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Genetic Divergence Studies for Yield and Physiological Traits in Foxtail Millet

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ABSTRACT
Genetic divergence analysis is a powerful tool in quantifying the degree of divergence between biological populations and to assess the relative contribution of different components of total divergence. The present investigation aimed to study the genetic divergence and clustering pattern of 60 foxtail millet genotypes for selection of suitable parents that can be utilized in hybridization programme. The analysis of data revealed significant differences among the genotypes for all the traits. Based on the genetic distance (D^2 value), the 60 accessions were grouped into 13 clusters. Of them, cluster I with 36 genotypes forms the largest followed by cluster IV and II with eight and five in each. The character relative injury at 30 DAS contributed the maximum to the divergence. Based on the average inter-cluster distance (D), the clusters XII and XII followed by clusters VIII and XIII were found to be highly divergent from the other clusters. Selection of parents from these clusters and using them in a breeding programme is advocated to develop divergence lines. Maximum diversity was observed between cluster XII (SiA 3546) and XIII (SiA 3596) followed by cluster VIII (SiA 3551) and XIII (SiA 3596).

***Key words**: Foxtail millet, Genetic Diversity, D^2 Analysis, Yield and Physiological Traits*

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INTRODUCTION

Foxtail millet (*Setariaitalica* L.) is one of the oldest cultivated small millets both for food and fodder. It ranks second in the total world production of small millets and it continues to have an important place in world agriculture providing food for millions of people in arid and semiarid regions. It is native to China, India and Pakistan with the rainfall ranging from 150-700 mm and regarded as an elite drought tolerant crop. In India, it is cultivated in Andhra Pradesh, Karnataka, Maharastra, Tamilnadu, Odissa, Rajasthan and Madhya Pradesh for staple food as well as fodder. In India, foxtail millet is cultivated in 98,000 ha. area with a production of 56 t ha^{-1} and productivity of 565 kg ha^{-1} and in Andhra Pradesh, it is cultivated in an area of 23,005 hectares with a production of 28,348 tonnes and productivity of 1232 kg ha^{-1} (Annual report, AICPMIP, 2015-16).

Foxtail millet (*Setariaitalica*L.) is one of the oldest domesticated plants in India and has the highest amount of calcium and potassium. It is known to survive under severe drought and osmotic stress and is able to recover from alleviation from stress. Selection of plants with a better drought tolerance is critical in dry environments. Successful crop establishment in semiarid regions depends on effective seed germination, which is strictly associated with the ability of seeds to germinate under low water availability. The main objective of this study was to evaluate the influence of drought stress on seeds of sixty different foxtail millet genotypes and to understand the effect of drought on seed germination. This will in turn allow plant breeders to select cultivars which are best suited for developing drought resistant cultivars. Genetic improvement mainly dependsupon the amount of genetic variability present in a population. In any crop germplasm serves as a valuable source of base population and provides scope for further genetic improvement of the crop. Choosing genetically diverse parents will enable the expansion of genetic base and development of superior types and greater success can be achieved through judicious choice of parents for hybridization based on genetic divergence. Crosses between divergent parents usually produce greater heterosis than those between closely related ones. Mahalanobis's D^2 statistics is a powerful biometrical technique for quantifying the degree of genetic divergence and grouping the genotypes into different clusters. Mahalanobis's D^2 statistics has been followed by several workers on a wide range of crop species, including foxtail millet, to measure the genetic distance among the breeding lines and to identify characters responsible for such divergence. The present investigation was aimed to study the genetic divergence and clustering pattern of the 60 foxtail millet accessions for selection of suitable parents for utilizing in hybridization programme.

Sixty genotypes were raised during *kharif,* 2016 in a RBD with two replications under rainfed conditions at Agricultural Research Station, Perumallapalle, Tirupati. Each treatment was planted in 2 rows of 3 m length with each row consisting of 40 plants. The recommended agronomic practices and plant protection measures were adopted uniformly. The observations were recorded on five randomly selected plants for nine yield and ten physiological traits i.e., days to 50% flowering, days to maturity, plant height, ear bearing tillers / hill, ear head length, test weight, number of grains / ear head, dry fodder yield / plant, grain yield per plant, leaf temperature at 30 and 45 DAS, SPAD chlorophyll meter reading at 30 and 45 DAS, specific leaf area at 30 and 45 DAS, relative injury at 30 and 45 DAS, and relative water content at 30 and 45 DAS. The mean data were subjected to Mahalanobis D^2 statistic (Rao, 1936) to assess the genetic divergence. The accessions were grouped into number of clusters on the basis of minimum generalized distances using the Tocher's method. The criterion was that any two varieties on an average showing higher D^2 values were grouped into different clusters.

RESULTS AND DISCUSSION

Analysis of variance revealed significant difference among the accessions for all the characters indicating the existence of wide genetic variation among them. Based on relative magnitude of D^2 values, 60 genotypes were grouped in 13 clusters, indicating the presence of large amount of diversity among the genotypes (Table 1). Among thirteen clusters formed, maximum number of 35 genotypes were grouped in cluster I, 8 in cluster IV and 5 in cluster III, 3 in cluster IX, single genotype each in Clusters, III, V, VI, VIII, X XI, XII and XIII (Table 1).

Table - 1: Cluster composition of 60 foxtail millet genotypes based on Tocher's method

Cluster number	No.of genotypes	Genotypes
I	35	SiA-3581, 3619, 3585, 3583, 3574, 3634, 3628, 3589, 3600, 3595, 3555, 3626, 3637, 3631, 3611, 3558, 3623, 3550, 3563, 3580, 3562, 3543, 3632, 3542, 3584, 3604, 3572, 3570, 3539, 3598, 3615, Krishnadevaraya (Check), Prasad (Check), SiA 3085 (Check)
II	5	SiA 3607, 3608, 3610, 3622, 3625
III	1	SiA 3554
IV	8	SiA 3586, 3605, 3560, 3575, 3578, 3591, 3545, 3156(Check)
V	1	SiA 3559
VI	1	Sri Lakshmi(Check)
VII	1	SiA 3636
VIII	1	SiA 3551
IX	3	Suryanandi(Check), SiA 3613, SiA 3618
X	1	SiA 3569
XI	1	Narasimharaya(Check)
XII	1	SiA 3545
XIII	1	SiA 3596

The intra- and inter-cluster D^2 values among the 13 clusters are presented in Table 2. The Intra-cluster average D^2 values ranged from 0.00 to 611.52. Among the clusters, cluster IX had the maximum intra cluster distance (611.52) followed by cluster IV (578.74), cluster II (407.81) and cluster I (358.62), while the clusters, III, V, VI, VIII, X XI, XII and XIII recorded zero values as they included only single genotype in each of them (Table 2).

The maximum inter-cluster D^2 value was recorded between cluster XII and XIII (2392.47) followed by between cluster VIII and XIII (2286.11) and cluster II and XIII (2216.66). Intra-cluster (D) and inter-cluster distance (D^2) among thirteen clusters of foxtail millet is presented in Fig.1. The genotypes in these clusters can be utilized as potential parents and crossing between these genotypes would result in high heterotic expression for yield and its components and physiological parameters. Thus, selection of parents from such clusters for hybridization programmes would result in novel recombinants. Theoretically, the maximum amount of heterosis will be manifested in cross combinations involving the parents belonging to the most divergent clusters. However, for a practical plant breeder, the objective is not only to gain high heterosis but also to achieve high level of production. In the present study, the maximum distance (D=48.91) existed between cluster XII (SiA 3546) and XIII (SiA 3596) followed by cluster VIII (SiA 3551) and XIII (SiA 3596) (D=47.81). It is to advocate that crosses involving the parents from the cluster VIII and XIII exhibit high heterosis. Keeping this view, it is to conclude that crosses between the genotypes belonging to clusters II and XIII and clusters II and X are selected to realize exhibit high heterosis as well as higher level of production. The minimum D^2 value was found between cluster VI and VII (204.20) followed by between cluster III and IV (290.26) and cluster VI and VIII (297.55) in increasing order.

Cluster means for yield and yield component traits and yield and physiological traits are given in the Table 3 and Table 4, respectively. They showed considerable differences between the clusters for all the characters. Cluster VII registered maximum values for days to 50% flowering, days to maturity, ear bearing tillers per hill, grain yield and fodder yield. Cluster XI recorded maximum values for plant height, ear head length, SLA at 30 and 45 DAS, SCMR at 30 and 45 DAS and leaf temperature at 30 DAS. Cluster X recorded maximum values for grains/ear head and leaf temperature at 45 DAS. Further, Cluster IX recorded maximum values for relative water content at 30 DAS. Cluster VIII recorded maximum mean values for SCMR at 30 DAS and RWC at 45 DAS. Inter-crossing the genotypes from these clusters could be suggested to generate wide range of variability subsequently followed by effective selection for these characters (Table 3 and Table 4).

Relative injury at 30 and 45 DAS contributed the maximum to the diversity followed by grain yield, relative water content, specific leaf area at 45 DAS, leaf temperature at 45 DAS and RWC at 45 DAS. The characters viz., SLA 30 DAS, fodder yield, SCMR at 45 DAS, grain yield, test weight, days to 50% flowering and SCMR at 30 DAS contributed to the genetic divergence in decreasing order. The characters *viz.,* days to maturity, plant height, ear bearing tillers, ear head length and leaf temperature at 30 DAS had similar contribution towards the genetic divergence (Table 5). The performance of genotypes and the characters with maximum contribution towards divergence should also be considered for inclusion of genotypes in the hybridization programmes for genetic improvement of foxtail millet. Similar results were recorded by the earlier researchers for days to 50% flowering (Geethanjali*et al.,* 2016 and Bendi and Sarma, 2016), for days to maturity (Lakshmana*et al.,* 2010 and Reddy *et al*., 2015), for plant height (Shanmuganathan*et al.,* 2006; Veenapriya*et al.,* 2010, Lin *et al*., 2012 and Gangurde*et al.,* 2016), for ear bearing tillers per hill (Reddy *et al*., 2015), for ear head length (Govindaraj*et al*., 2011), for test weight (Veenapriya*et al.,* 2010), for grain yield per plant (Kumar *et al.,* 2010 and Geethanjali*et al*., 2016), for fodder yield (Reddy *et al.,* 2015).

The genotypes with outstanding *per se* performance from the selected clusters are mentioned in the Table 6. Mainly five clusters were registered high mean values for the respective traits. Among five, Cluster VII includes the genotype, SiA 3636 which possesses the high cluster mean values with respect to days to 50% flowering, days to maturity, ear bearing tillers per hill, grain yield and fodder yield and Cluster XI includes the genotype, Narasimharaya recorded maximum values for plant height, ear head length, SLA at 30 and 45 DAS, SCMR at 30 and 45 DAS and leaf temperature at 30 DAS, Cluster IX includes the genotypes, Suryanandi, SiA 3613 and SiA 3618 recorded maximum values for relative water content at 30 DAS. These may serve as potential source for hybridization programme to obtain high yielding foxtail millet varieties for rain fed environment.

Table – 2: Intra cluster (diagonal) and inter-cluster distances of thirteen clusters in foxtail millet.

	1 Cluster	2 Cluster	3 Cluster	4 Cluster	5 Cluster	6 Cluster	7 Cluster	8 Cluster	9 Cluster	10 Cluster	11 Cluster	12 Cluster	13 Cluster
1 Cluster	358.62 (18.937)	572.11 (23.919)	486.62 (22.059)	630.89 (25.118)	596.84 (24.430)	498.66 (22.331)	566.48 (23.801)	503.01 (22.428)	787.31 (28.059)	1117.41 (33.428)	1110.52 (33.324)	797.15 (28.234)	1421.91 (37.708)
2 Cluster		407.81 (20.194)	1061.77 (32.585)	1102.25 (33.200)	1048.07 (32.374)	941.39 (30.682)	996.40 (31.566)	631.76 (25.135)	1400.52 (37.424)	2028.79 (45.042)	1646.71 (40.580)	1048.71 (32.384)	2216.66 (47.081)
3 Cluster			0.00 (0.00)	290.26 (17.037)	690.07 (26.269)	747.43 (27.339)	748.73 (27.363)	1032.38 (32.131)	888.24 (29.803)	379.89 (19.491)	645.38 (25.404)	1228.17 (35.045)	476.93 (21.839)
4 Cluster				548.74 (23.425)	834.58 (28.889)	921.77 (30.361)	1009.31 (31.770)	1192.92 (34.539)	1115.08 (33.393)	775.59 (27.849)	956.11 (30.921)	1286.90 (35.873)	821.50 (28.662)
5 Cluster					0.00 (0.00)	745.82 (27.310)	901.05 (30.017)	958.78 (30.964)	501.62 (22.397)	1349.33 (36.733)	1254.20 (35.415)	1222.55 (34.965)	1694.83 (41.168)
6 Cluster						0.00 (0.00)	204.20 (14.290)	297.55 (17.250)	536.94 (23.172)	1051.70 (32.430)	1167.62 (34.170)	534.40 (23.117)	1597.38 (39.967)
7 Cluster							0.00 (0.00)	338.21 (18.390)	747.12 (27.333)	975.61 (31.235)	1011.04 (31.797)	684.02 (26.154)	1552.58 (39.403)
8 Cluster								0.00 (0.00)	717.11 (26.779)	1632.26 (40.401)	1751.16 (41.847)	398.97 (19.974)	2286.11 (47.813)
9 Cluster									611.52 (24.729)	1305.03 (36.125)	1671.10 (40.879)	1020.00 (31.937)	1891.49 (43.491)
10 Cluster										0.00 (0.00)	523.20 (22.874)	1600.65 (40.008)	531.57 (23.056)
11 Cluster											0.00 (0.00)	1977.75 (44.472)	580.55 (24.095)
12 Cluster												0.00 (0.00)	2392.47 (48.913)
13 Cluster													0.00 (0.00)

Table – 3: Cluster means with respect to yield and yield component characters in Foxtail millet.

Character / Cluster	Days to 50% flowering	Days to maturity	Plant height (cm)	Ear bearing tillers/ hill	Ear head length (cm)	No of grains/ ear head	Grain yield/ plant (g)	1000 seed weight (g)	Fodder yield/plant (g)
1 Cluster	48.40	89.19	96.08	3.09	17.83	1630.11	6.41	3.56	4.60
2 Cluster	50.30	90.05	97.18	3.13	17.68	1561.70	6.20	3.62	4.18
3 Cluster	44.50	89.00	107.10	2.10	19.50	1767.00	6.19	2.60	4.73
4 Cluster	47.38	87.72	94.82	3.03	17.89	1684.13	5.96	3.34	4.67
5 Cluster	49.00	90.75	97.70	4.00	17.40	965.00	6.87	3.09	6.05
6 Cluster	49.00	85.50	96.95	3.20	19.10	1999.00	8.24	7.40	4.60
7 Cluster	52.50	91.50	115.20	4.60	20.90	2006.00	8.71	3.93	6.64
8 Cluster	45.00	89.00	107.80	3.30	18.00	1822.00	6.47	3.25	4.21
9 Cluster	46.50	86.67	96.53	3.10	18.77	1471.83	5.63	3.77	4.06
10 Cluster	43.50	84.00	103.40	3.70	17.30	2371.50	4.22	2.91	4.03
11 Cluster	52.00	89.00	122.50	4.25	23.30	1997.00	8.19	3.08	5.50
12 Cluster	44.50	86.00	109.60	2.40	17.00	1961.50	6.01	3.10	5.38
13 Cluster	48.00	86.25	108.00	2.50	20.30	2005.00	6.02	2.96	5.39

Table – 4: Cluster means with respect to physiological characters in Foxtail millet.

Character / Cluster	Specific leaf area at 30 DAS	Specific leaf area at 45 DAS	SCMR at 30 DAS	SCMR at 45 DAS	Leaf temperature at 30 DAS	Leaf temperature at 45 DAS	Relative membrane injury at 30 DAS	Relative membrane injury at 45 DAS	Relative water content at 30DAS	Relative water content at 45DAS
1 Cluster	163.83	174.24	37.16	39.65	34.94	35.41	56.04	71.81	89.90	91.76
2 Cluster	170.30	188.57	34.72	36.73	35.27	33.36	44.77	83.91	89.53	94.25
3 Cluster	164.48	167.90	37.85	36.84	33.00	34.74	75.54	73.01	91.00	90.99
4 Cluster	161.39	172.28	36.44	38.29	35.25	35.77	73.90	74.36	88.64	91.49
5 Cluster	193.91	190.91	35.26	36.89	37.00	34.80	57.20	55.68	91.08	92.79
6 Cluster	142.47	172.01	36.13	38.17	35.85	33.07	52.21	61.00	90.95	92.59
7 Cluster	168.82	158.17	32.00	39.24	34.00	35.55	51.94	60.05	90.78	91.40
8 Cluster	135.23	158.21	40.52	41.32	33.75	32.42	40.40	65.52	89.88	94.59
9 Cluster	152.31	167.89	35.43	37.25	36.49	30.01	54.11	52.34	91.74	92.42
10 Cluster	184.28	190.26	38.13	40.92	33.25	41.60	78.99	57.54	87.86	88.49
11 Cluster	199.67	258.33	42.45	41.81	37.25	38.05	71.77	63.70	91.07	86.14
12 Cluster	113.83	144.78	37.59	39.00	34.25	36.69	46.79	56.73	73.93	96.02
13 Cluster	145.68	216.72	34.38	38.89	35.00	25.78	91.97	75.08	91.10	84.06

Table – 5: Contribution of different grain yield and physiological characters to diversity in foxtail millet

S.No	Character	Times ranked first	Contribution (%)
1	Days to 50% flowering	2	0.11
2	Days to maturity	0	0.00
3	Plant height (cm)	0	0.00
4	Ear bearing tillers per hill	0	0.00
5	Ear head length (cm)	0	0.00
6	Number of grains / ear head	197	11.13
7	Grain yield/plant (g)	4	0.23
8	1000 seed weight (g)	4	0.23
9	Fodder yield (g)	21	1.19
10	Specific leaf area at 30 DAS	49	2.77
11	Specific leaf area at 45 DAS	70	3.95
12	SCMR at 30 DAS	1	0.06
13	SCMR at 45 DAS	10	0.56
14	Canopy leaf temperature at 30 DAS	0	0.00
15	Canopy leaf temperature at 45 DAS	63	3.56
16	Relative membrane injury at 30 DAS	683	38.59
17	Relative membrane injury at 45 DAS	503	28.42
18	Relative water content at 30 DAS	112	6.33
19	Relative water content at 45 DAS	51	2.88

Table - 6: Mean performance of top five clusters with selected genotypes for hybridization and promising characters in genotypes

S. No.	Cluster number	Selected genotypes for hybridization	Promising characters in genotypes
1	Cluster VII	SiA 3636	Early to days to 50% flowering, Early to days to maturity, High ear bearing tillers per hill, High grain yield, High fodder yield
2	Cluster XI	Narasimharaya	Dwarf plant height, Long Ear head length, Low Specific leaf area, High SCMR at 45 DAS, Low Leaf temperature at 30 DAS
3	Cluster X	SiA 3569	High grains per ear head, Low Leaf temperature at 45 DAS
4	Cluster VIII	SiA 3551	High SCMR at 30 DAS, High Relative water content at 45 DAS
5	Cluster IX	Suryanandi, SiA 3613,SiA 3618	High Relative water content at 30 DAS

Tocher's method

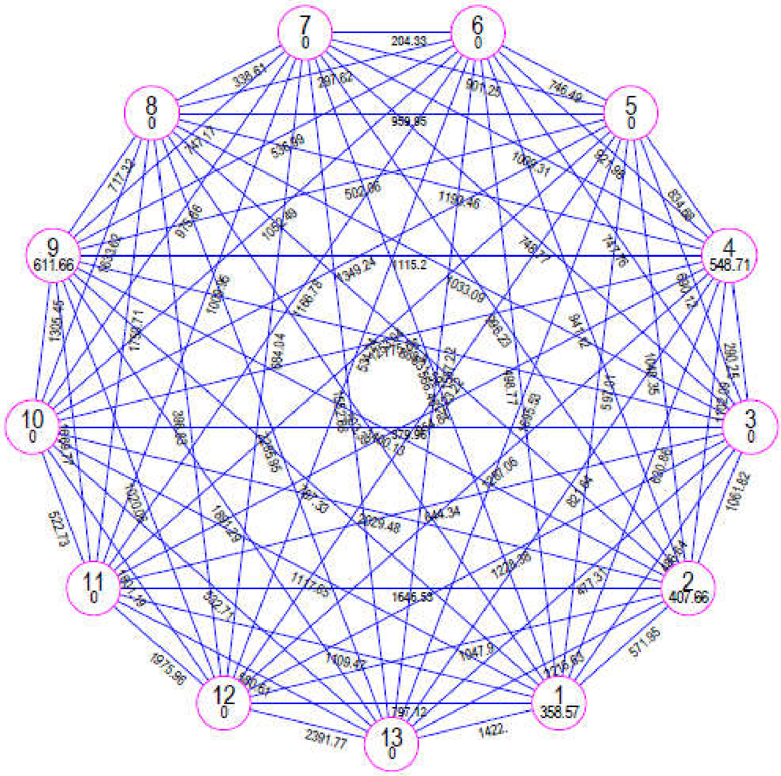

Fig - 1: Intra-cluster (D) and inter-cluster distance (D^2) among thirteen clusters of foxtail millet

REFERENCES

1. Annual report, AICPMIP, 2015-16
2. Bendi, R and Sarma, N. 2016. Studies on genetic association and inter-relationships among yield and quality traits in Finger millet (*EleusineCoracana* (L.) Gaertn.). *The Bioscan.* 11 (4): 3061-3063.
3. Gangurde, S. S., Moharil, M. P., Jadhav, P. V., Wandhare, M. S., Gawai, D., Dikshit, N and Dani, R. G. 2016. Research Article Genetic divergence studies in foxtail millet (*Setariaitalica* L.). *Electronic Journal of Plant Breeding*. 7(3): 514-519.
4. Geethanjali, S and Jagadeeswar, M. 2016. Genetic diversity and variability in foxtail millet germplasm based on morphological traits. *Electronic Journal of Plant Breeding.* 7 (2): 303-316.
5. Govindaraj, M., Selvi, B and Sudhirkumar, I. 2011. Genetic diversity Studies in Indigenous Pearl millet (*Pennisetumglaucum* (L.) R. Br.) Accessins Based on Biometrical and Nutritional Quality Traits. *Indian Journal of Plant Genetic Resources.* 24 (2): 186-193.
6. Kumar, D., Tyagi, V., Ramesh, B and Pal, S. 2010. Genetic diversity in finger millet (*Eleusinecoracana* L.). *Crop Improvement*: 37(1): 25-28.
7. Lakshmana D, Biradar B D, Madaiah D and Jolli R B. 2010. Genetic Diversity for Yield and its Component traits in pearl millet germplasm. *Indian Journal of PlantGenetic Resources* 23(2): 206-211.
8. Lin, H. S. 2012. Genetic diversity in the foxtail millet (*SetariaitalicaL.*) germplasm as determined by agronomic traits and microsatellite markers. *Australian Journal of Crop Science*. 6 (2): 342-349.
9. Rao, C, R. 1952. Advanced Statistical Methods in Biometric Research. *John Wiley and Sons, Inc.* New York. Pp. 390.
10. Reddy, C. V. C. M., Pullabai, P., Manjunath, J and Muniratnam, P. 2015. Genetic diversity and genotypes by trait analysis for yield and yield attributing traits in foxtail millet (*Setariaitalica*(L.) Beauv.). *International Journal of Agriculture innovations and Research.* 3 (6): 1726-1731.
11. Shanmuganathan M, Gopalan, A and Mohanraj K. 2006. Genetic variability and multivariate analysis in pearl millet (*Pennisetumglaucum*(L.) R. Br.) germplasm for dual purpose. *The Journal of Agricultural Sciences.* 2(1): 73-80.
12. VeenaPriya, K, V. Kumari R U, Suguna R and Usharani K S 2010. Studies on genetic distance between the diverse germplasm in pearl millet for fodder characters (*Pennisetumglaucum*(L.) R. Br.). *Electronic Journal ofPlant Breeding.* 1(4): 1035-1041.