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Research Article

Genetic variability studies involving maintainers on *maldandi* and *milo* source of male sterility in *rabi* sorghum [*Sorghum bicolor* (L.) Moench]

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Abstract
An experiment was conducted to know the variability among 22 maintainers on *maldandi* and *milo* source of male sterility in *rabi* sorghum along with four checks M 35-1, BJV-44, DJ6514 and PKV Kranti. The study revealed considerable amount of variability for all the characters studied. The genotypic and phenotypic coefficients of variation observed to be the highest for grain yield per-plant, the number of seeds per panicle and panicle weight. All the characters showed an arrow difference between PCV and GCV, indicating that the observed variability has been primarily due to genotypic differences with the least influence of environment. High heritability coupled with high genetic advance over mean was noticed for all the characters studied there by indicating that the selection would be effective in improvement of these characters as they are controlled by the additive genes. Based on mean performance the genotypes IS 14010 and IS 19445 were found significantly superior over the checks M35-1 and DJ6514.

Keywords
Sorghum, variability, heritability, genetic advance, GCV and PCV.

INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench] is one of the important cereal crop cultivated globally for food, fodder, feed and fuel. It ranks fifth after wheat, rice, maize and barley in area and production. It is the second cheapest source of energy and micronutrient after pearl millet. It is mainly grown in semi-arid tropics of Asia, Africa, America and Australia, In Africa and Asia sorghum grain is mainly used as food, while in the United States and Australia it is used to feed cattle (Reddy *et al*., 2013). Globally, sorghum is grown in an area of 42.50 million hectares to produce 59.91 million tonnes, with the productivity of around 1.60 tonnes per hectare. India produces about 4.56 million tonnes of sorghum grain from 1.96 million hectares in *Kharif* and 2.60 million hectares in *rabi*. The productivity of *kharif* sorghum is high 954 kg/ha compared to *rabi* 730 kg/ha (Anonymous, 2019). *Rabi* sorghum is extensively grown in Deccan Plateau, in the states of Maharashtra, Karnataka and Andhra Pradesh. *Rabi* sorghum has high value because of its good grain quality, large grain size and grain lustre

Variability is pre-requisite for any breeding programme aimed at improving the yield and related characters. Crop improvement depends upon the magnitude of genetic variability and the extent to which desirable characters are heritable. Genetic variability for yield and yield components is essential in the base population for successful crop improvement (Allard, 1960). Progress in any crop improvement venture depends mainly on the magnitude of genetic variability and heritability present in the source material. The extent of variability is measured by GCV and PCV, which provides information about the relative amount of variation in different characters..

Yield and yield components are quantitative characters and are polygenic in inheritance, which is greatly influenced by the environment. The phenotype of a character is the result of interaction between genotype and environment since heritability is also influenced by the environment, the information on heritability alone may not help the selection of characters. The heritability estimates along

with the predicted genetic advance will be more reliable (Johnson *et al.,* 1955).

MATERIAL AND METHODS

The experimental material consisted of 22 newly identified maintainerson *maldandi* and*milo* source of male sterility in *rabi* sorghum. These 22 genotypeswere evaluated for various yield component traits during *rabi* 2018-19 at Botany Garden, Department of Genetics and Plant Breeding, UAS, Dharwad along with four checks M35-1, BJV 44, DJ 6514 and PKV Kranti (Table.1). All there commended agronomic practices were followed to raise a good crop. The experiment was laid out in RCBD with three replications with a row length of 3 m and a spacing of 45 x 15cm. The observations were recorded on five randomly selected competitive plants for characters *viz.,* days to 50 per cent flowering, days to physiological maturity, plant height(cm), the number of leaves per plant, panicle length(cm), panicle width(cm),100seed weight(g), panicle weight(g),primaries panicle^{-1}and grain yield plant^{-1} (g). The data were subjected to the analysis of phenotypic and genotypic coefficient of variation as per the method suggested by Burton(1953) and heritability and genetic advance following the method of Johnson *et al.*(1955).

RESULT AND DISCUSSION

The analysis of variance for grain yield and its components (Table2) revealed significant differences among the genotypes for all the quantitative traits indicating the existence of considerable magnitude of genetic variability. Further, the genotypic coefficient of variation (Table3) observed to be the highest for the number of seeds per panicle (39.59), Panicle weight (37.88) and grain yield per plant (42.31)followed by hundred seed weight (24.80), the number of primaries per panicle (21.89) and panicle length (20.39). Higher estimates of these coefficients indicated the existence of wider variability for these characters. The magnitudes of PCV were higher than GCV for all the characters studied and a narrow difference between phenotypic coefficient of variation(PCV) and genotypic coefficient of variation(GCV), indicating that the observed variability has been primarily due to genotypic differences with the least influence of environment in the expression of these traits. Similar type of results were obtained by Chavan *et al.* (2010) and Khandelwal *et al.* (2015). Characters like days to 50 per cent flowering and days to maturity showed relatively lower values of PCV and GCV indicating the existence of least variation

Table1. Salient features of the checks used.

Sl. No.	Checks	Pedigree/Origin	Salient features
1	M 35-1	Selection from Maldandi landraces (ARS, Mohol, Maharashtra)	Popular rabi sorghum variety, excellent grain and fodder quality (bold and lustrous), drought tolerance, moderately tolerant to charcoal rot and shoot fly tolerance.
2	BJV 44	(CSV 216R × DSV 5) × CSV 216R (Developed by Vijayapura centre).	High yielding (grain and fodder), tall, bold round lustrous grain, semi compact head, suitable to deep soil.
3	DJ6514	Released variety from Dharwad centre	High yielding (grain and fodder), dwarf. susceptible line for shoot fly and Stem borer
4	PKV Kranti	SPV-1201 x Ringni (Akola)	High yielding (grain and fodder), tall, bold round lustrous grain, Suitable for medium to deep soils and irrigated. Pearly white round & very bold grain, tolerant to shoot fly.

in the material under study and there by less scope for improvement of these traits through selection. However, the coefficient of variation indicated only the extent of variability existed for different characters and did not indicate heritable portion of a character.

Grain yield per plant is positive and significantly correlated with days to 50 per cent flowering. The mean value of 74.78 days were recorded for flowering among the maintainers with a range of 59.33 to 89.00 days. The genotype IS 12833 (59.33 days) was earliest to reach 50 per cent flowering followed by IS 23521 (63.33 days) and IS24218 (66 days). Whereas, the genotype IS 30092 was late to flowering.The genotypic and phenotypic coefficient of variability recorded for this trait were 8.33 and 9.64 respectively. High heritability of 74.60 per cent coupled with moderate genetic advance of 14.82 over mean was recorded for days to 50 percentflowering.

The mean number of days to physiological maturity was 131.66 days with a range of 101.33 to 128.66 days. The genotype IS 12833 was earliest to physiological maturity at 101.33 days, while the genotype IS 30092 matured very late at 131.66 days.The genotypic and phenotypic coefficient of variability was relatively low at 4.95 and 6.48, respectively. The heritability estimates of 58.40 per cent with an expected genetic advance of 7.80 per cent over the mean were observed for days to physiological maturity.

Plant height varied significantly among the maintainers. The mean value of 249.21 cm was recorded for plant height with a range of 188.96 cm to 295.00 cm. The lines *viz.,* IS 10969 (295.00 cm), IS 13893 (292.26 cm) and IS 14010 (286.66 cm) were found to be taller. In contrast, the genotypes *viz.,* IS 20195 (188.96 cm) and IS 12833(192.36 cm) were found to be relatively shorter.

Table 2. Analysis of variance for yield and its components among twenty two maintainers of *rabi* sorghum

Source of variation	df	Days to 50 per cent flowering	Days to maturity	Plant height (cm)	Number of leaves plant $^{-1}$	Panicle length (cm)	Panicle width (cm)	Primaries panicle^{-1}	Panicle weight (g)	Number of seeds panicle^{-1}	Grain yield plant^{-1} (g)	100 seed weight (g)
Replicates	2	10.16	7.08	76.77	10.73	3.70	0.45	2.93	21.15	26985.90	15.67	0.00016
Treatments	25	129.70**	129.22**	2628.09**	5.66**	68.78**	5.92**	279.14**	1254.14**	1801979.75**	583.26**	1.99**
Error	50	13.24	24.78	31.57	0.51	1.52	0.17	2.24	18.32	40378.19	9.94	0.081

** - Significant at and 1 % level of probability

Table 3. Estimation of genetic variability parameters for yield and yield attributing traits in *rabi* sorghum

Traits	Days to 50percent flowering	Days to maturity	Plant height (cm)	Number of leaves	Panicle length (cm)	Panicle width (cm)	Primaries Panicle^{-1}	Panicle weight (g)	Number of seeds panicle^{-1}	Grain yield plant^{-1} (g)	100 seed weight (g)
PCV	9.64	6.48	12.01	15.86	21.08	19.28	22.16	38.72	40.93	43.41	26.34
GCV	8.33	4.95	11.80	13.90	20.39	18.46	21.89	37.88	39.59	42.32	24.80
h^2 (bs)%	74.60	58.40	96.50	76.80	93.60	91.70	97.60	95.70	93.60	95.10	88.70
GA	11.08	9.29	59.52	2.36	9.43	2.73	19.55	40.91	1526.93	27.76	1.55
GAM at 5 %	14.82	7.80	23.88	25.11	40.65	36.42	44.57	76.37	78.89	85.01	48.11
Mean	74.78	119.02	249.21	9.42	23.21	7.49	43.87	53.56	1935.43	32.66	3.22
Maximum Value	89.00	131.66	295.00	11.33	31.76	10.13	64.00	107.83	3446.33	81.06	4.76
Minimum Value	59.33	101.33	188.96	6.00	13.16	4.83	24.66	30.50	354.33	21.33	1.97

GCV : Genotypic Coefficient of Variation
PCV: Phenotypic Coefficient of Variation
h^2(bs) %: Broad Sense Heritability
GA : Genetic Advance
GAM : Genetic Advance over Mean

The genotypic and phenotypic coefficient of variability were 11.80 and 12.01respectively for plant height. The heritability estimate was high with 96.50 per cent coupled with a higher genetic advance of 23.88 per cent over mean

The mean value of 9.42 was recorded for the number of leaves per plant. The line IS 28833 (6) had minimum number of leaves followed by IS 20195 (7.33) and check DJ6514 (7.66). Whereas, the line IS 20195 (11.33) and check PKV Kranti (11.33) had a maximum number of leaves followed by IS 2413 (11), IS 3009 (11) and check BJV 44(11). Moderate genotypic and phenotypic coefficients of variation of 13.90 and 15.86 respectively were recorded for the number of leaves per plant. A high heritability value of 76.80 per cent with high genetic advance 25.11 per cent over mean was recorded.

The trait panicle width found varying from 4.83 cm to 10.13 cm among the maintainers with the mean of 7.49 cm. The check DJ 6514 recorded lowest the panicle width of 4.83 cm whereas, the genotype IS 10969 (10.13 cm) had border panicle width.The moderate phenotypic (19.26) and genotypic (18.46) coefficients of variation was observed for this trait. High heritability (91.70) per cent coupled with a high genetic advance (36.42) exhibited by this trait.

It was observed that the genotypes differed significantly for this trait. Panicle length ranged between 13.16 cm to 31.76 cm with a mean of 23.21 cm. The minimum panicle length was recorded by IS 11026 (13.16), whereas the highest length was exhibited by IS 13893 (31.76 cm) and IS 30092 (31.46 cm). The genotypic and phenotypic coefficient of variability for this trait were 20.39and 21.08, respectively. A higher heritability of 90.30 per cent was observed with a higher genetic advance of 40.65 over the mean.

Number of primaries per panicle found varied from 24.66 to 64.00 across the genotypes with a grand mean of 43.87. The genotype IS 3971 (24.66) recorded the lowest number followed by IS 9745 (31.00). In contrast the checks PKV Kranti (64.00) and BJV 44 (62.00) recorded maximum number of primaries per panicle.The phenotypic and genotypic coefficients of variations observed for this traitwas 22.16 and 21.89 respectively. High heritability of 91.70 per cent coupled with highgenetic advance of 44.57 per cent over the mean were recorded.

Table 4. Mean values of yield and its components among maintainers used for variability study

Sl. No.	Genotypes	Days to 50 per cent Flowering	Days to maturity	Plant height (cm)	Number of leaves	Panicle length (cm)	Panicle width (cm)	Primaries Panicle^{-1}	Panicle weight (g)	Number of seeds panicle^{-1}	Grain yield plant^{-1} (g)	100 seed weight (g)
1	IS 3971	66.66	114.00	255.33	10.00	29.23	6.50	24.66	31.00	837.33	22.80	2.32
2	IS 9745	76.00	127.66	223.33	9.00	29.30	8.50	31.00	41.66	389.33	25.53	4.69
3	IS 10969	73.00	119.00	295.00	11.33	26.10	10.13	46.33	56.13	2175.00	33.80	2.89
4	IS 11026	74.00	119.33	239.50	9.66	13.16	6.66	53.66	51.73	1727.66	23.93	4.76
5	IS 12833	59.33	101.33	192.36	6.00	23.26	6.36	43.00	47.66	2344.66	34.46	2.81
6	IS 13893	79.00	120.33	292.26	10.66	31.76	9.76	37.66	38.46	1516.33	24.06	3.15
7	IS 14010	74.00	120.66	286.66	10.33	27.83	6.76	35.33	53.56	2553.33	43.40	3.86
8	IS 14290	80.00	121.00	267.66	10.66	20.52	8.66	37.66	47.66	1041.00	24.26	2.98
9	IS 15744	71.00	115.66	250.33	10.00	17.42	8.06	47.33	35.00	1660.66	22.80	4.62
10	IS 17980	75.33	119.33	253.50	9.33	25.23	6.70	41.66	31.16	1352.00	22.93	2.01
11	IS 18039	75.66	117.66	236.66	8.00	23.50	7.00	35.66	37.33	1642.33	23.60	2.83
12	IS 19445	74.66	117.33	235.00	9.33	22.60	7.46	53.33	81.00	2873.00	45.33	4.42
13	IS 20195	76.00	121.00	188.96	7.33	17.66	6.16	48.33	30.50	1458.66	24.20	3.77
14	IS 20632	80.33	124.66	207.83	8.00	20.73	6.90	45.33	62.23	2006.66	34.40	4.70
15	IS 23521	63.33	107.66	261.66	9.00	25.12	6.60	33.00	38.83	1889.33	21.33	3.10
16	IS 24139	79.00	120.66	263.66	11.00	17.03	7.60	54.33	75.56	2858.33	39.53	1.97
17	IS 24218	66.00	110.33	252.33	8.33	21.96	5.90	47.66	41.61	1898.33	21.40	3.20
18	IS 25732	70.00	114.00	227.00	8.00	20.66	7.36	39.33	34.63	1860.33	23.40	3.45
19	IS 25910	86.00	128.66	273.00	10.00	21.96	9.23	35.00	44.83	2101.00	31.63	2.00
20	IS 28389	79.00	121.00	235.00	9.00	28.46	6.50	35.33	45.66	1890.66	24.06	3.00
21	IS 29187	68.33	112.33	256.00	9.00	24.73	7.93	37.00	52.30	354.33	21.93	2.80
22	IS 30092	89.00	131.66	251.00	11.00	31.46	6.50	53.00	78.10	1861.00	36.33	3.26
23	M 35-1	76.66	122.33	272.33	10.00	16.48	6.90	50.33	80.33	2985.66	45.90	2.93
25	DJ 6514	76.66	119.33	201.86	7.66	20.17	4.83	48.66	56.86	2874.33	37.33	2.05
24	BJV 44	74.66	121.33	278.00	11.00	21.16	9.93	62.00	91.06	2665.66	59.70	3.59
26	PKV Kranti	80.33	126.33	283.33	11.33	22.20	9.96	64.00	107.83	3446.33	81.06	3.51
27	**Grand Mean**	74.69	118.83	249.20	9.39	23.20	7.50	43.87	52.93	1928.73	32.93	3.33
28	**CD @5 %**	6.63	11.47	21.81	1.97	4.34	1.30	5.64	6.22	216.51	4.74	0.69

It was noticed that the panicle weight differed significantly among the genotypes from 30.50 g to 107.83 g with a mean value of 53.56 g. The genotypes *viz.,* IS 20195(30.50 g), IS 3971 (31.00 g) and 17980 (31.16 g) recorded minimum panicle weight. Whereas, the checks PKV Kranti (107.83 g) and BJV 44 (91.06 g) accounted for maximum panicle weight. High phenotypic and genotypic coefficients of variation of 38.72 and 37.88 respectively were noticed for panicle weight. High heritability of 95.70 per cent coupled with higher genetic advance of 76.37 over mean was recorded.

The trait grain yield per plant found varying significantly from 21.33 g to 81.06g across the maintainers with a grand mean of 32.66 g. The genotypes *viz*., IS 23521(21.33 g), IS 24218 (21.40 g) and IS 29187 (21.93 g) exhibited a lower grain yield per plant. In contrast the check PKV Kranti (81.06 g) followed by BJV 44 (59.70 g) recorded the highest grain yield per plant. Higher phenotypic and genotypic coefficients of variation of 43.41 and 42.32, respectively were recorded for this trait. A higher heritability of 95.10 per cent with relatively higher genetic advance of 85.01 over mean was recorded.

High level of variation was observed for the trait number of seeds per panicle with a mean of 1935.43. Number of seeds per panicle among the maintainers ranged from 354.33 to 3446.33. Fewer number of seeds per panicle were observed in the genotypes IS 29187 (354.33) followed by IS 9745 (389.43). In contrast maximum number of seeds per panicle were observed in checks *viz.,* PKV Kranti (3446.33) and M35-1 (2985.66).The phenotypic and genotypic coefficient of variability for this trait was relatively high at 43.41 and 42.32 per cent, respectively. High heritability of 93.60 percent coupled with higher genetic advance of 78.89 over mean was recorded.

Hundred seed weight significantly varied among maintainers ranging from 1.97g to 4.76 g with a grand mean of 3.22 g. The genotypes IS 24139 (1.97 g) and IS 17980(2.01 g) recorded relatively the lowest weight.

While, the genotypes *viz.,* IS 11026 (4.76 g),IS 20632 (4.70 g) and IS 19445 (4.42 g) recorded a maximum for 100 seed weight.The phenotypic and genotypic coefficient of variability were high at 26.34 and24.80 per cent, respectively. The heritability estimated was high with 88.70 per cent coupled with a higher genetic advance of 48.11 over mean was recorded.

The heritability estimates indicate the effectiveness of the character in phenotypic selection. As suggested by Johnson *et al.* (1955), heritability and genetic advance as per cent of mean together were more useful for predicting the resultant effect of selected genotypes than heritability alone. In the present study, high heritability (>75 per cent) coupled with a high genetic advance over mean (GAM) was noticed for all the characters except days to 50% flowering (74.60) and days to maturity (58.40)indicating that the selection made for the improvement of these characters would be effective as they are more likely to be controlled by additive gene actions. High heritability estimates observed in the present investigation are in accordance with the findings of Yaqoob *et al.* (2015), Yohannes *et al.* (2015) and Shamini (2018) for seed yield per plant in sorghum. High estimates of broad sense heritability and low genetic advance is due to the presence of non-additive genetic effects and high genotype and environment(G×E) interactions. Therefore, the simple selection may not be effective in improvement of these characters. Under such circumstances, it is desirable to adopt a limited selective inter mating followed by the selection, to exploit non additive portion of genetic variance. It can be concluded that variability parameters like GCV, PCV and heritability recorded high for majority of yield and yield attributing traits. So there is a more scope for improvement of these traits through simple selection. The genotypes IS 14010 and IS 19445 were found significantly superior over checks DJ 6514 and M35-1with bold seeds and can be used as material for future breeding programs.Days to 50 per cent flowering, plant height and seed weight per plant is positive and highly significant association with grain yield per plant (Ranjith *et al.* 2017). So, for the development of high yielding varieties in sorghum, days to 50 per cent flowering, plant height and seed weight should be considered during selection.

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