



Variability, Character Association and Path Coefficient Analyses in Italian Millet [*Setaria italica* (L.) Beauv]

A B M Sirisha, C Panduranga Rao, P V Rama Kumar, V Srinivasa Rao and M Sandhya
Department of Genetics and Plant Breeding, Agricultural College, Bapatla 522 101, Andhra Pradesh

ABSTRACT

Investigations on extent of character association and path coefficient analysis were conducted in Italian millet. Calcium content, carotene, grain yield per plant, ear weight and straw weight, showed wider variability in the genotypes studied during both seasons. Grain yield per plant had significant positive association with plant height, flag leaf area, ear length, ear weight and straw weight during *Kharif* and with days to maturity, ear weight, straw weight, 1000 grain weight and calcium content in *Rabi*. Path coefficient analysis revealed that flag leaf area, ear weight and straw weight during *Kharif* and productive tillers per plant, days to maturity, ear length, ear weight, straw weight, 1000 grain weight and calcium content in *Rabi* had positive direct effect on seed yield per plant.

Key words : Correlation, Italian Millet, Path Coefficient Analysis, Variability

Italian millet [*Setaria italica* (L.) Beauv] ranks second in the world's total production of millets (Murugan and Nirmalakumari, 2006). Breeding for higher yield is the major objective in any Italian millet improvement programme. Hence, present investigation was carried out to study the extent of variability, character association among yield and yield attributes and path coefficient analysis, in diverse genotypes of Italian millet.

MATERIAL AND METHODS

The experiment was conducted at Agricultural College Farm, Bapatla during *Kharif* 2007 with three replications and *Rabi* 2008 with four replications in randomized block design. Each genotype was sown in 4 rows with a length of 5 m and inter- and intra-row spacing of 25 x 10 cm, respectively. Recommended agronomic measures were undertaken. Data were recorded on ten randomly selected plants for productive tillers per plant, plant height (cm), flag leaf area (cm²), ear length (cm), ear weight (g), straw weight (g) and grain yield per plant (g). Days to 50% flowering, days to maturity, 1000 grain weight (g), crude protein %, calcium content (mg/100g) and carotene (mg/100g) were recorded on plot basis.

Analysis of variance was done following Panse and Sukhatme (1967). The phenotypic and genotypic correlations were worked as per Falconer (1964) and path coefficient analysis as suggested by Dewey and Lu (1959).

RESULTS AND DISCUSSION

The analysis of variance indicated significant differences among the genotypes for all characters. High PCV coupled with high GCV was observed for

calcium content, carotene, grain yield per plant, ear weight and straw weight during *Kharif* and *Rabi* seasons indicating the presence of wider variability for these traits in the genotypes studied. Presence of high heritability coupled with high genetic advance as per cent of mean as in case of plant height, flag leaf area, ear length, ear weight, straw weight, 1000 grain weight, crude protein%, calcium content, carotene and grain yield per plant during *Kharif* and in case of productive tillers per plant, flag leaf area, ear weight, straw weight, 1000 grain weight, crude protein%, calcium content, carotene and grain yield per plant in *Rabi* indicated the presence of additive genes and improvement in these characters may be possible through simple selection. Similar findings were reported by Sandhu *et al.* (1974). The estimates of mean, variability, heritability, genetic advance as per cent of mean are presented in Table 1.

All the traits showed the higher magnitude of genotypic correlations than phenotypic correlations (Table 2) indicating that there was strong inherent association between characters, which was truly reflected in phenotypic expression. Grain yield per plant had significant positive association with plant height, flag leaf area, ear length, ear weight and straw weight during *Kharif* and with days to maturity, ear weight, straw weight, 1000 grain weight and calcium content phenotypically and genotypically in *Rabi*. Based on the magnitude of correlation coefficient values flag leaf area, ear weight, straw weight and 1000 grain weight may be regarded as very closely related characters with seed yield per plant. Hence, higher yield could be obtained by exerting selection pressure over any of these traits. Similar findings were reported by Singh and Nagaraja Rao (1989) and Sandhu *et al.* (1974).

Table 1 Estimates of mean, variability, heritability, genetic advance as per cent of mean of Italian millet [*Setaria italica* (L.) Beauv] during Kharif 2007 and Rabi 2008

Character	Mean	Range		Coefficient of variation		Heritability (%) (board sense)	Genetic advance as per cent of mean (5% level)
		Minimum	Maximum	PCV (%)	GCV (%)		
Number of productive tillers/ plant	1.03	1.00	1.23	8.40	4.29	26.00	4.51
Days to 50% flowering (days)	10.84	3.20	19.20	33.91	31.44	86.00	60.06
Plant height (cm)	53.91	48.67	58.00	5.06	4.11	66.00	6.86
Days to maturity(days)	49.55	44.25	53.50	5.23	3.96	57.00	6.19
Flag leaf area(cm)	62.81	50.25	93.52	14.03	12.23	76.00	21.96
Ear length(cm)	106.31	78.13	123.15	7.84	6.63	72.00	11.56
Ear weight(g)	88.86	79.00	96.00	4.52	4.33	92.00	8.54
Straw weight(g)	81.50	74.25	86.75	3.52	3.06	75.00	5.46
1000 grain weight (g)	27.47	20.67	47.51	21.87	19.46	79.00	35.68
Crude protein %	69.46	50.26	107.55	19.37	18.84	95.00	37.73
Calcium content (mg/100g)	9.40	5.05	14.07	24.54	21.45	76.00	38.61
Carotene(mg/100g)	18.05	13.99	23.20	13.11	10.82	68.00	18.38
Grain yield/ plant(g)	2.39	1.47	5.21	33.79	31.33	86.00	59.84
	4.34	1.88	7.48	28.61	26.36	85.00	50.03
	2.93	2.19	5.95	20.92	20.37	95.00	40.87
	35.48	8.96	59.24	29.41	27.99	91.00	54.89
	1.62	1.05	2.44	25.61	22.92	80.00	42.24
	2.58	2.11	3.96	15.02	13.53	81.00	25.10
	6.98	4.30	8.93	15.32	13.93	83.00	26.13
	8.82	6.43	11.59	13.14	11.44	76.00	20.53
	3.21	1.60	7.73	35.92	34.39	92.00	67.82
	4.25	2.20	8.45	33.65	32.32	92.00	63.93
	0.20	0.10	0.43	33.73	32.26	91.00	63.57
	0.23	0.56	0.11	38.36	36.13	89.00	70.11
	1.74	0.95	4.19	41.08	38.95	90.00	76.07
	13.87	4.98	24.22	38.73	36.25	88.00	69.89

PCV = Phenotypic coefficient of variation GCV = Genotypic coefficient of variation K=Kharif R= Rabi

Table 2. Estimates of phenotypic and genotypic correlation coefficients among yield and yield components in Italian millet [*Setaria italica* (L.) Beauv] during Kharif 2007 and Rabi 2008

Character	Number of productive tillers plant ⁻¹	Days to 50% flowering	Plant height	Days to maturity	Flag leaf area	Ear length	Ear weight	Straw weight	1000 Grain weight	Crude protein %	Calcium content	Carotene	Grain yield plant ⁻¹
Number of productive tillers plant ⁻¹	—	-0.21**	0.17*	-0.21**	-0.01	0.15*	0.13	0.16*	0.07	0.08	0.02	-0.14	0.10
Days to 50% flowering	—	0.21**	0.06	0.25**	-0.31**	-0.04	-0.28**	0.33**	0.24**	0.05	-0.22*	-0.00	0.12
Plant height	0.29**	—	-0.31**	0.79**	-0.06	-0.21**	-0.30**	-0.19*	-0.08	-0.05	0.03	0.37**	-0.28**
Days to maturity	0.46**	-0.42**	0.29**	0.66**	0.05	0.23**	-0.05	0.41**	-0.15*	-0.14*	-0.03	0.32**	0.10
Flag leaf area	0.06	0.43**	—	-0.27**	0.37**	0.47**	0.46**	0.71**	-0.03	0.17*	0.16*	-0.18*	0.47**
Ear length	0.40**	1.02**	-0.34**	0.26**	0.34**	0.54**	0.09	0.27**	-0.05	0.05	0.13	0.10	-0.00
Ear weight	0.15	1.03**	0.39**	—	0.02	-0.14	-0.31**	-0.17*	-0.05	0.00	0.09	0.39**	-0.31**
Straw weight	0.33**	0.07	0.47**	0.03	0.01	0.19**	-0.04	0.51**	-0.08	-0.13	0.06	0.32**	0.25**
1000 grain weight	0.33**	-0.34**	0.41**	0.03	—	0.34**	0.23**	0.50**	-0.03	0.26**	0.12	0.03	0.27**
Crude protein %	0.36**	0.35**	0.59**	-0.19*	0.36*	0.61**	0.47**	0.15*	0.07	0.00	0.26**	-0.01	0.11
Calcium content	0.09	0.38**	0.72**	0.30**	0.73**	—	0.39**	0.47**	-0.06	0.12	0.02	-0.18**	0.37**
Carotene	0.25**	-0.07	0.54**	-0.35**	0.24**	0.49**	0.26**	0.25**	-0.08	0.00	0.29**	0.06	0.07
Grain yield plant ⁻¹	0.36**	-0.23**	0.81**	-0.08	0.51**	0.36**	—	0.62**	0.04	0.04	-0.11	-0.14	0.97**
	0.09	0.54**	0.30**	-0.19**	0.58**	0.55**	0.13	0.15*	0.27**	-0.09	0.17**	-0.00	0.46**
	0.26**	0.04	-0.03	0.62**	0.16*	0.31**	0.06	—	-0.02	0.20**	-0.01	-0.09	0.67**
	0.13	-0.04	-0.03	-0.06	-0.09	-0.08	0.31**	-0.04	0.19**	0.05	0.19**	0.16*	0.52**
	0.05	-0.22**	-0.03	-0.13	0.10	-0.12	0.05	0.20**	—	0.01	-0.03	-0.00	0.03
	0.05	-0.08	0.23**	0.02	0.31**	0.11	0.05	0.24**	-0.47**	—	-0.02	-0.11	0.35**
	0.02	0.08	0.03	-0.14	0.00	0.04	-0.10	0.05	0.00	0.08	0.08	-0.09	0.05
	-0.02	0.08	0.18**	0.09	0.13	0.00	-0.11	0.02	0.02	0.06	0.02	-0.08	-0.07
	-0.24**	-0.06	0.17**	0.08	0.28**	0.35**	0.19**	-0.02	-0.02	0.06	—	0.21**	-0.10
	-0.25	0.49**	-0.23**	0.42**	0.05	-0.21**	-0.17*	0.21**	-0.04	0.00	—	0.23**	0.14*
	-0.005	0.44**	0.12	0.39**	0.05	0.21**	-0.09	0.05	-0.01	-0.12	0.22**	—	-0.14
	0.24**	-0.36**	0.55**	-0.34**	-0.02	0.09	-0.01	0.18**	-0.13**	-0.12	0.26	—	0.02
	0.12	0.14*	-0.05	0.28**	0.11	0.09	0.47**	0.71**	0.05	0.07	-0.10	-0.17**	—
	—	—	—	—	—	—	—	0.55**	0.40**	-0.07	0.15*	0.03	—

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

K=Kharif R= Rabi

Values above diagonal indicate phenotypic correlation and values below diagonal indicate genotypic correlation coefficients, respectively

Table 3 Estimates of direct and indirect effects (phenotypic) of grain yield components on yield per plant in Italian millet [*Setaria italica*(L.) Beauv] during *Kharif 2007 and Rabi 2008*

Character		Number of productive tillers plant ⁻¹	Days to 50% flowering	Plant height	Days to maturity	Flag leaf area	Ear length	Ear weight	Straw weight	1000 Grain weight	Crude protein %	Calcium content	Carotene	Correlation with grain yield plant ⁻¹
Number of productive tillers plant ⁻¹	K	-0.033	0.007	-0.005	0.007	0.000	-0.005	-0.004	-0.005	-0.002	-0.002	-0.000	0.004	0.107
	R	0.019	0.004	0.0012	0.005	-0.006	-0.000	-0.005	0.006	0.004	0.001	-0.004	-0.000	0.124
Days to 50% flowering	K	-0.007	0.032	-0.010	0.025	-0.002	-0.007	-0.009	-0.006	-0.002	-0.001	0.001	0.012	-0.284**
	R	-0.016	-0.074	-0.021	-0.049	-0.004	-0.017	0.004	-0.031	0.011	0.010	0.002	-0.024	0.105
Plant height	K	-0.007	0.014	-0.045	0.012	-0.016	-0.021	-0.021	-0.032	0.001	-0.007	-0.007	0.008	0.475**
	R	-0.008	-0.039	-0.136	-0.035	-0.047	-0.074	-0.013	-0.037	0.006	-0.006	-0.017	-0.014	-0.009
Days to maturity	K	0.009	-0.035	0.012	-0.044	-0.001	0.006	0.014	0.007	0.002	-0.000	-0.004	-0.017	-0.315**
	R	0.038	0.098	0.038	0.149	0.001	0.028	-0.006	0.076	-0.012	-0.019	0.010	0.048	0.252**
Flag leaf area	K	-0.000	-0.000	0.005	0.000	0.014	0.004	0.003	0.007	-0.000	0.003	0.001	0.000	0.273**
	R	0.037	-0.006	-0.041	-0.001	-0.119	-0.074	-0.056	-0.018	-0.009	-0.001	-0.032	0.001	0.112
Ear length	K	-0.005	0.007	-0.016	0.005	-0.012	-0.034	-0.013	-0.016	0.002	-0.004	-0.000	0.006	0.376**
	R	-0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.000	-0.000	0.000	0.000	0.000	0.077
Ear weight	K	0.125	-0.274	0.422	-0.288	0.216	0.358	0.907	0.565	0.039	0.044	-0.103	-0.133	0.970**
	R	-0.117	-0.022	0.040	-0.016	0.196	0.109	0.417	0.063	0.114	-0.039	0.074	-0.002	0.462**
Straw weight	K	0.025	-0.029	0.108	-0.026	0.077	0.072	0.094	0.152	-0.004	0.031	-0.002	-0.014	0.670**
	R	0.145	0.182	0.118	0.223	0.066	0.109	0.066	0.436	0.083	0.022	0.085	0.071	0.523**
1000 grain weight	K	-0.000	0.000	0.000	0.000	0.000	0.000	-0.000	0.000	-0.010	0.004	0.000	0.000	0.032
	R	0.037	-0.023	-0.007	-0.013	0.012	-0.014	0.042	0.029	0.155	0.001	-0.004	-0.018	0.359**
Crude protein %	K	-0.001	0.000	-0.003	0.000	-0.004	-0.002	-0.000	-0.003	0.007	-0.018	-0.001	0.001	0.052
	R	-0.002	0.006	-0.002	0.006	-0.000	-0.000	0.004	-0.002	-0.000	-0.046	-0.000	0.004	-0.071
Calcium content	K	0.000	0.000	0.003	0.001	0.002	0.000	-0.002	-0.000	-0.000	0.001	0.019	0.004	-0.103
	R	-0.009	-0.001	0.005	0.003	0.011	0.013	0.008	0.008	-0.001	0.000	0.044	0.010	0.145*
Carotene	K	0.003	-0.008	0.004	-0.008	-0.000	0.004	0.003	0.002	0.000	0.002	-0.004	-0.021	-0.149
	R	0.000	-0.018	-0.005	-0.018	0.000	-0.003	0.000	-0.009	0.006	0.004	-0.013	-0.056	0.020

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

K=Kharif

R= Rabi

Table 4. Estimates of direct and indirect effects (genotypic) of grain yield components on yield per plant in Italian millet [*Setaria italica*(L.) Beauv] during *Kharif* 2007 and *Rabi* 2008

Character	Number of productive tillers plant ⁻¹	Days to 50% flowering	Plant height	Days to maturity	Flag leaf area	Ear length	Ear weight	Straw weight	1000 Grain weight	Crude protein %	Calcium content	Carotene	Correlation with grain yield plant ⁻¹
Number of productive tillers plant ⁻¹	-0.125	0.059	-0.058	0.050	0.019	-0.042	-0.042	-0.031	-0.012	-0.017	0.002	0.032	0.249**
Days to 50% flowering	-0.059	-0.017	-0.004	-0.017	0.019	0.002	0.020	-0.021	-0.015	-0.003	0.014	0.000	0.120
Plant height	0.070	-0.149	0.063	-0.153	0.002	0.050	0.057	0.035	0.006	0.013	-0.012	-0.073	-0.365**
Days to maturity	0.158	0.546	0.238	0.566	0.043	0.195	-0.039	0.296	-0.120	-0.138	-0.036	0.245	0.140**
Flag leaf area	0.002	-0.002	0.005	-0.002	0.002	0.003	0.003	0.004	-0.000	0.001	0.001	-0.001	0.553**
Ear length	-0.021	-0.134	-0.306	-0.119	-0.126	-0.222	-0.029	-0.092	0.010	-0.010	-0.054	-0.037	-0.058
Ear weight	-0.045	0.115	-0.039	0.112	0.003	-0.022	-0.039	-0.022	-0.007	0.002	0.010	0.047	-0.348**
Straw weight	-0.099	-0.353	-0.133	-0.340	-0.010	-0.102	0.030	-0.212	0.046	0.049	-0.028	-0.134	0.285**
1000 grain weight	0.004	0.000	-0.012	0.000	-0.025	-0.009	-0.006	-0.015	0.002	-0.008	-0.003	-0.001	0.291**
Crude protein %	0.077	-0.018	-0.094	-0.007	-0.230	-0.169	-0.117	-0.037	-0.024	-0.001	-0.065	0.005	0.117
Calcium content	-0.021	0.022	-0.038	0.012	-0.023	-0.065	-0.032	-0.036	0.005	-0.007	-0.000	0.013	0.461**
Carotene	-0.003	0.027	0.055	0.023	0.056	0.076	0.028	0.024	-0.009	0.003	0.027	0.007	0.092
	0.331	-0.377	0.530	-0.342	0.241	0.481	0.975	0.664	0.060	0.050	-0.116	-0.170	0.992**
	-0.142	-0.029	0.039	-0.036	0.207	0.149	0.404	0.053	0.125	-0.044	0.079	-0.004	0.478**
	0.028	-0.026	0.091	-0.022	0.065	0.062	0.076	0.111	-0.004	0.027	-0.002	-0.010	0.715**
	0.171	0.257	0.143	0.296	0.077	0.151	0.062	0.475	0.099	0.027	0.101	0.089	0.555**
	0.001	0.000	0.000	-0.000	-0.001	-0.001	0.000	0.000	0.013	-0.006	0.000	0.000	0.054
	0.075	-0.063	-0.009	-0.038	0.030	-0.034	0.088	0.059	0.284	0.000	-0.012	-0.039	0.406**
	0.002	-0.001	0.003	0.000	0.004	0.001	0.000	0.003	-0.007	0.015	0.001	-0.001	0.074
	0.001	-0.006	0.000	-0.003	0.000	0.001	-0.002	0.001	0.000	0.024	0.000	-0.003	-0.074
	0.000	0.001	0.004	0.002	0.002	0.000	0.002	0.000	0.000	0.001	0.021	0.004	-0.101
	-0.039	-0.010	0.028	0.013	0.045	0.056	0.031	0.034	-0.006	0.001	0.160	0.041	0.152*
	0.003	-0.006	0.002	-0.005	-0.000	0.002	0.002	0.001	0.000	0.001	-0.002	-0.012	-0.173**
	0.000	-0.058	-0.016	-0.051	0.003	-0.011	0.001	-0.024	0.018	0.016	-0.034	-0.130	0.039

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

K=Kharif R= Rabi

In path coefficient analysis (Table 3 and 4), it was observed that selection based on characters like ear weight, straw weight and 1000 grain weight with positive correlation with yield and positive direct effect towards yield will result in yield improvement *i.e.*, profuse plants with large panicles and more grain weight of Italian millet genotypes as also reported by Murugan and Nirmalakumari (2006).

Quality characters like calcium, crude protein and carotene, on the whole, may be improved independently of the yield. However, improvement of carotene can be made along with yield in *Kharif* and a balance between the two traits has to be maintained as they are negatively correlated with each other. Whereas calcium and yield may be improved together as indicated by results in *Rabi*.

Hence, from this study it is inferred that improvement in ear weight, straw weight and 1000 grain weight can be considered for the improvement of grain yield in breeding programmes. Carotene, crude protein and calcium content recorded wider variability in these genotypes which can be used in hybridization programme.

ACKNOWLEDGEMENTS

The authors are highly thankful to Project Coordinator, All India Coordinated Small Millets Improvement Project (AICSMIP), University of Agricultural Sciences (UAS), Bengaluru 560 065, Karnataka for providing seed material of Italian millet genotypes employed in this study and

Dr.B.V. Sessaiah, Professor and Head, Department of Soil Science and Agricultural Chemistry, Agricultural College, Bapatla for extending facilities to estimate crude protein and calcium of the seed samples.

LITERATURE CITED

- Dewey D R and Lu K H 1959.** A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agronomy Journal* 51(9):515-518.
- Falconer D S 1964.** An Introduction to Quantitative Genetics. 2nd Edition Oliver and Boyd Ltd., Edinburgh, pp 312-324.
- Murugan R and Nirmalakumari A 2006.** Genetic divergence in Italian millet (*Setaria italica* (L.) Beauv). *Indian Journal of Genetics and Plant Breeding* 66 (4):339-340
- Panse V G and Sukhatme P V 1967.** Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi, pp. 381.
- Sandhu T S, Arora B S and Yashvir Singh 1974.** Interrelationships between yield and yield components in foxtail millet. *Indian Journal of Agricultural Sciences* 44 (9):563-566
- Singh K D and Nagaraja Rao M 1989.** Association analysis in foxtail millet (*Setaria italica* (L.) Beauv). *Journal of Research APAU*, XVII : 68-69.

(Received on 18.12.2008 and revised on 18.03.2009)