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Correlation and path coefficient analysis studies in mutant PVK 801 genotype of sorghum (*Sorghum bicolor* (L.) Moench)

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Abstract
Mutation was induced in sorghum cultivar 'PVK 801' with the help of gamma rays and EMS. The experimental material comprised of different mutagenic treatments treated with different concentrations *viz*., 0.1%, 0.2%, 0.3% were EMS treatments and 10 kR + 0.1% EMS, 20 kR + 0.1% EMS, 30 kR + 0.1% EMS and 40 kR + 0.1% EMS were combination treatments and dry and wet control treatments were evaluated for correlation and path analysis for the grain yield and some of the independent traits in M_2 generation. All these treatments were grown in *randomized block design* with three replications during *Kharif* 2019. The correlation studies revealed that positive and significant genotypic and phenotypic correlation of grain yield per plant with number of primaries per panicle, flag leaf area and 100 seed weight. The characters exerted direct positive effect on grain yield per plant with days to panicle initiation, days to maturity, plant height (cm), number of primaries per panicle, panicle length (cm), panicle width (cm) and 100 seed weight. Hence these traits can be considered as selection indices for sorghum improvement programme. The component of residual effect of path analysis was 0.4298.

Keywords: Sorghum, mutation, correlation, path coefficient analysis, gamma rays, EMS

Introduction
Sorghum [*Sorghum bicolor* (L.) Moench] cultivation is the heart of dry land agriculture, it is a C4 and often cross pollinated plant with higher abiotic stress tolerance and higher photosynthetic efficiency. Cultivated sorghums originated about 5000-7000 years ago or earlier in Northern East Africa, probably in Sudan or Ethiopia. Sorghum ranks fifth in global cereal production and is an important source of food, feed, fiber and fuel. Sorghum is especially adapted to growth in hot, arid, or semi-arid climate. In India sorghum is grown in areas receiving 500 to 1000 mm annual rainfall and temperature varying from 26 to 32 ºC. Correlation coefficients nearly describe the existence of association between characters. It is rather difficult to explain a system of correlation as the indirect association of the character increase. A positive genetic correlation between two desirable traits makes the job of the plant breeder easy for improving both traits simultaneously. Even the lack of correlation is useful for the joint improvement of the two traits. On the other hand, a negative correlation between two desirable traits impedes or makes it impossible to achieve a significant improvement in both traits. The path coefficient method was developed by Wright (1921) [9] and described by Dewey and Lu (1959) [6] is useful in assessing whether association of characters with yield is having direct or indirect influence on yield or is a consequence in indirect effect through some other characteristics. Path analysis between yield and yield contributing character was carried out by using simple correlation coefficient.

Material and Method
Seven different mutagenic treatments of PVK 801 *viz*., T1 (0.1%), T2 (0.2%), T3 (0.3%) EMS treatments and T4 (10kR+0.1% EMS), T5 (20kR+0.1% EMS), T6 (30kR+0.1% EMS) and T7 (40kR+0.1% EMS) combination treatments obtained from B.A.R.C. Trombay, Mumbai, along with two control treatments *viz*., T8 (dry control) and T9 (wet control) were sown in Randomized Block Design with 3 replications, at spacing of 15 cm within plants and 45 cm between plants in M_2 generation. The present study was undertaken at the field of Department of Agricultural Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani.

The pure seed of PVK 801 variety of sorghum (*Sorghum bicolor* (L). Moench) was selected for mutagenic treatment. The observations were recorded on following eleven characters. Days to panicle initiation, days to 50% flowering, days to maturity, plant height (cm), number of primaries per panicle, number of grains per primary, panicle length (cm), panicle width (cm), flag leaf area (cm^2), grain yield per plant (g) and 100 seed weight. The data were subjected to analysis of genotypic and phenotypic correlation (Johnson *et al*., 1955) [7] and path coefficients (Dewey and Lu, 1959) [6].

Results and Discussion

The results of analysis of variance for M_2 generation of *Kharif* sorghum are evaluated in Table 1. Highly significant differences among the genotypes were observed for eleven characters indicating presence of sufficient amount of variability among genotypes for these eleven characters.

The genotypic and phenotypic correlation coefficients are presented in Table 2 and 3 respectively. Correlation analysis provides the information on nature and magnitude of association between different component characters with grain yield per plant, which is regarded as highly complex trait in which the breeder is ultimately interested, so it is a matter of great importance to the plant breeders to find out to which of the characters are correlated with grain yield and also how they are associated among themselves. Grain yield per plant was found positively and significantly correlated with number of primaries per panicle, flag leaf area and 100 seed weight at both genotypic and phenotypic level. In other words, these traits are important for improvement of grain yield in sorghum.

The results are in close agreement with Kole *et al*., (2008) [8], Nimbalkar *et al.*, (1988) [10] and Veerabadhiran *et al.*, (2001) [13]. The character plant height, panicle length, panicle width and number of grains per primary showed positive but non-significant correlation with yield. Other characters such as days to panicle initiation, days to 50% flowering and days to maturity showed negatively but significant correlation with yield. Grain yield per plant showed positive and non-significant association with the characters like, number of grains per primary, plant height, panicle length and width. Kumar *et al.* (2011) [9] reported that grain yield had positive association with number of primaries per panicle, number of grains per primary, panicle length. The genotypic correlation was generally higher than phenotypic correlation which might be due to masking effect of environment (Singh and Makne, 1980) [12].

Path coefficient analysis measures the direct influence of one variable upon the other and permits separation of correlation coefficient into components of direct and indirect effects. Partitioning of total correlation into direct and indirect effects provides actual information on contribution of characters and thus forms the basis for selection to improve the yields.

The results pertaining to the path analysis are in Table 4. The path coefficient analysis studies revealed that days to panicle initiation (0.29), days to maturity (0.43), plant height (0.95), number of primaries per panicle (0.37), panicle length (0.69), panicle width (0.16) and 100 seed weight (0.12) exerted positive direct effect on grain yield per plant. The similar results were reported by Kole *et al*., (2008) [8] and Puspitasari *et al*., (2012) [11] for plant height and 100 seed weight. The characters days to 50% flowering (-1.10), number of grains per primary (-0.13) and flag leaf area (-0.04) showed negative direct effect on grain yield per plant.

The plant height (0.95) had highest positive direct effect followed by panicle length (0.69), days to maturity (0.43), number of primaries per panicle (0.37), days to panicle initiation (0.29), panicle width (0.16) and 100 seed weight (0.12) are important characters for grain yield improvement. The days to 50% flowering (-1.10), showed very high negative direct effect on grain yield per plant and the character flag leaf area (-0.04) showed very low negative direct effect on grain yield per plant. The component of residual effect of path analysis was 0.4298. The higher residual effect indicated the inadequacy of the trait chosen for the path analysis.

Table 1: Analysis of variance for various characters in M_2 generation of PVK 801 sorghum genotype

Source of variation	D.F.	Mean sum of squares										
		Days to panicle initiation	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primaries per panicle	Number of grains per primary	Panicle length (cm)	Panicle width (cm)	Flag leaf area (cm2)	Grain yield per plant (g)	100 seed weight (g)
		1	2	3	4	5	6	7	8	9	10	11
Replication	2	20.91	4.23	2.77	45.29	2.75	4.34	0.52	0.44	27.69	22.27	0.013
Treatment	8	84.72**	165.81**	149.49**	986.56**	213.31**	149.36**	78.44**	2.19**	586.43**	325.65**	0.15**
Error	16	7.19	24.16	19.27	40.49	39.26	2.64	25.29	0.20	45.48	7.14	0.019

* and ** indicates significance at 5% and 1% level, respectively

Table 2: Genotypic correlation between yield and its components in M_2 generation of PVK 801 sorghum genotype

Sr. No.	Characters	Days to panicle initiation	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primaries/ panicle	Number of grains/ primary	Panicle length (cm)	Panicle width (cm)	Flag leaf area (cm^2)	100 seed weight (g)	Grain yield/plant (g)
		1	2	3	4	5	6	7	8	9	10	11
1	Days to panicle initiation	1	0.8543**	0.7210**	0.3327	-0.7372**	-0.9023**	-0.7631**	-0.7947	-0.7564**	-0.7713**	-0.8885**
2	Days to 50% flowering		1	0.9715**	0.4490**	-0.6105**	-0.8091**	-0.7468**	-0.7076	-0.9666**	-0.9141**	-0.7926**
3	Days to maturity			1	0.6222*	-0.7609**	-0.9918*	-0.7286**	-0.9586	-0.9265**	-0.8717**	-0.8401**
4	Plant height (cm)				1	-0.7228**	-0.6981**	-0.9092**	0.4286	-0.6557*	-0.3908	0.0355
5	No. of primaries /panicle					1	0.9926*	0.8993**	0.4236	0.9031**	0.7304	0.9930*
6	No. of grains/ primary						1	0.9204**	0.9705	0.9175**	0.9609	0.3729
7	Panicle length (cm)							1	0.2615	0.6749**	0.6321	0.9487
8	Panicle width (cm)								1	0.9566	0.8531	0.4020
9	Flag leaf area (cm^2)									1	0.9129**	0.8504**
10	100 seed weight (g)										1	0.9247**
11	Grain yield per plant (g)											1

Table 3: Phenotypic correlation between yield and its components in M_2 generation of PVK 801 sorghum genotype

Sr. No.	Characters	Days to panicle initiation	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primaries/ panicle	Number of grains /primary	Panicle length (cm)	Panicle width (cm)	Flag leaf area (cm^2)	100 seed weight (g)	Grain yield /plant (g)
		1	2	3	4	5	6	7	8	9	10	11
1	Days to panicle initiation	1	0.6317**	0.5965**	0.2394	-0.5532**	-0.5158**	-0.5724**	-0.2632	-0.4999**	-0.5103**	-0.6695**
2	Days to 50% flowering		1	0.8555**	0.4894**	-0.5538**	-0.6582**	-0.5750**	-0.2210	-0.7493**	-0.5816**	-0.5545**
3	Days to maturity			1	0.4802*	-0.6060**	-0.4868*	-0.6499**	-0.2211	-0.7929**	-0.5512**	-0.5307**
4	Plant height (cm)				1	-0.6489**	-0.5221**	-0.7250**	0.1171	-0.3827*	-0.1392	0.0347
5	No. of primaries/ panicle					1	0.4558*	0.6147**	0.0678	0.5967**	0.2343	0.4526*
6	No. of grains/ primary						1	0.5944**	0.1709	0.5221**	0.3353	0.2724
7	Panicle length (cm)							1	0.1312	0.5821**	0.3440	0.3597
8	Panicle width (cm)								1	0.2320	0.2152	0.3190
9	Flag leaf area (cm^2)									1	0.5687**	0.5888**
10	100 seed weight (g)										1	0.5348**
11	Grain yield per plant (g)											1

Table 4: Path coefficient analysis in M_2 generation of PVK 801 sorghum genotypes

Sr. No.	Characters	Days to panicle initiation	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primaries/ panicle	Number of grains /primary	Panicle length (cm)	Panicle width (cm)	Flag leaf area (cm^2)	100 seed weight (g)
		1	2	3	4	5	6	7	8	9	10
1	Days to panicle initiation	0.2996	0.1893	0.1787	0.0717	-0.1657	-0.1545	-0.1715	-0.0788	-0.1498	-0.1529
2	Days to 50% flowering	-0.6961	-1.1019	-0.9427	-0.5393	0.6102	0.7252	0.6336	0.2435	0.8257	0.6409
3	Days to maturity	0.2605	0.3736	0.4367	0.2097	-0.2646	-0.2126	-0.2838	-0.0965	-0.3463	-0.2407
4	Plant height (cm)	0.2278	0.4658	0.4570	0.9517	-0.6175	-0.4969	-0.6899	0.1115	-0.3642	-0.1325
5	No. of primaries / panicle	-0.2096	-0.2099	-0.2297	-0.2459	0.3790	0.1727	0.2329	0.0257	0.2261	0.0888
6	No. of grains / primary	0.0677	0.0863	0.0639	0.0685	-0.0598	-0.1312	-0.0780	-0.0224	-0.0685	-0.0440
7	Panicle length (cm)	-0.3956	-0.3974	-0.4491	-0.5010	0.4247	0.4108	0.6910	0.0907	0.4022	0.2377
8	Panicle width (cm)	-0.0427	-0.0359	-0.0359	0.0190	0.0110	0.0277	0.0213	0.1623	0.0377	0.0349
9	Flag leaf area (cm^2)	0.0240	0.0360	0.0381	0.0184	-0.0287	-0.0251	-0.0280	-0.0112	-0.0481	-0.0273
10	100 seed weight (g)	-0.0663	-0.0756	-0.0716	-0.0181	0.0304	0.0436	0.0447	0.0280	0.0739	0.1299
11	Grain yield per plant (g)	-0.5307	-0.6695	-0.5545	0.0347	0.3190	0.3597	0.3724	0.4526	0.5888	0.5348
	Partial R^2	-0.1590	0.7378	-0.2422	0.0330	0.1209	-0.0472	0.2573	0.0734	-0.0283	0.0695

R square = 0.8153, Residual effect = 0.4298

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