	44	65.38	1.67	5.33
39	CSV 22R (C)	321.05	233.96	3.68	54.47	56.67	61.7	1.33	4.33
40	Phule Suchitra (C)	261.83	171.31	2.77	58.13	50.1	74.1	2	3
	Mean	268.76	195.62	3.33	47.68	46.98	70.15	1.5	4.73
	SE	1.72	1.88	0.1	2.47	1.97	2.18	0.3	0.28
	CD at 5%	4.83	5.3	0.29	6.96	5.55	6.13	0.83	0.79

Table 3: Genetic variability parameters for eight characters studied in *rabi* sorghum

Sr. No.	Characters	Range		Mean	σ2(g)(Genotypic variance)	σ2(p)(Phenotypic variance)	GCV (%)	PCV (%)	h2 b.s. (%)	GA	GA as % of mean
		Minimum	Maximum								
1	Third leaf area (cm2/ plant)	198.2	341.3	269	2089.86	2094.68	16.54	16.89	88.89	86.2	38.98
2	Flag leaf area (cm2)	135.7	268.1	195.4	1101.94	1116.73	16.99	17.11	98.68	67.9	34.77
3	Leaf area index (%)	2.54	6.85	3.33	0.22	0.29	13.99	16.17	86.28	0.83	34.94
4	SCMR at 50% flowering	34.3	60.23	47.6	24.03	30.13	10.28	11.51	79.84	9.02	18.91
5	SCMR at Physiological maturity	32.6	58.5	46.94	17.54	20.89	9.12	12.12	80.36	10.4	22.19
6	Relative water content (%) at boot stage	54.9	92.3	70.14	35.45	40.19	8.49	9.04	88.24	16.5	26.42
7	Stay green score at 50 percent flowering	1	2.67	1.5	0.04	0.13	13.04	16.6	30.51	0.22	14
8	Stay green score at physiological maturity	3	7	4.74	0.07	0.41	6.12	10.89	22.84	0.32	5.28

Conclusion

This research project revealed presence of large amount of scope for a breeder in selecting superior genotypes for yield improvement in rabi sorghum after studying character association as this study recorded presence of large amount of variation for various traits related to drought tolerance. Generally, the traits which exhibit higher values for genotypic coefficient of variation, phenotypic coefficient of variation, high heritability coupled with high amount of genetic advance and significant and positive correlation with aspects related to yield and drought tolerance are used for identification of superior genotypes for drought tolerance. Among all the genotypes and checks VJV 107, VJV 106, PEC 30, RSV 1921, RSV 1945 and RSV 1984 recorded better performance when compared to all the checks and genotypes hence among the forty genotypes these are considered as the superior genotypes for traits related to yield as well as drought tolerance aspects. There by these genotypes can be used for drought tolerance aspects and play a major role in breeding for abiotic stress tolerance i.e. for drought and these genotypes can be advanced to next generation.

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