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Studies on genetic variability, correlation and path analysis for quantitative traits in finger millet

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Abstract
In the present study twenty six released and prerelease finger millet varieties were evaluated for seven yield components and three physiological traits related to thermo tolerance. Analysis of variance for twenty six finger millet genotypes revealed significant differences among the varieties for all ten traits studied indicating the presence of considerable genetic variability among the varieties studied. High PCV and GCV were recorded for fodder yield indicating sufficient variation among the genotypes for this trait and direct selection may be effective for fodder yield. High heritability along with high genetic advance was observed for fodder yield, grain yield, ear head length, SPAD chlorophyll meter reading and number of fingers per ear. Number of effective tillers per plant, fodder yield, number of fingers per ear and relative water content showed positive and significant correlation with grain yield. Path coefficients indicated that number of fingers per ear had largest direct contribution followed by number of productive tillers per plant, fodder yield, plant height and SCMR on grain yield.

Keywords: Finger millet, variability, correlation, path analysis, yield components

Introduction
Finger millet (*Eleusine coracana* Gaertn.) is the third most important millet crop after Sorghum and Pearl millet in India. It is one of the important hardy crop and largely grown in dry land area of southern states of India. It is commonly famous as "Nutritious millet" as the grains are nutritionally superior to many cereals. It contains protein (7-10%), calcium (344 mg/100 g), iron and other minerals. The carbohydrates present in finger millet have the unique property of slower digestibility. It is also rich in phosphorus (283 mg/100 g) and potassium (408 mg/100 g). (Rani Jadhav *et al.*, 2015) [18]. Even though finger millet area in India has decreased from 2.5 million ha in late 1980s to 1.02 million ha during 2018, the production remains constant during these years due to increase in productivity levels (Madhavilatha *et al.*, 2020) [12]. National average grain yield of finger millet is 1.36 ton/ha, although it has a potential to yield up to 3 t/ha. In finger millet low productivity levels are due to adoption of low yielding varieties and lack of varieties suitable for various biotic and abiotic stresses (Madhavilatha *et al.*, 2019) [13]. Continued improvement of yield remains the top priority in most of the breeding programs (Yan *et al.*, 2002) [24]. Yield is influenced by various growth and different yield component traits. Yield could be effectively achieved through yield component improvement since yield components have higher heritability than grain yield (Xiong, 1992) [23]. For yield improvement in any crop it is essential to develop genetically stable genotypes having high yield potential. It is therefore, necessary to estimate relative amounts of genetic and non- genetic variability exhibited by different characters using suitable parameters like genotypic coefficient of variability (GCV), heritability (H) and genetic gain. In addition to the genetic variability, knowledge on heritability and expected genetic advance helps the breeder to employ the suitable breeding strategy. Genetic variability together with heritability estimates would give a better idea on the amount of genetic gain expected out of selection (Burton, 1952 and Swarup and Chaugle, 1962) [3, 22]. The change in one character brings about a series of changes in the other characters, since they are interrelated. Therefore, the correlation studies are of considerable importance in any selection programme as they provide degree and direction of relationship between two or more component traits. So the genetic variability and correlation tools are very important for the breeder to enhance the grain yield of finger millet. Path analysis reveals whether the association of characters with yield is due to their direct effect on yield or is a consequence of their indirect effects via other component characters. Therefore the current study was carried out to assess the genetic

variability among genotypes for yield traits, to determine the interrelationship between grain yield and yield attributing traits and direct and indirect contribution of yield contributing traits on grain yield for finger millet improvement.

Material and Methods

In the present study twenty six promising finger millet released and prerelease varieties were evaluated for seven yield components and three physiological traits. The present study was conducted at Agricultural Research Station, Perumallapalle, Tirupati during Summer, 2020. Experiment was laid out in randomized complete block design with three replications. In each replication every genotype was planted in a plot with ten rows and each row having of three meter length by adopting 22.5 cm x 10 cm. All the recommended package of practices was adopted during entire crop season to raise healthy crop. Observations were recorded for seven yield attributing traits *viz.*, days to 50% flowering, plant height (cm), number of productive tillers per plant, ear head length (cm), number of fingers per ear, fodder yield (t/ha), grain yield (q/ha) and three thermo tolerance related traits *viz.*, SPAD chlorophyll meter reading (SCMR), leaf temperature and relative water content (%). Data were subjected to statistical analysis for assessing genetic variability, phenotypic and genetic coefficient of variation, genetic advance as percent mean for all the characters according to Burton and De Vane (1953) [4]. Broad sense heritability was estimated according to the method suggested by Johnson *et al*. (1955) [8]. Correlation coefficients among the characters under study were estimated according to the statistical techniques outlined by Panse and Sukhatme (1967) [16]. Total correlation coefficient of various yield contributing characters was partitioned into direct and indirect effects following the method adopted by Dewey and Lu (1959) [6].

Results and Discussion

Analysis of variance for twenty six finger millet genotypes revealed significant differences for all traits studied indicating the presence of considerable genetic variability among the genotypes studied. Phenotypic coefficient of variance (PCV) was slightly higher than genotypic coefficient of variance (GCV) for the traits studied indicating less interaction of traits with environment (Table 1). High PCV and GCV were recorded for fodder yield and number of effective tillers per plant indicating sufficient variation among the genotypes for these traits and direct selection may be effective for these characters. Significant variation for fodder yield and number of effective tillers per plant was also reported by Jyothsna *et al.*, (2016) [9]. Moderate GCV and PCV values were obtained by ear head length, number of fingers per ear, grain yield and SCMR. Similar findings were observed in the studies of Manyasa *et al.,* (2016) [15]. Among the traits, days to 50% flowering, plant height, leaf temperature and relative water content had low GCV and PCV values indicating the presence of limited genetic variability for these characters. Genotypic coefficient of variation is not a correct measure to know the heritable variation present and should be considered together with heritability estimates. Heritability estimates for all the traits under study were ranging from 38.7 to 97.0%. All the characters showed high heritability values except plant height (54.3) and number of effective tillers per plant (38.7) which recorded moderate heritability values. Fodder yield had high heritability value coupled with high GCV and PCV indicating that phenotypic selection could be effective in improvement of the trait. Kassahun and Solomon 2017 and Jyothsna *et al.*, (2016) [9] reported similar results for fodder yield. High heritability alone is not a sufficient criterion to exercise selection unless information is accompanied with substantial amount of genetic advance. Genetic advance is another important selection parameter which can be exploited along with heritability of the trait in varietal development. In the study high heritability along with high genetic advance was observed for fodder yield (57.79), grain yield (23.04%), ear head length (22.80), SCMR (22.06) and number of fingers per ear (21.35%) indicating the importance of additive gene action in governing the inheritance of these traits. These results are in accordance with Manoj Kumar *et al.*, (2015) [14] and Ganapathy *et al.*, (2011) [7] for fodder yield and grain yield.

Phenotypic and genotypic correlation coefficients were determined between ten quantitative traits and were presented in Table 2. Number of effective tillers per plant, fodder yield, number of fingers per ear and relative water content showed positive and significant correlation with grain yield at phenotypic level. This suggests selection for these traits would improve the grain yield in finger millet. Positive and significant phenotypic correlations were recorded between ear head length with number of fingers per ear (0.4775), plant height and ear head length (0.4340), plant height and leaf temperature (0.2350), number of fingers per ear and leaf temperature (0.2309), fodder yield with relative water content (0.2676) and leaf temperature and relative water content (0.2393). These results were in accordance with the earlier studies of Manyasa *et al.*, (2016) [15], Saundarya and Satish (2016) [9], Awol Assefa *et al.*, (2013) [2], Patil *et al.*, (2013) [17] and Sonnad *et al.*, (2008) [20]. Negative and significant phenotypic correlations were recorded between number of fingers per ear and SCMR; ear head length and SCMR; days to 50% flowering with relative water content, fodder yield and number of fingers per ear. Days to 50% flowering had negative genotypic and phenotypic correlations with key yield related traits like fodder yield, relative water content, number of fingers per ear and SCMR, which was also reported earlier by Manyasa *et al.*, (2016) [15]. Results indicated that number of effective tillers per plant, fodder yield and number of fingers per ear could be considered together in a positive direction towards an ultimate aim of developing high yielding finger millet genotypes. Presence of strong correlation among these traits indicated that improvement in one attribute would certainly lead to the improvement in other traits in desired direction.

In order to determine the contribution of various characters towards grain yield, it was necessary that the correlation between grain yield and component characters be partitioned into direct and indirect effects. The results of path coefficient analysis for yield components were presented in Table 3. Highest direct positive effects on grain yield were contributed by number of fingers per ear followed by number of productive tillers per plant, SCMR, plant height fodder yield and relative water content. These results were in accordance with the report of Das *et al.*, (2013) [5] for productive tillers per plant; Lule *et al.,* (2012) [11] for productive tillers per plant; Anuradha *et al*., (2013) [1] for number of fingers per panicle; Suryanarayana *et al*., (2014) [21] for plant height. Leaf temperature, ear head length and days to 50% flowering showed negative direct effects on grain yield. Similar finding was also reported earlier by Jyothsna *et al.*, 2016 [9].

In this study based on variability parameters, correlation and path coefficients number of fingers per ear and number of productive tillers per plant traits should be considered as selection criteria in developing high yielding finger millet genotypes.

Table 1: Genetic parameters for grain yield, yield component and thermo tolerance traits in finger millet varieties

Character	General Mean	Heritability in broad sense%	Genotypic coefficient of variation (GCV)%	Phenotypic coefficient of variation (PCV)%	Genetic advance (GA)%	Genetic advance as percent of mean (GAM)%
Days to 50% flowering	73	93.0	8.92	9.25	12.96	17.72
Plant height (cm)	86	54.3	7.82	10.62	10.27	11.88
Number of productive tillers per plant	2.6	38.7	20.59	23.45	0.49	18.71
Ear head length (cm)	8.1	68.9	13.33	16.07	1.86	22.80
Number of fingers per ear	6.6	70.6	12.33	14.67	1.42	21.35
Fodder yield (t/ha)	4.78	97.0	28.49	28.93	2.76	57.79
Grain yield (q/ha)	33.90	77.9	12.67	14.36	7.81	23.04
SCMR	32.43	90.4	11.26	11.84	7.15	22.06
Leaf temperature	27.53	96.4	4.56	4.64	2.54	9.23
Relative water content (%)	87.33	66.9	3.56	4.35	5.24	6.00

Table 2: Genotypic and Phenotypic correlations among yield component and thermo tolerance traits in finger millet varieties

Character		Days to 50% flowering	Plant height (cm)	Number of productive tillers per plant	Ear head length (cm)	Number of fingers per ear	Fodder yield (t/ha)	SCMR	Leaf temperature	Relative water content (%)	Grain yield (q/ha)
Days to 50% flowering	G	1.0000	0.0845	0.1621	0.2159	-0.2716	-0.2893	-0.0161	0.0003	-0.4283	-0.1881
	P	1.0000	0.0618	0.1062	0.1812	-0.2212*	-0.2818*	-0.0132	-0.0050	-0.3508**	-0.1441
Plant height (cm)	G		1.0000	-0.1758	0.5031	0.0174	0.1081	-0.0179	0.2666	-0.0762	0.0312
	P		1.0000	0.0714	0.4340***	0.0792	0.0468	0.0320	0.2350*	0.0084	0.0816
Number of productive tillers per plant	G			1.0000	-0.6612	-0.5542	0.0496	-0.0024	-0.1235	-0.0112	0.4189
	P			1.0000	-0.3044**	-0.2259*	0.0226	-0.0095	-0.0222	-0.0501	0.2845*
Ear head length (cm)	G				1.0000	0.5597	0.2537	-0.3165	0.2229	0.0693	-0.1777
	P				1.0000	0.4775***	0.1940	-0.2242*	0.1946	0.0085	-0.1153
Number of fingers per ear	G					1.0000	0.1510	-0.3910	0.2914	0.2769	0.2715
	P					1.0000	0.0928	-0.3051**	0.2309*	0.1255	0.2217*
Fodder yield (t/ha)	G						1.0000	0.0041	-0.0872	0.3400	0.3474
	P						1.0000	0.0066	-0.0815	0.2676*	0.2840*
SCMR	G							1.0000	-0.1262	0.0764	0.1868
	P							1.0000	-0.1003	0.0013	0.1516
Leaf temperature	G								1.0000	0.2889	-0.1552
	P								1.0000	0.2393*	-0.1453
Relative water content (%)	G									1.0000	0.2788
	P									1.0000	0.2021*

Table 3: Path analysis for yield component and thermo tolerance traits in finger millet varieties

Character	Days to 50% flowering	Plant height (cm)	Number of productive tillers per plant	Ear head length (cm)	Number of fingers per ear	Fodder yield (t/ha)	SCMR	Leaf temperature	Relative water content (%)	Grain yield (q/ha)
Days to 50% flowering	-0.0261	-0.0022	-0.0042	-0.0056	0.0071	0.0075	0.0004	0.0000	0.0112	-0.1881
	0.1419	0.0088	0.0151	0.0257	-0.0314	-0.0400	-0.0019	-0.0007	-0.0498	-0.1441
Plant height (cm)	0.0280	0.3314	-0.0583	0.1667	0.0058	0.0358	-0.0059	0.0883	-0.0253	0.0312
	0.0128	0.2077	0.0148	0.0901	0.0164	0.0097	0.0066	0.0488	0.0017	0.0816
Number of productive tillers per plant	0.1767	-0.1917	1.0902	-0.7208	-0.6042	0.0541	-0.0026	-0.1347	-0.0122	0.4189
	0.0282	0.0190	0.2657	-0.0809	-0.0060	0.0060	-0.0025	-0.0059	-0.0133	0.2845
Ear head length (cm)	-0.0066	-0.0155	0.0203	-0.0307	-0.0172	-0.0078	0.0097	-0.0068	-0.0021	-0.1777
	-0.0667	-0.1597	0.1120	-0.3679	-0.1757	-0.0714	0.0825	-0.0716	-0.0031	-0.1153
Number of fingers per ear	-0.3315	0.0213	-0.6763	0.6831	1.2204	0.1843	-0.4772	0.3556	0.338	0.2715
	-0.1204	0.0431	-0.1230	0.2600	0.5444	0.0505	-0.1661	0.1257	0.0683	0.2217
Fodder yield (t/ha)	-0.0085	0.0032	0.0015	0.0074	0.0044	0.0293	0.0001	-0.0026	0.0100	0.3474
	-0.0726	0.0121	0.0058	0.0500	0.0239	0.2576	0.0017	-0.0210	0.0689	0.2840
SCMR	-0.0099	-0.0110	-0.0015	-0.1937	-0.2392	0.0025	0.6119	-0.0772	0.0467	0.1868
	-0.0027	0.0066	-0.0020	-0.0463	-0.0630	0.0014	0.2065	-0.0207	0.0003	0.1516
Leaf temperature	-0.0001	-0.1026	0.0475	-0.0858	-0.1121	0.0336	0.0486	-0.3848	-0.1111	-0.1552
	0.0012	-0.0575	0.0054	-0.0476	-0.0565	0.0200	0.0245	-0.2448	-0.0586	-0.1453
Relative water content (%)	-0.0101	-0.0018	-0.0003	0.0016	0.0065	0.008	0.0018	0.0068	0.0236	0.2788
	-0.0659	0.0016	-0.0094	0.0016	0.0235	0.0502	0.0002	0.0449	0.1877	0.2021

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