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Estimates of variability, heritability and genetic advance in foxtail millet

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Abstract
Foxtail millet is one of the nutri-cereal which is grown for food, feed and fodder. It can address the context of climate change through its high resilience. Variability is the main prerequisite for any crop to sustain itself and feed the growing population. Hence, variability, heritability and genetic advance of foxtail millet breeding lines was studied at Agricultural Research Station, Vizianagaram during *kharif*, 2017. Among all genotypes, SiA 3222 is the earliest which can fit in the gap between any cropping system and also can be used in contingent planning. High variability existed for panicle length, peduncle length and leaf length followed by grain yield and fodder yield. High heritability with high Genetic Advance as percent Mean was recorded for panicle length, peduncle length, leaf length, days to maturity and grain yield suggesting primarily additive nature of gene action which responds well to selection.

Keywords: Genetic variability, heritability, foxtail millet, *Setaria italica*

Introduction
Foxtail millet (*Setaria italica* (L.) P. Beauv) also known as Italian millet is important crop next to finger millet among the seven small millets. It is also known by different names such as giant setaria, german millet, chinese millet, hungarian millet. It belongs to the family Poaceae with chromosome number 2n=18. It is grown for grain, which is used for human consumption and also as animal, poultry, cage birds feed and its straw is used as fodder. It is an annual, self pollinated nutritious food crop.

Foxtail millet is fairly drought tolerant but cannot tolerate water logging. It is a potential crop grown mostly on poor or marginal soils in southern Europe and in temperate, subtropical and tropical Asia which feeds millions of people. It can even grow at an altitude of 2000 msl. Foxtail millet ranks second in the world's total production of millets. In India it is cultivated in an area of 5 lakh hectares and the production of 2.9 million tons with productivity of 600 kg per hectare (Anonymous, 2016). At present, foxtail millet is cultivated in Andhra Pradesh, Karnataka, Maharashtra, Tamil Nadu, Rajasthan, Madhya Pradesh, Uttar Pradesh and north eastern states of India.

Foxtail millet grains are rich in protein, fibre, β carotene, minerals viz., calcium, iron, potassium, magnesium, zinc, antioxidants and vitamins (Rai, 2002). Millet based dietary fiber, improves glycemic control, decreases hyperinsulinemia and lowers plasma lipid concentrations in patients with type 2 diabetes (Jali *et al*., 2012) [7].

Grain yield of a crop being a complex character is influenced by many of its dependent traits and is controlled by polygenes as well as environmental influence. Knowledge on inheritance of yield and its related traits, heritability, expected genetic advance and association between various economic traits is necessary for planning successful selection procedure for evolving high yielding genotypes. Improvements of these traits depend on the existence of variability. The variability for traits of economic importance is the basic prerequisite for any crop improvement. In order to improve grain yields breeding of high yielding varieties either through heterosis breeding or pureline selection is essential.

Materials and Methods
In the present investigation, eight genotypes including one local check variety, were evaluated at Agricultural Research Station, Vizianagaram, Andhra Pradesh during *kharif*, 2017. Genotypes were sown in a randomized complete block design (RCBD) in three replications with a spacing of 30 × 7.5 cm per each entry. Fertilizers, 40-20-0 NPK kg/ha and need based plant protection measures were taken to raise a healthy crop. Observations were recorded on days to 50% flowering, plant height, No. of productive tillers/plant, panicle length, peduncle length, leaf length, leaf width, grain yield and fodder yield.

Analysis of variance and summary statistics were calculated as per Panse and Sukathme (1967). Analysis of variance may not reveal the absolute variability and this could be accessed through standardizing the phenotypic and genotypic variances by obtaining the coefficients of variability. Hence, the components of variation such as genotypic coefficients of variation (GCV) and phenotypic coefficients of variation (PCV) were computed as per Burton and Devane (1953) [4]. Further it is essential for selection to separate out the environmental influence from the total variability. This indicates the accuracy with which a genotype can be identified by its phenotypic performance and thus heritability in broad sense was computed as per Allard (1960) [1]. The estimates of heritability alone fail to indicate the response to selection. Therefore, the heritability estimates appeared to be more meaningful when accompanied by estimates of genetic advance. Hence the genetic advances as per cent mean (GAM) was also estimated. Heritability and genetic advancement were categorized into low, medium and high as per Johnson *et al*., (1955) [8]. Phenotypic correlations were calculated according to Falconer (1981) [6].

3. Results and Discussion

ANOVA table showed high significant differences among the genotypes studied for all the traits indicating presence of sufficient amount of variability (Table No. 1). The analysis of variance (ANOVA) showed highly significant differences ($P < 0.01$) among the genotypes for the entire yield and yield component traits studied (Table 1).

Summary statistics (Table No. 2) of eight genotypes studied indicated that days to 50% flowering ranged from 39 to 53 days and days to maturity ranged from 65 to 84 days respectively. Plant height varied from 117.2 to 158.8 cm with general mean of 135.9 cm. Number of productive tillers varied from 4.2 to 7.0 with general mean 5.3, Ear length ranged from 14 to 23.1 cm having general mean 18.4 cm, leaf length ranged from 30.5 to 52.5 cm having general mean 36.6 cm, leaf width ranged from 1.7 to 2.3 cm having general mean 2.0 cm and peduncle length ranged from 9.3 to 16.1 cm with general mean of 12.6 cm. Grain yield ranged from 18.6 q/ha (SiA 3222) to 28.9 q/ha (SiA 3223) while fodder yield had a wide range of 41.6 q/ha (SiA 3222) to 70.0 q/ha (SiA 3156).

In the present study foxtail millet genotypes exhibited moderate PCV and GCV (Table No. 3) for No. of productive tillers, peduncle length, leaf length, grain yield, fodder yield and panicle length specifying moderate variability for these traits. Days to 50% flowering, plant height and leaf width lesser variability as indicated by the GCV and PCV values. The values of PCV and GCV varied from 10.6 (plant height) to 21.9 (No. of productive tillers per plant) and 9.4 (plant height) to 19.7 (No. of productive tillers per plant) respectively. Days to 50% flowering and days to maturity had very narrow difference between PCV and GCV values which shows that major portion of PCV was contributed by GCV and this provides higher scope for improvement as these traits are determined by the genotype rather than by the environment.

In the present study, all the traits except fodder yield showed the high estimates of broad sense heritability indicating the truthfulness of GCV values for effective selection. Similar results were reported earlier by Nirmalakumari and Vetriventhan (2010) [10], Prasanna *et al*., (2013); Brunda *et al*., (2017), Anuradha *et al*., (2017). In general, population with more variations are expected to have high heritability compared to uniform population. The narrowness of difference between PCV & GCV and also high estimates of broad sense heritability can be mainly attributed to uniform environmental conditions in the experimental fields (Dabholkar, 1999). As the present study was taken up with utmost care in maintaining uniform environmental conditions, the difference between PCV & GCV can be attributed to genetically diverse genotypes for that particular traits.

High heritability and high GAM were recorded for days to 50% flowering, panicle length, peduncle length, leaf length and grain yield which suggests mostly the additive nature of gene action for these traits which respond to simple selection procedures like pure line selection or mass selection. These results are in consonance with those obtained by previous workers (Nirmalakumari, 2008; Nirmalakumari and Vetriventhan, 2010; Prasanna *et al*., 2013; Brunda *et al*., 2017) [10, 3].

Though grain yield is assumed to be governed by additive gene action it is better to know traits associated with grain yield. In the present study grain yield is positively and significantly associated with days to 50% flowering, days to maturity, plant height and No. of productive tillers/plant. Similarly days to maturity is associated with days to 50% flowering, plant height and No. of productive tillers/plant and grain yield. Hence the selection of grain yield can be relied upon indirect selection of days to maturity and plant height.

Table 1: Analysis of variance of eight foxtail millet genotypes

Source of Variations	df	Mean Squares									
		Days to 50% flowering	Days to maturity	Plant Height (cm)	No. of Prod. Tillers	Panicle length (cm)	Peduncle length (cm)	Leaf length (cm)	Leaf width (cm)	Grain Yield (q/ha)	Fodder Yield (t/ha)
Treatments	7	74.48**	156.85**	620.56*	3.98*	26.64*	19.19*	146.21**	0.17	54.64	270.53*
Replications	2	0.67	0.88	62.80	0.41	3.84	9.49	17.28	0.10	8.62	35.86
Error	14	2.05	4.49	136.19	0.78	8.10	3.25	33.08	0.07	6.03	89.33

Table: Mean table of eight foxtail millet genotypes

S. No.	Entry	Days to 50% flowering	Days to Maturity	Plant height (cm)	No. of productive tillers	Panicle length (cm)	Peduncle length (cm)	Flag Leaf length (cm)	Flag Leaf width (cm)	Grain Yield (q/ha)	Fodder Yield (q/ha)
1	SiA – 3223	52.7	84.3	158.8	7.0	23.1	9.3	52.5	2.3	28.9	63.7
2	SiA – 3156	48.0	76.0	134.5	5.3	18.7	11.0	37.8	1.9	28.4	70.0
3	SiA – 3085	48.3	81.0	150.2	7.0	20.8	10.5	34.4	1.8	28.4	65.4
4	PPSS – 7	49.3	79.3	136.0	4.3	14.0	14.4	31.0	2.0	25.8	50.2
5	Suryanandi	42.3	69.0	131.8	5.2	17.8	15.8	30.5	1.7	24.0	63.2
6	Prasad	43.7	72.7	140.8	4.5	20.7	16.1	38.2	2.0	20.4	41.6

7	Suryanandi	39.0	66.0	117.8	4.5	16.6	11.7	33.3	2.3	19.5	60.0
8	SiA – 3222	39.3	64.7	117.3	4.2	15.8	12.4	35.7	2.1	18.6	51.7
	GM	45.3	74.1	135.9	5.3	18.4	12.6	36.6	2.0	24.3	58.2
	CV	3.2	2.9	8.6	16.8	15.4	14.3	15.7	13.3	10.1	16.2
	CD	2.5	3.7	20.4	1.5	5.0	3.2	10.1	0.5	4.3	16.6

Table 3: Estimates of Variability parameters of eight foxtail millet genotypes

S. No	Parameters	Days to 50% flowering	Days to maturity	Plant Height (cm)	No. of Prod. Tillers	Panicle length (cm)	Peduncle length (cm)	Leaf length (cm)	Leaf width (cm)	Grain Yield (q/ha)	Fodder Yield (t/ha)
1	GCV	10.84	9.61	9.35	19.68	13.48	18.26	16.77	8.92	16.60	13.35
2	PCV	10.99	9.71	10.58	21.93	16.16	20.04	19.06	11.78	17.60	21.02
3	ECV	3.16	2.86	8.59	16.77	15.43	14.28	15.70	13.34	10.12	16.24
4	H^2 (Broad Sense)	97.25	97.13	78.05	80.50	69.59	83.07	77.38	57.28	88.97	40.35
5	Genetic Advance	9.98	14.47	23.13	1.90	4.27	4.33	11.13	0.28	7.82	10.17
6	GAM	22.02	19.52	17.01	36.37	23.16	34.28	30.38	13.91	32.25	17.47

Table 4: Association among ten traits studied in foxtail millet

	DFF	DM	PH	NPT	PL	Pedl	LfL	LfW	GY
DM	0.98**								
PH	0.88**	0.92**							
NPT	0.67	0.73*	0.82*						
PL	0.48	0.54	0.78*	0.79*					
Pedl	-0.41	-0.42	-0.31	-0.65	-0.39				
LfL	0.55	0.52	0.63	0.57	0.75*	-0.57			
LfW	-0.03	-0.03	-0.09	-0.08	0.06	-0.44	0.55		
GY	0.90**	0.88**	0.78*	0.77*	0.46	-0.49	0.37	-0.27	
FY	0.31	0.27	0.21	0.63	0.27	-0.65	0.16	-0.18	0.64

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