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# The Association Studies Between Yield and its Attributing Traits in $M_4$ Generation of *rabi* sorghum [*Sorghum bicolor* (L.) Moench]

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**ABSTRACT: The experiment was executed in Agricultural Research Station, Hagari during *rabi* 2020. The study was conducted in augmented design to ascertain the correlation and path analysis in 200 sorghum mutant lines of $M_4$ generation. The positive significant correlation with grain yield were shown by *viz.,* number of leaves, stem girth, plant height, panicle length, panicle width, panicle weight, 100-seed weight and fodder yield at phenotypic level. Among these traits panicle weight (r=0.9830) showed highest positive association with grain yield compared to other traits. The characters *viz.,* panicle weight, fodder yield, stem girth, days to maturity, panicle length, 100-seed weight, panicle width, SPAD 90 and number of leaves showed positive direct effects on grain yield per plant. These traits play a greater role in selection of desirable mutants and at same time, improvement of these characters will effectively increase the grain yield.**

**Keywords:** Correlation, Path analysis, Mutants, Sorghum.

## INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench], is popularly known as "Jowar" a cultivated diploid (2n = 20) tropical cereal $C_4$ grass plant, and it is the fifth most important cereal crop grown in the world. It is a monocotyledon plant of tropical origin, belonging to Poaceae family (Nagara, 2017). It is called as camel of crops due to the high tolerance of water and temperature stress and also high photosynthesis efficiency; it is considered as an important crop plant in arid and semi-arid regions (Anagholi *et al*., 2000). In India, it covers an area about 4.09 million hectare with production of 3.48 million tonnes and productivity of 845 kg/ha. In Karnataka, it is grown in 0.94 million ha with production of 0.89 million tonnes and productivity of 945 kg/ha (INDIASTAT, 2019). Major sorghum growing districts of Karnataka are Kalaburgi, Raichur, Koppal, Belagavi, Ballari and Vijayapur.

Mutation is considered as one of the driving forces of evolution. Induced mutation breeding is relatively quicker method to create variability for quantitatively inherited traits in different plants (Camargo *et al*., 2000). It is induced through both physical and chemical mutagens, in which gamma radiation is an important tool for inducing the genetic variability, which intern throw potential mutants for enhancing yield and its yield contributing traits (Thapa, 2004). One per cent sodium azide is utilized for inducing mutation in sorghum for enhancing germination rate, root length, shoot length, bold seeds and yield attributing traits (Dahot *et al*., 2011).

Correlation coefficients nearly describe the existence of association between characters. The method of path coefficient developed by Wright (1921) is helpful in assessing whether association of characters with yield is having direct or indirect effect on yield or is a consequence in indirect effect through some other traits. Yield is a complex character, which depends upon many independent contributing characters. Knowledge on type of association between yield and its components themselves greatly help in evaluating the contribution of different components towards yield, information on the nature of association between yield and its components help in simultaneous selection for many characters associated with yield improvements (Swamy *et al*., 2018). This study aims to measure the direct and indirect effect of traits on grain yield and association among yield traits by utilizing the correlation and path analysis.

## MATERIAL AND METHODS

Two line seeds *viz*., IS925 and Phule Vasudha of sorghum were sent to Bhabha Atomic Research Centre (BARC) Trombay, Mumbai. The 80 seeds of both the lines were irradiated with 300 Gy gamma rays and the irradiated seeds were also treated with 0.1 per cent

sodium azide. In $M_3$ generation 80 irradiated and 20 irradiated + 0.1 % sodium azide treated lines were selected in each genotypes at equilibrium moisture content of eight per cent. The $M_3$ progenies were raised at ARS Hagari. Hundred mutants from IS925 variety (80 irradiated and 20 irradiated + chemical treated) and 100 mutants from Phule Vasudha variety (80 irradiated and 20 irradiated + chemical treated) were selected from the $M_3$ generation and used as seed material along with checks *viz*., IS-2312, GS-23, DSV-4, E-36-1, DJ-6514, SPV-86 and M-35-1 for present investigation ($M_4$ generation).

Mutant population was grown in the field during *rabi* 2020 at Agricultural Research Station (ARS), Hagari. Geographically, the location is situated at North-Eastern Dry Zone (Zone-3) of Karnataka situated between 15˚ 14' N latitude and 77˚ 07' E longitude with an altitude of 414 meters above the mean sea level. Two hundred 200 mutants were sown in augmented design, (Federer, 1977) in 4 m length with inter row spacing of 45 cm and intra row spacing of 15 cm. Each genotype sown in one row and each block contained 50 mutants with 7 checks *viz*., DJ 6514, IS 2312, M 35-1, DSV-4, E-36-1, SPV-86 and GS 23 replicated in 4 blocks for evaluating yield and yield attributing traits. Observations on SPAD 45, SPAD 90, Days to 50 per cent flowering, Days to maturity, Number of leaves, Stem girth, Plant height, Panicle length, Panicle width, Panicle weight, 100-seed weight, Fodder yield and Grain yield per plant observations were recorded on five randomly selected mutant plants in each entry. Mean values were used for statistical analysis.

## RESULTS AND DISCUSSION

Study of correlations helps the plant breeder to know how the improvement of one character will bring the simultaneous improvement of other characters. Correlation coefficients shows the magnitude of linear association between the pairs of characters and estimates the degree of closeness and linear relationship between the two variables. Hence, correlation analysis is important to know the mutual relationship between the two variables. Yield is a polygenically inherited trait with low heritability and is highly fluctuated by environmental effects; hence direct selection is not desirable for its improvement. Hence, magnitude and direction of association of component characters with yield acts as a pre-requisite for successful breeding programmes.

The phenotypic correlation for thirteen parameters of yield and its attributing traits among 200 mutant lines was worked out, in order to estimate the nature and extent of association between each component. The results are represented in Table 1.

**Table 1: Estimation of correlation coefficients for yield and yield attributing traits in $M_4$ sorghum mutant lines.**

| CHARACTER | SPAD 45 | SPAD 90 | DFF | DM | NL | SG | PH | PL | PWD | PW | 100SW | FY | $r_{gypp}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SPAD 45** | 1 | 0.3945 ** | -0.0120 | -0.0444 | -0.0155 | 0.1328 | 0.0183 | 0.0666 | -0.0128 | 0.0040 | -0.0480 | 0.0254 | 0.0036 |
| **SPAD 90** | | 1 | -0.0634 | -0.0876 | 0.0076 | -0.0032 | 0.0141 | 0.0423 | -0.1397 * | -0.2290 ** | -0.0628 | -0.2579 ** | -0.2330** |
| **DFF** | | | 1 | 0.9509 ** | 0.1612 * | 0.1216 | 0.3063 ** | -0.1321 | -0.0834 | -0.1243 | 0.0355 | -0.1315 | -0.1370* |
| **DM** | | | | 1 | 0.1457 * | 0.1416 * | 0.2700 ** | -0.1303 | -0.0721 | -0.0824 | 0.0650 | -0.0929 | -0.0930 |
| **NL** | | | | | 1 | 0.1649 * | 0.2915 ** | 0.1748 * | 0.1462 * | 0.0216 | 0.0827 | 0.0094 | 0.0130* |
| **SG** | | | | | | 1 | 0.3951 ** | 0.4143 ** | 0.2918 ** | 0.3194 ** | 0.0875 | 0.3374 ** | 0.2890** |
| **PH** | | | | | | | 1 | 0.3134 ** | 0.1609 * | 0.0971 | 0.2260 * | 0.0525* | 0.0710 |
| **PL** | | | | | | | | 1 | 0.6043 ** | 0.5053 ** | 0.2540 ** | 0.5027 ** | 0.4810** |
| **PWD** | | | | | | | | | 1 | 0.6446 ** | 0.2481 ** | 0.6288 ** | 0.6260** |
| **PW** | | | | | | | | | | 1 | 0.1989 * | 0.9759 ** | 0.9830** |
| **100SW** | | | | | | | | | | | 1 | 0.1882 * | 0.2050** |
| **FY** | | | | | | | | | | | | 1 | 0.9660** |
| **GYPP** | | | | | | | | | | | | | 1 |

**Phenotypic residual value = 0.175** * = Significant at 5% ** = Significant at 1%

**SPAD 45=** Soil Plant Analysis Development at 45 days **SPAD 90=** Soil Plant Analysis Development at 90 days

**DFF** = Days to 50 per cent flowering **DM** = Days to maturity **NL**= Number of leaves **SG**= Stem girth (cm) **PH**= Plant height (cm)

**PL**= Panicle length (cm) **PWD**=Panicle width (cm) **PW**=Panicle weight (g) **100SW**=100-seed weight (g)

**FY**= Fodder Yield (g) **GYPP**= Grain yield per plant (g) $r_{gypp}$ = correlation value for grain yield per plant

Grain yield character showed positive significant association with the panicle weight (r=0.9830), fodder yield (r=0.9660), panicle width (r=0.6260), panicle length (r=0.4810) and 100-seed weight (r=0.2050) similar results reported by Susmita and Selvi (2012) and similarly stem girth (r=0.2890) and number of leaves (r=0.0130) phenotypic correlation results reported by Akatwijuka *et al.* (2019). The trait plant height (r=0.0710) and SPAD 45 (r=0.0036) were positive and non-significantly associated with grain yield this association was reported by Godbharle *et al.* (2010) and Swamy *et al*. (2018) respectively. While grain yield per plant trait showing negative and significant correlation with the SPAD 90 (r=-0.2330), days to 50 per cent flowering (r=-0.1370) and non-significantly associated with days to maturity (r=-0.0930) these are similar with the reports of Godbharle *et al*. (2010); Khandelwal *et al*. (2015). Therefore, by selecting the traits which are positively correlated with grain yield will have direct influence on the grain yield and indirect selection of these traits will simultaneously improve the yield and makes effective selection of traits.

The determination of correlation alone may be often misleading due to mutual cancellation of component traits, so it is mandatory to study the path co-efficient analysis. Path coefficient analysis shows a relative contribution of different traits towards grain yield. Genotypic correlation and phenotypic correlation was partitioned into direct and indirect effects to observe the direct effect of a trait on grain yield and its indirect effect through other characters. The results are represented in Table 2 and Fig. 1.

**Table 2: Phenotypic path of different yield components on grain yield in $M_4$ sorghum mutant lines.**

| | SPAD 45 | SPAD 90 | DFF | DM | NL | SG | PH | PL | PWD | PW | 100SW | FY | $r_{gypp}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SPAD 45** | **-0.0071** | -0.0028 | 0.0001 | 0.0003 | 0.0001 | -0.0009 | -0.0001 | -0.0005 | 0.0001 | 0.0001 | 0.0003 | -0.0002 | 0.0036 |
| **SPAD 90** | 0.0019 | **0.0047** | -0.0003 | -0.0004 | 0.0001 | 0.0001 | 0.0001 | 0.0002 | -0.0007 | -0.0011 | -0.0003 | -0.0012 | -0.2330** |
| **DFF** | 0.0004 | 0.0022 | **-0.0352** | -0.0335 | -0.0057 | -0.0043 | -0.0108 | 0.0047 | 0.0029 | 0.0044 | -0.0013 | 0.0046 | -0.1370* |
| **DM** | -0.0012 | -0.0023 | 0.0251 | **0.0263** | 0.0038 | 0.0037 | 0.0071 | -0.0034 | -0.0019 | -0.0022 | 0.0017 | -0.0024 | -0.0930 |
| **NL** | 0.0001 | 0.0001 | -0.0004 | 0.0003 | **0.0023** | 0.0004 | 0.0007 | -0.0004 | 0.0003 | 0.0001 | 0.0002 | 0.0001 | 0.0130* |
| **SG** | -0.0032 | 0.0001 | -0.0029 | 0.0034 | -0.0040 | **0.0241** | 0.0095 | 0.0100 | 0.0070 | 0.0077 | 0.0021 | 0.0081 | 0.2890** |
| **PH** | -0.0001 | 0.0001 | -0.0015 | 0.0013 | -0.0014 | 0.0019 | **-0.0049** | 0.0015 | 0.0008 | 0.0005 | 0.0011 | 0.0003 | 0.0710 |
| **PL** | -0.0010 | -0.0006 | 0.0020 | 0.0020 | 0.0026 | -0.0062 | 0.0047 | **0.0150** | 0.0091 | 0.0076 | 0.0038 | 0.0075 | 0.4810** |
| **PWD** | 0.0001 | 0.0007 | 0.0004 | -0.0004 | 0.0007 | 0.0015 | 0.0008 | -0.0031 | **0.0051** | 0.0033 | 0.0013 | 0.0032 | 0.6260** |
| **PW** | 0.0034 | -0.1943 | -0.1055 | -0.0699 | -0.0184 | 0.2710 | 0.0824 | 0.4287 | 0.5469 | **0.8484** | 0.1687 | 0.8279 | 0.9830** |
| **100SW** | -0.0007 | -0.0009 | 0.0005 | 0.0010 | 0.0012 | 0.0013 | 0.0034 | 0.0038 | 0.0037 | 0.0030 | **0.0149** | 0.0028 | 0.2050** |
| **FY** | 0.0039 | -0.0396 | -0.0202 | -0.0143 | 0.0014 | 0.0518 | 0.0081 | 0.0772 | 0.0966 | 0.1499 | 0.0289 | **0.1536** | 0.9660** |

**Phenotypic residual value = 0.175** * = Significant at 5% ** = Significant at 1% If correlation r =>0.1364
**SPAD 45=** Soil Plant Analysis Development at 45 days **SPAD 90=** Soil Plant Analysis Development at 90 days
**DFF** = Days to 50 per cent flowering **DM** = Days to maturity **NL**= Number of leaves **SG**= Stem girth (cm) **PH**= Plant height (cm) **PL**= Panicle length (cm) **PWD**=Panicle width (cm) **PW**=Panicle weight (g) **100SW**=100-seed weight (g) **FY**= Fodder Yield (g) **GYPP**= Grain yield per plant (g) $r_{gypp}$ = correlation value for grain yield per plant

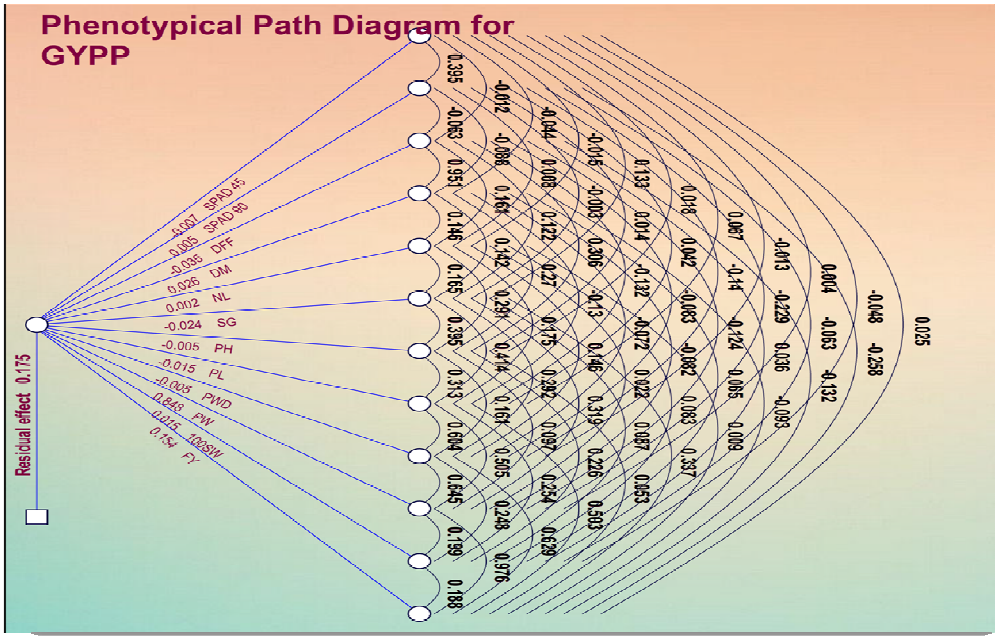


**Fig. 1.** Phenotypic path coefficient diagram showing influence of twelve major characters on grain yield per plant (GYPP) in $M_4$ sorghum mutant lines.

Nine out of twelve traits studied reveals that positive and direct effect on grain yield at phenotypic level. The traits like, panicle weight (0.8484), fodder yield (0.1536), days to maturity (0.0263), stem girth (0.0241), panicle length (0.0150), 100-seed weight (0.0149), panicle width (0.0051), SPAD 90 (0.0047) and number of leaves (0.0023) shows high magnitude and positive direct effects on grain yield. Concurrent results are reported by Susmita and Selvi (2012), Aml *et al*. (2012), Amare (2015). While trait like, days to 50 per cent flowering (-0.0352), SPAD 45 (-0.0071) and plant height (-0.0049) shows negative direct effects on grain yield. These results are in agreement with Pokriyal *et al.* (1976); Berenji (1990); Potdukhe *et al.* (1992); Shinde *et al*. (2014); Deshmukh *et al*. (2018). Among these traits panicle weight exerted maximum direct effect on grain yield per plant this result is similar to Shivaprasad *et al*. (2019). Negative direct contribution of plant height on grain yield was reported by Shinde *et al*. (2011).

Fodder yield (0.8279), panicle width (0.5469), panicle length (0.4287), stem girth (0.2710), 100-seed weight (0.1687) and plant height (0.0824) had the highest indirect contribution to grain yield through panicle weight. This indicates significance of these traits to panicle weight and grain yield, hence considering and simultaneous selection of these traits will play a vital role in improvement of yield.

It was clear from the path analysis that panicle weight, fodder yield, panicle width, days to maturity, stem girth, panicle length, 100-seed weight, panicle width, SPAD 90 and number of leaves were the most important components or characters showed high and positive direct effect on grain yield per plant. Hence, they may be considered as the most important yield contributing characters and more emphassis should be placed on these components while selecting for high yielding types in sorghum.

## CONCLUSION

After thorough study of correlation and path analysis, it concludes that traits *viz*., number of leaves, stem girth, panicle length, panicle width, panicle weight, 100-seed weight and fodder yield, more emphasis should be given for these traits while selecting the mutants for yield improvement.

## FUTURE SCOPE

Sorghum it is one of the important cereal crop grown in India. It is gaining more popularity due to its high tolerance of water and temperature stress and also high photosynthesis efficiency. It also has multiple uses such as food, livestock feed, ethanol production, starch production and production of adhesives and paper. Yield is a potential barrier to fulfil demands of future generations so by considering the yield and yield parameter association studies can breed for improved cultivar and with good quality traits. So this article provides enough information for future work.

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**Conflict of Interest.** None.

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