www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(11): 1072-1076

www.thepharmajournal.com
Received: 17-08-2023
Accepted: 30-10-2023

Lokesh Kumar Verma
Department of Genetics and Plant Breeding, UAS, Dharwad, Karnataka, India

BD Biradar
Department of Genetics and Plant Breeding, UAS, Dharwad, Karnataka, India

Ayyanna
Department of Genetics and Plant Breeding, UAS, Dharwad, Karnataka, India

P Kariyannanavar
Department of Genetics and Plant Breeding, UAS, Dharwad, Karnataka, India

Rakshith P
Department of Genetics and Plant Breeding, University of Agricultural Sciences, Raichur, Karnataka, India

Anusha
Ph.D. Scholar, Indian Institute of Horticulture Sciences, Bangalore, Karnataka, India

RS Prajwal
Department of Genetics and Plant Breeding, UAS, Dharwad, Karnataka, India

Corresponding Author:
P Kariyannanavar
Department of Genetics and Plant Breeding, UAS, Dharwad, Karnataka, India

Estimation of genetic parameters for grain yield and grain related traits in *rabi* sorghum [*Sorghum bicolor* (L.) Moench]

Lokesh Kumar Verma, BD Biradar, Ayyanna, P Kariyannanavar, Rakshith P, Anusha and RS Prajwal

Abstract
Generation mean analysis is the potent tool to provide information about different types of gene actions, interactions and genetic parameters. To determine the genetic parameters of grain yield and grain related quantitative traits, six generations of the four cross combinations *viz*., BJV44 × DSMR8, BJV44 × DSMR4, PKV Kranti × DSMR8 and PKV Kranti × DSMR4 were studied employing generation mean analysis during *rabi* of 2020. The estimates of heritability in the broad sense indicate a high portion of the phenotypic variation and is due to genetic variation for all the traits except for grain width in BJV44 × DSMR8 as here the broad sense heritability was between moderate to high. The extent of narrow sense heritability demonstrates that, except 100 grain volume, additive effects govern more traits than dominance effects. The current study suggests that selection will be successful, leading to a greater response rate, but delayed selection would be more fruitful.

Keywords: Sorghum, grain size, grain yield, heritability

Introduction
Sorghum [*Sorghum bicolor* (L.) Moench] is a C_4 plant with higher photosynthetic efficiency and shows tolerance to abiotic stress (Reddy *et al*., 2009) [11]. Sorghum originated in Africa and adapted to a diverse set of environments ranging from arid and semiarid to tropical across the world. After wheat, rice, maize, barley, and sorghum is the major cereal crop with respect to production. Sorghum is significant for providing micronutrients at a low cost, in addition to serving as a food and fodder crop. As a species, Sorghum bicolor (2n = 2x =20) is categorized into five different races: *bicolor*, *caudatum*, *durra*, *guinea*, and *kafir*, as well as several intermediate classes, and it belongs to the family Poaceae, subfamily panicoideae, and tribe Anthropocene (Harlan and de Wet, 1972) [4]. Sorghum is an often cross pollinated crop with an average of 5 to 10 *percent* cross pollination and it may exceed up to 40 percent (Barnaud *et al*., 2008) [2].

Grain size and other grain related traits *viz.*, grain width, grain length, grain thickness, 100 grain weight, grain volume, grain density, number of grains/panicle, and days to flowering exhibited positive and significant association with grain yield. Path analysis also showed a positive and significant direct & indirect effect on grain yield (Verma and Biradar, 2021) [13]. Therefore, a genetic study was planned and executed to know heritability so that these traits can be exploited for crop improvement.

Materials and Methods
In this study, each of the two promising varieties *viz.*, BJV44 and PKV Kranti were crossed with each of the two strong restorers on *maldandi* male sterile source *viz.*, DSMR-8 and DSMR-4 (Verma *et al.*, 2022) [12] two generate four crosses namely, BJV44 × DSMR8, BJV44 x DSMR4, PKV Kranti × DSMR8, and PKV Kranti × DSMR4. Six generations, *i e.*, P_1, P_2, F_1, F_2, B_1, and B_2 were generated for each cross combination during *the summer* and *Kharif* seasons-2020. The F1's of all the four crosses developed in summer-2020 and Kharif-2020, each of the F_1 was backcrossed with their P_1 and P_2 parents to develop B_1 and B_2 populations, respectively. At the same time, each F_1 advanced to produce F_2 populations. Since the development of six generations in four different crosses was time consuming process and there were not enough seeds for multiple seasons/year evaluation.

Therefore, the six generations were evaluated only during the post rainy season-2020 at Botany Garden, College of Agriculture, UAS, Dharwad, Karnataka, India. The experimental site is located at an altitude of 750 m above mean sea level, a latitude of 15.46ºN and a longitude of 75.01ºE.

To evaluate the six generations of all the four crosses, an experiment was carried out without replications; the population size and characteristics of the parents used are given in Table 1. All the recommended packages of practices were followed to raise a healthy crop. Data were recorded on 10 quantitative traits *viz.*, days to flowering, grain yield/plant (g), number of grains/panicle, 100 grain weight (g), 100 grain volume (cc), grain density, and plant height (cm). The grain size related traits *viz.*, grain length (mm), grain width (mm), grain thickness (mm), were measured using the vernier caliper while the volume of the 100 grains was measured based on the water displacement method.

Statistical analysis

The data collected on various quantitative traits were subjected to generation mean analysis using the methods described by Mather (1949) [10], scaling test (Hayman and Mather, 1955) [5] for associated scaling test, joint scaling test (Cavalli, 1952) [3], and Hayman (1958) [6] approach to find the significant nonallelic interaction. The validity of this model for the scaling tests and non allelic interactions was examined using I, method 2, a fixed effect model, which involves parents and one set of F1 crosses to determine the variance components of GCA and SCA.

Results and Discussion

The mean and variances for all the traits in different generations of four crosses are given in Table 2. The results showed enough variance for all the traits in all the crosses *viz.*, BJV44 × DSMR8, BJV44 × DSMR4, PKV Kranti × DSMR8, and PKV Kranti × DSMR4.

Components of genetic variation

Table 3 shows that for all the crosses for days to flowering, grain yield/plant, 100 grain weight, grain width, grain length, grain thickness, grain density, grains/panicle, and plant height, the additive variance (σ^2a) was observed to be greater than the dominant variance (σ^2d). PKV Kranti × DSMR4 was the only cross that showed higher additive variance than the dominant variance for 100 grain volume.

Except for BJV44 × DSMR8, all of the crosses had a degree of dominance less than unity for days to flowering and grain width while PKV Kranti × DSMR8 was the only cross where the degree of dominance was more than unity for grain yield/plant. All crosses except PKV Kranti × DSMR4 demonstrated the degree of dominance greater than unity dominance for 100 grain weight, grain thickness, 100 grain volume, and grains/panicle. Except for BJV 44 × DSMR4, all the crosses showed the degree of dominance greater than unity for grain length. Two crosses *viz.*, BJV44 × DSMR8 and PKV Kranti × DSMR8 showed a degree of dominance more than unity for grain density, whereas it was less than unity for the other crosses.

Heritability

Days to flowering and plant height showed moderate broad sense heritability, however, the rest of the traits in BJV44 × DSMR8 showed high broad sense heritability (Table 3). The traits 100 grain weight, grain thickness, and grain density in BJV44 × DSMR4 showed moderate heritability, whereas grain width had low heritability while the rest of the traits in the cross displayed high heritability. In PKV Kranti × DSMR8, all traits displayed high heritability, while grain thickness and plant height displayed moderate heritability.

Four characters namely grain width, grain length, grain thickness, and plant height displayed moderate heritability while the remaining traits displayed high heritability. Interestingly, all the traits in BJV44 × DSMR8 and PKV Kranti × DSMR8 showed high narrow sense heritability. Except for grain width, which had moderate narrow sense heritability in the BJV44 x DSMR4 cross, other traits showed high narrow sense heritability. The 100 grain volume showed low heritability in the PKV Kranti × DSMR4 cross, whereas the other traits showed high heritability. In all the crosses, all the traits except for 100 grain volume in PKV Kranti × DSMR4 the narrow sense heritability was observed in the range of moderate to high, whereas it was found to be low for 100 grain volume. These results are in agreement with those reported previously by Abd El-Hamid and Ghareeb, 2018 [1], Koubisy, 2019 [9] and Kariyannanavar *et al*, 2022 [7].

Table 1: Parents used and population size of the different generations of different crosses

	Cross-1: BJV44 × DSMR8		Cross-2: BJV44 x DSMR4	
Sl. No	**Generation**	**Population Size**	**Generation**	**Population Size**
1	P_1 (BJV-44- High grain yield and quality)	20	P_1 (BJV-44- High grain yield and quality)	20
2	P_2 (DSMR-4- Strong restorer and bold seeds)	20	P_2 (DSMR-4- Strong restorer and bold seeds)	20
3	F_1	20	F_1	20
4	F_2	453	F_2	453
5	B_1	158	B_1	158
6	B_2	157	B_2	157
	Cross-3: PKV Kranti × DSMR8		**Cross-4: PKV Kranti × DSMR4**	
1	P_1 (PKV Kranti- High grain yield and quality)	20	P_1 (PKV Kranti- High grain yield and quality)	30
2	P_2 (DSMR-8- Strong restorer and bold seeds)	22	P_2 (DSMR-4- Strong restorer and bold seeds)	24
3	F_1	19	F_1	22
4	F_2	455	F_2	453
5	B_1	156	B_1	156
6	B_2	154	B_2	158

Table 2: Mean and variance of four crosses for different characters under study

Cross	BJV44 × DSMR8		BJV 44 × DSMR-4		PKV Kranti × DSMR8		PKV Kranti × DSMR4	
Pedigree	**Mean**	**Variance**	**Mean**	**Variance**	**Mean**	**Variance**	**Mean**	**Variance**
1. Days to 50 percent flowering								
P_1	70.45	1.88	70.40	1.73	70.10	1.78	70.57	1.63
P_2	67.15	2.03	60.30	1.91	67.45	2.93	60.88	2.03
F_1	67.41	1.87	61.65	1.19	68.79	1.06	62.55	1.12
F_2	67.22	3.48	64.40	7.04	69.55	6.69	66.31	9.05
BC_1	70.18	2.08	66.16	2.75	70.22	1.81	68.21	3.07
BC_2	67.20	2.38	63.66	2.71	65.26	3.15	63.34	3.82
2. Grain yield per plant								
P_1	81.37	10.49	77.15	11.23	91.94	12.87	94.83	10.28
P_2	80.64	11.49	50.70	12.97	81.85	11.23	60.47	11.10
F_1	96.54	11.82	94.20	11.89	124.84	12.82	105.19	10.47
F_2	92.52	42.06	71.18	37.14	118.56	47.20	86.81	36.25
BC_1	116.53	20.07	78.11	12.24	120.02	20.54	103.12	17.23
BC_2	104.74	18.14	69.58	16.52	88.36	18.52	82.11	19.10
3. 100 grain weight								
P_1	3.942	0.106	3.887	0.116	4.440	0.108	4.412	0.112
P_2	3.830	0.112	4.034	0.120	4.073	0.111	4.242	0.110
F_1	3.613	0.037	3.477	0.103	3.721	0.012	3.878	0.005
F_2	3.578	0.348	3.681	0.243	3.946	0.279	4.311	0.197
BC_1	4.072	0.110	4.061	0.118	4.984	0.113	4.325	0.129
BC_2	4.031	0.117	3.894	0.121	4.325	0.118	4.284	0.122
4. Grain width								
P_1	3.843	0.018	3.984	0.019	4.101	0.019	4.182	0.018
P_2	3.980	0.014	4.187	0.024	4.06	0.014	4.298	0.015
F_1	3.723	0.016	4.339	0.015	4.300	0.014	4.304	0.018
F_2	3.862	0.057	4.228	0.026	4.110	0.051	4.199	0.043
BC_1	4.110	0.022	4.216	0.022	4.108	0.025	4.188	0.025
BC_2	4.051	0.021	4.314	0.017	4.117	0.022	4.227	0.021
5. Grain length								
P_1	4.813	0.028	4.836	0.056	4.985	0.030	4.979	0.027
P_2	4.661	0.026	5.035	0.051	4.758	0.027	4.884	0.030
F_1	4.831	0.024	5.052	0.055	5.382	0.019	4.987	0.029
F_2	4.692	0.094	4.887	0.232	4.883	0.087	4.599	0.070
BC_1	5.070	0.035	5.021	0.063	5.069	0.041	4.949	0.034
BC_2	4.832	0.033	5.106	0.057	4.890	0.033	4.885	0.037
6. Grain thickness								
P_1	2.846	0.016	2.808	0.021	3.088	0.016	3.103	0.018
P_2	2.781	0.015	2.863	0.027	2.834	0.018	2.854	0.025
F_1	2.644	0.016	2.803	0.022	2.953	0.016	2.758	0.021
F_2	2.753	0.041	2.758	0.053	2.851	0.031	2.841	0.046
BC_1	2.973	0.019	2.934	0.024	3.14	0.021	2.960	0.022
BC_2	2.812	0.019	2.833	0.030	2.841	0.023	2.793	0.029

Table 2: Contd….

Cross	BJV44 × DSMR8		BJV 44 × DSMR-4		PKV Kranti × DSMR8		PKV Kranti × DSMR4	
Pedigree	**Mean**	**Variance**	**Mean**	**Variance**	**Mean**	**Variance**	**Mean**	**Variance**
7. 100 Grain volume								
P_1	3.215	0.048	3.043	0.042	3.720	0.059	4.402	0.056
P_2	3.112	0.043	3.404	0.036	3.448	0.045	4.242	0.039
F_1	2.982	0.038	3.078	0.027	3.561	0.043	3.253	0.003
F_2	2.962	0.144	3.108	0.284	3.429	0.205	3.608	0.157
BC_1	3.634	0.084	3.415	0.108	3.994	0.070	3.608	0.101
BC_2	3.311	0.070	3.258	0.100	3.525	0.064	3.543	0.185
8. Grain density								
$\mathbf{P_1}$	1.2106	0.0029	1.2377	0.0081	1.1937	0.0033	1.1984	0.0012
P_2	1.2241	0.0025	1.8549	0.0179	1.1876	0.0032	1.2073	0.0018
F_1	1.1928	0.0116	1.1302	0.0067	1.0448	0.0029	1.1890	0.0019
F_2	1.2123	0.0380	1.2059	0.0213	1.1937	0.0103	1.1981	0.0105
BC_1	1.1224	0.0094	1.2134	0.0109	1.2466	0.0052	1.1987	0.0037
BC_2	1.2212	0.0096	1.1968	0.0067	1.2268	0.0044	1.2092	0.0033
9. Number of grains per panicle								
P_1	2075.20	4528.14	2002.43	45899.13	2082.55	4374.91	2163.48	4354.68
P_2	2119.09	4118.54	1264.55	17311.53	2016.90	3941.52	1481.63	4510.71

F_1	2683.28	3339.66	2731.26	42706.99	3356.93	3031.14	2713.51	4163.90
F_2	2467.63	12303.58	1968.45	100894.50	3058.92	11970.35	2035.32	11469.14
BC_1	2891.16	5602.36	1959.02	36390.93	2439.54	4894.45	2398.59	6605.38
BC_2	2627.30	4923.76	1802.79	40874.21	2041.13	4353.92	1936.55	7280.49
10. plant height								
P_1	281.06	16.57	284.56	32.26	298.40	21.43	299.47	24.39
P_2	241.81	17.81	235.70	39.35	251.23	19.66	235.61	31.15
F_1	250.20	13.60	268.91	22.78	253.46	19.98	276.29	18.66
F_2	270.38	34.98	262.27	73.81	270.44	42.53	253.41	48.47
BC_1	276.55	23.17	267.74	43.37	291.59	28.71	277.76	29.64
BC_2	244.16	23.32	247.35	49.18	245.25	25.66	244.76	37.99

Table 3: Estimates of various genetic parameters for the traits under study

Cross	BJV44 × DSMR8	BJV 44 × DSMR-4	PKV Kranti × DSMR8	PKV Kranti × DSMR4
1. Days to flowering				
σ^2g	1.56	5.54	4.98	7.58
σ^2a	2.49	8.61	8.43	11.22
σ^2d	-0.92	-3.07	-3.44	-3.64
σ^2p	3.48	7.04	6.69	9.05
σ^2b	0.45	0.79	0.75	0.84
σ^2h	0.72	1.22	1.23	1.24
Degree of dominance	1.23	-0.81	-1.21	-1.05
2. Grain yield per plant (g)				
σ^2g	30.65	25.14	34.77	25.67
σ^2a	45.91	45.52	55.34	36.18
σ^2d	-15.25	-20.38	-20.57	-10.51
σ^2p	42.06	37.14	47.20	36.25
σ^2b	0.73	0.68	0.74	0.71
σ^2h	1.09	1.23	1.17	1.00
Degree of dominance	2.73	2.19	-0.79	1.55
2. 100 grain weight (g)				
σ^2g	0.28	0.13	0.22	0.139
σ^2a	0.47	0.25	0.33	0.143
σ^2d	-0.19	-0.11	-0.11	-0.004
σ^2p	0.35	0.24	0.28	0.197
σ^2b	0.79	0.55	0.78	0.705
σ^2h	1.35	1.02	1.17	0.727
Degree of dominance	6.32	2.05	1.87	-3.436
3. Grain width (mm)				
σ^2g	0.04	0.007	0.036	0.026
σ^2a	0.07	0.011	0.055	0.040
σ^2d	-0.03	-0.004	-0.019	-0.015
σ^2p	0.06	0.026	0.051	0.043
σ^2b	0.72	0.285	0.710	0.595
σ^2h	1.24	0.449	1.082	0.938
Degree of dominance	3.39	-0.029	-5.059	-1.572
4. Grain length (mm)				
σ^2g	0.07	0.178	0.063	0.041
σ^2a	0.12	0.344	0.099	0.068
σ^2d	-0.05	-0.166	-0.036	-0.027
σ^2p	0.09	0.232	0.087	0.070
σ^2b	0.73	0.766	0.729	0.588
σ^2h	1.27	1.483	1.144	0.980
Degree of dominance	2.18	-3.091	2.236	4.544
5. Grain thickness				
σ^2g	0.03	0.030	0.015	0.024
σ^2a	0.04	0.053	0.019	0.040
σ^2d	-0.01	-0.023	-0.004	-0.016
σ^2p	0.04	0.053	0.031	0.046
σ^2b	0.62	0.565	0.471	0.534
σ^2h	1.07	0.999	0.601	0.877
Degree of dominance	1.55	2.152	1.356	-0.696
6. 100 grain volume				
σ^2g	0.10	0.251	0.157	0.132
σ^2a	0.14	0.360	0.275	0.029
σ^2d	-0.03	-0.109	-0.118	0.104

σ^2p	0.14	0.284	0.205	0.157
σ^2b	0.71	0.884	0.769	0.841
σ^2h	0.94	1.267	1.345	0.182
Degree of dominance	2.40	2.208	1.666	-4.283
7. Grain density				
σ^2g	0.03	0.011	0.007	0.009
σ^2a	0.06	0.025	0.011	0.014
σ^2d	-0.03	-0.014	-0.004	-0.005
σ^2p	0.04	0.021	0.010	0.010
σ^2b	0.81	0.537	0.702	0.836
σ^2h	1.50	1.176	1.066	1.338
Degree of dominance	1.38	-5.025	1.155	-0.950
8. Number of grains per panicle				
σ^2g	8472.09	63738.36	8375.67	7170.84
σ^2a	14081.05	124523.90	14692.34	9052.41
σ^2d	-5608.97	-60785.54	-6316.66	-1881.57
σ^2p	12303.59	100894.52	11970.35	11469.14
σ^2b	0.69	0.63	0.70	0.63
σ^2h	1.14	1.23	1.23	0.79
Degree of dominance	2.58	2.19	-2.22	1.75
10. Plant height				
σ^2g	19.59	44.52	22.27	25.25
σ^2a	23.47	55.06	30.69	29.31
σ^2d	-3.89	-10.55	-8.42	-4.06
σ^2p	34.98	73.81	42.53	48.47
σ^2b	0.56	0.60	0.52	0.52
σ^2h	0.67	0.75	0.72	0.61
Degree of dominance	-1.26	-0.70	-0.80	1.10

Conclusion

The traits of the crosses with a degree of dominance less than unity illustrate the importance of partial dominance and selection in the subsequent segregating generation. Over dominance has a role in most crosses where the degree of dominance is greater than unity for most traits. These findings imply that delayed selection for subsequent generations would be worthwhile. The estimates of heritability in the broad sense indicate a high portion of the phenotypic variation and is due to genetic variation for all the traits except for grain width in BJV44 × DSMR8 as here the broad sense heritability was between moderate to high (Kariyannanavar *et al*, 2023) [8]. The extent of narrow sense heritability demonstrates that, except 100 grain volume, additive effects govern more traits than dominance effects. The current study suggests that selection will be successful, leading to a greater response rate, but delayed selection would be more fruitful.

Conflict of Interest

The authors have no conflict of interest

References

1. Abd El-Hamid, EAM, Ghareeb ZE. Generation mean analysis for estimating some genetic parameters in four bread wheat crosses. In Proceeding of the Seventh Field Crops Conference, Giza, Egypt. 2018:18:17-29.
2. Barnaud, A, Trigueros G, McKey D, Joly HI. High outcrossing rates in fields with mixed sorghum landraces: how are landraces maintained?. Heredity. 2008:101(5):445-452.
3. Cavalli LL. An analysis of linkage in quantitative inheritance. An analysis of linkage in quantitative inheritance. HMSC, London; c1952. p. 135-144.
4. Harlan JR, De Wet JWJ. A simplified classification of sorghum. Crop Science. 1972;12:172-176.
5. Hayman BI, Mather K. The description of genic interactions in continuous variation. Biometrics. 1955;11(1), 69-82.
6. Hayman BI. The separation of epistasis from additive and dominance variation in generation mean. Heredity. 1958;12:371-390.
7. Kariyannanavar P, Wali MC, Biradar BD, Chattannavar SN, Kubsad VS. Univariate and character association studies in elite ‘B’ and ‘R’ lines against *maldandi* cytoplasm in *Rabi* sorghum [*Sorghum bicolor* (L.) Moench]. The Pharma Innovation. 2022;11(10):1788-1791.
8. Kariyannanavar P, Kajjidoni ST, Patil PV, Kachapur RM, Verma LK. A Productive Breeding Programme on Identifying the Elite Combiners for Early Vigour and Productivity Related Traits in identified Local Landraces of *rabi* sorghum [*Sorghum bicolor* (L.) Moench]. Biological Forum – An International Journal. 2023;15(2):972-976.
9. Koubisy YSI. Generation mean analysis of two bread wheat crosses under normal and late sowing date conditions. Egypt. J Agric. Res. 2019;97(2):589-607.
10. Mather K. Biometrical genetics. Dover publication Inc. New York; c1949.
11. Reddy BV, Ramesh S, Reddy PS, Kumar AA. Genetic Enhancement for Drought Tolerance in Sorghum. Plant Breeding Reviews. 2009;31:189.
12. Verma LK, Biradar BD, Patil SS, Chattannavar SN, Kubsad VS. Comparative analysis of restoration behavior of *milo* (104A, 401A) and *maldandi* (M31-2A) based male sterile lines in sorghum [*Sorghum bicolor* (L.) Moench]. Genetic Resources and Crop Evolution; c2022. p. 1-8.
13. Verma LK, Biradar BD. Correlation and path analysis for grain yield and yield attributes in rabi sorghum [*Sorghum bicolor* (L.) Monech]. The Pharma Innovation Journal, 2021;10(10):1211-1214.