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Research Article

Variability and path analysis studies in F_2 population of sorghum (*Sorghum bicolor* (L.) Moench)

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Abstract
A field experiment was conducted to evaluate Sorghum (*Sorghum bicolor* (L.) Moench) F_2 population of COS 28 x SPV 2308 and COS 28 x SPV 2307. These crosses were raised during *Kharif* 2018. Variability and path analysis was carried out for ten morphological traits *viz.,* plant height, days to flowering, the number of leaves, flag leaf length, flag leaf width, panicle length, panicle weight, the number of primaries, 100 seed weight and grain yield per plant. The mean value was found to be higher in COS 28 x SPV 2307 for the traits namely plant height and the number of leaves per plant. The mean value was found to be higher in the cross COS 28 x SPV 2308 for the traits *viz*., flag leaf length, flag leaf width, panicle length, panicle weight, the number of primaries, 100 seed weight and grain yield per plant. Variability studies revealed that the high PCV was observed in both the crosses for all the traits thus showing high environmental influence except days to flowering and the number of leaves. High GCV, heritability and Genetic advance as percentage of mean was found to be high for the traits namely flag leaf length and flag leaf width in COS 28 x SPV 2308 and for the traits panicle length and the number of primaries in COS 28 x SPV 2307. The traits exhibit high GCV, heritability and GAM are additive in nature which could be used as the selection criteria for increasing the yield potential. Path analysis revealed that both the crosses showed high direct effect for grain yield per plant through the traits *viz.,* flag leaf length, panicle length, panicle weight, the number of primaries and 100 grain weight. Flag leaf length, panicle length and the number of primaries exhibited high indirect effect through the trait panicle weight in both the crosses.

Keywords
Variability Studies, PCV, GCV, heritability, GAM and Path analysis

INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) is the fifth most important cereal in the world, after Wheat, Rice, Maize and Barley. Sorghum belongs to the family Poaceae and tribe Andropogoneae (Harlan and De Wet, (1972)). In India, sorghum is having 5.86 million hectares of area, 4.57 million tonnes of production and 779.6 Kg/ha productivity (FAO STAT, 2017). Studies on variability parameters are essential for a breeder to select the most promising parents for the next generation with high genotypic effect and less environmental influence. The study of heritability suggests the proportion of genotypic variances present in the phenotype that would be carried to the next generation. The study of the GAM suggests the improvement in the mean genotypic values of the progenies over the parental population. The traits that exhibit high heritability and high genetic advance as percent of mean would exhibit an additive gene action hence can be used as selection criteria for improving the yield of the population. The traits that exhibit low heritability and high genetic advance as percent of mean can also be taken as selection criteria since low heritability may be due to the environmental influence. The traits that show low heritability and low genetic advance as percent of mean should not be considered for selection.

The path analysis identifies the direct and indirect effects of different traits on grain yield. The traits that exhibit high direct effects are considered for selection for improving

grain yield. The traits that show high indirect effects also contribute to the increased yield of the population *via* some other traits.

MATERIALS AND METHODS

The study was carried out during *Kharif*'2018 at Department of Millets, Tamil Nadu Agricultural University, Coimbatore. The seed sources for parents namely COS 28, SPV 2307 and SPV 2308 and their F_1's were obtained from the Department of Millets, TNAU, Coimbatore. The F_2 of the crosses COS 28 x SPV 2308 and COS 28 x SPV 2307 were raised in 20 rows of 4m length with a spacing of 0.45m between rows and 0.15m between plants. These F_2 segregants were raised along with corresponding parents. During sowing two seeds per hill were sown and later one plant per hill was maintained. All the crop management practices were followed as per recommendation. Observations were recorded for 145 individual F_2 plants in the cross COS 28 x SPV 2308 and 181 F_2 plants in the cross COS 28 x SPV 2307 for 10 biometrical traits *viz.*, plant height (m), days to flowering (days), the number of leaves (no.), flag leaf length (cm), flag leaf width (cm), panicle length (cm), panicle weight (g), the number of primaries, 100 seed weight (g) and grain yield/plant (g). The variability analysis was carried out using MS excel and path analysis studies were carried out in OPSTAT software.

RESULTS AND DISCUSSION

The analysis of variance and genetic parameters for the important traits in the F_2 population of COS 28 x SPV 2308 and the cross COS 28 x SPV 2307 are presented in **table 1 and 2** respectively. The analysis of variance revealed the presence of significant differences among the yield related traits.

The F_2 population of COS 28 x SPV 2308 exhibited high PCV (20.58), low GCV (7.48), low heritability (13.22%) and low GAM (5.61%) for the plant height (cm). Moderate PCV (11.62), low GCV (6.69), medium heritability (33.14%) and low GAM (7.93%) were observed for the trait days to flowering (days). Number of leaves per plant (no.) was found to exhibit moderate PCV (12.66), low GCV (5.12), low heritability (16.35%), low GAM (4.27%). PCV, GCV, heritability and GAM were observed to be high for flag leaf length (cm) and flag leaf width (cm). High PCV (23.94), moderate GCV (18.12), medium heritability (57.26%) and high GAM (28.24%) were observed for panicle length (cm). High PCV (83.87), low GCV (8.21), low heritability (0.96%) and low GAM (1.66%) were observed for panicle weight (g). Pedda swamy (2013) also reported high PCV for panicle weight among 81 diverse genotypes of sorghum. High PCV (26.18), moderate GCV (16.50), medium heritability (39.72%) and high GAM (21.42%)

Table 1. Genetic Variability parameters for different traits in F_2 generation of COS 28 x SPV 2308

Sl. No	Traits	Mean	PV	EV	GV	PCV	GCV	h^2(%)	GA	GA as % of Mean
1	Plant height	175.26	1301.08	1129.02	172.06	20.58	7.48	13.22	9.83	5.61
2	Days to flowering	70.62	67.35	45.04	22.32	11.62	6.69	33.14	5.60	7.93
3	Number of Leaves	10.32	1.71	1.43	0.28	12.66	5.12	16.35	0.44	4.27
4	Flag Leaf length	31.41	147.79	52.14	95.65	38.71	31.14	64.72	16.21	51.60
5	Flag Leaf width	5.09	34.00	1.21	32.79	114.59	112.53	96.45	11.58	227.66
6	Panicle length	20.09	23.13	9.88	13.24	23.94	18.12	57.26	5.67	28.24
7	Panicle weight	31.51	698.69	691.99	6.7	83.87	8.21	0.96	0.52	1.66
8	Number of primaries	37.73	97.52	58.79	38.73	26.18	16.5	39.72	8.08	21.42
9	100 seed weight	1.91	0.32	0.14	0.18	29.68	22.22	56.07	0.66	34.28
10	Grain yield per plant	19.52	430.13	429.58	0.54	106.25	3.78	0.13	0.05	0.28

were observed for the trait number of primaries (no.). The trait 100 seed weight (g) exhibited high PCV (29.68), high GCV (22.22), medium heritability (56.07%) and high GAM (34.28%). High PCV (106.25), low GCV (3.78), low heritability (0.13%) and low GAM (0.28%) were observed for grain yield per plant (g). Lower genotypic coefficient of variation was noticed in all the traits of F_2 generation in comparison with phenotypic coefficient of variation.

The F_2 population of COS 28 x SPV 2307 exhibited moderate PCV (18.12), low GCV (9.13), low heritability (25.38%) and low GAM (9.47%) for plant height (cm). Moderate PCV (10.57), low GCV (6.03), medium heritability (32.62%) and low GAM (7.1%) was observed for the trait days to flowering (days). Number of leaves per plant (no.) was found to exhibit moderate PCV (14.02), moderate GCV (12.68), high heritability (81.75%) and high GAM (23.61%). High PCV (32.56), low GCV (5.98), low heritability (3.37%) and low GAM (2.26%) were observed for flag leaf length (cm). High PCV (28.86), moderate GCV (14.83), low heritability (26.4%) and moderate GAM (15.70%) were observed for flag leaf width (cm). PCV, GCV, heritability and GAM were observed to be high for panicle length (cm). Similar findings for high GCV, high PCV, high heritability and high GAM for panicle length were reported by Jain *et al.* (2012) and Pedda swamy (2013). High PCV (84.53), moderate GCV (13.71), low heritability (2.63%) and low GAM (4.58%) were observed

Table 2. Genetic Variability parameters for different traits in F_2 generation of COS 28 x SPV 2307

Sl. No	Traits	Mean	PV	EV	GV	PCV	GCV	h^2(%)	GA	GA as % of Mean
1	Plant height	186.08	1136.73	848.22	288.51	18.12	9.13	25.38	17.63	9.47
2	Days to flowering	70.50	55.49	37.39	18.10	10.57	6.03	32.62	5.01	7.1
3	Number of Leaves	11.10	2.42	0.44	1.98	14.02	12.68	81.75	2.62	23.61
4	Flag Leaf length	29.07	89.55	86.53	3.02	32.56	5.98	3.37	0.66	2.26
5	Flag Leaf width	4.31	1.55	1.14	0.41	28.86	14.83	26.4	0.68	15.70
6	Panicle length	18.20	21.93	6.00	15.93	25.73	21.93	72.66	7.01	38.51
7	Panicle weight	21.56	332.07	323.34	8.73	84.53	13.71	2.63	0.99	4.58
8	Number of primaries	33.61	110.56	43.7	66.86	31.28	24.33	60.47	13.1	38.97
9	100 seed weight	1.72	0.24	0.24	0.01	28.8	5.70	3.91	0.04	2.32
10	Grain yield per plant	13.95	256.09	255.31	0.78	114.7	6.33	0.31	0.10	0.72

for the trait *viz.,* panicle weight (g). Number of primaries (no.) exhibited high PCV (31.28), GCV (24.33), heritability (60.47%) and GAM (38.97%). The trait 100 seed weight (g) and grain yield per plant (g) showed high PCV (28.8), low GCV (5.70), low heritability (3.91%) and low GAM (2.32%). Lower genotypic coefficient of variation was noticed in all the traits of F_2 generation in comparison with phenotypic coefficient of variation.

Hence from the variability studies it was concluded that high PCV was observed in both the crosses for all the traits showing high environmental influence except for the traits namely plant height, days to flowering and the number of leaves. High GCV, heritability and GAM were found to be high for the traits namely flag leaf length and flag leaf width in the cross COS 28 x SPV 2308 and for the traits *viz.,* panicle length and the number of primaries in the cross COS 28 x SPV 2307. The traits that exhibit high GCV, heritability and GAM are additive in nature which could be used as the selection criteria for increasing the yield. The heritability estimates would give the best picture of the extent of advance to be expected by selection. The success of genetic advance depends on the measures *viz*., genetic variability, heritability and selection intensity of the population.

Table 3. Direct (diagonal) and Indirect effects of yield components with single plant yield in COS 28 x SPV 2308.

Traits	PH	DF	NL	FLL	FLW	PL	PW	NOP	GW	GYP
PH	0.0412	-0.0211	-0.0067	-0.0078	0.002	-0.0601	0.4962	0.0137	0.0109	0.4684
DF	-0.0257	0.0338	0.0011	0.0104	-0.0025	0.0536	-0.5779	-0.0139	-0.0151	-0.5362
NL	0.0069	-0.001	-0.0397	-0.001	0.0004	-0.0178	0.0884	0.0027	0.0051	0.044
FLL	0.0176	-0.0192	-0.0022	-0.0184	0.0034	-0.0416	0.4424	0.0115	0.0059	0.3995
FLW	0.0058	-0.0058	-0.0012	-0.0043	0.0146	-0.0151	0.0855	0.0033	0.0002	0.083
PL	0.0266	-0.0195	-0.0076	-0.0082	0.0024	-0.093	0.5647	0.0204	0.0084	0.4941
PW	0.0223	-0.0214	-0.0038	-0.0089	0.0014	-0.0573	0.9159	0.0165	0.0422	0.9069
NOP	0.0236	-0.0196	-0.0044	-0.0088	0.0020	-0.0791	0.6282	0.0240	0.0212	0.5870
GW	0.0047	-0.0053	-0.0021	-0.0011	0.0000	-0.0081	0.4001	0.0053	0.0965	0.4900
GYP	0.0412	-0.0211	-0.0067	-0.0078	0.0020	-0.0601	0.4962	0.0137	0.0109	0.4684

Residual effect = 0.4008

PH -Plant height(cm); **DF**-Days to flowering (days); **NL -**Number of leaves/Plant; **FLL** - Flag leaf length (cm); **FLW** - Flag leaf width (cm); **PL-**Panicle length (cm); **PW -**Panicle weight (g); **NOP**-Number of primaries; G**W**- 100 grain weight (g);

The path analysis for the cross COS 28 x SPV 2308 is presented in the **table 3.** Plant height, flag leaf length, panicle length, panicle weight, the number of primaries and 100 grain weight exhibited high direct effect with the grain yield per plant. Plant height, flag leaf length, panicle length, the number of primaries and 100 grain weight exhibited high indirect effect through the trait panicle weight. All the other traits contributed only negligible effects for the grain yield of the plant. The residual factor was observed to be 0.4008 which showed that there are some other traits that need to be studied for yield contribution. Warkad *et al.* (2008), Pedda swamy (2013), Kalpande *et al.* (2014)

and Sushil (2017) also reported a positive indirect effect of plant height for grain yield per plant. Deepalakshmi and Ganesamurthy (2007), Arunkumar (2013), Patil *et al.* (2014) and Sushil (2017) reported a positive indirect effect of panicle length for grain yield per plant. Warkad *et al.* (2010) used experimental material comprised of sixty four genotypes of sorghum collected by *in situ* selection from Vidarbha region also reported positive indirect effect of plant height for grain yield per plant.

The path analysis of the cross COS 28 x SPV 2307 is presented in the **table 4**. Flag leaf length, flag leaf width, panicle length, panicle weight, the number of primaries and 100 grain weight exhibited high direct effect with the grain yield per plant. Flag leaf length, flag leaf width, panicle length and the number of primaries exhibited high indirect effect through the trait panicle weight. Plant height and 100 seed weight showed moderate indirect effects through the trait panicle weight. All the other traits contributed only negligible effects for the grain yield of the plant. The residual factor was observed to be 0.3695 which showed that there are some other traits that are to be studied for yield contribution.

Table 4. Direct (diagonal) and Indirect effects of yield components with single plant yield in COS 28 x SPV 2307.

Traits	PH	DF	NL	FLL	FLW	PL	PW	NOP	GW	GYP
PH	-0.0698	-0.0334	-0.0011	0.0228	-0.0015	-0.0401	0.2336	0.0348	-0.003	0.1422
DF	0.0385	0.0607	0.0006	-0.0246	0.0015	0.0346	-0.2796	-0.0333	0.0016	-0.2001
NL	-0.0148	-0.0064	-0.0054	0.003	-0.0009	-0.018	0.1559	0.0174	-0.0021	0.1287
FLL	-0.0323	-0.0303	-0.0003	0.0492	-0.0031	-0.0629	0.3568	0.0546	-0.0026	0.329
FLW	-0.0222	-0.0186	-0.001	0.0314	-0.0048	-0.0527	0.3609	0.0433	0.0031	0.3396
PL	-0.0184	-0.0138	-0.0006	0.0203	-0.0017	-0.1521	0.4607	0.1150	0.0005	0.4100
PW	-0.0176	-0.0183	-0.0009	0.019	-0.0019	-0.0758	0.9251	0.0694	0.0194	0.9184
NOP	-0.0184	-0.0153	-0.0007	0.0203	-0.0016	-0.1326	0.4866	0.1319	0.002	0.4721
GW	0.0034	0.0016	0.0002	-0.0021	-0.0002	-0.0013	0.2905	0.0042	0.0619	0.3582
GYP	-0.0698	-0.0334	-0.0011	0.0228	-0.0015	-0.0401	0.2336	0.0348	-0.003	0.1422

Residual effect = 0.3695

PH -Plant height(cm); **DF**-Days to flowering (days); **NL -**Number of leaves/Plant; **FLL** - Flag leaf length (cm); **FLW** - Flag leaf width (cm); **PL-**Panicle length (cm); **PW -**Panicle weight (g); **NOP**-Number of primaries; G**W**- 100 grain weight (g);

Hence from the path analysis studies it was adjudged that high direct effect for grain yield per plant was contributed through the traits *viz.,* flag leaf length, panicle length, panicle weight, the number of primaries and 100 grain weight in both the crosses. Therefore the selection based on these traits ultimately leads to increased yield of the plant and the selection criteria based on these traits contribute for the direct improvement of the population yield. Flag leaf length, panicle length and the number of primaries exhibited high indirect effect through the trait panicle weight in both the crosses. Hence the selection based on these traits would further indirectly contribute to increased yield of the population through the panicle weight.

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