fixable in nature. The crosses showing high *sca* effects are expected to throw desirable segregants in subsequent generations. So they may be used in a breeding programme (Natarajan *et al.,* 1989). The crosses UPC 9202 x CO 5 and UPC 9103 x CO 5 were found to be the best specific combiners for green fodder and dry matter yields. In the present study, the cross UPC 9103 x CO 5 recorded higher *sca* effects for six traits out of the ten studied *viz.,* number of leaves, specific leaf weight, green fodder yield, dry matter yield, leaf:stem ratio and crude protein content. The estimation of genetic variation influences breeding methodologies. From this study it is inferred that for the improvement of traits governed by additive gene action, the simple progeny selection in the pedigree method of breeding may be adopted for the exploitation of additive genes. On the other hand, for characters, where predominance of non-additive genetic component has been found, breeding methods like modified recurrent selection or repeated crossing in segregating generations may prove useful in pooling up the desirable genes in one genotype by simultaneousuly exploiting non-additive variance.

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STABILITY OF GRAINYIELD IN PEARL MILLET

N. RAMAMOORTHI, K.S. JEHANGIR and N. NADARAJAN

National Pulses Research Centre,
Tamil Nadu Agricultural University
Vamban Colony 622 303

ABSTRACT

Five male steriles, 3 inbreds, 30-3 - way cross, 120 double cross and 6 varietal cross hybrids of pearl millet were evaluated under three environments with two replications. Highly significant genotype X environment interactions were recorded, the hybrids being more stable than parents. Eleven single cross, 23 three-way cross, 93 double cross and 5 varietal cross hybrids were with average stable performance.

KEY WORDS : Stability, Pearlmillet, G X E interaction

Pearl millet (*Pennisetum glaucum* (L.) R.Br.) is one of the important cereal crops in India. Several hybrids have been successfully released and found superior with respect to stability and productivity. Advancement in diversification of parents and their hybrids in pearlmillet is a contineous process and in heterosis breeding, information on stability of newly developed parents and behaviour of hybrids under different environments is quite important. The present study provides information on the lines of pearl millet and their hybrids, and its utility in breeding programme.

MATERIALS AND METHODS

Five male sterile lines (MS 732A, 861A, ICMA 1, 862A, and 302A) were mated with three inbred lines (Pt 811/9, Pt 1650 and Pt 2086) in line X tester design and 15 single cross hybrids were obtained. For the production of three - way cross hybrids, 15 Fl's were used as female parents and 3

Table 1. Annova for stability parameters

Source	df	MSS
Genotype	180	131.96**
Environments	2	58.43**
Genotype X environment	360	19.73*
Environment + (Geno + Env.)	362	19.94
Environment (linear)	1	116.97**
Genotype X Environment (linear)	180	17.53
Pooled error	540	14.35
Pooled deviation	181	21.81**

** Significant against pooled error at P 0.01

pollinators as male parents. The male parent used in producing the Fl was deleted and 30 three-way crosses were produced. In addition, all the 15 Fl'S were utilised and mated to have 120 double cross hybrids by avoiding duplication of parents already available in the Fl. The three pollinators were crossed in all possible combinations giving rise to six varietal cross hybrids.

Eight parents, 15Fl'S, 30 three-way cross, 120 double cross and 6 varietal cross hybrids along with checks X5 and Co7 were evaluated in randomised block design with two replications. Each variant was sown in sinble row of four m length with a spacing of 45X15 cm in all the three seasons. The first (E1), and third season (E3) trials were sown in red laterite soils (5.5 pH) during *rabi*'91 and summer '92 at Vamban and second season trial (E2) was sown during late *rabi* season in sodic soil (8.8pH) with high clay content at Soil Salinity Research Centre, Trichy. Eberhart and Russell (1966) model was utilised for estimating the stability parameters.

RESULTS AND DISCUSSION

In the present study, linear regression (b) is simply regarded as a measure of response of a particular genotype whereas the deviation from the regression line (s d) is considered as a measure of stability. The genotypes were classified into four classes of stability.

The analysis of variance (Table 1) showed that the mean differences among genotype and environments were highly significant. The genotype X environment interaction component was significant. A major portion of the environmental variation was accounted by the linear component. However, the genotype X ... ot si nificant while non-linear component was highly significant. Therefore, the deviation in the variances was mainly due to the genotypes rather than environments. Such a situations were also reported by Chaudhary *et al.* (1981). All adaptation parameters (x, b and s^{-2} d) for all the genotypes are given in Table 2. All the parents were stable except ICMA 1. Parents Pt 1650, Pt 2086 and 861 A were highly responsive to environmental changes (b>1), whereas Pt 811/9 was less responsive (b<1). However, grain yield of 861 A was the highest (32.42 g/plant) among all the parents.

Out of 15 single cross hybrids, 11 hybrids were stable (GXE present) and wide adaptability. Hybrids of ICMA 1 X Pt 811/9 and 302A X Pt 2086 were highly responsive to environmental changes (b>1), whereas 861 A X Pt 2086 was less responsive (b<1). Out of 11 stable hybrids, 732A X Pt 1650 had highest grain yield, non significant 'b' and s^{-2}d, hence highly adaptable to all environments.

Twenty three-way cross hybrids were stable and of them, (302AXPt2086) X Pt 811/9 was the most stable with non-significant s^{-2} d, average response and average grain yield of 33.98 g/plant. The hybrids (732 A X Pt 2086) X Pt 811/9, (302 A X Pt 1650) X Pt 811/9 and (732A X Pt 811/9) X Pt 1650 were highly responsive (b1) to environmental changes. These hybrids gave better yield under suitable environment and poor yield in unfavourable environments.

Ninety three double cross hybrids were stable (both b and s d non- significant or only b significant). Of them, (302A X Pt 811/9) X (732A X Pt 2086) was the most stable with non-significant s^{-2} d, average response (b=1.6) and average grain yield of 30.10 g/plant. The hybrids (861A X Pt 811/9) X (302A X Pt 2086), (861AXPt2086) X (732A X Pt 811/9) and 862AXPt811/9) X (732A X Pt 2086) were highly responsive (b>1) to environmental changes. The hybrid (862A X Pt 1650) X (ICMA 1 X Pt 2086) was the higher grain yielder (39.08) with low response (b= -2.25). Among the six varietal crosses, five hybrids were stable. Pt 1650 X Pt 2086 which was the high grain yielder (30.87 g/plant) with only s^{-2} d significant and above average response (b=1.63).

Table 2. Estimates of stability parameters for grain yield

Genotypes	X	'b'	S^{-2} d
Parents			
732 A	24.37	1.98	0.52
ICMA 1	16.53	-0.98	54.92
861 A	32.42	3.61	7.20
862 A	29.57	1.49	3.45
302 A	23.58	1.59	14.18
Pt 811/9	26.00	-8.13	-7.08
Pt 1650	14.98	12.35	-0.11
Pt 2086	29.40	5.53	-3.96
Single cross			
732 A X Pt 811/9	31.95	-0.62	-2.59
732 A X Pt 1650	33.78	3.40	-6.70
732 A X Pt 2086	31.02	-2.49	2.14
861 A X Pt 811/9	32.15	-2.16	5.49
861 A X Pt 1650	28.88	-3.38	-6.94
861 A X Pt 2086	26.03	-6.87	44.97**
ICMA 1 X Pt 811/9	27.95	12.85*	0.22
ICMA 1 X Pt 1650	25.50	3.44	52.48**
ICMA 1 X Pt 2086	25.70	2.53	-2.35
862 A X Pt 811/9	26.72	0.35	-6.73
862 A X Pt 1650	29.17	2.42	49.66*
862 A X Pt 2086	25.42	-2.59	-6.89
302 A X Pt 811/9	27.17	-13.36*	44.81**
302 A X Pt 1650	30.47	5.41	1.64
302 A X Pt 2086	30.55	7.05	-1.77
Three - way cross			
(732A X Pt811/9) X Pt 1650	28.77	7.89	-1.99
(732A X Pt811/9) X Pt 2086	29.82	-1.19	21.42*
(732A X Pt1650) X Pt 811/9	34.15	1.82	-5.44
(732A X Pt1650) X Pt 2086	36.57	3.03	-6.28
(732A X Pt2086) X Pt 811/9	33.50	10.83	-7.17
(732A X Pt2086) X Pt 1650	34.67	-6.20	69.68**
(861A X Pt1650) X Pt 1650	36.43	5.50	51.57**
(861A X Pt1650) X Pt 2086	31.22	2.84	18.06
(861A X Pt1650) X Pt 2086	31.10	4.36	-6.85
(861A X Pt1650) X Pt 2086	32.68	-2.26	4.97
(861A X Pt2086) X Pt 811/9	35.80	-1.14	-7.02
(861A X Pt2086) X Pt 1650	26.20	-6.60	-6.98
(ICMA 1 X Pt811/9) X Pt 1650	26.11	11.87	161.65**
(ICMA 1 X Pt811/9) X Pt 2086	32.82	-4.21	41.91**
(ICMA 1 X Pt1650) X Pt 811/9	31.90	0.21	66.30**
(ICMA 1 X Pt1650) X Pt 2086	29.92	-3.25	-0.31
(ICMA 1 X Pt2086) X Pt 1650	33.53	13.06*	-6.38
(ICMA 1 X Pt2086) X Pt 811/9	29.97	1.08	22.77*
(862A X Pt811/9) X Pt 1650	30.33	5.06	23.48*
(862A X Pt811/9) X Pt 2086	33.03	4.46	-6.10
(862A X Pt1650) X Pt 811/9	32.22	-5.34	32.75**
(862A X Pt1650) X Pt 2086	31.58	6.30	-7.15
(862A X Pt2086) X Pt 811/9	31.05	0.60	-6.90
(862A X Pt2086) X Pt 1650	30.07	2.34	-7.17
(302A X Pt811/9) X Pt 1650	31.12	4.71	-6.88
(302A X Pt811/9) X Pt 2086	25.12	-2.71	1.59
(302A X Pt1650) X Pt 811/9	28.82	8.01	-1.37
(302A X Pt1650) X Pt 2086	25.40	-8.30	11.84

Table 2. Contd.,

Genotypes	X	'b'	S^{-2} d
(302A X Pt2086) X Pt 811/9	33.98	1.19	-4.01
(302A X Pt2086) X Pt 1650	29.25	10.28	55.34**
Double cross			
(732AXPt2086)X(861AXPt811/9)	19.67	3.26	-3.78
(732AXPt 2086)X(861AXPt1650)	18.67	-7.78	5.35
(732AXPt 2086)X(ICMA1XPt811/9)	14.18	2.79	-1.42
(732AXPt2086)X(ICMA1XPt1650)	15.98	-12.98*	45.25**
(732AXPt2086)X(862AXPt811/9)	28.18	7.19	-6.93
(732AXPt2086)X(862AXPt1650)	15.70	-2.06	-6.89
(732AXPt2086)X(302AXPt811/9)	19.10	-7.18	19.80
(732AXPt2086)X(302AXPt1650)	22.02	6.82	46.11**
(732AXPt811/9)X(861AXPt2086)	16.42	-3.97	14.43
(732AXPt811/9)X(861AXPt1650)	17.02	1.21	-6.85
(732AXPt811/9)X(ICMA1XPt2086)	14.99	-1.13	-4.59
(732AXPt811/9)X(ICMA1XPt1650)	20.27	8.02	-3.25
(732AXPt811/9)X(862AXPt2086)	14.57	-3.71	-7.09
(732AXPt811/9)X(862AXPt1650)	16.25	0.31	-7.18
(732AXPt811/9)X(302AXPt2086)	18.92	1.58	-6.56
(732AXPt811/9)X(302AXPt1650)	17.73	3.95	-1.56
(732AXPt 1650)X(861AXPt2086)	16.58	0.77	-7.15
(732AXPt1650)X(861AXPt811/9)	20.03	-2.09	-6.28
(732AXPt1650)X(ICMAXPt2086)	24.32	4.20	-1.06
(732AXPt1650)X(ICMAXPt811/9)	20.77	3.33	15.89
(732AXPt1650)X(862AXPt2086)	18.88	-3.47	4.37
(732AXPt1650)X(862AXPt811/9)	21.25	5.33	12.45
(732AXPt1650)X(302AXPt2086)	17.10	-0.29	-4.74
(732AXPt1650)X(302AXPt811/9)	18.60	-3.47	-5.58
(861AXPt 2086)X(732AXPt 811/9)	24.38	9.88	-3.47
(861AXPt2086)X(732AXPt1650)	17.35	4.00	6.57
(861AXPt2086)X(ICMA1XPt811/9)	18.35	-6.99	-6.71
(861AXPt2086)X(ICMA1XPt1650)	25.60	8.92	29.71
(861AXPt2086)X(862AXPt811/9)	17.73	1.45	-6.85
(861AXPt2086)X(862AXPt1650)	15.22	-1.46	-6.65
(861AXPt2086)X(302AXPt811/9)	18.97	-3.06	-7.17
(861AXPt2086)X(302AXPt1650)	24.28	1.88	-7.15
(861AxPt811/9)X(732AXPt2086)	27.12	14.99*	52.30**
(861AxPt811/9)X(732AXPt1650)	18.05	-3.25	-1.83
(861AxPt811/9)X(ICMA1XPt2086)	15.72	2.21	-0.95
(861AxPt811/9)X(ICMA1XPt1650)	20.82	-13.10	40.75**
(861AxPt811/9)X(862AXPt2086)	30.27	14.16*	57.05**
(861AxPt811/9)X(862AXPt1650)	30.68	1.59	43.28**
(861AxPt811/9)X(302AXPt2086)	28.15	10.31	7.16
(861AxPt811/9)X(302AXPt1650)	18.58	2.13	32.33**
(861AXPt1650)X(732AXPt2086)	17.17	-3.37	-6.82
(861AXPt1650)X(732AXPt811/9)	19.72	3.13	4.80
(861AXPt1650)X(ICMA1XPt2086)	24.05	1.71	0.41
(861AXPt1650)X(ICMA1XPt811/9)	20.62	-0.30	27.93**
(861AXPt1650)X(862AXPt2086)	22.42	1.38	-2.13
(861AXPt1650)X(862AXPt811/9)	20.82	-0.70	7.74
(861AXPt1650)X(302AXPt2086)	22.20	-4.59	-0.81
(861AXPt1650)X(302AXPt811/9)	18.03	0.81	-7.71
(ICMA1XPt2086)X(732AXPt811/9)	19.13	1.26	-6.32
(ICMA1XPt2086)X(732AXPt1650)	19.20	3.96	-6.18
(ICMA1XPt2086)X(861AXPt811/9)	16.93	0.57	1.22
(ICMA1XPt2086)X(861AXPt1650)	15.55	2.89	-6.51

Table 2. Contd.,

Genotypes	X	'b'	$S^{-2}d$
(ICMA1XPt2086)X(302AXPt1650)	23.88	-0.45	48.96
(ICMA1XPt811/9)X(732AXPt2086)	22.28	6.12	-3.38
(ICMA1XPt811/9)X(732AXPt1650)	24.72	-4.75	-1.84
(ICMA1XPt811/9)X(861AXPt2086)	19.98	-4.45	118.98**
(ICMA1XPt811/9)X(861AXPt1650)	19.98	-1.92	9.41
(ICMA1XPt811/9)X(862AXPt2086)	20.47	3.70	1.38
(ICMA1XPt811/9)X(862AXPt1650)	26.00	4.25	30.27*
(ICMA1XPt811/9)X(302AXPt2086)	33.52	0.71	65.38**
(ICMA1XPt811/9)X(302AXPt1650)	20.23	-4.31	287.02**
(ICMA1XPt1650)X(732AXPt2086)	20.88	7.41	69.16**
(ICMA1XPt1650)X(732AXPt811/9)	19.98	2.38	-9.67*
(ICMA1XPt1650)X(861AXPt2086)	17.20	-0.49	25.73**
(ICMA1XPt1650)X(861AXPt811/9)	15.85	0.66	-5.02
(ICMA1XPt1650)X(862AXPt2086)	21.53	5.27	78.92**
(ICMA1XPt1650)X(862AXPt811/9)	31.22	0.48	20.65**
(ICMA1XPt1650)X(302AXPt2086)	26.15	1.49	1.58
(ICMA1XPt1650)X(302AXPt811/9)	16.65	-4.66	30.62**
(862AXPt2086)X(732AXPt811/9)	31.62	-1.74	63.51**
(862AXPt2086)X(732AXPt1650)	20.47	-6.35	102.74**
(862AXPt2086)X(861AXPt811/9)	17.72	-2.18	-6.56
(862AXPt2086)X(861AXPt1650)	14.83	0.33	-0.25
(862AXPt2086)X(ICMA1XPt811/9)	16.60	2.26	-0.80
(862AXPt2086)X(ICMA1XPt1650)	12.60	-0.69	4.32
(862AXPt2086)X(302AXPt811/9)	14.77	-6.55	4.66
(862AXPt2086)X(302AXPt1650)	14.90	-0.02	-5.66
(862AXPt811/9)X(732AXPt2086)	25.70	9.81	0.55
(862AXPt811/9)X(732AXPt1650)	17.90	1.06	11.06
(862AXPt811/9)X(861AXPt2086)	26.27	-4.63	60.23**
(862AXPt811/9)X(861AXPt1650)	31.18	-12.28	65.74**
(862AXPt811/9)X(ICMA1XPt2086)	23.32	3.74	15.61
(862AXPt811/9)X(ICMA1XPt1650)	15.67	0.03	8.68
(862AXPt811/9)X(302AXPt2086)	16.18	-6.14	-6.66
(862AXPt811/9)X(302AXPt1650)	36.63	6.69	108.70**
(862AXPt1650)X(732AXPt2086)	36.42	7.94	-6.92
(862AXPt1650)X(732AXPt811/9)	34.32	6.21	6.37
(862AXPt1650)X(861AXPt2086)	36.05	0.45	-7.02
(862AXPt1650)X(861AXPt811/9)	34.63	5.06	-3.31
(862AXPt1650)X(ICMA1XPt2086)	39.08	-2.25	5.83
(862AXPt1650)X(ICMA1XPt811/9)	30.05	7.59	15.25
(862AXPt1650)X(302AxPt2086)	30.22	-1.33	-1.10
(862AXPt1650)X(302AxPt811/9)	25.50	-2.15	-0.25
(302AXPt2086)X(732AXPt1650)	39.93	5.57	33.31**
(302AXPt2086)X(732AXPt811/9)	42.38	5.92	-4.22
(302AXPt2086)X(ICMA1XPt1650)	33.85	-4.56	25.60
(302AXPt2086)X(ICMA1XPt811/9)	33.30	-3.16	-6.42
(302AXPt2086)X(861AXPt1650)	27.38	-1.52	-7.13
(302AXPt2086)X(861AXPt811/9)	17.97	-0.36	5.65
(302AXPt2086)X(862AXPt1650)	16.10	-2.38	3.86
(302AXPt2086)X(862AXPt811/9)	27.83	1.96	18.36
(302AXPt811/9)X(732AXPt1650)	32.65	1.03	-4.16
(302AXPt811/9)X(732AXPt2086)	30.10	1.16	-6.83
(302AXPt811/9)X(ICMA1XPt1650)	20.35	-1.11	5.37
(ICMA1XPt2086)X(862AXPt811/9)	22.02	3.42	22.73*
(ICMA1XPt2086)X(862AXPt1650)	18.40	-3.90	1.15
(ICMA1XPt2086)X(302AXPt811/9)	25.08	1.61	39.67*

Table 2. Contd.,

Genotypes	X	'b'	$S^{-2}d$
(302AXPt811/9)X(ICMA1XPt2086)	29.29	4.85	90.17**
(302AXPt811/9)X(861AXPt1650)	28.53	-0.29	-6.33
(302AXPt811/9)X(861AXPt2086)	17.58	-2.44	14.78
(302AXPt811/9)X(862AXPt1650)	25.48	3.45	14.22
(302AXPt811/9)X(862AXPt2086)	18.72	-2.50	16.10
(302AXPt1650)X(732AXPt2086)	27.85	0.46	12.49
(302AXPt1650)X(732AXPt811/9)	33.32	1.94	-4.26
(302AXPt1650)X(ICMA1XPt2086)	32.62	5.61	-5.17
(302AXPt1650)X(ICMA1XPt811/9)	33.92	2.31	-1.50
(302AXPt1650)X(861AXPt2086)	23.40	-1.20	29.52**
(302AXPt1650)X(861AXPt811/9)	26.72	4.04	-4.80
(302AXPt1650)X(862AXPt2086)	19.45	0.84	17.13
(302AXPt1650)X(862AXPt811/9)	23.78	-1.22	2.19
Varietal cross			
Pt 811/9 X Pt 1650	29.68	-0.28	-1.70
Pt 811/9 X Pt 2086	28.50	7.84	-6.95
Pt 1650 X Pt 2086	30.87	1.63	28.61**
Pt 1650 X Pt 811/9	34.65	2.32	-5.67
Pt 2086 X Pt 811/9	25.17	-13.88**	-6.68
Pt 2086 X Pt 1650	17.68	-0.39	-5.37

'F' test for $s^{-2}d$: * Significant at P = 0.05,
** Significant at P = 0.01
't' test for 'b' : * Significant deviation from one.

The above genotypes were classified into four classes of stability (Table 3). An examination of the two parameters, namely 'b' and s^{-2} d for the individual parents and different types of hybrids revealed that 7 parents, 10 single cross, 19 three-way cross, 93 double cross and 5 varietal cross hybrids showed absence of G X E interaction (both 'b' and s^{-2} d nonsignificant) and only one single cross and one three-way cross hybrid regression mean squares were significant, indicating the predictability of above genotypes. However, 1 female parent, 3 single cross, 10 three-way cross, 24 double cross and 1 varietal cross hybrids had significant remainder mean square which make their performance unpredictable under changed environments. The remaining genotypes: 1 single cross and 3 double cross hybrids had significant regression mean square as well as non linear portions of G X E interactions in respect of these genotypes. The genotypes studied in the present investigation did not exhibit uniform pattern of stability and environmental response (linear). These two attributes appear to be specific for individual genotypes. This means that even with varying levels of responsiveness, high proporation of

Table 3. Distribution of parents and hybrids on the basis of individual G X E interaction components for grain yield

Parameter	Parents	Single cross	Three way cross	Double cross	Varietal cross
Predictable					
G X E present					
(both B and s d nonsignificant)	7	10	19	93	5
G X E present					
(onlu b significant)	-	1	1	-	-
Unpredictable					
Both b and s^{-2} d significant	-	1	-	3	-
Only s^{-2} d significant	1	3	10	24	1
Total	8	15	30	120	6

additive gene interactions may be involved in determining high stability.

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CORRELATION AND PATH COEFFICIENT ANALYSIS IN COTTON

R.KOWSALYA AND T.S.RAVEENDRAN
School of Genetics
Tamil Nadu Agricultural University
Coimbatore 641 003

ABSTRACT

Correlation and path coefficient analysis made in 10 *Gossypium hirsutum* genotypes, 12 *G.barbedense* accessions, 3 cytosteriles and their isogenic maintainers revealed the importance of number of sympodia and number of bolls per plant to be considered for yield improvement by selection. Shorter duration may tend to reduce the seed cotton yield.

KEY WORDS : Cotton, Correlation, Path Analysis

Correlation of characters is a measure of strength of relationship between a group of characters. The estimation of correlation coefficient is an important step in planning selection experiments as it forms the basis for developing a selection index. A breeder is interested to assess the correlated response of the yield components in selection programmes besides the yield *per se*, because yield is a function of not only its components but also their inter-relationships. Paramasivam and Udayasoorian (1989) reported association of seed cotton yield with other related characters. Path coefficient analysis is used to determine the direct effect of each independent character on a dependent character among a group of metrical traits. This will be useful to work out the cause and effect relationship so that the selection will be more effective. An attempt was made in this study to find out the various effects of yield components on cotton ield.

MATERIALS AND METHODS

A total number of 22 accessions in the species *G.hirsutum* and *G.barbedense*, 3 cytosteriles and their isogenic maintainers formed the material for study. The crop was raised during summer irrigated season (February - June) of 1993 at the Cotton Breeding Station, Tamil Nadu Agricultural University, Coimbatore, in a randomised block design with three replications. The genotypes or raised in plots of 6m row and spacing of 75 x 30 cm had a population of 10 plants in a row. All the recommended agronomic practices were followed to raise a good crop. The data for correlation and path coefficient analysis were recorded for plant height, number of sympodia per plant, days to 50 per cent flowering, number of bolls per plant, boll weight, seed cotton yield, ginning out-turn, pollen stainability, 2.5 per cent span length and bundle strength. Correlation coefficients (Goulden 1959)