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Studies on correlation and path coefficient analysis in foxtail millet [*Setaria italica* (L.) BEAUV]

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Abstract
The present investigation consists of 40 genotypes of Foxtail Millet, which were grown in the Field Experimentation Centre of the Department of Genetics and Plant breeding, SHUATS, Prayagraj during *Kharif* 2019 following RBD with three with three replications. The data were recorded on 13 characters to study the analysis of variance, heritability, genetic advance, coefficient of variation, correlation coefficient and path analysis. Based on the mean performance genotype ISE1419, were identified as best genotypes for grain yield per plant. Highly significant variation was obtained for all characters studies. The values of PCV were higher than that of GCV for all the characters. High heritability estimates coupled with high genetic advance as percent mean were observed for Harvest index(%) followed by test weight, Grain yield, No. of basal tillers, Inflorescence width. Thus these traits are predominantly under the control of additive gene action and these Charecters can be improved by selection. Moderately high genetic advance observed for Days to 50% flowering, leaf width, flag leaf length Biological yield and No. of days to maturity. These traits appear to be under the control of both additive and non additive gene actions. The present study revealed that grain yield per plant was positively and significantly correlated with Days to 50% flowering, No. of Days to maturity, Plant height, Panicle length, Inflorescence width, Biological yield, Harvest index, Test weight. Path analysis studies revealed that Days to 50% flowering, Panicle length, Peduncle length, Biological yield, Harvest index and Test weight had true relationship with grain yield per plant by establishing significant positive association and positive direct effect at phenotypic level. Considering the nature and magnitude of character associations and direct and indirect effects, it can be inferred that days to 50% flowering, Panicle length, Peduncle length Biological yield, Harvest index and test weight could serve as important traits in any selection programme for developing high yielding foxtail millet genotypes.

Keywords: Foxtail millet, GCV, PCV, heritability, variability, genetic advance, correlation analysis and path coefficient analysis

Introduction

Foxtail millet [*Setaria italica* (L.) Beauv.] Is the most important cereal since ancient times in India and China. It became a major crop 4100 years ago (Cao, 1986) [6]. Vavilov (1926) [18] cited East Asia including China and Japan as the principal center of diversity. Foxtail Millet [*Setaria italica* (L.) Beauv.] A self-pollinating crop (2n=18) is grouped under the family Poaceae and sub family Panicoidae (Fedorov, 1974) [8]. Foxtail millet is one of the oldest cultivated small millets grown both for food and fodder. It ranks second in the total world production of millet; and continues to have an important place in world agriculture, providing food for millions of people in arid and semi arid regions. It is native to China. In India and Pakistan grown under rainfall ranging from 150-700 mm, is regained as an elite drought-tolerant crop. Andhra Pradesh, Karnataka and Tamil Nadu are the major foxtail millet growing states in India contributing about 79 per cent of the total area (Munirathnam *et at*., 2006) [15].

Foxtail millet is a promising source of micro nutrients and protein compared to other cereals. Foxtail millet grain is (per 100g) rich in protein (12.3%), iron (2.8 mg), calcium (31 mg) as compared to rice (7.9% protein and 1.8 mg iron) according to Millet Network of India (MINI). It also contains high quantity of beta carotene. They have a higher proportion of non starchy polysaccharides and dietary fiber. They release sugars very slowly and thus have a low glycemic index (GI) and hence can be used in therapeutic diet but its potential role as low GI food has remained unrealized and unexploited.

The low GI diet has been shown to reduce blood glucose levels (Anjuthathola *et al.*, 2011) [2],

Genetic variation increases the genetic diversity in and among populations allowing for new traits to become more or less prominent in the gene pool. The correlation analysis in combination, can give a better insight, into cause and effect relationship between different pairs of characters. The correlation measures the relationship existing between pairs of traits.

The aim of correlation studies is primarily to know the suitability of various characters for indirect selection because selection on any particular trait may bring about undesirable changes in other associated characters (Singh, 1988). The estimates of correlation coefficients mostly indicate the inter-relationships of the characters whereas path analysis permits the understanding of the cause and effect of related characters (Wright, 1921) [19]. The path analysis reveals whether the association of characters with yield is due to their direct effect on yield or is a consequence of their indirect effects via other component characters. Thus the correlation and path analysis in combination, can give a better insight, into cause and effect relationship between different pairs of characters.

Materials and Methods

The present investigation was carried out at Field Experimentation Centre, Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Science, Prayagraj, U.P. during *Kharif* -2019. The experimental materials constituted 40 foxtail millet genotypes which is received from ICRISAT, Hyderabad. The experiment was laid out in the Randomized Block Design with three replication and has three rows with spacing of row to row 30 cm and plant to plant 10 cm. The genotypes were sown by line sowing in each plot by imposing randomization in each replication.

Observations were recorded on days to 50% flowering, days to maturity, plant height (cm), leaf length, leaf width, panicle length, inflorescence width, peduncle length, number of basal tillers, biological yield (g), harvest index (%), Test weight (g), Grain yield per plant (g).

The data were subjected to the analysis of variance (Fisher and Yates 1938) [10] and further, biometrical procedures were followed to estimate genotypic and phenotypic coefficient of variation (Burton 1952) [5], heritability in broad sense (Burton and Devane 1953), genetic advance (Johnson *et al.* 1955) [12], correlation (Al-Jibouri *et al.*, 1958) [1] and path coefficient analysis (Dewey and Lu 1959) [7].

Result and Discussion

The analysis of variance for 13 different quantitative characters are presented in table 1.

The results showed significant differences for mean sum of square at 1% level for all the characters under study among 40 genotypes.

This suggested that the genotype selected for present study were quite variable and considerable levels of variability were present among them thus, indicating ample scope for selection of different quantitative characters for foxtail millet improvement. This finding was accordance with the finding of Yogeesh *et al.* (2015) [20] and Kumari *et al.* (2010) [14].

Table 1: Analysis of Variance for 13 different quantitative parameters in Foxtail millet genotypes

Characters	Mean of sum square		
	Replication df =2	**Treatment df = 39**	**Error df = 78**
Days to 50% flowering	469.40	424.75**	11.13
No. of Days to maturity	441.45	426.54**	12.20
Plant height (cm)	1344.97	7361.02**	345.27
Panicle length (cm)	5.12	22.93**	6.04
Flag leaf length (cm)	27.75	102.63**	9.71
Peduncle length (cm)	31.54	39.86**	6.95
Leaf width (cm)	0.017	0.18**	0.0028
No. of basal tillers	0.0023	24.31**	0.06
Inflorescence width (cm)	0.016	2.05**	0.013
Biological yield (g)	3.66	12.60**	0.058
Harvest index (%)	28.39	352.38**	3.96
Test weight (g)	1.29	11.78**	0.079
Grain yield (g)	0.44	1.19**	0.01

** = Significance at 1% level of significance and
* = Significane at 5% level of significance

The PCV was higher than GCV for all the characters under study which indicated that the environment factors influencing the characters studied. High magnitude of genotypic coefficient variation (GCV) were recorded for Grain yield (g) (64.603), Harvest index (%) (53.037), Test weight (g) (34.421), Inflorescence width (cm) (43.339), No. of basal tillers (43.861), Peduncle length (cm) (34.617), Leaf width (cm) (26.431), Flag leaf length (cm) (23.253), Days to 50% flowering (22.27) and Panicle length (cm) (21.017).

High magnitude of Phenotypic coefficient variation (PCV) were recorded for Grain yield (g) (65.257), Harvest index (%) (53.935), Peduncle length (cm) (44.244), No. of basal tillers (44.047), Inflorescence width (cm) (43.767), Test weight (g) (34.891), Panicle length (cm) (30.276), Leaf width (cm) (27.055), Flag leaf length (cm) (26.651), Days to 50% flowering (23.159) and Plant height (cm) (20.815).

In the present investigation, the heritability estimate were found to be high (>60) for Test weight (g) (97.3), Harvest index (%) (96.7), Grain yield (g) (98.00), Biological yield (g) (98.1), No. of basal tillers (99.2), Inflorescence width (cm) (98.6), Leaf width (cm) (95.4), Peduncle length (cm) (61.22), Flag leaf length (cm) (76.1), Days to 50% flowering (92.5) and No. of Days to maturity (91.9). Whereas moderate estimates were observed for Plant height (cm) (27.10), Panicle length (cm) (48.22). Similar results have been reported by Kumari *et al.* (2010) [14], Nirmalakumari and Vetriventhan (2010) [16], Suryanarayana *et al.* (2014) [17] reported high heritability for grain yield and peduncle length.

Genetic advance was highest for Days to 50% flowering (23.267), No. of Days to maturity (23.206) and Harvest index (%) (21.831). Similar findings by Nirmalakumari *et al.* (2010)

[16], Vetriventhan (2011) reported high genetic advance for days to 50% flowering.

Genetic advance as mean percent was highest for Harvest index (%) (107.438), Test weight (g) (69.953), Inflorescence width (cm) (88.406), Peduncle length (cm) (55.795), Leaf width (cm) (53.194), No. of basal tillers (89.972), Days to 50% flowering (44.143), Flag leaf length (cm) (41.794), Panicle length (cm) (30.055), Biological yield (g) (29.198), Grain yield (g) (131.748), No. of Days to maturity (27.042). Similar findings by S.M. Brunda *et al.* (2014) [4] reported that high genetic advance for grain yield.

Genotypic correlation between grain yield per plant showed positive significant genotypic association with Days to 50% flowering (0.441**), No. of Days to maturity (0.434**), Plant height (cm) (0.577**), Panicle length (cm) (0.346**), Inflorescence width (cm) (0.205*), Biological yield (g) (0.794**), Harvest index (%) (0.984**), Test weight (g) (0.774**).

Phenotypic correlation coefficient analysis revealed that grain yield plant^{-1} (g) showed positive significant phenotypic association with Days to 50% flowering (0.412**), No. of Days to maturity (0.402**), Plant height (cm) (0.293**), Panicle length (cm) (0.233*), Inflorescence width (cm) (0.202*), Biological yield (g) (0.781**), Harvest index (%) (0.982**) and Test weight (g) (0.757**).

Similar findings are with Nirmalakumari and Vetriventhan (2010) [16] for plant height Ulangathan and Kumari (2014) [16] for test weight and flag leaf length, Kavya (2017) [13] and Ayesha *et al*. (2019) [3] for plant height, flag leaf length and panicle length

The genotypic path coefficient among the different grain yield (g) plant^{-1} traits in foxtail millet were worked out to assess the association among themselves. Revealed that highest direct positive effect on grain yield (g) plant^{-1} was exhibited by days to 50% flowering, panicle length (cm), peduncle length (cm), leaf width (cm), biological yield (g) and harvest index (%).

The phenotypic path coefficient among the different grain yield (g) plant^{-1} traits in foxtail millet were worked out to assess the association among themselves. Revealed that highest direct positive effect on grain yield (g) plant^{-1} was exhibited by no. of days to maturity, panicle length (cm), peduncle length (cm), biological yield (g), harvest index (%) and test weight (%).

Similar findings for direct and indirect effects in phenotypic and genotypic path coefficient analysis are with Nirmalakumari and Vetriventan (2015) and S.M. Brunda *et al*., (2014) [4].

Conclusion

It is concluded that genotype ISE1419 has recorded the highest yield followed by ISE 90, ISE907, ISE751, ISE96 superior for grain yield (g) plant^{-1} and other yield components under Prayagraj agro-climatic conditions. In general, PCV values were higher than GCV values which indicating the influence of environment on the expression of characters studied. Genetic advance was highest for Days to 50% flowering, No. of Days to maturity and Harvest index (%). Where as Genetic advance as mean percent was highest for Harvest index (%), Test weight (g), Inflorescence width (cm), Peduncle length (cm), Leaf width (cm), No. of basal tillers, Days to 50% flowering, Flag leaf length (cm), Panicle length (cm), Biological yield (g), Grain yield (g), No. of Days to maturity indicating a pre dominance of additive gene effects and the possibilities of effective selection upon these traits for improvement of Foxtail millet. Based on the results of correlation and path analysis it can be concluded that selection based on characters like Test weight Biological yield, plant height and panicle length had positive contribution with yield and positive significant direct effect towards yield results in yield improvement. Hence profuse plants with large panicles and more test weight may result in higher yield in genotypes of foxtail millet.

Since these findings are based on one year testing further research is needed substantiate the results.

Table 2: Estimation of genetic parameters for grain yield and other components

S. No.	Characters	Vg	Vp	GCV	PCV	h2% (Broad sense)	Genetic advance	Genetic Advance as% of Mean (GA%M)
1.	Days to 50% flowering	137.87	149	22.27	23.15	92.5	23.26	44.14
2.	No. of Days to maturity	138.11	150.31	13.69	14.28	91.9	23.20	27.04
3.	Plant height (cm)	128.58	473.85	10.84	20.81	27.10	12.16	11.63
4.	Panicle length (cm)	5.62	11.67	21.01	30.27	48.22	3.392	30.05
5.	Flag leaf length (cm)	30.97	40.68	23.25	26.65	76.1	10.003	41.79
6.	Peduncle length (cm)	10.97	17.92	34.61	44.24	61.22	5.33	55.79
7.	Leaf width (cm)	0.059	0.062	26.43	27.05	95.4	0.49	53.19
8.	No. of basal tillers	8.082	8.15	43.86	44.04	99.2	5.83	89.97
9.	Inflorescence width (cm)	0.68	0.69	43.33	43.76	98.1	1.68	88.40
10	Biological yield (g)	4.18	4.24	14.27	14.37	98.6	4.184	29.19
11.	Harvest index (%)	116.1	120	53.03	53.93	96.7	21.83	107.43
12.	Test weight (g)	0.39	0.40	34.421	34.89	97.3	1.27	69.95
13.	Grain yield (g)	3.90	3.98	64.60	65.25	98.00	4.02	131.74

Table 3: Genotypic correlation coefficient for 13 quantitative parameters in foxtail millet

S. No.	Characters	Days to 50% flowering	No. of Days to maturity	Plant height (cm)	Panicle length (cm)	Flag leaf length (cm)	Peduncle length (cm)	Leaf width (cm)	No. of basal tillers	Inflorescence width (cm)	Biological yield (g)	Harvest index (%)	Test weight (g)	Grain yield (g)
1.	Days to 50% flowering	1.00	0.856**	0.9313**	0.8536**	0.5052**	-0.5424**	0.3836**	0.0041	0.534**	0.475**	0.404**	0.377**	0.441**
2.	No. of Days to maturity		1.00	0.9138**	0.8533**	0.5059**	-0.5462**	0.3966**	-0.0007	0.546**	0.467**	0.397**	0.369**	0.434**
3.	Plant height (cm)			1.00	0.6968**	0.8248**	-0.4305**	0.4235**	-0.0001	0.689**	0.687**	0.529**	0.446**	0.577**
4.	Panicle length (cm)				1.00	0.5309**	-0.4959**	0.4341**	0.1652	0.351**	0.305**	0.323**	0.255**	0.346**

5.	Flag leaf length (cm)					1.00	0.135	0.499**	-0.0416	0.548**	0.194*	0.0022	0.1053	0.029
6.	Peduncle length (cm)						1.00	-0.0443	-0.1716	0.0063	-0.0661	-0.1235	0.190*	-0.118
7.	Leaf width (cm)							1.00	-0.0027	0.166	0.278**	0.116	0.206*	0.159
8.	No. of basal tillers								1.00	-0.1642	-0.0493	0.1418	0.0255	0.095
9.	Inflorescence width (cm)									1.00	0.397**	0.1599	0.182*	0.205*
10.	Biological yield (g)										1.00	0.687**	0.668**	0.794**
11.	Harvest index (%)											1.00	0.748**	0.984**
12.	Test weight (g)												1.00	0.774**
13.	Grain yield (g)													1.00

* = Significane at 5% level of significance ** = Significance at 1% level of signifance

Table 4: Phenotypic correlation coefficient for 13 quantitative parameters in foxtail millet

S. No.	Characters	Days to 50% flowering	No. of Days to maturity	Plant height (cm)	Panicle length (cm)	Flag leaf length (cm)	Peduncle length (cm)	Leaf width (cm)	No. of basal tillers	Inflorescence width (cm)	Biological yield (g)	Harvest index (%)	Test weight (g)	Grain yield (g)
1.	Days to 50% flowering	1.00	0.9974 **	0.4197 **	0.5251 **	0.4036 **	-0.4002 **	0.3582 **	0.002	0.5075 **	0.4539 **	0.3716 **	0.3539 **	0.412**
2.	No. of Days to maturity		1.00	0.4251 **	0.5348 **	0.4084 **	-0.3999 **	0.3703 **	-0.0032	0.5206 **	0.4453 **	0.3607 **	0.3432 **	0.402**
3.	Plant height (cm)			1.00	0.6041 **	0.5580 **	-0.0573	0.2123 *	0.0219	0.3745 **	0.3427 **	0.2729 **	0.2172 *	0.293**
4.	Panicle length (cm)				1.00	0.4780 **	-0.3505 **	0.3021 **	0.1239	0.2492 **	0.2085 *	0.2196 *	0.178	0.233*
5.	Flag leaf length (cm)					1.00	0.1909 *	0.4100 **	-0.0284	0.4866 **	0.1513	0.0114	0.0758	0.0238
6.	Peduncle length (cm)						1.00	-0.0282	-0.1266	0.0079	-0.0606	-0.0997	0.1265	-0.0995
7.	Leaf width (cm)							1.00	-0.0034	0.1632	0.2719 **	0.1072	0.1944 *	0.1505
8.	No. of basal tillers								1.00	-0.1623	-0.0488	0.1393	0.0248	0.0935
9.	Inflorescence width (cm)									1.00	0.3907 **	0.157	0.1758	0.202*
10.	Biological yield (g)										1.00	0.6658 **	0.6535 **	0.781**
11.	Harvest index (%)											1.00	0.7248 **	0.982**
12.	Test weight (g)												1.00	0.757**
13.	Grain yield (g)													1.00

* = Significane at 5% level of significance ** = Significance at 1% level of signifance

Table 5: Direct and indirect effects of genotypic path coefficient for thirteen characters in foxtail millet genotypes

S. No.	Characters	Days to 50% flowering	No. of Days to maturity	Plant height (cm)	Panicle length (cm)	Flag leaf length (cm)	Peduncle length (cm)	Leaf width (cm)	No. of basal tillers	Inflorescence width (cm)	Biological yield (g)	Harvest index (%)	Test weight (g)	Grain yield (g)
1.	Days to 50% flowering	0.361	0.361	0.336	0.308	0.182	-0.196	0.139	0.002	0.193	0.171	0.146	0.136	0.441**
2.	No. of Days to maturity	-0.367	-0.367	-0.336	-0.313	-0.186	0.201	-0.146	0.000	-0.200	-0.172	-0.146	-0.135	0.434**
3.	Plant height (cm)	-0.011	-0.011	-0.012	-0.008	-0.010	0.005	-0.005	0.000	-0.008	-0.008	-0.006	-0.005	0.577**
4.	Panicle length (cm)	0.052	0.052	0.043	0.061	0.033	-0.030	0.027	0.010	0.022	0.019	0.020	0.016	0.346**
5.	Flag leaf length (cm)	-0.022	-0.022	-0.036	-0.023	-0.044	-0.006	-0.022	0.002	-0.024	-0.009	0.000	-0.005	0.029
6.	Peduncle length (cm)	-0.013	-0.013	-0.010	-0.012	0.003	0.023	-0.001	-0.004	0.000	-0.002	-0.003	0.004	-0.118
7.	Leaf width (cm)	0.004	0.004	0.004	0.004	0.005	0.000	0.009	0.000	0.002	0.003	0.001	0.002	0.159

8.	No. of basal tillers	0.000	0.000	0.000	-0.003	0.001	0.003	0.000	-0.020	0.003	0.001	-0.003	-0.001	0.095
9.	Inflorescence width (cm)	-0.002	-0.002	-0.002	-0.001	-0.002	0.000	-0.001	0.001	-0.003	-0.001	-0.001	-0.001	0.205*
10.	Biological yield (g)	0.110	0.108	0.159	0.071	0.045	-0.015	0.064	-0.011	0.092	0.232	0.159	0.155	0.794**
11.	Harvest index (%)	0.331	0.325	0.433	0.264	0.002	-0.101	0.095	0.116	0.131	0.563	0.820	0.613	0.984**
12.	Test weight (g)	-0.002	-0.002	-0.002	-0.001	-0.001	-0.001	-0.001	0.000	-0.001	-0.003	-0.004	-0.005	0.774**
13.	Grain yield (g)	0.441	0.434	0.577	0.346	0.029	-0.118	0.159	0.095	0.205	0.794	0.984	0.774	1.000

Table 6: Direct and indirect effects of phenotypic path coefficient for thirteen characters in foxtail millet genotypes

S. No.	Characters	Days to 50% flowering	No. of Days to maturity	Plant height (cm)	Panicle length (cm)	Flag leaf length (cm)	Peduncle length (cm)	Leaf width (cm)	No. of basal tillers	Inflorescence width (cm)	Biological yield (g)	Harvest index (%)	Test weight (g)	Grain yield (g)
1.	Days to 50% flowering	-0.142	-0.141	-0.059	-0.074	-0.057	0.057	-0.051	0.000	-0.072	-0.064	-0.053	-0.050	0.412**
2.	No. of Days to maturity	0.162	0.163	0.069	0.087	0.066	-0.065	0.060	-0.001	0.085	0.072	0.059	0.056	0.402**
3.	Plant height (cm)	-0.005	-0.005	-0.011	-0.007	-0.006	0.001	-0.002	0.000	-0.004	-0.004	-0.003	-0.003	0.293**
4.	Panicle length (cm)	0.012	0.012	0.014	0.022	0.011	-0.008	0.007	0.003	0.006	0.005	0.005	0.004	0.233*
5.	Flag leaf length (cm)	-0.011	-0.011	-0.015	-0.013	-0.027	-0.005	-0.011	0.001	-0.013	-0.004	0.000	-0.002	0.024
6.	Peduncle length (cm)	-0.006	-0.006	-0.001	-0.005	0.003	0.015	0.000	-0.002	0.000	-0.001	-0.002	0.002	-0.100
7.	Leaf width (cm)	0.000	-0.001	0.000	0.000	-0.001	0.024	-0.001	0.027	0.000	0.000	0.000	0.000	0.151
8.	No. of basal tillers	0.024	0.022	0.000	-0.002	0.000	0.002	0.024	-0.013	0.002	0.001	-0.002	0.000	0.094
9.	Inflorescence width (cm)	-0.012	-0.012	-0.009	-0.006	-0.011	0.000	-0.004	0.004	-0.023	-0.009	-0.004	-0.004	0.202*
10.	Biological yield (g)	0.108	0.106	0.081	0.049	0.036	-0.014	0.065	-0.012	0.093	0.237	0.158	0.155	0.781**
11.	Harvest index (%)	0.305	0.296	0.224	0.180	0.009	-0.082	0.088	0.114	0.129	0.546	0.819	0.594	0.982**
12.	Test weight (g)	0.002	0.002	0.001	0.001	0.000	0.001	0.001	0.000	0.001	0.003	0.004	0.005	0.757**
13.	Grain yield (g)	0.412	0.402	0.293	0.233	0.024	-0.100	0.151	0.094	0.202	0.781	0.982	0.757	1.000

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