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Genetic variability and correlation for yield and yield related traits in Foxtail millet

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Abstract

Foxtail millet is a crop known for its nutritional significance and climate resilience. This study was conducted with 31 genotypes which were evaluated for 11 traits in a randomized block design with three replications. The results of the variability parameters revealed a high phenotypic and genotypic coefficient of variation, heritability and genetic advance as percent of mean for flag leaf length, panicle length, peduncle length and thousand grain weight. Except for days to maturity and single plant yield, all traits recorded a high heritability and high genetic advance. These above mentioned two traits were found to have a high heritability with low genetic advance as percent of mean indicating the presence of non-additive gene action. The principal component analysis revealed a higher genetic variability for all traits depicting five reliable PCs with eigen values greater than one. PC1 contributed the maximum towards over all variance (25.10 %), while PC2 and PC3 contributed 16.48 % and 13.92 %, respectively. The genotypes *viz.,* SiA 3085, SiA 3156, RAU 2, GPUF-3, GPUF-16, Garuda, Renadu, Narasimharaya, and Krishnadevaraya were found to be elite for yield and their associated traits in biplots. These genotypes could be exploited as parents for developing high yielding segregants. The traits *viz.,* thousand grain weight, number of productive tillers and peduncle length recorded a significant positive correlation with single plant yield. Hence, these traits could be effectively employed as selection indices in foxtail millet improvement for yield.

Keywords: Foxtail millet, PCV, GCV, Principal component analysis, correlation

Foxtail millet (*Seteria italica*), a nutritionally rich crop, is known to be genetically diverse with a C_4 photosynthetic system. This is one of the oldest cultivated crops among millets, highly adapted to arid zones and predominantly cultivated by resource-poor farmers primarily for food and feed in dry regions (Ramesh *et al.*, 2023). It is cultivated across varied regions of the world, particularly in Africa and Asia. Globally, China accounts for 80 % of the overall cultivation area of foxtail millet (Liu *et al.,* 2025). The average productivity of foxtail in India is about 762 kg per hectare (Hariprasanna, 2023, Tiwari *et al.*, 2024). Andhra Pradesh, Karnataka and Tamil Nadu are the major producers of foxtail millet with 79 % of the total area of foxtail millet being grown in Andhra Pradesh (Jhansi *et al.,* 2025). Owing to its nutritional significance, there is a high demand among consumers for millet-based foods to support the nutrition and food security (Pramitha *et al.,* 2023; Gomanth Kumar *et al.*, 2023).

Foxtail millet is a highly self-pollinated crop with a chromosome number of 2n = 2x = 18. Among all millets, it has the least genome complexity due to its diploid genome and is considered a model crop for tapping the novel genes for climate and nutritional resilience. Foxtail millet has been reported to comprise of an extensive genetic variability for its yield and its associated traits (Vardhan *et al.,* 2024; Nirmalakumari and Vetriventhan, 2010) To harness the variability for effective selection, breeders focus on yield, stability and stress resilience. This underscores the importance of characterizing yield-associated traits (Anand *et al.*, 2020). Earlier studies on foxtail millet germplasm have also reported considerable genetic diversity and variability based on morphological traits (Geethanjali and Jegadeeswaran, 2016) Srilatha *et al.* (2020) based on evaluation of 71 genotypes for 10 quantitative and eight nutritional traits, reported a higher phenotypic coefficient of variation, genotypic coefficient of variation, heritability and genetic advance for grain yield per plant, productive tillers per plant, and panicle length. Anand *et al.* (2020) concluded that higher

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phenotypic and genetic coefficient of variation along with high heritability and genetic advance were observed for plant height, panicle length, and grain output per plant. Their study also revealed positive correlation of the above traits with grain yield. Therefore, to facilitate the selection and improvement of morphological traits in foxtail millet for developing high yielding segregants, this study was carried out using 31 genotypes collected from various research stations in India.

The present investigation was conducted during *kharif,* 2025 at the Karunya Institute of Technology and Sciences, located at about 11˚ 56' N latitude and 76˚ 44' E longitude at an altitude of 467 m above MSL. The experimental material comprised of 31 genotypes of foxtail millet collected from research stations across India (**Table 1**). The experiment was laid out in a Randomized Block Design with three replications with a spacing of 20×10 cm. The recommended package of practices for raising the genotypes were adopted (Singh *et al.,* 2023). Eleven traits namely, days to 50% flowering, number of basal tillers, culm diameter (mm), plant height (cm), flag leaf length (cm), flag leaf width (cm), peduncle length (cm), panicle exertion (cm), days to maturity, single plant yield (g) and thousand grain weight (g) were recorded. The data observed were subjected to variability (Johnson *et al.*, 1955), principal component (Jolliffe, 2002) and correlation analyses (Panse and Sukhatme,1967). The statistical analyses were performed using R software (version 4.5.3) with Metan.

The analysis of variance revealed a significant variation among the genotypes for all traits. This indicated that the genotypes subjected to the study exhibited higher genetic variation for all the traits recorded (**Table 2**).

Table 1. Details of foxtail millet genotypes used in the study

S No.	Genotype	Place of collection
1	Lepakshi	ICAR-IIMR, Hyderabad.
2	HMT 100-1	ICAR-IIMR, Hyderabad.
3	SiA 3085	RARS, Nandyal, ANGRAU, Andhra Pradesh
4	SiA 3156	RARS, Nandyal, ANGRAU, Andhra Pradesh
5	RAU 2	ICAR-IIMR, Hyderabad.
6	SiA 326	RARS, Nandyal, ANGRAU, Andhra Pradesh
7	Suryanandi (SiA 3088)	RARS, Nandyal, ANGRAU, Andhra Pradesh
8	DHF t 109-3	ICAR-IIMR, Hyderabad.
9	HN 46	ICAR-IIMR, Hyderabad.
10	ATL 1	TNAU, Coimbatore (Tamil Nadu).
11	Garuda	RARS, Nandyal, ANGRAU, Andhra Pradesh
12	Renadu	RARS, Nandyal, ANGRAU, Andhra Pradesh
13	Narasimharaya	Andhra Pradesh/Karnataka
14	krishnadevaraya	RARS, Nandyal, ANGRAU, Andhra Pradesh
15	PS-4	ICAR-IIMR, Hyderabad.
16	K2	ICAR-IIMR, Hyderabad.
17	K3	ICAR-IIMR, Hyderabad.
18	CO7	ICAR-IIMR, Hyderabad.
19	SR16	ICAR-IIMR, Hyderabad.
20	Srilakshmi	RARS, Nandyal, ANGRAU, Andhra Pradesh
21	FxV- 652	ICAR-IIMR, Hyderabad.
22	FxV-647	ICAR-IIMR, Hyderabad.
23	CFxMV-1	ICAR-IIMR, Hyderabad.
24	ATL 2	ICAR-IIMR, Hyderabad.
25	GPUF-3	ICAR-IIMR, Hyderabad.
26	GPUF-16	ICAR-IIMR, Hyderabad.
27	SiA 3159(Mahanandi)	RARS, Nandyal, ANGRAU, Andhra Pradesh
28	Red Foxtail	Telangana
29	Andhra local	Andhra Pradesh
30	Kolli local	Dhan Foundation, Tamil Nadu
31	*Kothatara thenai*	Dhan Foundation, Tamil Nadu

Table 2. ANOVA for 11 quantitative traits of foxtail millet

S. No.	Characters	Mean sum of squares		
Degrees of freedom		Genotype	Replication	Error
		30	2	60
1	Days to 50% flowering	124.1305***	2.914	1.2584
2	Days to maturity	100.0746***	1.8172	1.3283
3	Plant height	462.8849***	37.033	12.8297
4	Flag leaf length	63.0808***	0.38	1.226
5	Flag leaf width	0.1764***	0.0037	0.0028
6	Number of productive tillers	0.6274***	0.0009	0.0128
7	Panicle length	17.0548***	0.9523	0.7127
8	Peduncle length	24.6392***	0.0315	0.6345
9	Culm diameter	2.3314***	0.0179	0.1513
10	Thousand-grain weight	1.0880***	0.0056	0.0124
11	Seed yield per plant	28.5707***	3.3321	0.7771

Mean performance

The genotypes subjected to the study exhibited a significant variation for all traits and among all, ATL 1 exhibited a higher *per se* performance for single plant yield and number of productive tillers **(Table 3)**. Followed by that, SiA3159 and K3 showed a higher desirable performance for single plant yield. For thousand grain weight, the genotypes *viz.,* SiA3159, SiA3156 and SR 16 recorded a higher *per se* performance. Therefore, these genotypes with desirable yield and yield related attributes could be forwarded for breeding of high yielding lines in future.

Considering the flowering for all genotypes, Garuda had the earliest days to flowering than the rest of the genotypes. For both yield and early flowering, the genotypes namely, ATL 1 and SiA3159 were highly desirable for their mean performance and could be forwarded in breeding trials for developing early and high yielding cultivars in future. Similar performance of these genotypes for yield related traits were also reported by Gobikashri *et al*. (2023).

Variability parameters

Among all the traits, a higher phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) with lower environmental coefficient of variation (ECV) was observed for flag leaf length, panicle length, peduncle length and thousand grain weight. Thus, these traits were highly variable among the genotypes, and this variability is attributed to the influence of genetic factors with a lower environmental influence. Similar results have also been reported in foxtail millet by Vardhan *et al.* (2024). Further, except for single plant yield, all the other traits exhibited a low environmental coefficient of variation (**Table 4**). Moderate environmental influence on yield was also observed Vardhan *et al.* (2024).

It was observed that except for days to maturity and single plant yield, high heritability and genetic advance was observed for all traits. This suggests that effective selection could be executed for all traits due to the predominance of additive gene action. Similar findings have been reported by Ramesh *et al.* (2023). However, high heritability and low genetic advance was observed for single plant yield and days to maturity. This indicated the presence of non-additive gene action and hence heterosis breeding could be a viable approach for improvement of these traits. Similar observations for these traits were also reported by Ramesh *et al.* (2023) and Thakre *et al.* (2023).

Principal Component Analysis (PCA)

The PCA is a multivariate analysis that is used to depict and analyze the interrelationship among the variables and it relatively compresses a large set of data into small principal components (PC) based on their correlation. This favorably analyses the entire variability in percentage contribution (Singh *et al.* 2023). There were five reliable PCs with eigen values greater than 1 and these five PCs comprised of the entire population variance. Among them, PC1 had the highest contribution towards the overall variability (25.10 %). Followed by this, PC2, PC3 PC4 and PC5 contributed 16.48, 13.92,11.55 and 10.33%, respectively (**Table 5**). The PCs having eigen values greater than 1.0, had contributed up to 77.38 % of the total variation in the population. (**Table 5**).

Further, the variable contributions of traits towards the individual PCs depict the influence of the overall variability contributed by their respective PCs. PC1 included the positive contributions for variability by single plant yield, panicle length, flag leaf width and number of productive tillers. Successively, PC2 had negative loadings contributed by peduncle length, days to maturity and days to 50% flowering. Thus, the traits comprising of positive loadings were observed to be positively correlated towards the PC1 and increase of these parameters would enhance the total variance contributed by PC1 and *vice-versa* is for the negative loadings in PC2. The findings of Singh *et al.* (2023) and Yu *et al.* (2024) revealed similar results in PCA for these traits. Successively, the traits namely, plant height, thousand grain weight and

Table 3. Mean performance of genotypes for quantitative traits

Genotypes	DFF	DM	PH	FLL	FLW	NPT	PEL	PLE	CD	TWG	SPY
Lepakshi	60.33	90.00	78.08	16.62	1.23	4.00**	16.62**	7.41	5.62	1.53	4.56
HMT 100-1	50.00**	94.67	105.82	16.63	1.63**	2.90	13.41**	9.84	4.54	1.82	5.99
SiA 3085	49.00**	84.67	111.62**	10.02	1.03	3.40	10.03	9.63	5.26	1.65	4.04
SiA 3156	45.00**	80.00**	114.21**	15.23	1.03	3.80**	11.24	13.62**	4.91	3.65**	9.27
RAU 2	50.00**	85.00	105.62	13.83	1.24	3.80**	10.84	11.82	4.99	3.55**	8.37
SiA 326	50.00**	80.00**	84.46	17.62	1.24	2.60	13.41**	11.84	5.66	3.27**	10.72**
Suryanandi (SiA 3088)	45.00**	80.00**	102.43	18.45	1.24	4.00**	9.24	10.62	7.14**	2.73	8.63
DHF t 109-3	51.00**	84.67	94.44	15.45	0.84	2.60	9.23	8.43	5.95	3.07	5.62
HN 46	50.00**	80.33**	107.63*	16.46	1.04	2.60	9.63	8.25	5.30	3.26**	6.49
ATL 1	49.67**	80.33**	114.64**	22.44**	1.77**	4.40**	11.24	14.23**	5.58	2.59	15.83**
Garuda	33.33**	65.33**	80.84	19.05	1.65**	4.20**	8.84	10.03	6.53**	2.40	10.95**
Renadu	57.00	86.33	86.03	20.01	1.61**	3.20	9.45	8.24	6.13	3.14*	6.32
Narasimharaya	56.33	85.67	106.82	21.25*	1.44**	3.80**	9.03	11.03	6.43*	3.35**	11.42**
Krishnadevaraya	57.33	90.00	87.44	36.42**	1.03	3.20	8.44	10.43	5.93	1.86	8.01
PS-4	59.67	90.00	112.03**	10.03	1.03	3.40	10.03	9.63	6.38*	3.43**	10.64**
K2	60.33	90.00	92.64	20.44	0.84	3.60	8.05	7.85	4.41	2.63	6.42
K3	56.00	85.00	82.23	18.84	1.63**	3.80**	12.82**	18.64**	4.61	2.92	14.64**
CO7	56.00	90.00	112.84**	22.46**	1.24	3.60	19.24**	16.83**	4.54	3.22**	13.66**
SR16	56.00	80.00	80.46	22.64**	1.04	3.40	12.07	8.64	4.72	3.62**	7.54
Srilakshmi	50.33**	85.00	101.85	19.64	1.44**	3.60	12.24*	8.46	4.13	3.34**	6.66
FxV- 652	51.33**	86.00	85.07	23.24**	1.24	3.60	11.06	7.84	4.71	3.33**	6.73
FxV-647	56.00	85.00	101.03	21.64**	1.03	3.40	10.46	9.44	5.27	3.22**	8.70
CFxMV-1	59.67	90.00	112.82**	20.44	1.04	3.60	10.85	9.66	5.34	2.84	5.13
ATL 2	64.00	90.33	113.46**	21.22*	1.41**	4.00**	11.04	9.63	5.91	3.45**	6.42
GPUF-3	47.33**	80.33**	112.66**	22.66**	1.06	3.20	8.84	10.65	6.32*	3.13	8.46
GPUF-16	50.00**	80.00**	115.23**	19.23	1.25	4.20**	10.44	17.03**	6.51**	2.94	10.40**
SiA 3159 (Mahanandi)	49.67**	84.67	114.02**	19.24	1.24	3.20	9.83	15.22**	6.72**	3.90**	14.73**
Red Foxtail	47.00**	86.00	112.21**	18.63	1.44**	3.80**	11.83	12.24*	7.15**	3.26**	6.40
Andhra local	60.00	90.00	100.28	17.81	1.29	3.75*	9.05	10.77	7.32**	3.23**	6.46
Kolli local	59.67	95.00	110.07**	18.03	1.25	3.60	8.64	10.66	5.42	2.42	7.44
Kothatara thenai	61.33	90.00	98.83	19.84	1.04	3.40	10.04	10.45	6.47*	2.64	6.42
MEAN	**53.17**	**85.30**	**101.22**	**19.21**	**1.24**	**3.54**	**10.87**	**10.94**	**5.67**	**2.95**	**8.49**
SE	0.65	0.67	2.07	0.64	0.03	0.07	0.49	0.46	0.22	0.06	0.51
CD (5%)	**1.81**	**1.86**	**5.79**	**1.79**	**0.09**	**0.18**	**1.36**	**1.29**	**0.63**	**0.18**	**1.43**
CD (1%)	**2.41**	**2.47**	**7.69**	**2.38**	**0.11**	**0.24**	**1.81**	**1.71**	**0.84**	**0.24**	**1.89**

*,** significant at 5% and 1% probability level, respectively

Note: DFF - Days to 50% flowering; DM - Days to maturity; PH - Plant height (cm); FLL - Flag leaf length (cm); FLW - Flag leaf width (cm); NPT - Number of productive tillers; PLE - Panicle length (cm); PEL - Peduncle length (cm); CD - Culm diameter (mm); TWG - Thousand grain weight (g); SPY - Single plant yield (g), SE – Standard error, CD- Critical difference.

flag leaf width had negative contributions in PC3. While in PC4, it was number of productive tillers and culm diameter and in PC5 it was by flag leaf length, thousand grain weight and single plant yield. Thus, these traits were negatively associated to their respective PCs and similar findings were also reported by Bai *et al.* (2024) (**Table 6**). Hence, selection for positively variable traits from this population would further confer for higher variability and effective selection to develop varieties with better yields and other associated characteristics. (Xue *et al.*, 2025; Reddy *et al.*, 2020).

Scree plot and PCA biplot

The scree plot and PCA biplot analyses showed that the

Table 4. Variability parameters for yield and other component traits in foxtail millet

Characters	Mean	Range		PCV (%)	GCV (%)	ECV (%)	h^2 (%)	GAM (%)
		MIN.	MAX.					
Days to 50% flowering	53.17	33.00	64.00	12.22	12.04	2.11	97.02	24.42
Days to maturity	85.30	65.00	95.00	6.86	6.73	1.35	96.12	13.58
Plant height (cm)	101.22	74.87	120.20	12.61	12.10	3.54	92.12	23.93
Flag leaf length (cm)	19.21	9.10	37.54	24.33	23.64	5.76	94.00	47.31
Flag leaf width (cm)	1.24	0.78	1.86	19.82	19.36	4.27	95.36	38.94
Number of basal tillers	3.54	2.47	4.47	13.19	12.80	3.20	94.10	25.57
Panicle length (cm)	10.88	7.41	20.31	22.82	21.46	7.66	88.43	41.57
Peduncle length (cm)	10.94	7.06	19.73	26.87	25.86	7.28	92.65	51.28
Culm diameter (mm)	5.67	4.10	7.73	16.51	15.02	6.86	82.76	28.16
Thousand-grain weight (g)	2.95	1.44	4.02	20.66	20.31	3.77	96.67	41.14
Single plant yield (g)	8.49	3.69	18.95	37.34	35.87	11.98	92.26	7.00

PCV= Phenotypic coefficient of variation, GCV = Genotypic coefficient of variation, ECV =Environmental coefficient of variation, h^2 = Heritability (broad sense), GAM= Genetic advance mean

Table 5. Eigenvalues, percentage of variation, and cumulative percentage for principal components

Principle Component	Eigen Value	Percentage of variance	Cumulative percentage
PC1	2.76	25.10	25.10
PC2	1.81	16.48	41.58
PC3	1.53	13.92	55.50
PC4	1.27	11.55	67.05
PC5	1.14	10.33	77.38
PC6	0.67	6.10	83.48
PC7	0.63	5.69	89.17
PC8	0.52	4.70	93.87
PC9	0.41	3.77	97.64
PC10	0.17	1.55	99.19
PC11	0.09	0.80	99.99

Table 6. Contribution of the first five PCs to variation in foxtail millet genotypes

Parameter	PC1	PC2	PC3	PC4	PC5
Days to 50% flowering	-0.34	**-0.43**	-0.21	-0.29	-0.16
Days to maturity	-0.36	**-0.47**	-0.24	-0.22	0.09
Plant height	0.14	-0.06	**-0.63**	-0.06	0.29
Flag leaf length	0.01	-0.14	0.26	-0.41	**-0.66**
Flag leaf width	**0.35**	-0.16	**0.31**	-0.20	0.24
Number of basal tillers	0.31	-0.13	0.11	**-0.43**	0.31
Panicle length	**0.46**	-0.30	-0.19	0.02	-0.08
Peduncle length	0.08	**-0.52**	0.19	0.37	0.16
Culm diameter	0.14	0.36	-0.23	**-0.52**	0.05
Thousand-grain weight	0.18	0.07	**-0.44**	0.27	**-0.42**
Single plant yield	**0.50**	-0.18	-0.07	0.03	**-0.29**

early principal components had a considerable impact on the overall variance among the traits (**Fig. 1 and Fig. 2**). According to the scree plot, the maximum variance was observed due to PC1, followed by the second and PC2 and PC3. There was a gradual decrease in the eigenvalues starting from PC4 and PC5. This indicated that the first few PCs were more reliable than others in describing total variance (Reddy *et al*., 2020). Additionally, the biplot analysis for PCA revealed that single plant yield was positively correlated with plant height, flag leaf length, flag leaf width, number of productive tillers, culm diameter, and thousand grain weight. However, there was an inverse or negative relationship observed among the traits namely, days to 50% flowering, days to maturity, culm diameter and peduncle length, as these traits were found to be perpendicularly placed in the biplot (Reddy *et al*., 2020)

In the biplots, the genotypes *viz.,* SiA 3085, SiA 3156, RAU 2, GPUF-3, and GPUF-16 were placed in close vicinity of panicle length, thousand grain weight, and culm diameter in the quadrants (**Fig. 3**). Thus, these genotypes have indicated their excellence in the above-mentioned characteristics influencing higher yield attributes. The geneotypes *viz*., Garuda, Renadu, Narasimharaya, and Krishnadevaraya were found to be superior for their number of productive tillers and peduncle length. Red foxtail millet, Andhra Local, and Kolli Local had a higher day to maturity and days to 50% flowering genotypes. Thus, they were found to be as long duration cultivars and genotypes like Lepakshi, HMT 100-1, SiA 326, Suryanandi (SiA 3088), DHF t 109-3, and HN 46 were found to be placed in the intermediate part of biplots, indicating an average level of performance for all yield related traits. The results of the current study concur with

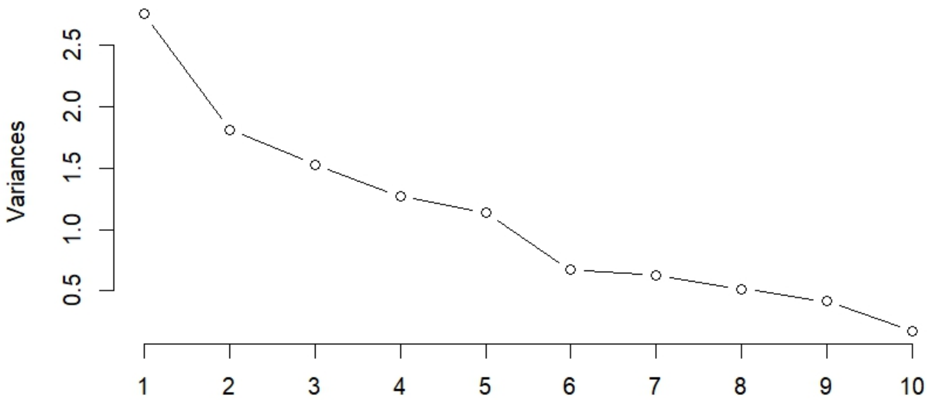

Fig. 1. Scree plot diagram using principal components and their eigenvalues

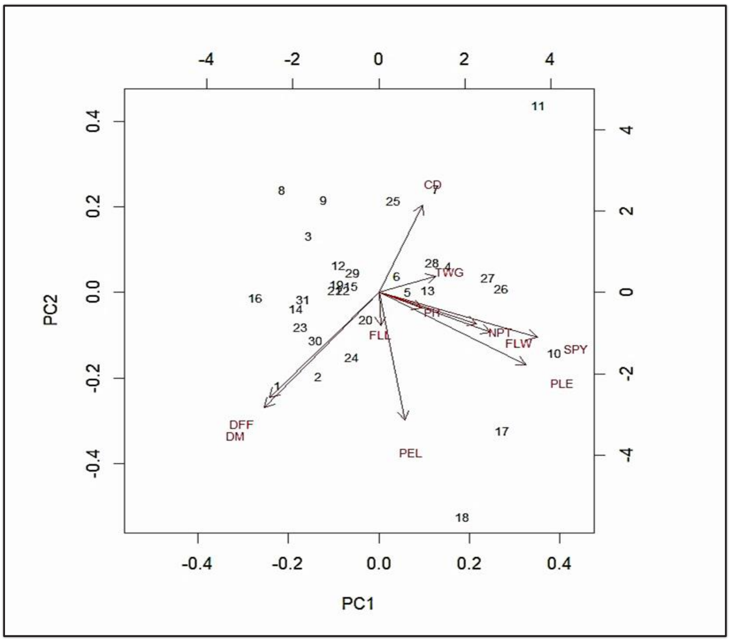

Fig. 2. Biplot diagram of PC1 and PC2

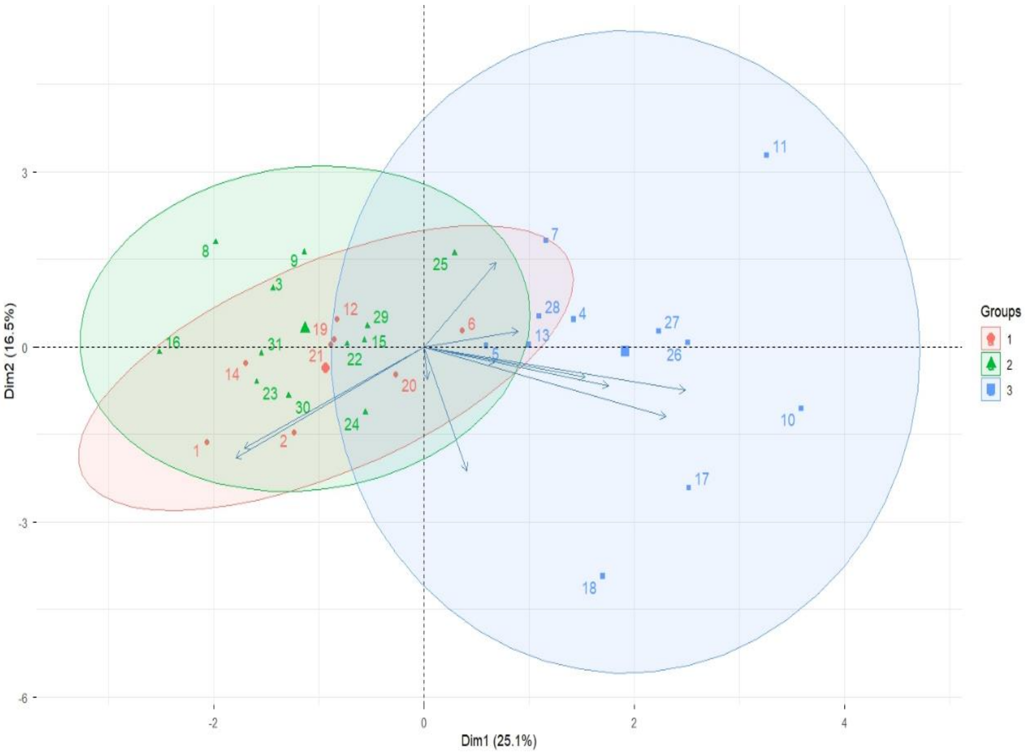

Fig. 3. Clustering of genotypes based on PC scores

findings of Harish and Lavanya, (2022) who emphasized the importance of panicle, peduncle length, and tiller characteristics for determining foxtail millet yield. Thus, these genotypes with key trait indicators could be favorably utilized in hybridization programs for developing high yielding segregants in future.

The clustering of genotypes for variability in PCA biplot indicated the presence of three groups depicted by red, green and blue in the **Fig. 3**. The genotypes which were clustered under the red zone were found to be placed near the origin implying the less variability among them. However, the genotypes grouped under green were mapped in the negative quadrant of PC1 and slightly dispersed in PC2. These were moderately variable with an intermediate performance for yield related traits. Finally, those genotypes placed in the blue zone were mapped towards the positive side of PC1, depicting a higher phenotypic performance and genetic variability. Thus, the genotypes namely, CO 7, K3, ATL 1, GPUF-16, SiA 3159, Garuda, Suryanandi, SiA 3156, Red foxtail millet, Narasimhraya and RAU 2 falling under this group could be identified as diverse genotypes with unique trait combinations for higher yield. Similar findings for desirable genotypes from clusters in PCA were also reported by Yu *et al.* (2024).

Pearson's Correlation

Correlation analysis is a statistical tool used to measure the degree and direction of association between two or more traits, and is widely used in crop improvement programs to identify characters that can be used for indirect selection of yield. In the present study, significant correlations were observed between yield and its component traits in foxtail millet (**Fig.4**). This indicated the potential for indirect selection by utilizing trait indicators as reported by Gobikashri *et al.* (2023). Among all the traits, thousand grain weight, number of productive tillers and peduncle length had a significant positive correlation with single plant yield. Days to 50% flowering was found to be negatively correlated with single plant yield. A significant positive intercorrelation between peduncle length and plant height, thousand seed weight and plant height was observed. The number of productive tillers was found to be positively correlated with flag leaf width and peduncle length. Flag leaf width was positively correlated with single plant yield and peduncle length. Similar positive correlation between thousand grain weight, peduncle length, number of productive tillers, plant height and single plant yield was also reported by Pallavi *et al.* (2020). Thus, these traits could be identified as efficient indicators for selection of high yielding genotypes in foxtail millet. Further, the days to 50% flowering was found to be negatively correlated with single plant yield. Thus, development of high yielding cultivars in foxtail millet needs to be emphasized with minimum compromise in yield and its associated traits. Similar findings for the negative correlation between flowering and yield were also observed by Vardhan *et al.* (2025).

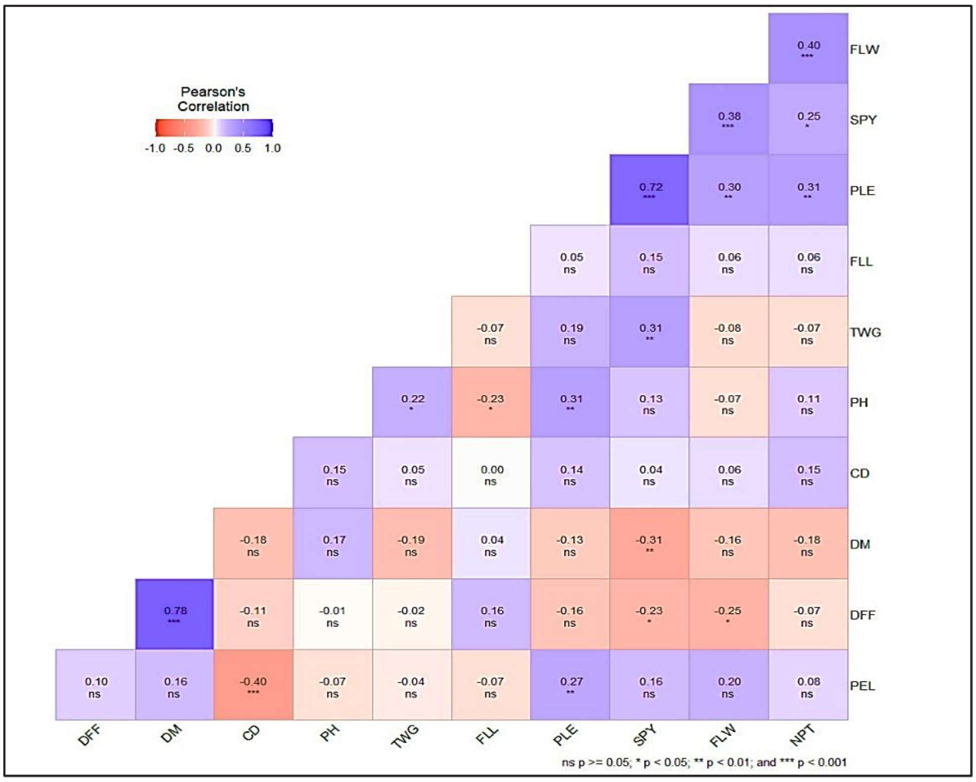

Fig. 4. Pearson's correlation heatmap of yield and its component traits in foxtail millet

Note: DFF - Days to 50% flowering; DM - Days to maturity; PH - Plant height ; FLL - Flag leaf length ; FLW - Flag leaf width; NPT - Number of productive tillers; PLE - Panicle length; PEL - Peduncle length; CD - Culm diameter; TWG - Thousand grain weight; SPY - Single plant yield

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