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ISSN: 0975-928X
Volume: 10
Number: 4

EJPB (2019) 10(4):1383-1389
DOI: 10.5958/0975-928X.2019.00177.7

https://ejplantbreeding.org
Research Article
Genetic variability, correlation and path coefficient studies in sorghum
[Sorghum bicolor (L.) Moench] mutants

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(Received: 24 Apr 2019; Revised: 16 May 2019; Accepted: 21 May 2019)

Abstract
The present study was undertaken to assess genetic variability present in the mutant derived from Chincholli-2 and JP 1-5
landraces in M4 generation and estimate the correlation and path coefficients among yield and attributing traits. The present
study revealed wide variation for morphological and yield contributing traits. Among the genetic parameters studied, high
phenotypic and genotypic coefficient of variation (PCV, GCV), heritability and genetic advance was observed for panicle
length, panicle weight, panicle width, seed weight and grain yield. Significant positive correlations were observed between
grain yield and number of leaves, plant height, stems girth, panicle length, panicle area indicating the role and importance of
these traits in the development of high yielding varieties. The path analysis revealed positive and direct effect of days to
maturity, number of leaves, plant height, stem girth, panicle length, panicle weight and panicle width on grain yield per
plant. This study would help in developing high yielding mutants for deep black soils of northern Karnataka under rainfed
conditions.

Key words
Sorghum, Correlation, Path coefficient, Mutation breeding

Introduction
Sorghum is an important food crop in the world after corn, wheat, rice and barely. It is a
multipurpose crop that can be used as a source of
food, feed and fuel. It is primarily an important
food source in the semi-arid regions of Africa and
Asia, but also has wide utilization as livestock feed
and biofuel. It has wide adaptability and requires
fewer inputs and drought tolerance compared to
other crops. India is a major sorghum growing
country in the world covering 4.9 m. ha with
production of 4.7 m. tonnes. In India, it is grown as
a dual purpose crop for serving both grain and
fodder requirements of the farming community.

Rabi sorghum improvement was initiated in the
early seventies through the selections from land
craces and pure lines. The traditional and widely
preferred land races were ineffective as donor of
favorable gene complex in traditional breeding. To
enhance the breeding program and to create new
genic variation, mutation breeding has been
utilized. Mutation breeding has played an important
role in crop improvement (Larik and Jamro, 1993)
with an objective of increasing the genetic
variability effective for selection. It has been found
that irradiation of seeds with physical or chemical
mutagens would lead to increase in mutation
frequency, promote favorable gene modifications
and creates wide genetic variability (Mike, 1996).

In order to utilize this variation for genetic
improvement, knowledge of association between
morphological and yield contributing traits are
required, which will help in evaluating the
contribution of these traits. Often selections made
based on phenotypic performance may not lead to
expected genetic advance, due to the presence of
environmental factors and undesirable association
between component traits. Hence, the knowledge
of correlation between complex quantitative traits
and genetic variability parameters will help in
designing efficient selection strategies for
identifying desirable mutants. The path coefficient
analysis helps in partitioning correlation coefficient
into direct and indirect effects across various traits.
This would also help in assessing the casual effect
relationships and effective selection (Khandelwala
et al., 2015). In the present investigation, two
sorghum varieties i.e., Chincholli local and JP-1-5
were selected for improving the yield levels using
mutation breeding techniques.

Materials and Methods
Two landraces, viz., Chincholli local and JP-1-5
were earlier subjected to physical (gamma rays @
300Gy) and chemical mutagens (Ethyl Methane
Sulphonate @ 0.1%). M1 and subsequent
generations were grown as plant to row progenies
at Agricultural Research Station (ARS),
Kalaburagi. In each generation, selections were performed for grain yield and charcoal rot tolerance. In M	extsubscript{4} generation (2015-16), a total of 148 mutant lines consisting of 61 mutants of chincholli-2 and 87 mutants of JP-1-5 were selected for planting. They were sown in Augmented design, (Federer, 1977) in 4 blocks of 4m length with inter row spacing of 45 cm and intra row spacing of 15 cm. Each block contained 37 mutants and eight checks viz., DJ 6514, IS 2312, M 35-1, DSV-4, E-36-1, SPV-86, JP-1-5, Chincholli replicated in four blocks. The observations were recorded on five randomly selected mutant plants in each entry for eleven traits (days to 50 per cent flowering, days to maturity, plant height (cm), panicle length (cm), panicle neck length (cm), number of leaves, stem girth (cm), panicle width (cm), panicle weight (g), 100-seed weight (g) and grain yield per plant (g)). Analysis of variance was carried out as per the Panse and Sukhatme (1978). Genotypic and phenotypic coefficient of variability, heritability and genetic advance as per the standard method suggested by Burton (1952). The direct and indirect effects were studied through path analysis as per the procedure of Dewey and Lu, 1959. The statistical analysis of the phenotypic data on individual trait was carried out based on mean values of each mutant using INDOSTAT package (version 8.5).

**Results and Discussions**

The present study was carried out to estimate the genetic variability and correlations among yield and yield contributing traits. A landrace, Chincholli-2 was initially irradiated with gamma rays at 300 Gy and selfed progenies were forwarded from M	extsubscript{1} to M	extsubscript{4} generations. The variability found was enormous among the yield contributing traits in the M	extsubscript{4} and subsequent generations and selections were made for grain yield traits and charcoal rot tolerance. Among the M	extsubscript{4} families selected, significant amount of variability was observed for most of morphological and yield characters studied viz., days to 50% flowering, days to maturity, plant height, stem girth, panicle length, panicle weight, panicle width, 100 seed weight and grain yield per plant. Range, mean, PCV, GCV, heritability estimates in broad sense and genetic advance as percent mean for these characters is presented in Table 1. Plant height, panicle neck length, panicle weight and grain yield per plant have shown higher range values. The presence of such wide range of variation of the traits indicated that the presence of large amount of genetic variation among the mutants. High values of PCV and GCV were observed for the traits like panicle weight, panicle width and seed yield per plant. Moderate values were observed for plant height, panicle length, stem girth and 100 seed weight. In another case, low values of GCV were also observed for days to 50 per cent flowering, days to maturity, number of leaves and panicle neck length which indicated that improvement of this traits through selection is less effective due to lack of genetic variability among the. Yaqoob et al. (2015) observed high PCV and GCV for plant height, leaf area index, stalk yield per plant and grain yield per plant, moderate for number of leaves and 100 grain weight and low for days to 50 percent flowering and maturity. In general, GCV value was generally smaller than their corresponding PCV values for all the traits considered indicating the contribution of environmental variance to the total phenotypic variance of the trait. Narrow difference between PCV and GCV was observed for days to 50 per cent flowering and maturity, plant height, panicle length, stem girth, panicle width, panicle weight, grain yield per plant and 100-seed weight. This showed that these characters were less affected by environmental fluctuations and offer better scope for selection. On the other hand, number of leaves and panicle neck length showed wide difference for PCV and GCV values, indicating the role of environment.

In the present study, high heritability was observed for days to 50 per cent flowering, days to maturity, plant height, panicle neck length, stem girth, panicle width, panicle weight, grain yield per plant and seed weight. Similarly, Anand and Kajjidoni (2014) also assessed genetic variability for grain size and productivity in kharif sorghum and reported high heritability values of more than 90% for plant height and grain yield per plant in the sorghum mutant progenies. High heritability along with high genetic advance as per cent mean was observed for plant height, stem girth, panicle weight, panicle width, 100 seed weight, panicle length and grain yield per plant. These characters were found to be under additive gene action thus enabling for selection. Sushil (2014) evaluated 102 land races of forage sorghum and observed high heritability accompanied with high genetic advance for days to flowering, plant height, number of leaves per plant and leaf length. For the days to 50 per cent flowering, days to maturity and number of leaves heritability estimates were moderate to high and genetic advance as per cent mean was low, which is in accordance with Tariq et al., 2012. In addition, dry matter yield, fresh weight per plant and dry weight per plant showed high heritability.
except for number leaves per plant (moderate heritability). This could be due presence of non additive nature and influence of environment. Hence, selection for the trait would not be rewarding (Tariq et al., 2012).

The grain yield had significantly positive correlation with number of leaves, plant height, stem girth, panicle length, panicle weight and panicle width (Table 2). Deepalakshmi and Ganesamurthy (2007) evaluated 16 genotypes of white grain sorghum, where they found seed yield was positively and significantly correlated with days to maturity, number of leaves per plant and ear head weight. Similarly plant height, panicle length, panicle width, and stem girth had highly significant positive correlation with yield per plant which is in accordance with findings of Girish et al. (2016) evaluated 25 lines of sorghum during rabi season 2015 and reported seed yield per plot showed significant positive correlation with plant height, ear head length, 100 seed weight, fodder yield and lodging percentage. Therefore, the positive association of grain yield with these traits suggested that the possibility of simultaneous improvement of grain yield through indirect selection of these positively correlated traits.

In the present study, out of 11 characters, days to maturity, number of leaves, plant height, stems girth, panicle length, panicle weight and panicle width were contributed positive and direct effect towards grain yield (Table 3). Among these, panicle weight has high positive direct effect whereas, the direct effects of other characters were negligible. Panicle weight exerted maximum direct effect on grain yield per plant followed by days to maturity, plant height, stem girth, panicle width, number of leaves and panicle length. It indicated that if other factors are held constant, an increase in these characters individually will reflect in an increased yield. Many other workers have also considered panicle weight, days to maturity, plant height, stem girth, panicle length, and panicle width to be most important yield components having direct effect. Amare et al. (2015) investigated in 16 sorghum varieties, path analysis indicated plant height, panicle weight and harvest index showed high positive phenotypic direct effect on yield whereas panicle yield showed negligible positive phenotypic direct effect with considerable indirect via panicle weight. While other characters like days to 50% flowering, panicle neck length and seed weight had negative direct effects on grain yield. These results were in conformity with the observations made by Mahendrakumar et al. (2014) in rice mutants.

The indirect effects of number of leaves, plant height and stem girth were positive and minimal via panicle weight on grain yield and the indirect effects of panicle length and panicle width were positive and moderate via panicle weight. The direct effects of days to 50 per cent flowering and 100 seed weight were negative and contribute positively towards yield. This could be due to positive indirect effects of both characters towards yield through other characters. The indirect effects of days to 50 per cent flowering, days to maturity, number of leaves, plant height, stem girth, panicle neck length, panicle length, panicle weight, panicle width and 100 seed weight via other characters were negligible. Shinde et al. (2014) studied the correlation among yield and its attributing traits in 120 F₆ derived lines. The path analysis of different characters in this study revealed positive and direct effects of panicle breadth and seed weight on grain yield, while number of grains per panicle are indirectly and positively associated with grain yield.

References
Amare, K., Zeleke, H. and Bultosa, G. 2015. Variability for yield, yield related traits and association among traits of sorghum [Sorghum Bicolor (L.) Moench] varieties in Wollo, Ethiopia. J. of Plant Breed. and Crop Sci., 7(5): 125-133.

Anand, Y. and Kajjidoni, S.T., 2014, Genetic enhancement of grain size and other productivity related traits through induced variability in kharif sorghum. Karanataka J. Agric. Sci., (2): 121-124.

Burton G.W., 1952. Quantitative inheritance of grasses. Proceedings of 6th International Grassland Congress, 1: 227-283.

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

Dewey, D. R. and Lu, K. H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. Agron. J., 51: 515-518.

Federer, W. T. 1977. Experimental Design: Theory and Application. McMillan, New York.

Girish, G. Kiran, S. B. Lokesh, R. Kulkarni, V. V. Rachappa, V. Yogesh, L. N and Talwar, A. M. 2016. Character association and path analysis in advanced breeding lines of rabi sorghum [Sorghum bicolor (L.) Moench]. J. of Appl. and Natural Sci., 8 (1): 35–39.
Khandelwala, V., M. Shukla, V.S. Nathawat and B.S. Jodha. 2015. Correlation and path coefficient analysis for agronomical traits in sorghum under shallow saline soil condition in arid region. Electronic J. Plant Breed. 6(4): 1143-1149.

Larik, A.S. and G.H. Jamro, 1993. Genotypic response to physical mutagens. Proc. 2nd All. Pak. Int. Sci. Conference, December 20-30. PP 161-163

Mahendrakumar, V. B. Ibrahim, M. Lokesh, R. Mahanthshivayogayya, K. and Vishwanath, J. 2014. Evaluation and molecular characterization of advanced mutant lines in rice. M.Sc. (Agri.) Thesis, University of Agricultural Sciences, Raichur, India.

Mike, A. 1996, 70 years- induced mutation to be reconsidered Mut. Breed. News Letters, 42: 22-25.

Panse, V.G. and Sukhatme, P.V. 1978. Statistical method for Agriculture workers, 3rd Edn. ICAR, New Delhi.

Shinde, D. G. Biradar, B. D. Salimath, P. M. Kamatar, M. Y. and Hundekar, A. R. 2014. Correlation, direct and indirect effects among productivity traits in the derived lines of B x B, B x R and R x R crosses in rabi sorghum. Karnataka. J. Agric. Sci., 27(4): 519-521.

Sushil, K., 2014, Genetic variability in land races of forage sorghum [Sorghum bicolor (L.) Moench] collected from different geographical origin of India. Prime Research on Medicine 3(2), 146-153.

Tariq, A. S. Akram, Z. Shabbir, G. Gulfraz, M. Khan, K. S. Iqbal, M. S. and Mahmood, T. 2012. Character association and inheritance studies of different sorghum genotypes for fodder yield and quality under irrigated and rainfed conditions. African J. of Biotech., 11 (38): 9189-9195.

Yaqoob, M. Hussain, N. and Rashid, A. 2015. Genetic variability and heritability analysis for yield and morphological traits in sorghum [Sorghum bicolor (L.) Moench] genotypes. J. Agric. Res., 53(3) 331-343.
Table 1. Mean, range and genetic parameters for yield and yield attributing traits in sorghum mutants (M₄)

| Character | Range | Co-efficient of variation | Heritability (%) | Expected Genetic advance @ 5% | Genetic advance as % of mean |
|-----------|-------|---------------------------|------------------|-------------------------------|-------------------------------|
|           | Min.  | Max.                      | GCV | PCV | broad sense |                               |                               |
| DFF       | 55.00 | 72.00                     | 68  | 2.60 | 2.94        | 78.63                        | 3.23                          | 4.76                          |
| DM        | 102.00| 117.00                    | 112 | 2.52 | 2.69        | 87.33                        | 5.43                          | 4.85                          |
| NL        | 6.50  | 13.33                     | 11  | 7.02 | 11.28       | 38.77                        | 0.97                          | 9.01                          |
| PH        | 75.00 | 221.00                    | 160 | 12.89| 16.11       | 64.00                        | 34.34                         | 21.25                         |
| SG        | 0.95  | 2.53                      | 1.51| 16.98| 19.00       | 79.89                        | 48.60                         | 31.26                         |
| PNL       | 4.00  | 19.67                     | 9.30| 7.63 | 24.23       | 9.92                         | 0.44                          | 4.95                          |
| PL        | 7.00  | 22                        | 12.34| 14.74| 19.55       | 56.83                        | 2.80                          | 22.89                         |
| PW        | 8.67  | 69.33                     | 36.74| 26.87| 33.41       | 64.69                        | 16.33                         | 44.52                         |
| PWT       | 1.17  | 5.70                      | 3.63| 20.93| 22.71       | 84.97                        | 1.44                          | 39.75                         |
| 100SW     | 1.85  | 4.07                      | 2.94| 11.69| 13.02       | 80.71                        | 64.36                         | 21.64                         |
| GYPP      | 4.50  | 41.26                     | 19.33| 27.55| 34.82       | 62.61                        | 8.72                          | 44.91                         |

DFF= Days to 50% flowering  DM = Days to maturity  NL= Number of leaves (cm)  PH= Plant height (cm)  SG= Stem girth (cm)  PNL= Panicle neck length (cm)  PL= Panicle length (cm)  PW = Panicle Weight (gm)  PWT = Panicle width (cm)  100SW= 100 Seed weight (gm)  GYPP= Grain yield per plant (gm)
Table 2. Correlations coefficients for yield and attributing traits in sorghum mutants

| Character | DM    | NL     | PH     | SG      | PNL    | PL     | PW     | PWT    | 100SW  | \( r_{GP} \) |
|-----------|-------|--------|--------|---------|--------|--------|--------|--------|--------|------------|
| DFF       | 0.6490 ** | 0.0858 | 0.1141 | 0.1459  | -0.1132 | 0.1413 | 0.0122 | 0.0063 | 0.0954 | 0.0276     |
| DM        | 1     | 0.0911 | 0.1016 | 0.1505 * | -0.1675 * | 0.2236 ** | 0.0451 | -0.0381 | -0.1490 * | 0.1095  |
| NL        | 1     | 0.6093 ** | 0.4492 ** | -0.3958 ** | 0.2553 ** | 0.1221 | 0.4188 ** | -0.0616 | 0.1849 * |            |
| PH        | 1     | 0.3408 ** | -0.0441 | 0.4645 ** | 0.1958 ** | 0.5500 ** | -0.0861 | 0.2398 ** |            |           |
| SG        | 1     | -0.2859 ** | 0.0745 | 0.1776 * | 0.3330 ** | 0.0733 | 0.2229 ** |            |           |            |
| PNL       | 1     | 0.0942 | 0.0790 | 0.0429 | -0.1143 | -0.0025 |            |            |           |            |
| PL        | 1     | 0.2426 ** | 0.2407 ** | -0.3121 ** | 0.2550 ** |            |            |           |           |            |
| PW        | 1     | 0.3192 ** | 0.0831 | 0.9090 ** |            |            |            |           |           |            |
| PWT       | 1     | 0.0338 | 0.3291 ** |            |            |            |            |           |           |            |
| 100SW     | 1     | 0.0498 |            |            |            |            |            |           |           |            |
| GYPP      | 1     |        |            |            |            |            |            |           |           |            |

** = Significant at 1 per cent  
* = Significant at 5 per cent

DFF= Days to 50% flowering  
DM = Days to maturity  
NL = Number of leaves (cm)  
PH = Plant height (cm)  
SG = Stem girth (cm)  
PNL = Panicle neck length (cm)  
PL = Panicle length (cm)  
PW = Panicle Weight (gm)  
PWT = Panicle width (gm)  
100SW= 100 Seed weight (gm)  
GYPP= Grain yield per plant (gm)
Table 3. Phenotypic path analysis of different yield components among sorghum mutants

| Characters | DFF | DM  | NL  | PH  | SG  | PNL | PL  | PW  | PWT | 100SW | r<sub>GYPP</sub> |
|------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|----------------|
| DFF        | -0.0518 | 0.0547 | 0.001 | 0.0036 | 0.0031 | 0.0062 | 0.0007 | 0.0109 | 0.0001 | -0.0010 | 0.0276 |
| DM         | -0.0336 | 0.0842 | 0.0011 | 0.0032 | 0.0032 | 0.0092 | 0.0011 | 0.0403 | -0.0008 | 0.0015 | 0.1095 |
| NL         | -0.0044 | 0.0077 | **0.0121** | 0.019 | 0.0096 | 0.0218 | 0.0013 | 0.1089 | 0.0084 | 0.006 | 0.1849** |
| PH         | -0.0059 | 0.0086 | 0.0074 | **0.0311** | 0.0073 | 0.0024 | 0.0024 | 0.1747 | 0.0111 | 0.009 | 0.2398*** |
| SG         | -0.0076 | 0.0127 | 0.0054 | 0.0106 | **0.0213** | 0.0157 | 0.0004 | 0.1584 | 0.0067 | -0.0008 | 0.2229*** |
| PNL        | 0.0059 | -0.0141 | -0.0048 | -0.0014 | -0.0061 | **-0.0550** | 0.0005 | 0.0705 | 0.0009 | 0.0012 | -0.0025 |
| PL         | -0.0073 | 0.0188 | 0.0031 | 0.0145 | 0.0016 | -0.0052 | **0.0051** | 0.2164 | 0.0048 | 0.0032 | 0.255** |
| PW         | -0.0006 | 0.0038 | 0.0015 | 0.0061 | 0.0038 | -0.0043 | 0.0012 | **0.8920** | 0.0064 | -0.0009 | 0.909** |
| PWT        | -0.0003 | -0.0032 | 0.0051 | 0.0171 | 0.0071 | -0.0024 | 0.0012 | 0.2847 | **0.0201** | -0.0003 | 0.3291** |
| 100SW      | -0.0049 | -0.0126 | -0.0007 | -0.0027 | 0.0016 | 0.0063 | -0.0016 | 0.0741 | 0.0007 | **-0.0103** | 0.0498 |

Phenotypic residual value = 0.399

** = Significant at 1 per cent
* = Significant at 5 per cent

DFF= Days to 50% flowering  DM = Days to maturity  NL= Number of leaves (cm)  PH= Plant height (cm)
SG= Stem girth (cm)  PNL= Panicle neck length (cm)  PL= Panicle length (cm)  PW = Panicle Weight (gm)
PWT = Panicle width (cm)  100SW= 100 Seed weight (gm)  GYPP= Grain yield per plant (gm)

r<sub>GYPP</sub> = correlation value for grain yield per plant
Electro
nic Journal of Plant Breeding, 10(4):1383-1389 (Dec 2019)
ISSN 0975-928X
DOI: 10.5958/0975-928X.2019.00177.7
https://ejplantbreeding.org