JA 1287

1033

VARIABILITY, HERITABILITY AND CORRELATIONS AMONG MORPHOLOGICAL TRAITS IN FINGER MILLET (*ELEUSINE CORACANA* (L.) GAERTN.)

S. C. GUPTA[1] and J. N. MUSHONGA[2]

[1]

[2]Crop Breeding Insititute, P.O. Box 8108, Causeway, Harare, Zimbabwe.

SUMMARY

Three hundred and twenty two finger millet (*Eleusine coracana* (L.) Gaertn.) germplasm accessions collected from Zimbabwe were evaluated at Aisleby and Henderson during the 1988/89 and 1989/90 rainy seasons. The data were recorded on grain yield and nine morphological traits to study the genetic variability and the heritability for each trait as well as the genetic and phenotypic correlations between traits. Differences between finger millet accessions for grain yield, finger length, finger width, number of fingers per head, 1000 grain weight and threshing percentage were significant at both locations, while differences in finger yield and number of productive tillers per plant were significant only at Aisleby. Number of days to flowering and plant height were recorded only at Aisleby and the differences among accessions were significant. Heritability in the broad sense for days to flowering was high (0.60), those for finger length, threshing percentage and 1000 grain weight were moderate (0.21 to 0.46), whereas the estimates were low (0.01 to 0.29) for the rest of the traits. The correlation coefficients indicated that grain yield can be increased by selecting for high threshing percentage, high grain weight, early flowering and high finger yield.

INTRODUCTION

Finger millet (*Eleusine coracana* (L.) Gaertn.) is an important traditional food crop of Africa and Asia. In Africa, it is extensively grown in Uganda, Tanzania, Ethiopia, Kenya, Rwanda, Burundi, Zimbabwe, Zambia and Malawi (Food and Agriculture Organization of United Nations, 1990). It is used for food and for brewing. The grain stores well for a long period of time and, for this reason, some farmers consider it as an insurance crop. In Zimbabwe, most of the finger millet is grown in areas over 600 m above mean sea level (MSL) and with an annual rainfall of 500 to 900 mm. Most of the areas are in Masvingo, Midlands and Manicaland Provinces (Shumba, 1984). Improvement in any crop depends upon the extent of genetic variability present for the different traits and the association between traits. Finger millet accessions collected in Zimbabwe from 1985 to 1988 were utilized to study the variability, heritability and correlations among morphological traits.

MATERIALS AND METHODS

The trial comprised 324 finger millet accessions collected from all provinces of Zimbabwe. The accessions were planted in a lattice design with two replications each at Aisleby farm on 29 November 1988 and at Henderson Research Station on 16 December 1989. Aisleby is located 15 km south west of Bulawayo at 1305 m above MSL and Henderson is located near Mazowe at

1292 m above MSL. The total rainfall during the cropping season was 332 mm at Aisleby and 810 mm at Henderson. The soils at Aisleby are sandy derived from forest sand stone. At Henderson the soils are sandy clay loams. The trial at Aisleby was given protective irrigation while the trial at Henderson was rainfed only. The fertilizer rate at Henderson was 32 kg N, 56 kg P_2O_5 and 28 kg K_2O per hectare as basal application and 51 kg N in form of urea was applied as top dressing four weeks after planting. No fertilizer was applied at Aisleby as the soils were rich due to previous use of sewage effluent. The plot size at both locations was 4.0 m^2. The number of days to flowering, plant height, finger length, number of fingers, finger width, number of productive tillers, finger yield, grain yield, 1000 grain weight and threshing percentage were recorded according to the standard finger millet descriptors (IBPGR/ ICRISAT, 1985). Number of days to flowering, finger yield, grain yield and threshing percentage were recorded on per whole plot basis and the remaining characters except 1000 grain weight were recorded on five random plants per plot. One thousand grain weight was obtained by multiplying the weight of 200 grains. The weight of 200 grains was estimated from two random samples per plot and the samples were drawn after threshing the whole plot. Number of fingers and number of productive tillers were recorded on per head and per plant basis, respectively, on five randomly chosen plants per plot.

Two finger millet accessions failed to establish, therefore a randomized block design was employed to analyse each site separately using analysis of variance (Steel and Torrie, 1980). All data were subjected to analysis of co-variance using the SAS programme (SAS Institute, 1985). Genetic and phenotypic variances and covariances were computed by equating expected variance and covariance components to the appropriate mean squares and cross products using random models. Variance and covariance components were used to compute genetic and phenotypic correlations and heritability in the broad sense. Correlations were estimated using the standard formula:

$$r_{xy} = Cov_{xy}/(V_x \cdot V_y)^{1/2}$$

where Cov_{xy} is covariance, and

V_x and V_y are the respective variances for traits x and y.

Heritability estimates in the broad sense were calculated by dividing genetic variances with their respective phenotypic variances.

RESULTS

Differences between the finger millet accessions were significant for grain yield, finger length, number of fingers, finger width, 1000 grain weight and threshing percentage at both locations (Table 1). Differences between accessions ... to flowering and plant height which were recorded only at Aisleby. Significant variation between accessions in number of productive tillers and finger yield were observed only at Aisleby. Pooled analysis of data over locations could not be conducted as error mean squares were heterogeneous for all the traits except finger length, number of fingers and number of productive tillers.

Means over accessions, ranges between accessions and heritability estimates in the broad sense for the ten traits are presented in Table 2. At both locations, a similar trend in variation was observed for most of the traits except for finger length, finger yield and grain yield. The accessions showing early flowering were SDFM 284, 1603, 301, 323 and 1638, those showing long fingers were SDFM 1702, 1596, 360, 332 and 1166, while accessions with wider fingers were SDFM 305, 288, 1634, 1577 and 291. High number of fingers per head were observed in accessions SDFM 1568, 247, 1656, 1680 and 1661, and high number of productive tillers per plant were recorded in accessions SDFM 219, 1662, 1118, 261 and 306. The accessions with large seed size (*i.e.* high 1000 grain weight) were SDFM 333, 1596, 270, 232 and 1665. Several accessions, namely, SDFM 1701, 1677, 1559, 1636 and 263, had over 70 per cent threshing.

Heritability was highest for number of days to flowering (0.60), moderate for finger length, threshing percentage and 1000 grain weight (0.21 to 0.46) and low for the rest of the traits.

TABLE 1. – ACCESSION MEAN SQUARES, F VALUES AND COEFFICIENT OF VARIATION FOR TEN TRAITS IN FINGER MILLET AT AISLEBY IN 1988/89 AND HENDERSON IN 1989/90

Trait	Aisleby			Henderson		
	Mean square	F value	CV (%)	Mean square	F value	CV (%)
Number of days to flowering	117.480**	4.04	5.8	–	–	–
Plant height (cm)	144.250**	1.44	9.1	–	–	–
Finger length (cm)	3.660**	2.68	20.5	2.651**	2.18	18.2
Finger width (mm)	1.951**	1.56	12.6	2.062*	1.28	13.8
Number of fingers	3.296**	1.62	16.5	3.480**	1.46	19.2
Number of productive tillers	14.318*	1.22	31.3	12.573	1.11	30.9
Finger yield (t/ha)	1.489**	1.73	19.1	0.266	1.02	27.4
Grain yield (t/ha)	0.782**	1.80	22.1	0.138*	1.23	29.0
Grain weight (g/1000 grains)	0.100**	2.03	9.4	0.109**	1.55	10.8
Threshing (%)	60.413**	1.89	9.2	86.754**	1.81	11.1

* $P < 0.05$; ** $P < 0.01$

MORPHOLOGICAL TRAITS IN FINGER MILLET GERMPLASM GROWN AT AISLEBY (A) AND HENDERSON (H) DURING 1988/89 AND 1989/90 RAINY SEASONS, RESPECTIVELY

Trait	Location	Mean ± S.E.	Range	Heritability
Number of days to flowering	A	92.44 ± 3.815	84.50 - 125.50	0.60
Plant height (cm)	A	109.62 ± 7.080	85.00 - 128.50	0.18
Finger length (cm)	A	5.70 ± 0.827	3.00 - 13.50	0.46
	H	6.08 ± 0.781	3.40 - 9.95	0.37
Finger width (mm)	A	8.87 ± 0.791	4.30 - 12.50	0.22
	H	9.20 ± 0.899	6.00 - 11.50	0.12
Number of fingers	A	8.65 ± 1.010	5.50 - 13.50	0.24
	H	8.02 ± 1.091	4.50 - 13.50	0.19
Number of productive tillers	A	10.98 ± 2.426	5.50 - 20.00	0.10
	H	10.92 ± 2.383	5.00 - 19.00	0.05
Finger yield (t/ha)	A	4.84 ± 0.655	2.22 - 7.00	0.27
	H	1.86 ± 0.360	0.58 - 3.17	0.01
Grain yield (t/ha)	A	2.99 ± 0.466	1.12 - 4.75	0.29
	H	1.16 ± 0.237	0.27 - 1.96	0.10
Threshing (%)	A	61.51 ± 4.000	35.41 - 74.29	0.31
	H	62.13 ± 4.892	43.33 - 75.94	0.29
Grain weight (g/1000 grains)	A	2.35 ± 0.157	1.70 - 3.35	0.34
	H	2.45 ± 0.188	1.78 - 3.10	0.21

At both locations, the genetic correlations were generally higher than the corresponding phenotypic correlations. Genetic and phenotypic correlations at both locations were significant and positive (0.89 to 0.94) between grain yield and finger yield (Table 3). Grain yield showed significant and positive correlation with threshing percentage and significant and negative correlation with number of days to flowering. High genetic and phenotypic correlations were found for finger length with finger width, finger width with 1000 grain weight, and 1000 grain weight with threshing percentage (Table 3).

Traits correlated[a]			Aisleby		Henderson	
			Genetic correlation	Phenotypic correlation	Genetic correlation	Phenotypic correlation
DFL	vs	PHT	–0.34**	–0.17**	–	–
		FL	0.20**	0.09	–	–
		FN	0.02	–0.01	–	–
		Tiller	–0.24**	0.05	–	–
		FYD	–0.05	–0.05	–	–
		GYD	–0.27**	–0.15**	–	–
		FW	0.21**	0.11*	–	–
		GWT	–0.13*	–0.06	–	–
		Thres	–0.55**	–0.26**		
PHT	vs	FL	0.32**	0.21**	–	–
		FN	–0.20**	–0.12*	–	–
		Tiller	0.09	0.02	–	–
		FYD	–0.09	–0.03	–	–
		GYD	0.07	0.00	–	–
		FW	–0.05	0.06	–	–
		GWT	0.08	0.08	–	–
		Thres	0.34**	0.06	–	–
FL	vs	FN	–0.04	0.00	0.30**	0.05
		Tiller	–0.21**	–0.04	–0.89**	–0.09
		FYD	–0.05	0.03	0.65**	0.02
		GYD	–0.09	–0.01	0.14*	–0.02
		FW	0.40**	0.18**	0.39**	0.23**
		GWT	0.35**	0.24**	0.16**	0.01
		Thres	–0.13*	–0.10	–0.08	–0.09
FN	vs	Tiller	–0.41**	–0.07	–0.42**	–0.02
		FYD	0.07	0.05	–0.24**	0.10
		GYD	0.02	0.02	–0.20**	0.08
		FW	–0.05	–0.06	–0.01	0.01
		GWT	–0.05	–0.06	–0.13*	–0.06
		Thres	–0.13*	–0.05	–0.18**	–0.03
Tiller	vs	FYD	0.14*	0.06	–0.74**	0.03
		GYD	0.30**	0.07	0.30**	0.04
		FW	–0.14*	0.00	–0.52**	–0.01
		GWT	–0.20**	–0.02	–0.22**	–0.03
		Thres	0.39**	0.04	0.12*	0.01
FYD	vs	GYD	0.90**	0.90**	0.94**	0.89**
		FW	0.01	0.10	1.28**	0.10
		GWT	–0.06	0.02	0.13*	–0.01
		Thres	0.22**	0.14*	0.91**	0.01
GYD	vs	FW	0.07	0.09	0.32**	0.10
		GWT	0.14*	0.08	0.34**	0.08
		Thres	0.62**	0.53**	0.99**	0.44**
PW	vs	GWT	0.39**	0.21**	0.46**	0.11*
		Thres	–0.20**	0.01	–0.03	0.00
GWT	vs	Thres	0.47**	0.13*	0.43**	0.22**

* $P < 0.05$; ** $P < 0.01$

[a] DFL = Number of days to flowering; PHT = Plant height; FL = Finger length; FN = Number of fingers; Tiller = Number of productive tillers; FYD = Finger yield; GYD = Grain yield; FW = Finger width; GWT = 1000 grain weight; Thres = Threshing percentage.

Most of the other phenotypic correlations were non-significant especially at Henderson. Significant and positive phenotypic correlations were observed for number of days to flowering with finger width, plant height with finger length, finger length with 1000 grain weight, and finger yield with threshing percentage. Significant and negative phenotypic correlations were observed for number of days to flowering with plant height and threshing percentage, and for plant height with number of fingers per head (Table 3).

Number of days to flowering was significantly and positively correlated genetically with finger width and finger length, and negatively correlated genetically with threshing percentage, plant height, number of productive tillers and 1000 grain weight. Plant height showed significant and positive genetic correlation with finger length and threshing percentage, and significant negative genetic correlation with number of fingers per head. At both locations, a significant positive genetic correlatlon was observed between finger length and 1000 grain weight, finger yield and threshing percentage, and between grain yield and 1000 grain weight. Significant and negative genetic correlations were observed for finger length with number of productive tillers, number of fingers with number of productive tillers and for threshing percentage and number of productive tillers with finger width and 1000 grain weight. Some genetic correlations at Aisleby were not in agreement with the corresponding estimates at Henderson. Thus number of productive tillers was positively correlated genetically with grain yield at Aisleby and negatively correlated at Henderson (Table 3). Furthermore, genetic correlations between most traits were higher at Aisleby than corresponding estimates at Henderson.

DISCUSSION

The finger millet accessions included in this study represent different geographical areas of Zimbabwe. The differences among these accessions were significant for grain yield and component traits of yield. As large variation exists for many useful traits, a systematic selection between accessions for grain yield and other traits will be useful. Based on mean performance over the two locations, few finger millet accessions were selected for each trait. These accessions can be utilized for further selection and in crossing programmes. Kempanna and Thirumalachar (1968) and Goud and Lakshmi (1977) found significant variation for grain yield and number of tillers per plant. Joshi and Mehra (1989) reported significant variation for days to heading, plant height, finger length, number of fingers and grain yield but observed no significant differences for number of effective tillers. In the present study, the differences between accessions for number of productive tillers and finger yield were significant only at Aisleby. Apparently, these traits are more influenced by environment than the other traits studied. Therefore, further research is necessary involving bigger plot sizes and several plants per plot for estimating finger yield and number of productive tillers.

Certain component or indicator characters which were highly heritable and strongly associated with yield might serve as guides for making selection. In the present study, several traits contributing to grain yield were moderately heritable and the differences between accessions were significant. Early flowering was highly heritable and accessions could be selected for this trait. Three traits, namely, finger length, threshing percentage and 1000 grain weight, were moderately heritable. Kempanna and Thirumalachar (1968) and Joshi and Mehra (1989) reported grain yield as a highly heritable trait and this is probably because their studies were based on a few selected varieties. Finger length was moderately heritable, which is in conformity with the findings of Patnaik (1968) and Joshi and Mehra (1989). Joshi and Mehra (1989) reported high estimates of heritability for number of days to heading which is in agreement with our findings on number of days to flowering. Joshi and Mehra (1989) also observed moderate heritabilities for plant height and number of fingers per head which were low in the present study. Our findings on heritabilities of number of productive tillers and number of fingers are in agreement with Patnaik (1968). The heritability estimates for different traits were consistently higher at Aisleby than at Henderson. This is mainly because of higher F values or less environmental variation at Aisleby compared to Henderson. This suggests that selection at Aisleby will be more effective than at Henderson.

Most of the phenotypic and genetic correlations between traits observed at Aisleby were supported by the findings at Henderson. Grain yield can be increased by selecting for high threshing percentage, large seed size and early flowering. In addition to these traits, finger yield was the most important trait contributing to grain yield ($r^2 = 0.79$ to 0.88) at both locations. Since there were no significant differences between accessions for this trait at Henderson, the results should be considered with caution. Most of the late flowering accessions had poor seed setting resulting in poor threshing percentage and low grain yield. Late flowering accessions should not be used in the breeding programme unless they have some useful traits which can be transferred into early maturing accessions.

M'Shonga (1974) reported highly significant and positive correlations for grain yield with threshing percentage, grain weight per head and number of seeds per head. Shanthakumar (1988) indicated that grain yield per plant was positively correlated with number of productive tillers per plant, number of fingers per ear and ear weight per plant. A positive correlation between grain yield and seed size was reported by Prabhakar and Prasad (1983) and is in

... our findings. The correlation between grain yield and number of days to heading was reported to be positive (Patnaik, 1968) and negative (Chaudhari and Acharya, 1969). The differences may be due to the use of different types of material in the two studies.

Finger length was positively correlated with finger width at both locations. This suggests that genetic improvement can be achieved simultaneously for both traits. Most of the early flowering lines were of tall stature as indicated by the negative correlation between the two traits. This is a desirable combination: tall plants should be easier to harvest and early flowering lines are likely to produce more grain as indicated by the negative correlation between number of days to flowering and grain yield.

ACKNOWLEDGEMENTS

We are grateful to Miss R. Mokwena and Mr O. Mhere for their assistance and to Dr L. R. House for suggestions in the preparation of this paper.

REFERENCES

CHAUDHARI, L. B. and ACHARYA, R. C. 1969. Genetic variability and path coefficient analysis of components of ragi (*Eleusine coracana*). *Experimental Agriculture* **5**: 295–300.

FOOD AND AGRICULTURE ORGANISATION OF UNITED NATIONS. 1990. Structure and characteristics of the world millet economy. CCP:GR 90/4, July 1990, FAO, Rome.

GOUD, J. V. and LAKSHMI, P. V. 1977. Morphological and genetical variabilities for quantitative characters in ragi (*Eleusine coracana* Gaertn.). *Mysore Journal of Agricultural Sciences* **11**: 438–443.

IBPGR/ICRISAT. 1985. Descriptors for Finger Millet. IBPGR Secretariat, FAO, Rome, Italy: 1–20.

JOSHI, H. C. and MEHRA, H. S. 1989. Investigations of variation, heritability, and genetic advances in ragi germplasm from U.P. Hills. In: *Proceedings of a National Seminar on Finger Millet Genetics and Breeding in India*, A. Seetharam and B. T. Shankare Gowda (ed.). Indian Council of Agricultural Research, UAS, Bangalore, India. pp. 73–75.

KEMPHANNA, C. and THIRUMALACHAR, D. K. 1968. Studies on the genotypic variation in ragi (*Eleusine coracana*). *Mysore Journal of Agricultural Sciences* **2**: 29–34.

M'SHONGA, S. 1974. Finger millet (*Eleusine coracana*) seed selection programme at Chibero Agricultural College. *Rhodesia Agricultural Journal* **71**: 51–55.

PATNAIK, M. C. 1968. Variation and correlation in finger millet. *Indian Journal of Genetics and Plant Breeding* **28**: 225–229.

PRABHAKAR and PRASAD, M. N. 1983. Correlation and path analysis in segregating populations of finger millet (*Eleusine coracana* Gaertn.). *Madras Agricultural Journal* **70**: 366–371.

SAS INSTITUTE 1985. SAS/STAT Guide for personal computers, version 6 edition Carry, NC:SAS Institute Inc. 378pp.

SHANTHAKUMAR, G. 1988. Inheritance of plant pigmentation, grain colour, character association, path analysis and heritability of yield and its components in finger millet (*Eleusine coracana* Gaertn.). Thesis abstract. *Mysore Journal of Agricultural Sciences* **23**: 117.

SHUMBA, E. M. 1984. A new look at small grain cereals as persistent droughts hit the communal lands. *Zimbabwe Agricultural Journal* **81**: 169–171.

STEEL, R. G. D. and TORRIE, J. H. 1980. *Principles and Procedures of Statistics* 2nd ed. McGraw-Hill Book Co. New York. 663pp.