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RESEARCH ARTICLE

GENETIC VARIABILITY, CORRELATION AND PATH ANALYSIS IN FOXTAIL MILLET (*SETARIA ITALICA* (L.) BEAUV) GERMPLASM FOR YIELD CONTRIBUTING TRAITS

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ABSTRACT

An investigation was carried out with 50 elite foxtail millet (*Setaria italica* (L.) Beauv) germplasm to evaluate the extent of genetic variability, correlation and path analysis of yield and its components during *rabi*, 2016. Analysis of variance showed highly significant differences for all the 13 characters studied ensure the existence of variability among the genotypes. High heritability coupled with high genetic advance was observed for all the traits except for days to 50 % flowering, which had high heritability and moderate genetic advance. The trait grain yield had strong correlation with its component traits like straw yield per plant, single panicle weight, panicle width, panicle length, flag leaf length, plant height, number of tillers per plant, length of inflorescence and number of productive tillers per plant. Path analysis revealed that length of inflorescence had high direct effect on grain yield, while other traits had negligible amount of direct effect on grain yield.

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INTRODUCTION

Foxtail millet [*Setariaitalica* (L.) P. Beauv.] is one of the world's oldest cultivated crops. It ranks second in the world's total production of millets and is an important staple food for millions of people in southern Europe and Asia (Marathee, 1993). In India the crop is cultivated on a very limited area of around 0.1 million hectares in sporadic patches in the states of Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra, Madhya Pradesh, Uttar Pradesh and North Eastern states with an annual production of 0.29 million tones and productivity of 600 kg /ha. In Tamil Nadu, it is grown in an average area of about 3000 ha (Nirmalakumari *et al*., 2005) covering western zones especially Coimbatore, Madurai, Dindugul, Erode, Salem and Thirunelveli districts (Senthil *et al*., 2005). The nutrient quality of foxtail millet is similar to common millet comprising 11 % protein, 4% oil and 7% crude fibre. Mature grain has higher content of essential amino acids and vitamins (thiamine, riboflavin and niacin).The grain is a good source of protein and contains β-carotene, minerals *viz*., calcium, iron, potassium, magnesium, zinc, antioxidants and vitamins (Rai, 2002). Wide genetic diversity is available in foxtail millet, and characterizing these resources is a prerequisite for its genetic improvement.

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A diversified germplasm collection plays a key role in both breeding and genomic research for any crop species. Besides genetic variability, knowledge on heritability and genetic advance measures the relative degree to which a character is transmitted to progeny, thereby helps the breeder to employ a suitable breeding strategy to achieve the objective. Keeping the above points in view, the present investigation was carried out to find out the extent of genetic variation, heritability and genetic advance among 49 foxtail millet accessions received from ICRISAT germplasm collection along with the local check CO 7.

MATERIALS AND METHODS

The experimental material comprised of 49 foxtail millet germplasm accessions collected from ICRISAT, Hyderabad and the local check variety Co 7. The experiment was carried out during *rabi,* 2016 in Randomized Block Design (RBD) with three replications. Each entry was sown in single row with spacing of 60 cm between rows and 15 cm between plants. The package of practices recommended by Tamil Nadu Agricultural University for foxtail millet was followed throughout the cropping period. Observations on 13 quantitative characters *viz.*, days to 50% flowering, plant height, number of tillers per plant, number of productive tillers per plant, flag leaf length, flag leaf width, panicle exertion, length of inflorescence, panicle length, panicle width, single panicle weight, straw yield per plant and grain yield per plant were recorded on five randomly selected plants for each genotype at various stages of crop growth. The data obtained was then subjected to standard statistical procedures by Panse and Sukhatme (1985), Burton (1952), Lush (1940), Johnson *et al.* (1955), Dewey and Lu (1959) and Lenka and Misra (1973).

RESULTS AND DISCUSSION

Analysis of variance for the 13 quantitative characters indicated that there is significant difference between the genotypes for all the characters studied. (Table 1). Superior genotypes with superior yield contributing traits, yield better progenies is the fundamental concept of plant breeding. Among all the genotypes studied, ISe 132 registered minimum days for 50% flowering of 45.67 days with a mean grain yield of 17.19 g. The genotype ISe 289 was found to be significantly superior with higher mean value for the maximum of four yield and yield contributing characters *viz.*, number of productive tillers per plant (10.13), panicle width (1.38 cm), single panicle weight (5.93 g) and grain yield per plant (22.25 g) (Table 2). Hence, these genotypes could be considered for various crop improvement programmes like direct release as a variety or as a parent in hybridization programme.

In the present study, it was found that the trait grain yield per plant (80.20) had the highest phenotypic coefficient of variation (PCV) followed by straw yield per plant (70.94), single panicle weight (61.40), number of tillers per plant (30.84), number of productive tillers per plant (27.33), panicle exertion (22.13) and panicle length (20.42). Moderate phenotypic co-efficient of variation was recorded by characters *viz*., flag leaf width (19.59), flag leaf length (18.65), plant height (17.49) and panicle width (15.24). The genotypic co-efficient of variation (GCV) was high for the characters *viz*., grain yield per plant (77.31), straw yield per plant (68.42), single panicle weight (61.11), number of tillers per plant (30.07), number of productive tillers per plant (26.06), while moderate (10-20%) GCV was observed for panicle exertion (18.33), panicle length (18.28), flag leaf length (17.52), plant height (17.42), flag leaf width (17.03), length of inflorescence (16.39) and panicle width (14.65). Days to 50 % flowering was the only trait which recorded low PCV and GCV of 6.97 and 6.35, respectively (Table 2).

In this experiment, the values of phenotypic variance were greater than that of genotypic variance. The trait straw yield per plant showed a greater difference in phenotypic and genotypic variance. A very close relationship was found between GCV and PCV for most of the characters revealing the least influence of environment for the expression. In the present investigation, high PCV and GCV were observed for the traits like grain yield per plant, straw yield per plant, single panicle weight, number of tillers per plant, number of productive tillers per plant, panicle exertion and panicle length. Similar results have been reported by Nirmalakumari*et al.*(2008),Srisha*et al.*(2009), Tyagi *et al.*(2011), Prasanna *et al.*(2013), Nirmalakumari and Vetriventhan (2014) and Kavya (2016) for grain yield per plant;Srisha*et al.*(2009), Tyagi *et al*. (2011),Prasanna *et al.*(2013), Brunda*et al.*(2014) and Kavya (2016) for straw yield per plant and Yogeesh*et al.*(2015), Nirmalakumari and Vetriventhan (2014) and Kavya (2016) for number of tillers per plants and number of productive tillers per plant; Nirmalakumari*et al.*(2008) and Kavya (2016) for panicle exertion. Gurunadharao and Apparao (1984) and Srisha *et al.* (2009) for panicle length. Moderate PCV was recorded for flag leaf width, flag leaf length, plant height, length of inflorescence and panicle width, which is similar to the findings of Nirmalakumari *et al.*(2008) and Kavya (2016). The only trait that exhibited low PCV was days to 50 % flowering and similar finding was earlier reported by Srisha *et al.*(2009), Velzaco and Rimeri (2012), Prasanna *et al.*(2013), Nirmalakumari and Vetriventhan (2014) and Yogheesh *et al.*2015). Heritability is the ratio of genotypic variance to phenotypic variance and is expressed in percentage. It is the heritable portion of phenotypic variance. All the characters studied in the present investigation had high heritability. The highest heritability was expressed by plant height (99.22%), followed by single panicle weight (99.06%) number of tillers per plant (95.07%), straw yield per plant (93.02%), grain yield per plant (92.92%), panicle width (92.42%), number of productive tillers per plant (90.88%), length of inflorescence (89.87%), flag leaf length (88.23%), days to 50% flowering (82.93%), panicle length (80.14%), flag leaf width (75.67%) and panicle exertion (68.59%).(Table 3). These findings were agreement with the earlier workers Kavya (2016) for plant height; Srisha *et al.*(2009), Tyagi *et al.*(2011), Prasanna *et al.*(2013), Brunda *et al.*(2014) and Kavya (2014) for straw yield per plant; Nirmalakumari *et al.*(2008), Srisha *et al.*(2009), Tyagi *et al.*(2011), Prasanna *et al.*(2013), Nirmalakumari and Vetriventhan (2014) and Kavya (2016) for grain yield per plant; Velzaco and Rimeri (2012) and Brunda *et al.*(2014) for panicle width; Velzaco and Rimeri (2012), Prasanna *et al.*(2013), Brunda*et al.*(2014), Nirmalakumari and Vetriventhan (2014) and Kavya (2016) for number of productive tillers per plant; Nirmalakumari *et al.*(2008) and Tyagi *et al.*(2011) for flag leaf length; Prasanna *et al.*(2013), Brunda *et al.*(2014), Nirmalakumari and Ventriventhan (2014), Yogeesh*et al.*(2015) and Kavya (2016) for days to 50% flowering; Prasanna *et al.*(2013), Brunda *et al.*(2014), Nirmalakumari and Vetriventhan (2014) and Kavya (2016) for panicle length; Nirmalakumari *et al.*(2008), Tyagi *et al.*(2011) for flag leaf width and Nirmalakumari *et al.*(2008) and Kavya (2016) for panicle exertion.

Genetic advance is a measure of genetic gain under selection. The characters that had high genetic advance were plant height (35.74%), number of tillers per plant (60.41%), number of productive tillers per plant (51.18%) flag leaf length (33.9%), flag leaf width (30.53%) panicle exertion (31.27%), length of inflorescence (32%), panicle length (33.71%), panicle width (29.03%), single panicle weight (125.29%) straw yield per plant (135.94 %) and grain yield per plant (153.52%). Days to 50% flowering (11.91%) had medium genetic advance as percentage of mean, while no trait had low genetic advance. (Table 3). High genetic advance as per cent of mean was recorded by the traits grain yield per plant followed by straw yield per plant and single plant weight. This was in accordance with the earlier reports of Tyagi *et a*l.(2011), Prasanna *et al.*(2013), Nirmalakumari and Vetriventhan (2014), Kavya (2016) for grain yield per plant and Tyagi *et al.*(2011), Prasanna *et al.* (2013), Brunda*et al.* (2014) and Kavya (2016) for straw yield per plant. The only character that showed moderate genetic advance as per cent of mean was days to 50 % flowering. Kavya (2016) reported similar results.

Table 1. ANOVA for 13 characters in 50 foxtail millet genotypes

	Days to 50 % flowering	Plant height (cm)	Number of tillers/ plant	Number of productive tillers/ plant	Flag leaf length (cm)	Flag leaf width (cm)	Panicle exertion (cm)	Length of inflorescence (cm)	Panicle length (cm)	Panicle Width (cm)	Single panicle weight (g)	Straw Yield/ Plant (g)	Grain Yield/ plant (g)
Replication	0.23	0.07	0.80	1.49	8.14	0.06	3.19	0.59	0.79	0.001	0.01	0.65	0.28
Treatment	37.45*	594.63*	9.39*	5.32*	45.53*	0.18*	31.13*	49.14*	8.89*	0.07*	4.36*	283.68**	76.18*
Error	2.40	1.54	0.15	0.17	1.93	0.02	4.12	1.77	0.68	0.002	0.01	6.92	1.88

*, ** Significant at 5 % and 1 % level, respectively

Table 2. Mean, range, coefficient of variation, heritability and genetic advance as per cent of mean for 13 characters in 50 xtail millet genotypes

Characters	Mean	Range/ Genotype		GCV	PCV	ECV	Heritability	GA(%) of mean
		Minimum	Maximum					
Days to 50 % flowering	53.80	45.67 (ISe 132)	64.33 (ISe 1858)	6.35	6.97	2.88	82.93	11.91
Plant height (cm)	80.71	54.61 (ISe 936)	120.40 (ISe 144)	17.42	17.49	1.54	99.22	35.74
Number of tillers/ plant	5.83	3.27 (ISe 1408)	12.23 (CO 7)	30.07	30.84	6.84	95.07	60.41
Number of productive tillers/ plant	5.03	2.53 (ISe 1408)	10.13 (ISe 289)	26.06	27.33	8.25	90.88	51.18
Flag leaf length (cm)	21.75	14.94 (ISe 200)	34.23 (ISe 745)	17.52	18.65	6.40	88.23	33.91
Flag leaf width (cm)	1.38	0.96 (ISe 956)	2.03 (ISe 745)	17.03	19.58	9.66	75.67	30.53
Panicle exertion (cm)	16.37	10.33 (ISe 403)	26.85 (ISe 710)	18.33	22.13	12.40	68.59	31.27
Length of inflorescence (cm)	24.24	15.71 (ISe 1846)	34.84 (ISe 796)	16.39	17.28	5.50	89.87	32.00
Panicle length (cm)	9.05	6.05 (ISe 200)	12.60 (ISe 144)	18.28	20.42	9.10	80.14	33.71
Panicle width (cm)	0.99	0.69 (ISe 1402)	1.38 (ISe 289)	14.65	15.24	4.19	92.42	29.03
Single panicle weight (g)	1.97	0.51 (ISe 1406)	5.93 (ISe 289)	61.11	61.40	5.96	99.06	125.29
Straw yield/ plant (g)	14.04	4.23 (ISe 1406)	43.91 (ISe 237)	68.42	70.94	18.73	93.02	135.94
Grain yield/ plant (g)	6.44	1.50 (ISe 1408)	22.25 (ISe 289)	77.31	80.20	21.33	92.92	153.52

Table 3. Simple correlation coefficient for yield and yield attributing characters of 50 foxtail millet genotypes

Characters	Days to 50 % flowering	Plant height (cm)	Number of tillers/ plant	Number of productive tillers/ plant	Flag leaf length (cm)	Flag leaf width (cm)	Panicle exertion (cm)	Length of inflorescence (cm)	Panicle length (cm)	Panicle width (cm)	Single panicle weight (g)	Straw Yield/ plant (g)	Grain Yield/ plant (g)
Days to 50 % flowering	1.000	0.314**	0.027	-0.123	0.305**	0.255*	0.270**	0.159	0.304**	0.320**	0.471**	0.436**	0.398**
Plant height (cm)		1.000	-0.007	-0.108	0.369**	0.438**	0.095	0.223*	0.294**	-0.056	0.112	0.337**	0.366**
Number of tillers/ plant			1.000	0.787**	0.077	0.026	0.141	0.194	0.252*	-0.054	-0.053	0.244*	0.264**
Number of productive Tillers/ plant				1.000	0.029	-0.085	0.075	0.410**	0.482**	0.297**	0.288**	0.407**	0.422**
Flag leaf length (cm)					1.000	0.641**	0.387**	0.354**	0.374**	0.374**	0.296**	0.354**	0.384**
Flag leaf width (cm)						1.000	0.371**	0.720**	0.140	0.173	0.028	0.031	0.047
Panicle exertion (cm)							1.000	0.125	0.039	0.068	0.091	0.006	0.083
Length of inflorescence (cm)								1.000	0.573**	0.293**	0.245*	0.299**	0.287**
Panicle length (cm)									1.000	0.467**	0.524**	0.529**	0.512**
Panicle width (cm)										1.000	0.610**	0.539**	0.590**
Single panicle weight (g)											1.000	0.820**	0.830**
Straw yield/ plant (g)												1.000	0.949**
Grain yield/ plant (g)													1.000

*, ** Significant at 5 % and 1 % level, respectively

Table 4. Direct and indirect effects of different yield attributing traits with grain yield of 50 foxtail millet genotypes

Characters	Days to 50 % flowering	Plant height (cm)	Number of tillers/ plant	Number of productive tillers/ plant	Flag leaf length (cm)	Flag leaf width (cm)	Panicle exertion (cm)	Length of inflorescence (cm)	Panicle length (cm)	Panicle width (cm)	Single panicle weight (g)	Straw Yield/ plant (g)	Grain Yield/ plant (g)
Days to 50 % flowering	0.095	0.031	0.003	-0.012	0.031	0.026	0.028	0.200	-0.363	0.124	0.357	-0.005	0.398
Plant height (cm)	-0.030	-0.092	0.001	-0.035	0.171	0.144	-0.127	0.289	-0.351	-0.021	0.085	-0.004	0.366
Number of tillers/ plant	0.008	-0.002	0.267	0.252	0.036	0.008	-0.192	0.255	-0.308	-0.020	-0.043	-0.003	0.264
Number of productive Tillers/ plant	-0.040	-0.035	0.211	0.319	0.014	-0.030	-0.120	0.534	-0.597	0.115	0.224	-0.005	0.422
Flag leaf length (cm)	0.146	0.171	0.021	0.009	0.453	0.214	-0.529	0.468	-0.480	0.152	0.233	-0.004	0.384
Flag leaf width (cm)	0.084	0.144	0.007	-0.030	0.311	0.312	-0.543	0.973	-0.154	0.071	0.024	0.000	0.047
Panicle exertion (cm)	-0.381	-0.127	0.040	0.030	0.188	0.133	-1.280	0.161	-0.050	0.027	0.069	0.000	0.083
Length of Inflorescence (cm)	-0.015	0.061	0.065	0.193	0.116	-0.990	0.012	1.257	-0.704	0.113	0.189	-0.003	0.287
Panicle length (cm)	-0.029	0.081	0.085	0.235	0.130	-0.171	0.004	0.767	-1.153	0.190	0.411	-0.006	0.512
Panicle width (cm)	-0.030	-0.014	-0.017	0.137	0.124	-0.240	0.007	0.372	-0.576	0.381	0.470	-0.006	0.590
Single panicle weight (g)	-0.043	0.030	-0.018	0.134	0.096	-0.041	0.009	0.314	-0.625	0.236	0.757	-0.009	0.830
Straw yield/ plant (g)	-0.041	0.092	0.080	0.190	0.117	-0.039	0.000	0.383	-0.649	0.211	0.626	-0.011	0.949
Grain yield/ plant (g)													

Residual effect = 0.1595302 Diagonal values indicate direct and indirect effect

Selection for the traits having high heritability coupled with high genetic advance is likely to accumulate more additive gene leading to further improvement of performance. In the present investigation, high heritability along with high genetic advance was observed for all the characters studied except days to 50% flowering. Hence, these traits must be given importance during selection in advancing segregating generation. High heritability coupled with high genetic advance was reported earlier by Nirmalakumari *et al.*(2008), Srisha *et al.*(2009), Tyagi *et al.*(2011), Prasanna *et al.*(2013), Nirmalakumari and Vetriventhan (2014) and Kavya (2016) for the trait grain yield per plant, which implied the presence of additive gene effects, controlling these traits. Hence, selection should be effective for improvement of traits governed by additive genes.

The most complex and important economic trait, single plant yield exhibited high genetic advance as per cent of mean coupled with high heritability, PCV and GCV values, which indicated the availability of sufficient variation in the genotypes under study.

The correlation co-efficient analysis measures the mutual relationship between various plant characters and determines the component characters on which selection can be imposed for genetic improvement in yield. The inter relationship among the 13 characters estimated through correlation co-efficient at simple levels is presented in table 3. Grain yield per plant recorded high significant positive correlation with its components characters like, straw yield per plant (0.949), single panicle weight (0.830), panicle width (0.590), panicle length (0.512), flag leaf length (0.422), plant height (0.398), number of tillers per plant (0.366), length of inflorescence (0.287) and number of productive tillers per plant (0.264). This result is agreement with the earlier studies reported by Brunda *et al.*(2015) and Kavya (2016) for straw yield per plant, panicle width and panicle length; Tyagi *et al.*(2011) and Kavya (2016) for flag leaf length; Nirmalakumari and Vetriventhan (2014), Brunda *et al.*(2015) for plant height. Hence these characters have to be given importance during the selection programme to improve the yield potential of foxtail millet genotypes.

In the present investigation, days to 50% flowering was positively and significantly inter correlated with plant height, flag leaf length, flag leaf width and panicle exertion. These results are in agreement with earlier findings reported by Nirmalakumari and Vetriventhan (2014) and Prasanna *et al.*(2014) for plant height; Tyagi *et al.*(2011) for flag leaf length and flag leaf width. Plant height was positively and significantly inter correlated with flag leaf length, flag leaf width, days to 50% flowering, panicle length, panicle width, single panicle weight and straw yield per plant. These results are in agreement with the reports of Nirmalakumari and Vetriventhan (2014), Brunda *et al.* (2015) and Kavya (2016) for panicle length and Brunda *et al.* (2015) for panicle width and straw yield per plant. Number of tillers per plant showed positive and significant inter correlation with number of productive tillers per plant, length of inflorescence, panicle length and straw yield per plant. Similar findings were reported by Brunda *et al.* (2015) and Kavya (2016) for panicle length and straw yield per plant. Panicle length had significant positive inter correlation with panicle width, single panicle weight and straw yield per plant. These results are in harmony with the findings of Prasanna *et al.* (2014) and Brunda *et al.* (2015) for panicle width and Brunda *et al.* (2015) and Kavya (2016) for straw yield per plant. Panicle width showed positive and significant inter correlation with straw yield per plant and single panicle weight. The characters number of tillers per plant and number of productive tillers per plant showed negative non-significant correlation with panicle width. Brunda *et al.*(2015) reported same findings for panicle width. From the above mentioned facts, it is clear that all the yield component traits *viz*., plant height, number of tillers per plant, number productive tillers plant, flag leaf length, flag leaf width length of inflorescence, panicle length, panicle width, single panicle weight and straw yield per plant are inter correlated among themselves except the characters days to 50% flowering and panicle exertion. Therefore, these traits are to be given priority during selection programme to increase single plant yield.

The relationship between yield and yield components may be negative or positive. In such situation, path co-efficient analysis would be useful, as it permits the separation of direct effect from indirect effect through other related traits by partitioning the genotypic correlation co-efficient (Dewey and Lu, 1959). In the present study, direct and indirect effects of yield contributing characters on grain yield were worked out and presented in table 4. High positive direct effect on single plant yield was exhibited by length of inflorescence, single panicle weight, flag leaf length, panicle width, number of productive tillers per plant, flag leaf width, number of tillers per plant and days to 50 % flowering. This is in accordance with the earlier findings of Brunda *et al.*(2015) and Kavya (2016) for panicle width and number of tillers per plant; Prasanna *et al.*(2014) and Nirmalakumari and Vetriventhan (2014) for days to 50% flowering. As for as indirect effects are concerned, high indirect effect was noticed for length of inflorescence followed by panicle exertion, panicle length, flag leaf length, flag leaf width, straw yield per plant, panicle width, single panicle weight, number of tillers per plant, number of productive tillers plant and plant height. These results are in accordance with the findings of Prasanna *et al.* (2013), Nirmalakumari and Vetriventhan (2014), Brunda *et al.* (2015) and Kavya (2016). From the above discussion, it can be concluded that the characters *viz*., length of inflorescence, single panicle weight, flag leaf length, panicle width, number of productive tillers per plant, flag leaf width, number of tillers plant and days to 50 % flowering could be used as selection indices for improvement of grain yield. Path analysis indicated that length of inflorescence had the highest direct effect on grain yield per plant followed by single panicle weight, number of productive tillers per plant, flag leaf width, number of tillers per plant and days to 50% flowering. Most of the traits were found to have indirect contribution towards grain yield per plant through length of inflorescence. It may be concluded that improvement in grain yield per plant could be done by selection of these characters.

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