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RESEARCH PAPER

Correlation and Path Coefficient Analysis for Yield and Yield-Related Traits in Foxtail Millet (*Setaria italica* L.)

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ABSTRACT

The present study was conducted to assess the association and direct and indirect effects of yield and its component traits in foxtail millet (*Setaria italica* L.). Twenty genotypes were evaluated during *kharif,* 2019 at Agricultural Research Station, Vizianagaram, Andhra Pradesh, in a Randomized Block Design with three replications. Mean performance of genotypes show that considerable variation was observed among the genotypes for all the traits studied, indicating the presence of sufficient variability for selection and improvement. Analysis of correlation revealed significant positive association of grain yield with plant height, number of productive tillers per plant and fodder yield, indicating that these traits play a vital role in determining grain yield. Path coefficient analysis revealed that fodder yield exhibited the highest positive direct effect on grain yield, followed by plant height and panicle length, signifying their importance in selection for yield improvement. Traits such as days to maturity and plant height also showed considerable indirect effects through fodder yield. These findings indicate that simultaneous improvement of yield and its related traits can be achieved by selecting for fodder yield, plant height, and panicle length.

HIGHLIGHTS

- Significant variation was observed among 20 foxtail millet genotypes for yield and yield-contributing traits.
- Significant associations were observed between grain yield and biomass related traits such as number of productive tillers per plant, plant height and fodder yield.
- As usual days to maturity was highly correlated with days to 50% flowering. It was as well significantly and positively correlated with fodder yield indicating that longer the duration higher the biomass production.
- Direct positive effect of fodder yield, plant height and panicle length emphasizes that these traits can be selected for improvement of grain yield in foxtail millet
- The study suggests that simultaneous selection for fodder yield, plant height, and panicle length would enhance grain yield in foxtail millet.

Keywords: Foxtail millet, correlation, association, path coefficient, grain yield

Millets are gaining global attention due to their superior nutritional quality, climate resilience, and adaptability to marginal environments. Among the small millets, foxtail millet (*Setaria italica* L.) occupies a special place owing to its short duration, drought tolerance, and nutrient richness. It serves as a dual-purpose crop for both grain and fodder

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and plays a vital role in dryland agriculture, particularly in regions prone to erratic rainfall and poor soil fertility. In recent years, the increased focus on climate-smart agriculture and nutritional security has renewed research interest in foxtail millet improvement Harsha Vardhan *et al*. (2024). Grain yield in foxtail millet is a complex quantitative trait governed by multiple genes and strongly influenced by environmental factors. Therefore, direct selection for yield may not always be effective in early generations. A clear understanding of the interrelationship among yield and its component traits is essential for identifying reliable selection indices. Correlation analysis provides information on the degree of association among traits; however, it does not explain the underlying cause effect relationship. Path coefficient analysis complements correlation analysis by partitioning these associations into direct and indirect effects, thereby helping identify traits that have a true contributory role in yield enhancement (Sharma & Dangi, 2021). Earlier studies in foxtail millet have reported considerable variability and significant associations among yield components such as plant height, productive tillers, panicle length, and fodder yield Harish *et al.* (2022) Gandhi *et al*. (2024). Several researchers have highlighted the importance of these traits as potential indicators for improving grain yield under both normal and stress conditions. However, trait association patterns often differ across environments, and limited information is available under the agro-ecological conditions of Andhra Pradesh. Hence, the present investigation was undertaken to study the interrelationship among yield and yield-attributing traits and to identify key traits exerting significant direct and indirect effects on grain yield in foxtail millet genotypes. The findings of this study are expected to provide useful insights for effective selection and genetic improvement of foxtail millet in dryland production systems.

MATERIALS AND METHODS

The experiment was conducted at the Agricultural Research Station, Vizianagaram, Andhra Pradesh, during *kharif* 2019 using 20 foxtail millet genotypes. The genotypes were laid out in a Randomized Block Design (RBD) with three replications. Each genotype was sown in a plot of ten rows of 3m length with recommended spacing and standard agronomic practices. Observations were recorded on the following traits Days to 50% flowering (DFF), Days to maturity (DM), Plant height (PH, cm), Number of productive tillers per plant (NPT), Panicle length (PL, cm), Fodder yield (FY, q/ha), Grain yield (GY, q/ha). Mean data from all replications were used for statistical analysis. Correlation coefficients among traits were computed using Pearson's correlation method and significance was tested at 5% and 1% levels. Path coefficient analysis was carried out to assess direct and indirect effects of component traits on grain yield using genotypic correlation values as per Dewey and Lu (1959). Analysis was done by using the package agricolae, PB Perfect.

RESULTS AND DISCUSSION

Mean Performance of Genotypes

The mean performance of twenty foxtail millet genotypes for yield and its component traits is presented in Table 1. Considerable variation was observed among the genotypes for all the traits studied, indicating the presence of sufficient variability for selection and improvement. Days to 50% flowering ranged from 39.7 days (IIMR Fxm-5) to 50.0 days (SiA 4200 and IIMR Fxm-4) with a mean of 46.2 days, indicating the presence of both early and medium-duration types. Days to maturity ranged between 69.0 days (IIMR Fxm-5) and 82.0 days (SiA 4200), with a mean of 76.87 days. Such variability offers scope for selecting genotypes suitable for different agro-climatic conditions. Plant height showed substantial variation, ranging from 135.8 cm (IIMR Fxm-5) to 166.2 cm (SiA 4200), with a mean of 146.76 cm, suggesting the existence of tall and medium-statured genotypes that could contribute to higher fodder and grain yield. The number of productive tillers per plant varied from 2.4 (IIMR Fxm-5) to 4.0 (GPUF-3) with a mean of 2.98, reflecting a moderate range in tillering ability.

Panicle length varied from 19.0 cm (IIMR FT-1) to 26.2 cm (IIMR Fxm-5) with an overall mean of 22.89 cm, indicating that panicle length can serve as a useful yield-contributing trait. Grain yield ranged from 22.5 q/ha (PKS 22) to 34.5 q/ha (SiA 3159) with a mean of 29.50 q/ha, while fodder yield ranged from 43.9 q/ha (IIMR Fxm-5) to 64.7 q/ha (SiA 4200) with a mean of 52.99 q/ha. The genotypes SiA 3159,

Table 1: Mean values of twenty Foxtail millet genotypes for yield and its component triats

Sl. No.	Entry	Days to 50% flowering	Plant Height (cm)	Days to Maturity	No. of Productive Tillers/ Plant	Panicle length (cm)	Grain Yield (q/ha)	Fodder Yield (q/ha)
1	SiA 3159	48.7	148.5	79.7	2.5	25.2	34.5	58.7
2	SiA 3156	48.0	143.7	78.0	2.7	21.3	34.1	56.0
3	GPUF-2	45.0	155.5	75.0	3.1	22.7	33.8	50.8
4	SiA 4200	50.0	166.2	82.0	3.1	25.8	33.4	64.7
5	DHFt 109-3-2	47.3	149.1	77.7	2.9	21.8	33.2	54.5
6	IIMR Fxm-4	50.0	156.9	80.3	2.8	26.0	32.2	59.3
7	SiA 3303	42.0	139.7	73.3	2.7	21.1	31.8	44.1
8	SiA 3085 (LC)	44.3	153.6	76.3	3.5	21.8	31.4	49.9
9	DHFt 109-3-1	46.7	154.4	77.3	3.2	23.9	31.3	58.9
10	GPUF-3	48.0	141.5	78.7	4.0	23.6	31.0	57.2
11	DHFt 109-3 (C)	46.3	141.5	76.7	3.5	23.4	30.9	52.0
12	GPUF-4	48.7	142.9	80.3	3.1	23.6	29.7	58.1
13	IIMR FXM-2	46.3	145.5	76.3	2.7	21.2	27.9	52.1
14	IIMR Fxm-5	39.7	135.8	69.0	2.4	26.2	27.6	43.9
15	SiA 3220	45.7	143.3	76.3	2.7	23.3	26.1	52.0
16	TNSi 364	45.0	154.0	77.0	3.3	21.3	25.9	53.0
17	TNSi 354	46.0	141.7	76.7	2.8	21.6	24.9	49.3
18	TNSi 337	45.3	143.4	75.3	2.5	23.6	24.6	48.2
19	IIMR FT-1	45.3	141.1	75.3	2.7	19.0	23.3	46.5
20	PKS 22	45.7	136.9	76.0	3.3	21.7	22.5	50.5
	Mean	46.20	146.76	76.87	2.98	22.89	29.50	52.99
	CD (5%)	2.32	17.77	3.48	0.81	3.84	7.44	9.41
	CD (1%)	3.11	23.81	4.67	1.09	5.14	9.96	12.61
	CV (%)	3.04	7.33	2.74	16.53	10.14	15.26	10.75

SiA 3156, and SiA 4200 recorded superior grain and fodder yields and can be considered promising for dual-purpose utilization.

The coefficient of variation (CV) was moderate for most traits, indicating reliability of data and consistent performance across replications. The lowest CV (2.74%) was recorded for days to maturity, while the highest (16.53%) was for number of productive tillers per plant, suggesting that tillering exhibited greater environmental influence. The observed variability is in accordance with the findings of Rani *et al*. (2022) who reported wide ranges for plant height, panicle length, and yield traits in foxtail millet genotypes. The presence of such variability provides an excellent opportunity for selecting high-yielding and stable genotypes under rainfed conditions.

Correlation Analysis

The correlation coefficients among yield and its related traits revealed that grain yield exhibited significant and positive correlations with plant height, number of productive tillers per plant and fodder yield, indicating that improvement in these traits would directly enhance yield. Plant height recorded a highly significant positive association with grain yield (r = 0.51***), indicating the importance of taller plants in contributing to yield through increased panicle size and biomass. Fodder yield (r = 0.22*) also showed a positive and significant relationship with grain yield, reflecting the dual-purpose nature of foxtail millet where biomass accumulation supports both grain and fodder productivity. Moderate positive associations of grain yield were also observed with panicle length and days to maturity, although these were not significant. Days to 50% flowering showed a weak and non-significant correlation with grain yield, suggesting its lesser influence on productivity. These results are in close conformity with earlier

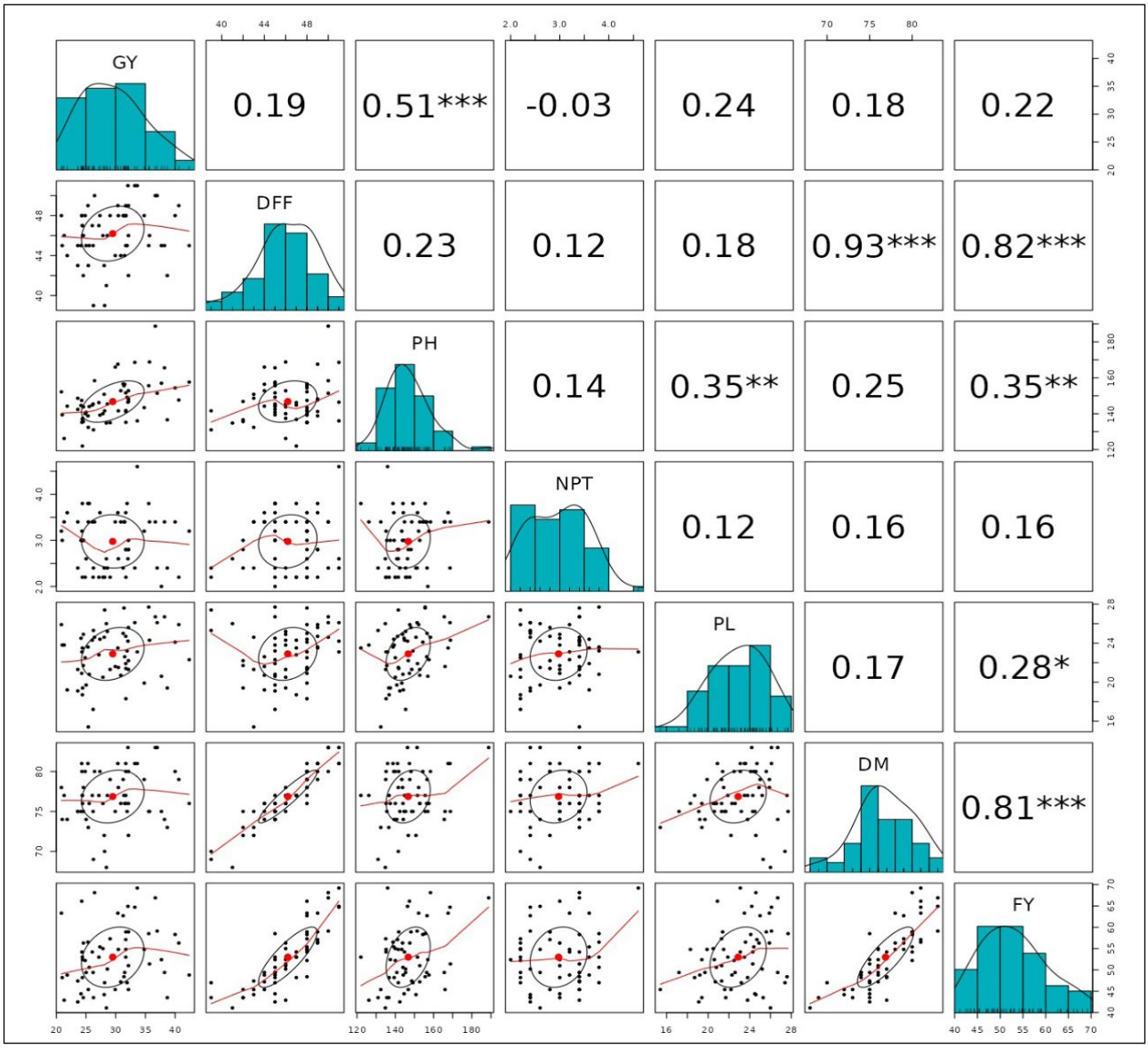

Fig. 1: Genotypic correlation among yield and other related traits in twenty foxtail millet genotypes

reports in foxtail millet by Kumari *et al.* (2021) and Kavitha *et al.* (2023), who also reported positive association of yield with plant height, productive tillers, and panicle length. The significant positive correlation between plant height and panicle length (0.35**) indicates that taller plants tend to bear longer panicles suggesting the usefulness of plant height as an indirect selection criterion for improving panicle traits. The very strong association between days to first flowering and days to maturity (0.93**) Sivakumar *et al.* (2018) reflects their close developmental linkage, implying that selection for early flowering will simultaneously lead to early maturity. The highly significant positive correlations of fodder yield with days to maturity (0.81**), days to first flowering (0.82**), plant height (0.35**), and panicle length (0.28*) suggest that fodder yield is largely dependent on growth duration, vegetative vigour and panicle development. Similar findings was observed by Tripathi *et al.* (2018) and Khandelwal *et al.* (2018) Path coefficient analysis further supports these findings by indicating that phenological traits and plant height exert both direct and indirect effects on biomass accumulation, emphasizing their importance as key determinants for simultaneous improvement of yield and fodder productivity.

Path Coefficient Analysis

Path coefficient analysis partitioned the correlation

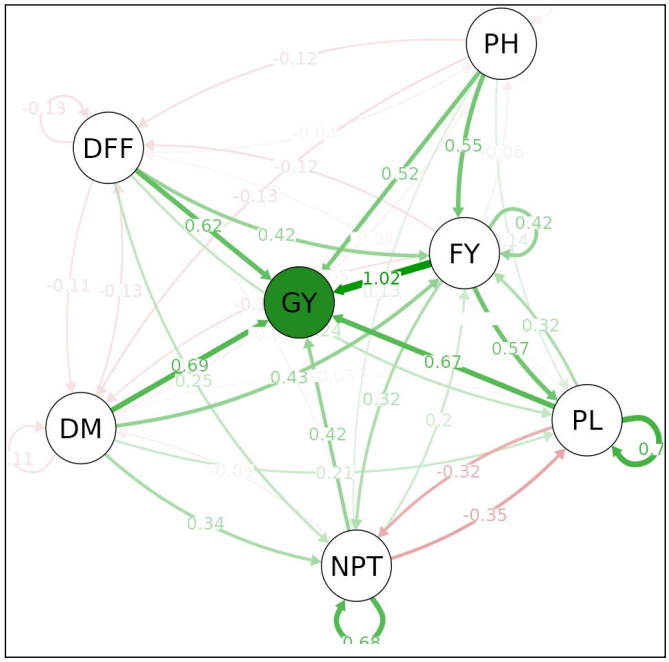

Fig. 2: Genotypic path coefficient diagram showing direct and indirect effects of component traits on grain yield

The thickness and color of arrows represent the magnitude and direction of effects among traits including plant height (PH), panicle length (PL), number of productive tillers (NPT), fodder yield (FY), days to first flowering (DFF) and days to maturity (DM)

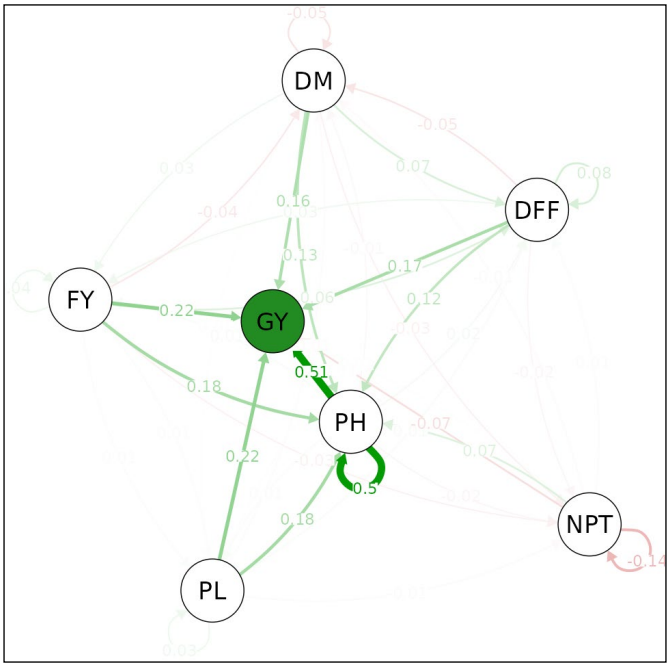

Fig. 3: Phenotypic path coefficient diagram showing direct and indirect effects of component traits on grain yield

The thickness and color of arrows represent the magnitude and direction of effects among traits including plant height (PH), panicle length (PL), number of productive tillers (NPT), fodder yield (FY), days to first flowering (DFF) and days to maturity (DM)

Table 2: Genotypic path coefficients depicting direct and indirect effects of component traits on grain yield

Genotypic Path Analysis - Effects							
	DFF	**PH**	**NPT**	**PL**	**DM**	**FY**	**Correlations GY**
DFF	-0.12594	-0.0443	0.25121	0.23658	-0.11245	0.41797	0.6230695
PH	-0.11903	-0.04687	0.12646	0.13722	-0.13131	0.55435	0.5208304
NPT	-0.04651	-0.00871	0.68022	-0.35268	-0.05685	0.20072	0.4161906
PL	-0.03971	-0.00857	-0.3197	0.75038	-0.03094	0.32305	0.674507
DM	-0.12536	-0.05448	0.34231	0.20548	-0.11297	0.43031	0.6852967
FY	-0.12397	-0.06119	0.32157	0.57091	-0.11449	0.4246	1.0174155
Residuals: -0.0409							

Table 3: Phenotypic path coefficients depicting direct and indirect effects of component traits on grain yield

Phenotypic Path Analysis - Effects							
	DFF	**PH**	**NPT**	**PL**	**DM**	**FY**	**Correlations GY**
DFF	0.07875	0.12347	-0.01783	0.00561	-0.04917	0.03037	0.1712531
PH	0.01943	0.50047	-0.01903	0.01147	-0.01404	0.01311	0.5114197
NPT	0.0099	0.06716	-0.1418	0.00219	-0.00955	0.00659	-0.0653435
PL	0.01376	0.17892	-0.00967	0.03209	-0.0086	0.0106	0.2170422
DM	0.07285	0.13222	-0.02547	0.00519	-0.05315	0.02995	0.1616119
FY	0.06499	0.17822	-0.0254	0.00925	-0.04325	0.03681	0.2206449
Residuals: 0.7148							

coefficients into direct and indirect effects (Fig. 2). The results indicated that fodder yield exerted the highest positive direct effect on grain yield, followed by plant height and panicle length, suggesting that these are the most reliable selection criteria for yield improvement. Days to maturity and plant height had substantial indirect effects through fodder yield, indicating that they influence grain yield indirectly via their contribution to biomass accumulation. Number of productive tillers also contributed indirectly through panicle length and fodder yield. Negative direct effects were observed for days to 50% flowering and days to maturity, indicating that earliness alone may not ensure higher yield unless supported by improved biomass and panicle traits. The predominance of positive direct effects of fodder yield and plant height suggests that genotypes with higher biomass and robust plant stature can be selected for simultaneous improvement in grain yield. These findings are consistent with the earlier results of Patil *et al*. (2020) and Suryanarayana *et al*. (2022) in foxtail millet and other small millets.

CONCLUSION

The present investigation revealed significant variability among foxtail millet genotypes for yield and yield-contributing traits. Correlation analysis identified plant height, number of productive tillers, and fodder yield as the major traits positively associated with grain yield. Path coefficient analysis further established that fodder yield had the highest positive direct effect on grain yield, followed by plant height and panicle length. Therefore, selection for these traits can effectively enhance grain yield potential in foxtail millet improvement programmes.

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