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Genetic variability and path analysis in little millet (*Panicum sumatrense* L.)

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Abstract
The present study comprises of forty-four genotypes of little millet out of which twenty seven genotypes collected from local area of Konkan region while remaining seventeen genotypes were collected from zonal agriculture research station Kolhapur. These genotypes were cultivated in a Randomized Block Design with two replications at Education and Research Farm, Department of Agricultural Botany, College of Agriculture, Dapoli during the *Kharif* 2021. As a result of the current investigation, it is clear that a wide range of variability exists for various traits, along with high heritability and high genetic advance as percentage of the mean for significant yield traits. Days to maturity, thousand seed weight, protein content, calcium content had a positive direct effect on grain yield. Therefore, these features might be used in direct selection in order to increase little millet's grain output. Path coefficient analysis shown that, the characters *viz*., days to maturity, thousand seed weight, protein content, calcium content and straw yield per plant had positive direct effect on grain yield.

Keywords: Little millet, genotypes, genetic variability, path analysis etc

Introduction

Little millet (*Panicum sumatrense* L.) is one of the most important millets. It belongs to the family ponceau and sub family panicoid. In India it is commonly known as Sama, Samoa, moray, vary and kutki. It is self-pollinated crop and having basic chromosome number (tetraploid=2n=4x=36). Small millets being cultivated in India on an area of 6,19,000 ha. with production of 4,41,000 tones (Gowari and Shivkumar, 2020) [5]. In Maharashtra small millets occupied an area of about 36,962 ha with a production of 16,720 tones and the productivity level is 452 kg/ha, while area under small millets in Konkan region is 8,431 ha with production of 4500 tones and productivity is 530 kg/ha (Anonymous, 2021). It contains carbohydrate (60-75 g), crude fiber (4-8 g), protein (7-10 g) calcium (12-30 mg) and iron (7-13 mg) per 100 g which is more nutritious as compared to other cereals. (Himanshu *et al.*, 2018) [6]. Little millet can be grown in tropical and subtropical climates, and it is well known for its drought tolerance capacity. It is considered as one of the least waters demanding crop and it is suitable for late sowing, rain fed condition, drought tolerant, multiple and contingent cropping system. Compared to other small millets and staple food crops like rice and wheat, little millet contains fairly good amount of iron.

Variability arises as a result of variances in the genetic makeup of people in a group or changes in the environment in which they are raised. Knowledge of genetic variability in respect of yield structure in any species is valuable in plant breeding programmed. It helps in choice of the best yield attributes either for selection or hybridization. This may be achieved by estimating the genetic parameters *viz*; GCV, PCV heritability and genotypic advanced for grain yield and its component characters. Although, path coefficient analysis is helpful to recognize direct and indirect causes of correlation and also enables us to compare the causal factors on the genetic basis of their contribution.

Material and Methods

A total of 44 little millet genotypes were used in this experiment, which was done in *Kharif* 2021 at the Education and Research Farm Department of Agricultural Botany, College of Agriculture, Dapoli, using a randomized block design (RBD) with two replications. A plot measuring 0.40 X 10.5 m^2 was maintained, with a row-to-row distance of 20 cm and a plant-to-plant distance of 15 cm. The following data were collected for each replication: Days to 50% flowering, days to maturity, plant height (cm), number of tillers per plant, panicle length (cm), thousand seed weight (g), Grain yield (kg/plot), grain yield (q/ha), straw yield (kg/plot), grain yield per plant (g), straw yield per plant (g), Protein content (%), Calcium content (mg), Fiber content (%), Iron content (mg), Fat content (%).

Analysis was done on the average of all the plants for each characteristic under each replication (Panse and Sukhathme, 1967) [11]. Using the mean square values from the ANOVA table, the estimate of genotypic variance and phenotypic variance was calculated in accordance with the method recommended by Johnson *et al*. (1955) [7]. Based on the technique recommended by Burton *et al*., (1953) [2] the phenotypic and genotypic coefficients of variance were estimated. The approach outlined by Lush (1949) was used to estimate heredity per cent in a broad sense, while Robinson *et al*. (1949) [13] methods was used to classify features as having high, moderate, or low heritability The Johnson *et al*, (1955) [7] technique was used to evaluate genetic advance, which was represented as a percentage of the mean. According to the technique recommended by Johnson *et al*., (1955) [7] traits were categorised as having high, moderate, or low genetic advance. To establish a cause-and-effect relationship, the genotypic and phenotypic correlation coefficients were partitioned in direct and indirect effect by path analysis as suggested by Dewey and Lu (1959) [3].

Results and Discussion

Genetic variability

Any breeding programmed for genetic improvement must start with the fundamental knowledge of the genetic variability present in the crop. If selection is solely based on yield, it won't be very effective unless and until sufficient variability information is available to set the selection programmed for further improvement.

Analysis of variance exposed significant differences among the genotypes for all the quantitative characters *viz*., days to 50% flowering, days to maturity, number of productive tillers per plant, plant height, panicle length, thousand seed weight, grain yield (kg/plot), grain yield (q/ha), straw yield (kg/plot), protein content (%), calcium content (mg), fiber content (%), iron content (mg), fat content (%), straw yield per plant (g) and grain yield per plant (g) representing the presence of extensive genetic variation in the experimental material. Similar results were observed by Nirmalakumari *et al*. (2010) [10], Selvi *et al*. (2014) [4] and Anuradha *et al*. (2017) [1].

Table 1: Analysis of variance for yield and yield contributing traits in little millet.

Sr. No.	Characters	Mean sum of squares		
		Replication (1)	Genotype (43)	Error (43)
1	Days to 50% flowering	7.102	45.348**	4.335
2	Days to maturity	1.375	45.13**	9.375
3	Plant height(cm)	4.590	350.43**	20.080
4	Number of productive tillers per plant	0.382	0.357**	0.153
5	Panicle length(cm)	0.241	8.164*	4.058
6	Thousand seed weight(g)	0.003	0.012**	0.001
7	Grain Yield (kg/plot)	0.002	0.015**	0.004
8	Grain yield (q/ha)	1.005	8.388**	2.206
9	Straw Yield(kg/plot)	0.069	0.278**	0.124
10	Grain yield per plant (g)	0.003	1.603**	0.194
11	Straw yield per plant(g)	0.046	3.419**	0.488
12	Protein content (%)	0.001	1.221**	0.013
13	Calcium content (mg)	0.046	30.287**	1.627
14	Fiber content (%)	1.182	7.182**	0.619
15	Iron content (mg)	0.016	8.461**	0.133
16	Fat content (%)	0.005	3.124**	0.003

*Significant at 5% level. **Significant at 1% level

The total variability in each of the sixteen characters could be divided into three components *viz*., phenotypic, genotypic and environmental variation. Out of these, the genotypic variation is of prime importance which helps to determine the heritable and non-heritable portion of variation with respect to characters under study. The result showed that magnitude of phenotypic variance was higher than genotypic variance denoting the influence of environment. Similar finding was observed by Govindaraj *et al*. (2011) [4].

The variability of phenotypes was often higher than the variability of their corresponding genotypes. The genotypic coefficient of variation allows for comparison of the degree of variation and aids in determining the genetic stability of various features. According to estimations of PCV the genotypes were extremely varied for fat content (40.67%), followed by calcium content (34.13%), iron content (29.45%), fiber content (24.18%), grain yield per plant (22.87%), straw yield per plant (22.25), straw yield per plot (19.48%), grain yield per plot (18.70%), grain yield per ha (18.63%), number of productive tillers per plant (16.62%), protein content (13.57%). These results are in agreement with Shingane *et al*. (2016) [16] for number of productive tillers per plant, iron content, grain yield per plant and straw yield per plant. Also, Kavya *et al*. (2017) [8] observed similar results for PCV often higher than GCV.

Heritability is a useful metric for measuring how traits are passed down from one generation to the next and serves as a tool for us to choose superior genotypes from a wide range of genetic populations. In the present investigation, high evaluation of heritability in broad sense was observed for the characters fat content (99.81%), followed by protein content (97.91%), iron content (96.91%), thousand seed weight (93.75%), calcium content (89.80%), plant height (89.16%), fiber content (84.13%), days to 50% flowering (82.55%), grain yield per plant (78.39%) and straw yield per plant (75.04%) showing that these characters may serve as effective selection parameters during breeding programme for the improvement of Little millet productivity. Similar results were reported by Anuradha *et al*. (2017) [1] and Kavya *et al*. (2017) [8] for grain yield per plant and straw yield per plant.

Whereas Number of productive tillers per plant (40.20%), straw yield per plot (38.25%) and panicle length (33.59%) recorded low estimates of heritability. These findings are in conformity with Subramanian *et al.* (2010), Patil *et al.* (2013) [12], Sao *et al.* (2017) [14] and Shivangi *et al.* (2017).

Table 2: Estimates of phenotypic ($\sigma^2 p$), genotypic ($\sigma^2 g$) and environmental ($\sigma^2 e$) variance for little millet genotypes.

Sr. No.	Characters	Phenotypic variance	Genotypic variance	Environmental variance
1	Days to 50% flowering	24.84	20.51	4.33
2	Days to maturity	27.25	17.88	9.38
3	Plant height(cm)	185.26	165.17	20.08
4	Number of productive tillers per plant	0.26	0.10	0.15
5	Panicle length(cm)	6.11	2.05	4.06
6	Thousand seed weight(g)	0.01	0.01	0.00
7	Grain Yield (kg/plot)	0.01	0.01	0.00
8	Grain yield (q/ha)	5.29	3.09	2.20
9	Straw Yield(kg/plot)	0.20	0.08	0.12
10	Grain yield per plant (g)	0.90	0.70	0.19
11	Straw yield per plant(g)	1.95	1.47	0.49
12	Protein content (%)	0.62	0.60	0.01
13	Calcium content (mg)	15.96	14.33	1.63
14	Fiber content (%)	3.90	3.28	0.62
15	Iron content (mg)	4.30	4.16	0.13
16	Fat content (%)	1.56	1.56	0.00

Genetic advancement forecasts the genetic improvement under selection. Because heritability, phenotypic standard deviation, and selection intensity all play a role in determining its estimated value, genetic advance expressed as a percentage of the mean provides a more accurate indicator of how well selection has worked to improve a characteristic. The genetic advance ranged from grain yield per plot (0.12) to plant height (25.00). The estimate of genetic advance as per cent of mean ranged from panicle length (4.21%) to fat content (83.63%). The traits such as fat content (83.63%) followed by calcium content (63.14%), iron content (58.79%), fibre content (41.90%), grain yield per plant (36.93%), straw yield per plant (34.40%), protein content (27.37%), grain yield per plot (22.54%), and grain yield per ha (22.41) revealed higher estimate of genetic advance as per cent mean, which clearly specified that highest priority should be given for these characters while formulating selection strategies and selection of these characters may be effective. Panicle length (4.21%) and days to maturity (5.53%) showed minimum genetic advance as per cent of mean. Similar results were observed by Savankumar *et al.* (2018) [15] for days to maturity.

However, estimation of heritability along with genetic advance is more useful in predicting the resultant effect from selecting the best individual. In the present study, high heritability coupled with high genetic advance as per cent of mean was noticed in fat content (99.81, 83.63), iron content (96.91, 58.79), calcium content (89.80, 63.14), fibre content (84.13, 41.90,), grain yield per plant (78.39, 36.93), straw yield per plant (75.04, 34.40) and protein content (97.91, 27.37). It showed the presence of minor environmental impact and dominance of additive gene action in their expression. High heritability along with low genetic advance were detected for thousand seed weight (93.75, 9.23), plant height (89.16, 17.70), days to 50% flowering (82.55, 8.78), days to maturity (65.60, 5.53), grain yield per plot (58.51, 22.54), grain yield per ha (58.39, 22.41), number of productive tillers per plant (40.20, 13.76), straw yield per plot (38.25, 15.35), and panicle length (33.59, 4.21) specifying these traits may be controlled by non-additive gene action. Similar results were recorded by Sao *et al.* (2017) [14] for grain yield per plant and straw yield per plant.

Table 3: Estimates of genetic parameters of various characters of little millet genotypes.

Sr. No.	Characters	PCV (%)	GCV (%)	ECV (%)	H(^{2}bs) (%)	GA	GAM (%)
1	Days to 50% flowering	5.16	4.69	2.16	82.55	8.48	8.78
2	Days to maturity	4.09	3.31	2.40	65.60	7.05	5.53
3	Plant height(cm)	9.64	9.10	3.17	89.16	25.00	17.70
4	Number of productive tillers per plant	16.62	10.54	12.85	40.20	0.42	13.76
5	Panicle length(cm)	6.08	3.52	4.95	33.59	1.71	4.21
6	Thousand seed weight(g)	4.78	4.63	1.18	93.75	0.15	9.23
7	Grain Yield (kg/plot)	18.70	14.30	12.02	58.51	0.12	22.54
8	Grain yield (q/ha)	18.63	14.24	12.02	58.39	2.77	22.41
9	Straw Yield(kg/plot)	19.48	12.05	15.31	38.25	0.35	15.35
10	Grain yield per plant (g)	22.87	20.25	10.63	78.39	1.53	36.93
11	Straw yield per plant(g)	22.25	19.28	11.12	75.04	2.16	34.40
12	Protein content (%)	13.57	13.43	1.96	97.91	1.58	27.37
13	Calcium content (mg)	34.13	32.34	10.90	89.80	7.39	63.14
14	Fiber content (%)	24.18	22.17	9.63	84.13	3.42	41.90
15	Iron content (mg)	29.45	28.99	5.18	96.91	4.14	58.79
16	Fat content (%)	40.67	40.63	1.74	99.81	2.57	83.63

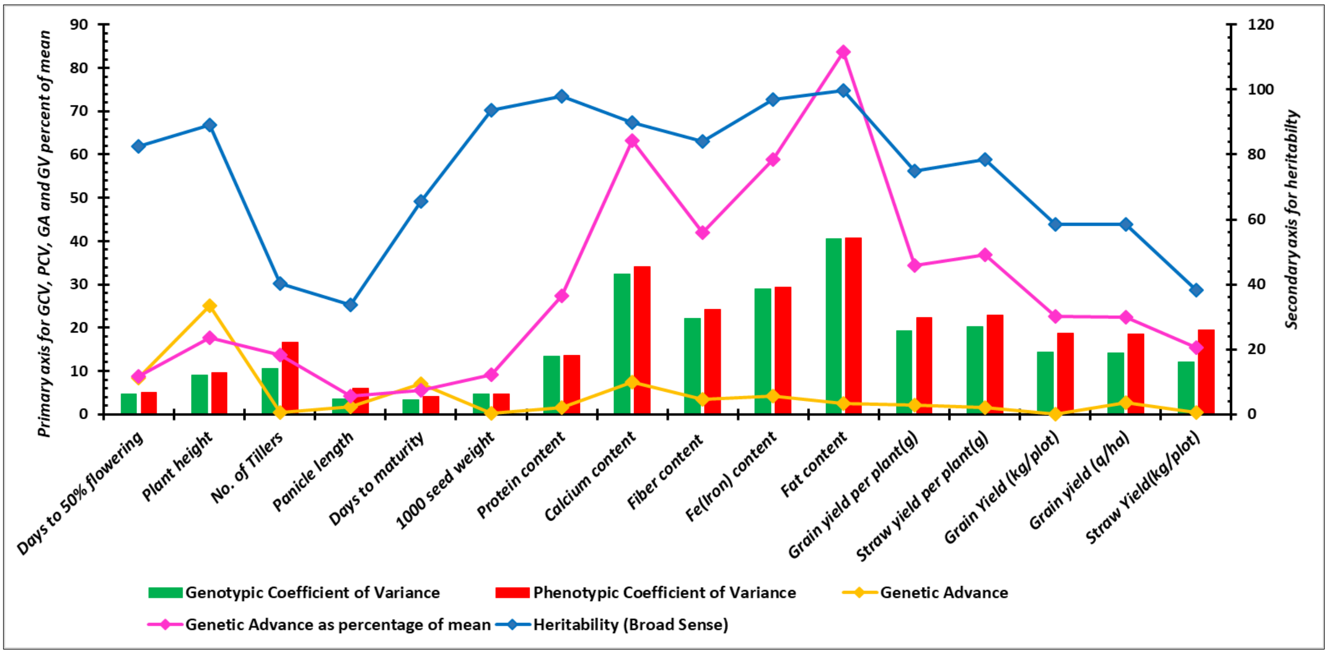

Fig 1: Shows a graphical representation of genotypic and phenotypic coefficient of variation, heritability and genetic advance as a percentage of the mean.

Table 4: Path analysis for different characters at phenotypic levels in little millet genotypes.

	DF	PH	NT	PL	DM	TW	PC	CC	Fibber C	Fe C	Fat C	SY	GY
DF	-0.035	-0.004	-0.001	0.002	0.027	0.002	0.015	0.004	0.001	-0.004	0.000	0.111	0.116
PH	-0.010	-0.014	-0.008	0.003	0.003	0.001	0.006	-0.012	-0.006	0.002	-0.001	0.050	0.014
NT	0.001	0.003	0.034	-0.002	0.005	0.001	0.019	0.013	0.007	0.004	0.000	0.409	0.4937**
PL	0.008	0.005	0.008	-0.008	-0.002	0.001	-0.003	-0.002	-0.001	0.001	0.002	0.068	0.078
DM	-0.026	-0.001	0.004	0.000	0.037	0.002	0.001	0.002	0.006	-0.004	0.001	0.061	0.085
TW	-0.004	-0.001	0.002	0.000	0.004	0.016	-0.007	-0.001	0.000	-0.002	-0.001	-0.032	-0.019
PC	-0.008	-0.001	0.010	0.000	0.001	-0.002	0.064	0.022	-0.005	0.005	-0.003	0.465	0.5469**
CC	-0.003	0.003	0.008	0.000	0.001	0.000	0.026	0.054	0.002	0.001	-0.002	0.412	0.5016**
FIC	-0.001	0.002	0.006	0.000	0.007	0.000	-0.008	0.004	0.035	0.002	0.000	0.181	0.228*
FEC	0.007	-0.001	0.007	0.000	-0.006	-0.002	0.015	0.002	0.003	0.023	-0.002	0.177	0.2194*
FAC	-0.001	-0.001	0.001	0.002	-0.006	0.002	0.018	0.013	0.001	0.006	-0.009	0.099	0.125
SY	-0.004	-0.001	0.016	-0.001	0.003	-0.001	0.033	0.025	0.007	0.004	-0.001	0.887	0.9674**

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

DF- Days to 50% flowering	PH- Plant Height (cm)	NT- Number of tillers per plant	PL- Panicle Length (cm)
DM- Days to maturity	TW- Thousand seed weight (g)	PC- Protein content	CC- Calcium content
Fiber C- Fiber content	Fe C- Iron content	Fat C- Fat content	SY- Straw yield per plant
GY- Grain yield per plant			

Table 5: Path analysis for different characters at genotypic levels in little millet genotypes.

	DF	PH	NT	PL	DM	TW	PC	CC	Fiber C	Fe C	Fat C	SY	GY
DF	-0.415	-0.015	0.033	-0.007	0.336	0.002	0.023	0.000	0.000	0.004	0.002	0.190	0.1526
PH	-0.138	-0.045	0.076	-0.021	0.050	0.001	0.009	-0.001	0.008	-0.001	0.010	0.091	0.0391
NT	0.074	0.018	-0.188	0.025	0.034	0.002	0.043	0.001	-0.014	-0.005	0.002	0.851	0.8441**
PL	0.082	0.025	-0.123	0.038	0.018	0.003	-0.007	0.000	0.001	-0.002	-0.041	0.023	0.0185
DM	-0.341	-0.005	-0.016	0.002	0.410	0.002	0.003	0.000	-0.009	0.003	-0.018	0.064	0.0956
TW	-0.046	-0.003	-0.020	0.007	0.063	0.015	-0.011	0.000	0.000	0.002	0.012	-0.029	-0.0091
PC	-0.106	-0.004	-0.090	-0.003	0.015	-0.002	0.090	0.001	0.006	-0.004	0.026	0.698	0.629**
CC	-0.036	0.011	-0.081	0.002	0.031	0.000	0.038	0.003	-0.003	-0.001	0.024	0.644	0.6315**
FIC	0.000	0.009	-0.063	-0.001	0.096	0.000	-0.014	0.000	-0.040	-0.001	0.003	0.237	0.2254
FEC	0.100	-0.003	-0.058	0.004	-0.094	-0.002	0.022	0.000	-0.003	-0.015	0.024	0.263	0.2379
FAC	-0.009	-0.005	-0.005	-0.017	-0.082	0.002	0.026	0.001	-0.001	-0.004	0.090	0.145	0.1421
SY	-0.070	-0.004	-0.141	0.001	0.023	0.000	0.056	0.002	-0.008	-0.004	0.012	1.129	0.9948**

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

DF- Days to 50% flowering	PH- Plant Height (cm)	NT- Number of tillers per plant	PL- Panicle Length (cm)
DM- Days to maturity	TW- Thousand seed weight (g)	PC- Protein content	CC- Calcium content
Fiber C- Fiber content	Fe C- Iron content	Fat C- Fat content	SY- Straw yield per plant
GY- Grain yield per plant			

Path analysis

The relationship between two trait pairs is measured by the correlation. However, a dependent characteristic is an interaction between a number of parts that are associated with one another. The path analysis considers the relationship of cause and effect between the variables by dividing the association into direct and indirect effects through other independent variables to produce any such dependent variable.

Path coefficient analysis shown that the characters *viz*., days to maturity, thousand seed weight, protein content, calcium content and straw yield per plant had positive direct effect on grain yield at both level while, days to 50% flowering and plant height exhibited negative direct effect on seed yield per plant at both phenotypic and genotypic levels. The character panicle length and fat content had positive direct effect on grain yield per plant at phenotypic level and negative direct effect at genotypic level. The character number of productive tillers per plant, fiber content and iron content had positive direct effect on grain yield per plant at phenotypic level and negative direct effect at genotypic level.

Conclusion

As a result of the current investigation, it is clear that a wide range of variability exists for various traits, along with high heritability and high genetic advance as percentage of the mean for significant yield traits like plant height, days to 50% flowering, days to maturity, thousand seed weight, protein content, calcium content, iron content, fat content and grain yield per plant. Therefore, selections based on the traits could directly increase productivity in little millet. These features might be used in direct selection in order to increase little millet's grain output.

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