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Genetic Variability Studies in Foxtail millet (*Setaria italica* L.)

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ABSTRACT: Foxtail millet is being an underutilized crop which has more nutritional benefits and has more genetic resources. It is essential to utilize that resources for improving desirable traits majorly yield components. Seventy germplasm accessions along with two check varieties were evaluated at the Centre of Excellence in Millets, Tamil Nadu Agricultural University, Athiyandal, Tiruvannamalai during *rabi*, 2023. Variability, heritability and genetic advance as per cent of mean was estimated for analyzing variations and for better selection of elite germplasm accessions. For this purpose, observations were recorded for eleven biometrical traits including days to 50% flowering, days to maturity, plant height (cm), number of productive tillers, flag leaf length(cm), flag leaf width (cm), panicle length (cm), bristle length (cm), 1000 grain weight (g), single plant grain yield (g) and single plant stover weight (g). In this investigation, phenotypic coefficient of variation (PCV) was slightly more than the genotypic coefficient of variation (GCV) showed that relatively less influence of environmental impacts on the traits. Both, PCV and GCV were observed highest in the single plant stover weight, and lowest in the traits days to 50% flowering and days to maturity for PCV and GCV respectively. Considering heritability in relation with genetic advance as per cent of mean, it was noted that high heritability with high genetic advance was recorded for the traits *viz.*, plant height, number of productive tillers, panicle length, bristle length, 1000 grain weight, single plant grain yield and single plant stover weight. This shows that, these traits are highly governed by additive gene action and the environmental effects would be very low and selection for these traits may be rewarding. Low heritability with medium genetic advance has been observed in the trait flag leaf width depicts relatively high influence of environment and presence of non-additive gene action.

Keywords: Foxtail millet, variability, heritability, genetic advance, PCV and GCV.

INTRODUCTION

Commonly millets are said to be 'nutricereals' because of its extraordinary nutritional benefits. Among the millets, foxtail millet is having all the nutrients including proteins, dietary fibers, calcium, vitamins, etc., in considerable amounts. Foxtail millet (*Setaria italica* L.) is a highly self-pollinated crop of Poaceae with very minimum percentage of cross pollination numbering 4% (Li *et al.,* 1935) and having the chromosome number of 2n = 2x = 18. It possesses inflorescence named spike with numerous spikelets and bristles. A pair of glumes in spikelet covers two flowers in which one is sterile and the other is bisexual. This bisexual flower has three stamens and two long styles with brushy stigma (Hector, 1936). Anthesis of the flowers usually occurs around midnight and morning time which changes according to the environments (Malm and Rachie 1971). Foxtail millet is the world's second highest millet crop in terms of production (Yang *et al.,* 2012). It is drought tolerant, heat and stress tolerant crop and widely grown in warm and temperate regions of the world after the pearl millet. Micronutrients are more in foxtail millet with low glycemic index and having more amount of phytochemicals and phenolic compounds which provide much therapeutic benefits (Goudar *et al.,* 2011; Yang *et al.,* 2022; Mal *et al.,* 2010). Consuming this foxtail millet results in reducing the blood glucose levels and also playing a main role in reducing cholesterol levels in individuals (Ghimire *et al.,* 2018; Kamatar *et al.,* 2014a; Kamatar *et al.,* 2014b). This crop is also less prone to pests and diseases creating a

scenario to cultivate without any doubts and also this foxtail millet possesses anti-pest nature when compared to other cereals and pulses which are stored in the same storage conditions (Saini *et al.,* 2021). Further, this crop is relatively less duration compared to staple cereal crops like rice and wheat. Even the fact is like this, the production and consumption factors of foxtail millet in India places with the top countries like China, Europe, Africa and America. But, in India, the production of foxtail millet crop is limited to Andhra Pradesh, Karnataka, Tamil Nadu, Uttar Pradesh, Uttarakhand, Maharashtra, Rajasthan, Gujarat and North Eastern States (Saini *et al.,* 2021). This creates foxtail millet to focus on its way of improving not only the production of the crop and also its morphological, physiological and genetic characteristics. For improving the crop's stature and performance, it is essential to avail the crop in breeding programmes to express its hidden performances and manipulated traits in desirable ways. For this, it is essential to have some superior genotypes for yield and related traits. The evaluation of germplasm can be done to identify superior lines which can be used in breeding programmes for the improvement of yield and quality aspects. Yield is the complex trait which has to be focused more as it has the major role in cultivation and consumption of the crop. Most importantly, it is much essential to analyze the variation among the germplasm lines and for analyzing the characters how they are inherited to one another. This can be done by finding heritability of the individual characters and genetic advance as per cent of mean. Now, research activities have been undertaken by various organizations throughout the world for improving its yield and other desirable traits. The United Nations also proposed this year 2023 as the 'International Year of Millets' by considering its importance in various aspects like food, feed and fodder to develop its stature all over the world (FAO). Nowadays, people are moving to consume millets and the millet era is yet to be started soon. Here the morphophysiological characterization in respect to the variability, heritability and genetic advance is done to evaluate the diversity of the germplasm accessions for its important and desirable biometrical traits.

MATERIALS AND METHODS

The Plant materials were collected from the Ramaiah Gene bank, Department of Plant Genetic Resources, Tamil Nadu Agricultural University, Coimbatore. Seventy germplasm accessions were raised in Randomized Block Design (RBD) along with two checks namely, Co 7 and ATL 1 in two replications. The accessions are sown during rabi, 2023 at the Centre of Excellence in Millets, Tamil Nadu Agricultural University, Athiyandal, Tiruvannamalai Dt and located at the latitude of 12.07286°N and longitude of 78.9904410°E. The soil holds the pH of 9.38. The district has tropical climate and the average annual rainfall is3510 mm (Season and Crop Report, 2021-2022). The seeds are sown with the row ratio of 3 × 3meter plots with ten lines in each plot. The spacing between the accessions was given with the ratio of 30 × 30 cm and within the accessions is 30 x 10 cm. Thinning was done after seven days of sowing. Various biometrical traits were observed including days to fifty per cent flowering, days to maturity, plant height (cm), number of productive tillers, flag leaf length (cm), flag leaf width (cm), panicle length (cm), bristle length (cm), 1000 grain weight (g), single plant grain yield (g) and single plant stover weight (g) and were observed.

The statistical analysis of the mean values was analyzed, thus ANOVA for RBD and variability was obtained using the standard methods given by Panse and Sukhatme (1954). The significance test also done using the 'F' table suggested by Snedecor (1961). Phenotypic and genotypic variances were estimated using the formula given by Lush (1940). Phenotypic and Genotypic coefficient of variations are calculated using the formula of Burton (1952). Heritability (h^2) in the broad sense and genetic advance as per cent of mean was estimated using the method given by Johnson *et al.* (1955).

RESULTS AND DISCUSSION

The ANOVA was performed with 11 quantitative traits and showed positively significant for all the traits. Hence, the wide range of variations is available among the accessions and can be taken for further analysis (Table 1).

Table 1: ANOVA table for 11 quantitative traits in Foxtail millet germplasm accessions.

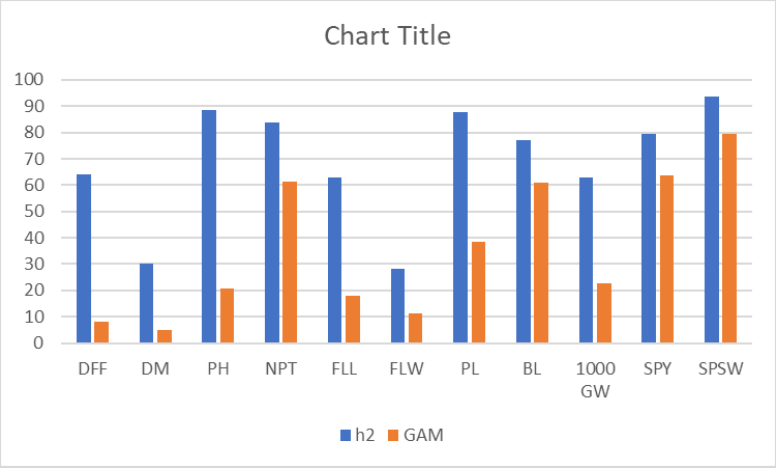
Characters	Mean sum of squares		
	Replication df=1	Treatment df=71	Error df=71
Days to 50 % flowering	3.6736	14.6963**	3.2229
Days to maturity	0.5625	56.2112**	30.0273
Plant Height (cm)	43.4062	522.5371**	32.3880
Number of productive tillers	0.2492	2.1100**	0.1879
Flag leaf length (cm)	21.3829	26.9871**	6.1108
Flag leaf width (cm)	0.0006	0.1100**	0.0616
Panicle length(cm)	5.2441	23.9650**	1.5458
Bristle length (cm)	0.0087	0.1103**	0.0142
1000 grain weight (g)	0.0564	0.3779**	0.0859
Single plant grain yield (g)	2.9213	12.5218**	1.4396
Single plant stover weight (g)	2.0046	66.4652**	2.1957

* Significance at 5% ** Significance at 1%

Variability studies are used widely for bringing the genetically diversified germplasm lines in accordance with its various quantitative traits particularly yield and yield related components. So, the PCV and GCV are more helpful in finding the variations in the accessions. Here, Both PCV and GCV showed a narrow range of differences in the accessions resulting in considerable variations present in the accessions. In this study, Both PCV and GCV are low in the characters days to 50 % flowering and days to maturity possessing 6.17% and 7.76% as PCV and 4.94% and 4.28% as GCV respectively as obtained by Nirmalakumari and Vetriventhan (2010); Srilatha *et al.* (2020).

For the characters plant height, flag leaf length, flag leaf width and 1000 grain weight, the PCV and GCV both are moderate and panicle length also moderate for GCV only as mentioned by Nirmalakumari and Vetriventhan (2010); Toppo *et al.* (2023). PCV and GCV are high for the traits *viz*., number of productive tillers, bristle length, single plant grain yield and single plant stover weight. The same results were obtained by Nirmalakumari and Vetriventhan (2010); Toppo *et al.* (2023) for number of productive tillers per plant and single plant grain yield; Bhakuni *et al.* (2021) for bristle length and single plant grain yield; Karvar *et al.* (2020) for single plant stover weight.

Heritability in broad sense accompanied with Genetic advance as per cent of mean provides the criteria for the selection of germplasm as the h^2 gives the inheritance percentage of the traits in successful generations and GAM provides the information on suitable selection procedures. In the present study, low heritability percentage was obtained for the trait flag leaf width with the magnitude of 28.16%. Same result was obtained by Bhakuni *et al.* (2021). This character possess low heritability due to high influence of environment in this character. Heritability percentage is moderate for the trait days to maturity possessing 30.36%. Similar results were observed by Ramana *et al.* (2022). Hence, this character is affected by both environmental and genetic effects. The high percentage of heritability is observed for the traits days to 50% flowering (64.03%), plant height (88.33%), number of productive tillers (83.65%), flag leaf length (63.07%), panicle length (87.88%), bristle length (77.15%), 1000 grain weight (62.96%) and single plant grain yield (79.38%). The same findings were observed by Nirmalakumari and Vetriventhan (2010). And also, heritability is high for the single plant stover weight as obtained by Kavya *et al.* (2017). Thus, these characters are less influenced by environment and due to high genetic effects.



DFF - Days to 50% Flowering; DM - Days to Maturity; PH - Plant Height (cm); NPT - Number of Productive Tillers; FLL - Flag Leaf Length (cm); FLW - Flag Leaf width (cm); PL - Panicle Length (cm); BL – Bristle Length (cm); 1000 GW – 1000 grain Weight (g); SPY - Single Plant Yield (g); SPSW- Single Plant Stover Weight (g).

Fig. 1. Heritability and genetic advance as per cent of mean for 11 biometrical traits.

Genetic advance as per cent of mean is low for the traits days to 50% flowering and days to maturity possessing the values of 8.14% and 4.85% respectively. These findings were obtained by Prasanna *et al.* (2013). And it shows moderate for the characters flag leaf length and flag leaf width having 18.16% and 11.12% percentage respectively. The same results were proposed by Kavya *et al.* (2017). Genetic advance as per cent of mean is high for the characters plant height (20.91%), number of productive tillers (61.32%), panicle length (38.61%), bristle length (61.00%), 1000 grain weight (22.73%) and single plant grain yield (63.68%) as observed by Nirmalakumari and Vetriventhan (2010); Prasanna *et al.* (2013) and genetic advance as per cent of mean is high for the single plant stover weight (79.58%) as Kavya *et al.* (2017) (Table 2 and Fig. 1).

Table 2: Variability, heritability and genetic advance as per cent of mean of 11 different quantitative traits of the foxtail millet germplasm accessions

Characters	Particulars						
	Mean	Minimum	Maximum	PCV (%)	GCV (%)	Heritability, h^2(Broad sense)	Genetic advance as % of mean
Days to 50 % flowering	48.52	44.50	61.50	6.17	4.94	64.03	8.14
Days to maturity	84.63	73.00	96.50	7.76	4.28	30.36	4.85
Plant Height (cm)	144.97	119.20	199.37	11.49	10.80	88.33	20.91
Number of productive tillers	3.01	1.33	5.84	35.58	32.55	83.65	61.32
Flag leaf length (cm)	29.11	20.72	38.85	13.98	11.10	63.07	18.16
Flag leaf width (cm)	1.53	0.95	2.13	19.17	10.17	28.16	11.12
Panicle length(cm)	16.75	11.35	28.27	21.33	19.99	87.88	38.61
Bristle length (cm)	0.65	0.17	1.15	38.38	33.71	77.15	61.00
1000 grain weight (g)	2.75	1.79	3.70	17.53	13.91	62.96	22.73
Single plant grain yield (g)	6.78	2.30	12.60	38.95	34.70	79.38	63.68
Single plant stover weight (g)	14.20	5.72	35.00	41.27	39.93	93.60	79.58

Thus, the characters plant height, number of productive tillers, panicle length, bristle length, 1000 grain weight, single plant grain yield and single plant stover weight possess high heritability with high genetic advance. So, it is governed by additive gene action. Similar findings were observed by Nirmalakumari and Vetriventhan (2010). Hence, the selection in accordance with these traits is helpful in inheritance of these traits to further generations. High heritability with low genetic advance is observed for the character days to 50% flowering as proposed by Bhakuni *et al.* (2021). It may be governed by non-additive gene effects and so the selection for this trait may not be rewarding.

CONCLUSIONS

The evaluation and characterization of foxtail millet germplasm accessions provides the wide range of information on variations in which the germplasm lines taken, which plays a vital role in improving the crop for its desirable yield and yield related traits. In India, a wide range of foxtail millet genetic resources available as such. The utilization of these resources is very mandatory to uncover the nutritional benefits of millets and also by improving these resources in accordance with its yield, will be more helpful for farmers to cultivate profitably. So, in view of unearthing the hidden treasure of desirable variations in a boundless germplasm accessions, a small effort has been taken for the evaluation of germplasm accessions along with some check varieties to expose its contributable variations among the different quantitative traits. Thus, in the present study, the PCV and GCV are very slightly differed showing very low environmental effects influencing the traits. In this study, it can be concluded that single plant stover weight has relatively high heritability (93.60 %) with high genetic advance (79.58 %), so it is governed by additive gene action and hence the selection can be done for these traits as it is inherited genetically and also the traits plant height, number of productive tillers, panicle length, bristle length, 1000 grain weight and single plant grain yield have showed the same results. The trait flag leaf width has low heritability among the traits taken for the study with a percentage of 28.16% with moderate genetic advance (11.12 %). Low genetic advance was recorded for the trait days to maturity with magnitude of 4.85%. This shows that the trait is highly influenced by environments and genetic effects are less in that trait. Medium heritability was observed for the trait days to maturity (30.36 %) and can be interpreted as it may involve both additive and non-additive gene action.

FUTURE SCOPE

This study is more helpful in selecting and utilizing elite germplasm accessions for improving a new variety with desirable characters.

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Conflict of Interest. None.

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