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Estimates of Variability, Character Association and Path Analysis among Components of Yield in Foxtail Millet (*Setaria italica*)

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ABSTRACT: The present study was aimed to realize the magnitude of variability and character association studies of yield parameters among advanced lines developed through crossing between inbred lines of diverse origin to obtain best performing new varieties to replace existing old varieties in order to enhance area under millet cultivation which provides national nutritional security. The present investigation was carried out to study the variability, heritability, genetic advance as per cent of mean, character association and path coefficient analysis among seventeen advanced lines. The data were recorded on yield parameters like days to 50% flowering, plant height (cm), days to maturity, number of productive tillers per plant, grain yield (kg/ha) and fodder yield (kg/ha). High heritability coupled with high genetic advance as percent of mean was observed for number of productive tillers and grain yield. Correlation study indicated that fodder yield, number of productive tillers and days to maturity had significant positive association with grain yield. The path analysis indicated that fodder yield and days to 50% flowering had positive direct effects on grain yield. Hence, selection may be exercised on these traits to improve grain yield.

Keywords: Variability, Character association, Direct effects, Foxtail millet.

INTRODUCTION

Millets are unique among the cereals because of their richness in calcium, dietary fibre, polyphenols and protein. The contribution of pearl millet to the total Fe and Zn intake from all food sources has been reported to very widely vary across rural India. Foxtail millet (*Setaria italica*) is also considered as very important nutricereal and it is cultivated all over the world and is the important millet among small millets. Grain is used for human consumption and straw is used for fodder purpose. Malt can be prepared out of sprouted seeds, it can be also used in preparation of alcoholic beverages. It is having high nutraceutical values which is beneficial for diabetic patients. It is widely cultivated in developing countries like China and India followed by South Korea, North Korea, Japan, Russia, Australia, France and United States. It can be considered as a climate resilient crop as it is grown in drought situations because of its high water use efficiency nature (Feldman *et al*., 2017). It will show tolerance to the soils which are nutrient poor.

Among the wide range of health promoting components, they are known to be rich in antioxidants, phenolics, dietary fiber, protein, fat, starch, vitamins and minerals (Yang *et al*., 2013). It is a promising source of nutrients and each 100g of grain contain protein(12.3g), carbohydrate (60.9g), fat (4.3g), crude fiber (8.0g), minerals (3.3g), calcium (31mg), phosphorus (290mg) (National Institute of Nutrition, (NIN), Hyderabad). The phenolics present in foxtail millet act as antioxidants by reducing the amount of free radical produced in the body. They are also known for their ability as reducing agents, metal chelators and reactive oxygen quenchers (Chandrasekara and Shahidi 2010). The intake of 50 g of foxtail millet per day significantly improved the glycemic control, especially the postprandial glucose, in free-living subjects with IGT. The glucose-lowering effect of foxtail millet might be a result of the interaction of increased leptin concentrations, decreased insulin resistance and reduced inflammation (Xin *et al.*, 2018). Liu *et al.* (2016) identified several accessions which are enriched with lutein, zeaxanthin, carotenoid and selenium. The instant millet mix made with finger millet and foxtail millet was found to be good source of mineral such as calcium (102.5±0.98mg), magnesium (104.1±0.98mg) and phosphorus (222.53±1.66mg) (Wandhekar *et al*., 2021). Yakun *et al*. (2021) identified 116 flavonoid compounds in foxtail millet and 33 differential flavonoid metabolites between high and poor eating quality varieties. Sandhya *et al*, (2020) identified 22 genotypes which were found to be Lysine rich genotypes from one hundred germplasm accessions of foxtail millet that were procured from ICRISAT. Among 10 genotypes of foxtail millet, it was found that, the content of different nutritional and physicochemical characters like protein was 13.29g, the fat content (3.83), the crude fibre (2.98), total mineral content (2.0g), the Energy value (3.79) and the low calorific value of 363 Kcal reported by Shilpa Huchchannanavar *et al*. (2019).

Millets cultivation area is reduced as these were cultivated in poor soils with neglected fertilizer management and due to lack of high yielding varieties. Higher yields will be achieved in millets, as they are fertilizer responsive.The use of 60:30:20 kg N: P_2O_5: K_2O per hactare nutrients increased the grain and straw yields by 69.94 and 86.14 percent, respectively in brown top millet (Sukanya *et al*., 2021).

Grain yield is a polygenic character and is difficult to enhance the yield potential by selecting yield per se. Therefore, identification of characters which are related with yield and intercorrelated among the yield traits themselves is essential tool in selection process. Correlation study gives the information on association of different characters with grain yield. The path analysis provides the measurement of direct and indirect effects of independent yield traits on the dependent trait *i.e.* grain yield.

MATERIAL AND METHODS

Seventeen Advanced breeding lines of foxtail millet were received from All India Coordinated Small Millets Improvement Project (AICSMIP), IIMR, Hyderabad (Table 1). The field experiment was conducted at Regional Agricultural Research Station, Palem (16°30″18″N latitude and 78°19″E longitude and 458 m mean sea level) during *Kharif*, 2020 under rainfed condition. The rainfall received during the crop growing period was 475 mm. These lines were evaluated in Randomised Block Design with three replications. The plot contains 10 rows with the row length of 3 m. The inter and intra row spacing was 22.5 × 10 cm. Recommended dose of fertilizers were applied at the time of sowing and the seeds were sown by hand sowing. Thinning was carried out after 21 days. Observations were recorded randomly by taking five plants and data were taken for the yield traits *viz.*, days to 50% flowering, plant height (cm), days to maturity, number of productive tillers per plant, grain yield (kg/ha) and fodder yield (kg/ha) were recorded. The data was analyzed for genetic parameters (Burton (1952); Johnson *et al.* (1955), correlation analysis (Snedecor and Cochran (1967) and path coefficient analysis (Dewey and Lu 1959). The statistical analysis was done by using INDOSTAT.

RESULTS AND DISCUSSION

A. Variability

All the advanced lines have shown significant difference for all the characters as per analysis of variance. In the present investigation the extent of variation among advanced lines in respect of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) is presented in Table 2. The results revealed that PCV was higher than GCV for all the characters which means influence of environment on the genotypes (Table 3). The characters plant height (45.3, 43.33), grain yield (43.65, 37.6) and number of productive tillers (43.25, 38.9) have exhibited high PCV and GCV respectively, indicating a greater scope of genetic enhancement through the selection of these characters. Same results were reported by Nandini *et al.* (2018); Lakshmi Pallavi *et al.* (2020).

B. Heritability and Genetic Advance

The genetic relationship between parents and progeny is measured by heritability. The heritability alone is not sufficient to select better genotypes and it should be accompanied with genetic advance as percent of mean. Genetic advance is a measure of genetic gain under selection. Hence the effectiveness of selection depends upon genetic advance of the trait along with heritability because of accumulation of additive genes which are further leading to yield improvement. High heritability along with high genetic advance was reported for the characters number of productive tillers and grain yield. Same results were obtained by Ashok *et al.* (2016); Dhruv *et al.* (2020); Karvar *et al.* (2020); Kavya *et al.* (2017); Pavani *et al.* (2019). Plant height recorded high heritability and low genetic advance. Hence, from the above result it can be concluded that number of productive tillers and grain yield are good selection parameters for genetic enhancement of foxtail millet.

C. Character association studies

The mutual relationship among yield traits is determined by correlation analysis on which selection can be practiced for achieving higher yields. Correlation studies (Table 4) revealed that the characters fodder yield (r_g=0.676**) and number of productive tillers (r_g=0.327**) have exhibited significant positive association with grain yield genotypically. Same was reported by Anand *et al.* (2020); Nirmalakumari and Vetriventhan (2010). Grain yield exhibited phenotypic significant association with the component characters namely fodder yield (r_p=0.649**), number of productive tillers (r_p=0.521**) and days to maturity (r_p=0.386**). The component character number of productive tillers has high positive association with days to maturity followed by days to 50% flowering genotypically and significant positive association with plant height followed by days to 50% flowering phenotypically (Kamal and Vasundhara 2021). Fodder yield had high positive correlation with plant height followed by days to maturity genotypically and with days to maturity followed by number of productive tillers. Hence these component characters can be given importance in inclusion of selection process during improvement of yield potential of foxtail millet.

The trait plant height had negative association with days to maturity and fodder yield phenotypically. Grain yield had very low association with days to 50 % flowering both phenotypically and genotypically. Days to 50% flowering very high significant association with days to maturity and number of productive tillers. Fodder yield had positive association with plant height genotypically.

D. Path coefficient analysis

Partitioning of direct effect from indirect effect via other component characters can be done by using path analysis (Dewey and Lu 1959). The phenotypic direct and indirect effects of component traits on grain yield is represented in Table 5. The traits which have registered high positive direct effects with grain yield are fodder yield, days to 50% flowering and number of productive tillers per plant (Ayesha *et al.*, 2019; Brunda *et al.*, 2015). Grain yield had negative direct effect with days to maturity and plant height. But days to maturity had positive indirect effect on grain yield via days to 50% flowering and fodder yield. Hence this character can be considered as it indirectly contributing towards grain yield (Amarnath *et al.*, 2018). Number of productive tillers reported positive indirect effect via days to 50 % flowering on grain yield. Hence, it has contribute to grain yield directly and indirectly. Selection for number of productive tillers is very promising in yield improvement.

The genotypic direct and indirect effects of component traits on grain yield is represented in Table 6. Path analysis revealed that days to 50% flowering had the highest positive direct effect on grain yield followed by number of productive tillers and fodder yield genotypically. Negative direct effect was exhibited by days to maturity and plant height. Plant height and days to maturity had indirect contribution towards grain yield through days to 50% flowering and number of productive tillers, suggesting that these traits also included in selection criteria of yield.

Table 1: The foxtail millet advanced lines employed in the present study.

Sr. No.	Advanced lines	Pedigree
1.	SiA 3159	Srilakshmi × SiA 1378
2.	SiA 3303	SiA 326 × SiA 3088
3.	SiA 4200	GP 445 × Prasad
4.	GPUF 4	CO_7 × TNSi 365-2
5.	IIMR FxM-5	Selection from GS 957
6.	GPUF 15	CO_6 × TNSi 355-2
7.	CRS FxM-1	Selection from ISe 426
8.	CRS FxM-2	Selection from KOPFM 82
9.	SiA 4210	Prasad × GS 445
10.	SiA 4213	Selection from Nallamallahills, Onkaram
11.	TNSi 379	SiA 306 × TNSi 360
12.	TNSi 380	SiA 306 × TNSi 351
13.	IIMR FxM-6	Selection from ISe 1009
14.	IIMR FxM-7	Selection from ISe 1593
15.	SiA 3156	Selection from SiA 2871
16.	DHFt 109-3	CO_5 × GPUS 30
17.	PKS-22	Pure line selection from ISC 1820

Table 2: Analysis of variance for yield and yield components among 17 advanced lines of Foxtail millet (*Setaria italica*).

Source of variation	Degree of freedom	Days to 50% flowering	Plant height (cm)	Days to maturity	Number of productive tillers	Grain yield (kg/ha)	Fodder yield (kg/ha)
Replications	2	38.72	86.3	71.35	0.41	56981.2	20388.77
Treatments	16	102.3**	430.62**	101.08***	0.45**	85599.17**	130755.25**
Error	32	16.9	55.3	20.16	0.13	36373.24	7183.74

Table 3: Mean performance and genetic parameters among 17 advanced lines of Foxtail millet (*Setaria italica*).

Sr. No.	Traits	Range		Mean	Coefficient of variation		Heritability (%) (Broad sense)	Genetic advance as % of mean (5% level)
		Minimum	Maximum		PCV (%)	GCV (%)		
1.	Days to 50% flowering	**38**	**56.7**	48.43	19.37	14.33	95	21.08
2.	Plant height (cm)	79	121.3	102.7	45.3	43.33	73	15
3.	Days to maturity	62.7	83	75.89	9.05	6.84	75	23.67
4.	Number of productive tillers	3.07	4.3	3.67	43.25	38.9	54	25.8
5.	Grain yield (kg/ ha)	1254.33	1945.67	1682.16	43.65	37.6	48	31.21
6.	Fodder yield (kg/ha)	2647	3432	3073.12	41.71	38.4	40.3	29.92

Table 4: Genotypic correlation (upper) and phenotypic correlation (lower) of yield attributes among 17 advanced lines of Foxtail millet (*Setaria italica*).

Traits	Days to 50% flowering	Plant height (cm)	Days to maturity	Number of productive tillers	Fodder yield (kg/ha)	Grain yield (kg/ ha)
Days to 50% flowering	**1.000**	0.245	0.968	0.670	0.259	0.092
Plant height (cm)	0.022	**1.000**	0.041	0.574	1.281	0.160
Days to maturity	0.895^{***}	-0.176	**1.000**	0.677	0.495	0.015
Number of productive tillers	0.287^{*}	0.317^{*}	0.272	**1.000**	0.052	0.327^{**}
Fodder yield (kg/ha)	0.139	-0.350^{*}	0.264	0.183	**1.000**	0.676^{**}
Grain yield (kg/ ha)	0.081	0.130	0.386^{**}	0.521^{**}	0.649^{**}	**1.000**

Table 5: Direct and indirect effects (phenotypic) of yield attributes on yield among 17 advanced lines of Foxtail millet (*Setaria italica*).

Traits	Days to 50% flowering	Plant height (cm)	Days to maturity	Number of productive tillers	Fodder yield (kg/ha)
Days to 50% flowering	**0.356**	0.008	0.319	0.102	0.049
Plant height (cm)	-0.001	**-0.004**	0.007	-0.001	0.001
Days to maturity	-0.419	0.082	**-0.468**	-0.127	-0.123
Number of productive tillers	0.041	0.045	0.038	**0.142**	-0.026
Fodder yield (kg/ha)	0.104	-0.262	0.197	-0.137	**0.747**
Partial R^2	0.029	0.0005	-0.040	-0.003	0.485

R Square = 0.4710 Residual Effect = 0.7274 Diagonal bold letters indicate direct effects.

Table 6: Direct and indirect effects (genotypic) of yield attributes on yield among 17 advanced lines of Foxtail millet (*Setaria italica*).

Traits	Days to 50% flowering	Plant height (cm)	Days to maturity	Number of productive tillers	Fodder yield (kg/ha)
Days to 50% flowering	**6.083**	1.492	5.891	4.077	1.574
Plant height (cm)	-0.388	**-1.581**	-0.065	-0.908	2.025
Days to maturity	-7.362	-0.313	**-7.602**	-5.144	-3.766
Number of productive tillers	1.383	1.186	1.397	**2.064**	0.106
Fodder yield (kg/ha)	0.191	-0.944	0.365	0.038	**0.737**
Partial R^2	-0.562	0.253	0.114	0.262	0.499

R Square = 0.566; Residual Effect = 0.659; Diagonal bold letters indicate direct effects.

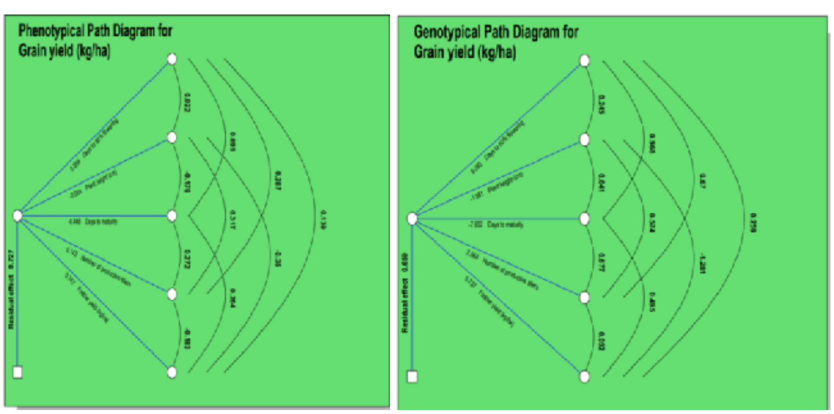

Fig. 1.

CONCLUSION

The results from the above study revealed that the component characters number of productive tillers per plant, fodder yield and days to maturity can be taken as selection parameters for yield improvement in foxtail millet. These traits have shown high GCV, PCV, high heritability coupled with high genetic advance and has shown positive association with grain yield as per correlation analysis. The path analysis revealed that these traits contribute to grain yield immensely both directly and indirectly through other related traits.

FUTURE SCOPE

The seventeen genotypes showed variability for many of the quantitative characters and can be used for improvement of grain yield by simple phenotypic selection. These can also be used as parents in further crossing programme and selection will be carried out to isolate superior segregants.

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Conflict of Interest. None.

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