Genetic Variability and Character Association in Common Millet Germplasm of Odisha

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Eleven germplasm collections of common millet (*Panicum miliaceum* L.) along with one check variety were evaluated under 10 environments during *kharif* 2003 to *kharif* 2004 at the Central Research Station, OUAT, Bhubaneswar. Observations recorded on 14 metric traits including grain yield were analyzed to assess the extent of genetic variability and the magnitude of character association in the genotypes tested. Analysis of variance revealed highly significant differences due to genotypes, environments and genotype x environment interactions for all the characters. Germplasm accessions exhibited significant variability for different traits. KCM 120 was the earliest to flower and high yielding with the highest panicle number and harvest index. KCM 424, KCM 14 and KCM 325 were late maturing but high yielders having higher mean performance for most of the characters. Moderate to high estimates of heritability along with moderate to high genetic advance (GA) and genotypic coefficient of variation (GCV) were observed for grain yield and all the component traits except plant height and panicle number. Significant positive association of grain yield with plant height, flag leaf length, flag leaf area, panicle length, panicle weight, panicle yield, biological yield, harvest index and 1000-grain weight was observed. Path analysis pooled over environments revealed that flag leaf length, panicle weight, 1000-grain weight and plant height had maximum contribution towards grain yield.

Key Words: Character association, Common millet, Genetic variability, *Panicum miliaceum*, Proso millet

Introduction

Common millet otherwise known as proso millet (*Panicum miliaceum* L.) is mostly cultivated in India as grain crop under adverse soil and climatic conditions. Nutritionally, the grains are rich in protein, minerals, vitamins and even superior to major cereals in certain nutritional parameters. It occupies substantial area in Bihar, Andhra Pradesh and Odisha as an important constituent of dry land agriculture. The first attempt to collect the available germplasm (250 numbers) was made in 1961 under PL-480 project on 'Storage, maintenance and distribution of millet germplasm'. Realising the importance of conservation of millet genetic resources, a germplasm unit was established at Bangalore in 1980 (Seetharam, 1997; Seetharam and Rao, 1998). The broadening of varietal base by evolving varieties of different maturity periods will definitely impart further stability to production. The knowledge of genetic variability in the available germplasm and association of yield with component traits will be quite helpful in evolving genotypes with higher yield potential.

Materials and Methods

The investigation was carried out at the Central Research Station Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, during the period from *kharif* 2003 to *kharif* 2004 under 10 different environmental conditions generated through different dates of sowing. The test genotypes consisting of 11 local germplasm collected from five tribal districts of Odisha were evaluated along with variety Tarini of OUAT, as check. The local germplasm included KCM 14 and KCM 424 (IC 273532 and 321839, collected from district Gajapati), KCM 120, KCM 122, KCM 285 and KCM 291(IC 298429, 298431, 321700 and 321706, collected from district Kandhamal), KCM 137 (collected from district Rayagada), KCM 171(IC No. 298480, collected from district Koraput) and KCM 296, KCM 298 and KCM 325 (IC No.321711, 321713 and 321741, collected from district Kalahandi). The genotypes were sown in ramdonized complete block design with three replications and observations were recorded for grain yield and 13 component characters *i.e.* days to

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heading, plant height, flag leaf length, flag leaf area, panicle length, panicle exsertion, panicle number, panicle weight, panicle yield, straw yield, biological yield, harvest index and 1000-grain weight. The coefficient of variability, heritability in broad sense and genetic advance (GA) were computed following Hanson *et al.* (1956) and Johnson *et al.* (1955). The genotypic and phenotypic correlations and path coefficients were computed following Al-Jibouri *et al.* (1958) and Dewey and Lu (1959).

Results and Discussion

The pooled analysis over environments showed that differences due to genotypes, environments and genotype x environment interactions were highly significant for all the characters (Table 1). Performance of the genotypes showed wide range of variation for all the characters (Table 2). The overall varietal means for grain yield ranged from 14.4 g in KCM 171 to 23.4 g in KCM 424. The earliest to flower was KCM 120 (62.7 days), while the late maturing genotype was KCM 424 (100.3 days). Plant height varied from 99.6 cm in KCM 122 to 111.7 cm in Tarini. Mean for flag leaf length ranged from 18.3 cm in KCM 122 to 23.2 cm in KCM 424 and the same varieties had extreme values for flag leaf area ranging from 9.6 sq cm to 13.8 sq cm. KCM 122 registered the lowest panicle length (21.9 cm) while KCM 424, the maximum (28 cm). Panicle exertion among the test entries varied from 2.3 cm in KCM 137 to 7.2 cm in KCM 424. The varietal means over environments for panicle number ranged from 26.3 in KCM 296 to 33.3 in KCM 120. The

Table 1. Analysis of variance for 14 characters of 12 genotypes pooled over 10 environments

Character	Mean square				
	Reps/Env. (20)	Genotype (11)	Environment (9)	G x E (99)	Pooled error (220)
Grain yield (GY)	1.4	281.16**	668.57**	68.08**	1.13
Days to heading (DH)	2.4	2676.75**	15250.14**	147.84**	1.08
Plant height (PH)	0.4	318.53**	5530.39**	107.52**	1.32
Flag leaf length (FLL)	0.2	72.8**	59.25**	6.49**	0.22
Flag leaf area (FLA)	0.1	47.14**	58.81**	6.13**	0.10
Panicle length (PL)	0.3	114.67**	122.66**	8.45**	0.31
Panicle exsertion (PE)	0.03	50.62**	16.89**	6.48**	0.10
Panicle number (PN)	0.4	75.27**	3608.03**	55.16**	1.14
Panicle weight (PW)	0.003	0.45**	3.69**	0.11**	0.003
Panicle yield (PY)	0.9	391.97**	1083.41**	78.44**	2.39
Straw Yield (SY)	1.0	863.61**	5112.05**	298.46**	2.05
Biological yield (BY)	2.1	1656.06**	6192.58**	490.49**	3.29
Harvest index (HI)	1.8	214.8**	896.41**	61.39**	2.13
1000-grain weight (GW)	0.01	0.91**	0.14**	0.03**	0.0003

Figures in parentheses indicate the degrees of freedom

Table 2. Mean performance of 12 genotypes for 14 characters pooled over 10 environments

Genotype	GY** (g)	DH	PH (cm)	FLL (cm)	FLA (cm^2)	PL (cm)	PE (cm)	PN	PW (g)	PY (g)	SY (g)	BY (g)	H I (%)	GW (g)
KCM 14	20.9	96.8	108.0	22.4	12.2	27.0	4.5	30.4	0.94	26.4	61.3	87.7	24.8	2.14
KCM 120	20.7	62.7	106.8	21.8	12.4	26.6	3.9	33.3	0.86	27.8	41.2	69.0	29.2	1.69
KCM 122	14.6	92.0	99.6	18.3	9.6	21.9	4.3	29.4	0.79	20.3	49.3	69.6	21.7	1.82
KCM 137	16.1	93.1	106.6	19.8	10.5	25.0	2.3	30.7	0.83	22.3	52.6	74.9	21.8	1.83
KCM 171	14.4*	92.4	104.5	21.4	11.9	24.7	5.1	28.8	0.77	20.4	53.1	73.5	19.6	1.73
KCM 285	16.6	90.0	107.4	19.6	10.6	23.8	3.4	29.1	0.85	22.3	52.4	74.7	22.4	1.80
KCM 291	17.3	94.8	103.2	19.1	9.8	22.8	4.6	28.9	0.90	23.1	49.2	72.3	24.6	1.64
KCM 296	16.1	93.2	105.6	20.3	10.7	25.3	3.5	26.3	0.91	22.2	51.1	73.4	22.2	1.75
KCM 298	17.4	93.8	107.6	22.3	12.1	27.1	3.5	29.5	0.87	23.7	52.4	76.1	22.7	1.78
KCM 325	19.1	96.1	107.2	21.2	11.0	27.9	3.3	29.8	0.98	25.9	53.2	79.1	24.2	1.71
KCM 424	23.4	100.3	111.1	23.2	13.8	28.0	7.2	30.1	1.15	30.9	61.7	92.5	26.1	2.18
Tarini	22.9	92.8	111.7	22.5	12.6	25.7	2.6	29.7	1.13	30.5	54.9	85.4	27.1	1.97
Mean	**18.3**	**91.5**	**106.6**	**21.0**	**11.4**	**25.5**	**4.0**	**29.7**	**0.91**	**24.7**	**52.7**	**77.4**	**23.9**	**1.84**
C.D.5%	**0.5**	**0.4**	**0.5**	**0.2**	**0.1**	**0.2**	**0.1**	**0.5**	**0.02**	**0.7**	**0.6**	**0.8**	**0.6**	**0.01**
C.D.1%	**0.6**	**0.6**	**0.7**	**0.3**	**0.2**	**0.3**	**0.2**	**0.6**	**0.03**	**0.9**	**0.9**	**1.1**	**0.9**	**0.01**

**Abbreviation for characters as in Table 1

*The underlined figures indicate the highest (double) and the lowest (single) values panicle weight ranged from 0.77 g in KCM 171 to 1.15 g in KCM 424, while the extreme values for panicle yield ranged from 20.3 g in KCM 122 to 30.9 g in KCM 424. Among the test entries KCM 120 recorded the lowest straw yield of 41.2 g whereas KCM 424, the highest (61.7 g) and the same varieties had extreme values for biological yield ranging from 69 g to 92.5 g. The harvest index varied from 19.6% in KCM 171 to 29.2% in KCM 120. Mean for 1000-grain weight varied from 1.64 g in KCM 291 to 2.18 g in KCM 424.

The highest yielder KCM 424 was the late maturing genotype having maximum values for flag leaf length and area, panicle length, panicle exertion, panicle weight, panicle yield, straw yield, biological yield, and 1000-grain weight with higher plant height and harvest index. The earliest flowering genotype KCM 120 was high yielder with the highest panicle number and harvest index possessing the minimum values for straw yield and biological yield. Besides KCM 424 and KCM 120, high grain yield was recorded by KCM 14, KCM 325 and Tarini with relatively higher mean performance for at least 6 to 7 component characters. Thus, it is evident that the germplasm accessions exhibited significant variability for different traits.

The parameters of genetic variability estimated for 14 characters of common millet pooled over 10 environments indicated high genotypic and phenotypic coefficient of variation for panicle exertion, grain yield, panicle yield, panicle weight, flag leaf area and days to heading and it was moderate for harvest index, 1000-grain weight, straw yield, biological yield, flag leaf length and panicle length while low for the remaining two characters i.e. plant height and panicle number (Table 3). The estimates of heritability in broad sense was high ranging from 65.4% to 96.6% for all the characters except panicle number, thus indicating the predominance of heritable component of variation for the traits.

The predicted genetic advance was of moderate to high magnitude for all the characters studied except plant height and panicle number. Moderate to high estimates of heritability along with moderate to high genetic advance and genotypic coefficient of variation (GCV) were observed for grain yield and all the component traits except plant height and panicle number indicating preponderance of additive gene action thus rendering ample scope for selection in varietal improvement.

These parameters of variability unbiased by GE interaction were of great value in selection. The results thus indicate that the evaluation of varietal characters across environments rather than at individual environment leads to precision in predicting probable future performance of the varieties in respect of the characters studied (Bradley *et al.*, 1988).

Positive association of grain yield was significant with all the component characters except days to heading, panicle exertion, panicle number and straw yield in pooled analysis over 10 environments while the correlation coefficients of grain yield with these characters varied greatly from environment to environment indicating differential response of the genotypes for their character expression in different environments (Table 4). It was further revealed that grain yield had significant positive association with days to heading and panicle number in only one environment and significant negative association with days to heading in one environment. Significant positive correlation of grain yield with panicle length, panicle exertion and 1000-grain weight was observed

Table 3. Estimates of coefficient of variability (GCV and PCV), heritability (h^2) in broad sense and genetic advance (GA) for 14 characters of 12 genotypes pooled over 10 environments

Character	GCV	PCV	h^2 (%)	GA	GA (% of mean)
Grain yield (GY)	14.6	16.8	75.8	4.8	26.2
Days to heading (DH)	10.0	10.3	94.5	18.4	20.1
Plant height (PH)	2.5	3.1	66.2	4.4	4.2
Flag leaf length (FLL)	7.1	7.4	91.1	2.9	13.9
Flag leaf area (FLA)	10.2	11.0	87.0	2.2	19.6
Panicle length (PL)	7.4	7.7	92.6	3.7	14.6
Panicle exsertion (PE)	30.2	32.3	87.2	2.3	58.0
Panicle number (PN)	2.8	5.3	26.7	0.9	2.9
Panicle weight (PW)	11.5	13.3	74.8	0.2	20.5
Panicle yield (PY)	13.1	14.7	80.0	6.0	24.2
Straw Yield (SY)	8.2	10.2	65.4	7.2	13.7
Biological yield (BY)	8.1	9.6	70.4	10.8	13.9
Harvest index (HI)	9.5	11.2	71.4	3.9	16.5
1000-grain weight (GW)	9.3	9.5	96.6	0.3	18.9

Table 4. Phenotypic (r_p) and genotypic (r_g) correlation coefficients of grain yield with 13 other characters of 12 genotypes in 10 environments and pooled over environments

Env. (D/S)	Corr.	DH	PH	FLL	FLA	PL	PE	PN	PW	PY	SY	BY	HI	GW
1 (5.7.03)	r_p	0.250	0.316	0.188	–0.053	0.481	–0.042	0.373	0.755**	0.928*	0.584*	0.740**	0.727**	0.358
	r_g	0.253	0.316	0.188	–0.056	0.483	–0.037	0.374	0.765	1.167	0.590	0.745	0.723	0.362
2 (20.7.03)	r_p	0.353	0.612*	0.616*	0.763**	0.693*	–0.009	0.187	0.817**	0.972**	0.627*	0.796**	0.614*	0.469
	r_g	0.356	0.618	0.623	0.772	0.701	–0.009	0.187	0.830	0.983	0.632	0.801	0.611	0.473
3 (5.8.03)	r_p	0.547	0.781**	0.684*	0.602*	0.765**	0.211	0.032	0.753**	0.995**	0.720**	0.831**	0.374	0.528
	r_g	0.558	0.789	0.698	0.613	0.777	0.210	0.033	0.767	1.018	0.726	0.839	0.358	0.535
4 (5.9.03)	r_p	0.183	0.299	0.171	0.244	0.069	0.542	0.352	0.649*	0.945**	0.682*	0.859**	0.580*	0.820**
	r_g	0.187	0.301	0.174	0.248	0.072	0.548	0.357	0.670	0.955	0.701	0.872	0.579	0.827
5 (5.10.03)	r_p	–0.306	0.640*	0.666*	0.797**	0.579*	0.229	0.695*	0.973**	0.989**	–0.462	0.488	0.964**	0.337
	r_g	–0.310	0.642	0.675	0.801	0.583	0.231	0.707	0.981	0.992	–0.466	0.490	0.965	0.337
6 (5.11.03)	r_p	–0.675*	0.892**	0.627*	0.720**	0.550	–0.410	–0.311	0.966**	0.992**	0.630*	0.882**	0.744**	0.396
	r_g	–0.686	0.898	0.632	0.725	0.556	–0.413	–0.318	0.970	0.996	0.635	0.887	0.744	0.399
7 (5.12.03)	r_p	–0.250	0.579*	0.330	0.378	0.337	0.327	0.115	0.846**	0.941**	0.135	0.599*	0.844**	0.591*
	r_g	–0.251	0.588	0.340	0.389	0.341	0.331	0.107	0.873	0.962	0.135	0.606	0.843	0.597
8 (20.5.04)	r_p	0.505	0.319	0.669*	0.633*	0.452	0.721**	–0.115	0.608*	0.857**	0.059	0.492	0.849**	0.390
	r_g	0.509	0.325	0.685	0.645	0.458	0.728	–0.121	0.623	0.873	0.062	0.502	0.850	0.394
9 (5.6.04)	r_p	0.679**	0.040	0.034	0.088	0.077	0.661*	–0.231	0.922**	0.985**	0.193	0.640*	0.776**	0.511
	r_g	0.685	0.047	0.027	0.086	0.081	0.672	–0.243	0.938	0.996	0.194	0.645	0.773	0.518
10 (25.6.04)	r_p	0.343	0.392	0.289	0.373	0.229	0.611*	0.038	0.845**	0.940**	0.357	0.590*	0.367	0.651*
	r_g	0.354	0.423	0.296	0.381	0.235	0.634	0.033	0.889	0.974	0.375	0.612	0.321	0.683
Pooled	r_p	–0.049	0.803**	0.762**	0.758**	0.670*	0.240	0.453	0.878**	0.990**	0.390	0.766**	0.858**	0.637*
	r_g	–0.067	0.842	0.793	0.786	0.692	0.242	0.538	0.893	0.997	0.399	0.779	0.873	0.658

*, **Significant at the 5% and 1% level, respectively. (D/S) : Date of sowing

Table 5. Phenotypic path indicating direct and indirect effects of component traits on grain yield of 12 genotypes of common millet pooled over 10 environments

Character	DH	PH	FLL	FLA	PL	PE	PN	PW	PY	SY	BY	HI	GW	Corr. with GY
DH	**–1.273**	0.158	0.017	0.365	–0.016	0.235	–0.874	1.411	0.457	–1.478	0.012	0.146	0.792	–0.049
PH	–0.130	**1.544**	4.639	–4.063	–0.772	0.010	0.315	3.449	–4.192	–0.952	0.017	–0.161	1.098	0.803**
FLL	–0.004	1.263	**5.672**	–4.947	–0.888	0.331	0.447	2.799	–3.977	–0.874	0.015	–0.154	1.077	0.762**
FLA	0.090	1.221	5.462	**–5.137**	–0.789	0.479	0.515	2.742	–4.043	–0.810	0.015	–0.158	1.172	0.758**
PL	–0.020	1.163	4.912	–3.956	**–1.025**	0.163	0.448	2.492	–3.427	–0.742	0.013	–0.138	0.786	0.670*
PE	–0.259	0.014	1.622	–2.127	–0.145	**1.157**	–0.008	1.095	–1.171	–0.703	0.008	–0.025	0.781	0.240
PN	0.795	0.347	1.809	–1.890	–0.328	–0.007	**1.400**	0.174	–2.338	0.454	0.001	–0.192	0.229	0.453
PW	–0.404	1.197	3.567	–3.164	–0.574	0.285	0.055	**4.451**	–4.531	–1.033	0.018	–0.191	1.204	0.878**
PY	0.113	1.260	4.390	–4.043	–0.684	0.264	0.637	3.925	**–5.138**	–0.632	0.016	–0.264	1.145	0.990**
SY	–1.012	0.791	2.666	–2.240	–0.409	0.438	–0.342	2.475	–1.747	**–1.858**	0.019	0.036	1.575	0.390
BY	–0.681	1.186	4.067	–3.570	–0.639	0.439	0.064	3.716	–3.766	–1.650	**0.022**	–0.103	1.682	0.766**
HI	0.604	0.806	2.836	–2.641	–0.460	0.094	0.872	2.764	–4.413	0.217	0.007	**–0.308**	0.480	0.858**
GW	–0.534	0.897	3.233	–3.185	–0.426	0.478	0.169	2.835	–3.113	–1.548	0.019	–0.078	**1.890**	0.637*

P(R) = .091 R SQR (PC) = 100.820
Bold and diagonal values indicate the direct effect of component traits on grain yield

in three environments whereas in five environments with plant height, flag leaf length, flag leaf area, and straw yield. There was significant positive correlation of grain yield with biological yield and harvest index in eight environments while with panicle weight and panicle yield in all the ten environments. At the genotypic level, the correlation of grain yield with the component characters reflected similar pattern of association as at the phenotypic level. But the genotypic correlation coefficients were higher in magnitude (direction remaining same) as compared to phenotypic values in most of the characters. Thus, higher genotypic correlation coefficients in case of positive association and lower in case of negative association would reinforce selection based on these characters would be effective in desired direction as observed in earlier studies (Hawalder, 1991; Prasad *et al*., 1995; Manoharan and Sibasubramanian, 1984; Sen and Hamid, 1986).

The correlation of grain yield with its component traits at phenotypic level was analyzed over environments to assess the cause and effect relationship of yield *per se versus* other characters by partitioning into direct and indirect effects at phenotypic level. Among the characters with positive direct effect on grain yield it was found that, the direct effect in positive direction was the highest (5.672) for flag leaf length followed by panicle weight (4.451), 1000-grain weight (1.890), plant height (1.544), panicle number (1.400) and panicle exertion (1.157). On the other hand, the highest direct negative effect was exhibited by panicle yield (–5.138) followed by flag leaf area (–5.137), straw yield (–1.858), days to heading (–1.273) and panicle length (–1.025). The positive indirect effect *via* flag leaf length was maximum for flag leaf area (5.462) followed by panicle length (4.912), plant height (4.639), panicle yield (4.390), biological yield (4.067), panicle weight (3.567), 1000-grain weight (3.233), harvest index (2.836), straw yield(2.666), panicle number (1.809) and panicle exertion (1.622). Through panicle weight all the characters had high positive indirect effect, highest being 3.925 for panicle yield followed by biological yield (3.716), plant height (3.449), 1000-grain weight (2.835), flag leaf length (2.799),harvest index (2.764), flag leaf area (2.742), panicle length (2.492) and straw yield (2.475). All characters except days to heading had substantial indirect negative effect via flag leaf area and panicle yield. It is evident from both direct and indirect effects of the characters at phenotypic level that flag leaf length, panicle weight and 1000-grain weight contributed substantially towards grain yield thus suggesting that selection based on these characters would be more effective for yield improvement of common millet.

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