Variability and path analysis studies in F₂ population of sorghum (Sorghum bicolor (L.) Moench)

S. Subhashini*, D. Kavithamani, B. Selvi and N. Vadivel

Department of Millets, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore-641003, Tamil Nadu, India
E-Mail: subhagokul199646@gmail.com

Abstract
A field experiment was conducted to evaluate Sorghum (Sorghum bicolor (L.) Moench) F₂ 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...
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), moderate 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  | 50.27       | 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 (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), low 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%)

https://doi.org/10.37992/2020.1102.072

412
Table 2. Genetic Variability parameters for different traits in F<sub>2</sub> generation of COS 28 x SPV 2307

| Sl. No | Traits                | Mean   | PV      | EV      | GV      | PCV     | GCV     | h²(%)   | 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<sub>2</sub> 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  |
|----------------------|------|------|------|------|------|------|------|------|------|------|
|                      | 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; GW - 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 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; GW - 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.

ACKNOWLEDGMENTS

The author whole heartedly thanks Department of Millets, Centre of Plant Breeding and Genetics, Tamil Nadu Agricultural University for sparing F₂ seed materials and providing field facilities to conduct the experiments successfully.

REFERENCES

Arunkumar, B. 2013. Genetic variability, character association and path analysis studies in sorghum (Sorghum bicolor (L.) Moench). The Bioscan. 8(4): 1485-1488.

Deepalakshmi, A., and K. Ganesamurthy. 2007. Studies on genetic variability and Character association in kharif sorghum (Sorghum bicolor (L.) Moench). Indian J. of Agric. Res., 41 (3):177-182.

FAOSTAT. 2017. Food and Agricultural Organization of the United Nations. Last Modified May 21,2017.http://www.fao.org/faostat/.

Harlan, J. R. and De Wet, J. 1972. A Simplified Classification of Cultivated Sorghum. Crop sci., 12(2): 172-176. [Cross Ref]

Jain, S. and Patel, P. 2012. Genetic variability in land races of forage sorghum (Sorghum bicolor (L.) Moench) collected from different geographical origin of India. Intl. J. of Agric. Sci., 4(2): 182. [Cross Ref]

Kalpande, H., S. Chavan, A. More, V. Patil, and P. Unche. 2014. Character association, genetic variability and component analysis in sweet sorghum (Sorghum bicolor (L.) Moench). J. of Crop and Weed. 10 (2):108-110.

Patil, C., Rathod, A., Vaghela, P., Yadav, S., Patade, S. and Shinde, A. 2014. Study of correlation and path analysis in dual purpose sorghum (Sorghum bicolor (L.) Moench). Intl. J. of Agric. Sci., 10(2): 608-611.
Pedda swamy, D. 2013. Genetic variability and character association for yield and yield attributes in sorghum (Sorghum bicolor (L.) Moench). Acharya N. G. Ranga Agricultural University Rajendranagar, Hyderabad.

Sushil, K. 2017. Studies on relationship among yield components and selection criteria for yield improvement in sorghum (Sorghum bicolor (L.) Moench). *Intl. J. of Plant Sci.*, 12 (2):156-159. [Cross Ref]

Warkad, Y., Potdukhe, N., Dethe, A., Kahate, P. and Kotgire, R. 2008. Genetic variability, heritability and genetic advance for quantitative traits in sorghum germplasm. *Agric. Sci. Digest.* 28(3): 165-169.