Tropical Agricultural Research Vol. 10 1998, 425-432

Combining Ability and Heterosis of Some Productivity Traits in Pearl Millet [*Pennisetum glaucum* (L.) R. Br.]

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ABSTRACT. *Nine male sterile lines belonging to three diversified source such as A1, A2 and 732 A were crossed with ten restorer lines. The resulting F1 hybrids were evoluated for different productivity traits such as plant height, 50% flowering, number of productive tillers, panicle length, panicle girth, 100 grain weight and grain yield per plant. From these observations combining ability and heterosis were worked out to choose the best performing parents as well as hybrids. Predominance of non-additive gene action was reported for all the character in the present study. The parents such as 851A,ICMA 92777 A, 852 A, PT 5573 and PT 5576 were considered as general combiners. The crosses 3024 × PT5573 and 852 A × PT5567 were recommended for high grain yield through heterosis breeding.*

INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the most widely grown cereal crop under short growing seasons in the arid and semi arid regions of the world. It is a protogynous and cross pollinated crop amenable for the development of heterozygous populations, which can be utilized for the production of high grain yielding hybrids. The discovery of cytoplasmic male sterility (CMS) has made a major break through in the development of hybrids. With the introduction of Georgia male sterility in pearl millet through Tift 23 A to India in 1962 and subsequently the release of the HB 1 reportedly doubled the millet production between 1965 and 1970 (Burton, 1983). The knowledge of combining ability effects and the corresponding variances is important in the choice of selecting parents and it can be further used for exploiting heterosis to produce high performing new recombinations. The research on the diversification of CMS lines gained momentum because of genetic vulnerability of the female parents and the hybrids carrying the same cytoplasm. Hence the utilization of diverse cytoplasmic male sterile lines has been attempted for breeding of best hybrids. The present study

reports the heterosis of the hybrids and the combining ability analysis of pearl millet (*Pennisetum glaucum* (L.) R. Br.) male sterile lines taken from three systems of male sterility and the testers.

MATERIALS AND METHODS

Nine male sterile lines, namely ICMA 91444 A, ICMA 92444 A, ICMA 92666 A, ICMA 92777 A, 851 A, 852 A, 302 A, 306 A and 732 A, which included three cytoplasmioc groups A1, A2 and 732 A sources were crossed with ten restorers in a Line *x* Tester fashion in Rabi (winter season) 1996. The crossed seeds were sown as F1 seeds in Kharif (wet season) 1997 with two replications as a randomized block design at Millet Breeding Station, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore, India. Each entry was represented by two rows of three meters length with a spacing of 50 cm. The plant to plant spacing with in the row was 15 cm. All the agronomic practices were made as for commercial crop. The data with respect to seven characters *viz.*, 50% flowering, plant height, number of productive tillers, panicle length, panicle girth, 100 grain weight and grain yield per plant were recorded on the hybrids and the parents. These data were subjected to Line *x* Tester analysis and the general combining abilities (gca) of the parents and specific combining abilities (sca) of the crosses were worked out, as suggested by Kempthrone (1957). The degree of heterosis in F1 over mid parent, better parent and standard heterosis were calculated and expressed in percentage (Turner, 1953).

RESULTS AND DISCUSSION

The mean performance of the hybrid lines and the testers with respect to the measured parameters is shown in Table 1. The hybrids and the Line *x* Tester interaction was significant for all the characters studied. The variance due to lines was significant for all the characters except for 50% flowering and grain yield per plant. The over all variances for the testers were also significant for all the traits except for number of productive tillers. SCA variance was more pronounced than that of GCA variance, so non–additive gene actions were noticed. This result is in confirmity with the findings of Pethani and Kapoor (1995).

Parents with high negative gca effect coupled with negative mean *per se* for 50% flowering was considered the best for exploiting earliness in hybrids. The lines ICMA 92666 A, ICMA 92444 A and the testers PT 5573,

PT 5574, PT 5575 expressed high significant negative gca effects (Table 2). The highest negative significant sca effect was registered in the crosses 851 A × PT 5570 and ICMA 92777 × PT 5572. Best crosses showing significant specific combining ability effects for all the characters are shown in Table 2. The crosses ICMA 9277 A × PT 5572 and ICMA 92666 A × PT 5574 recorded significant negative relative heterosis (di), heterobeltiosis (dii) and standard heterosis (diii), at 50% flowering. Crosses showing high heterosis for all the characters are shown in Table 3.

Table 1. Mean performance and combining ability effects of parents.

Parents	DF	PH	NPT	PL	PG	GW	GY
Lines							
ICMA91444A	103.9	50.5	4.0	23.9	8.8	1.2	19.1
ICMA92444A	111.2	50.0	5.1	16.0	8.7	0.9	13.5
ICMA92666A	129.5	50.5	5.0	17.9	8.7	0.9	19.2
ICMA92777A	112.6	52.0	2.4	15.6	9.2	1.0*	26.9
851A	135.9	52.5	5.6	19.1	8.2	0.8	20.3
852A	139.3	51.5	3.9	16.1	7.6	0.8	13.2
302A	148.2	52.0	3.9	13.5	4.4	1.0	12.0
306A	139.8	52.5	4.3	13.5	7.4	0.7	18.0
732A	77.2	53.0	2.9	18.0	7.0	0.9	16.5
Tester							
PT 5567	149.5	51.0	5.0	20.4	8.7	0.9	38.5
PT 5568	135.3	51.5	3.7	18.4	8.9	0.7	19.0
PT 5569	144.9	51.0	2.8	18.7	8.3	0.8	23.8
PT 5570	140.4	53.5	3.6	15.7	8.5	0.7	20.5
PT 5571	183.6	53.5	5.2	24.5	9.6	1.0*	40.0
PT 5572	147.5	51.5	3.4	24.8	16.8	0.8	16.2
PT 5573	178.0	49.5	2.9	20.5	11.3	1.4	26.9
PT 5574	96.1	48.5	3.9	17.6	7.9	0.8	19.3
PT 5575	147.2	50.5	3.2	19.4	7.2	0.5	28.8
PT 5576	162.2	51.0	3.3	22.9	10.7	1.0	21.8
SE	97.6	0.87	0.32	3.1	1.6	0.01	35.6

DF: days to 50% flowering; PH: plant height (cm); NPT: number of productive tillers; PL: panicle length (cm); PG: panicle girth (cm); GW: 100 grain weight (g); GY: grain yield (g per plant); SE: standard error of the means.

The parents 851 A and PT 5571 had positive gca effects. Out of this, PT 5571 expressed high *per se* performance for plant height. The parent with

Table 2. Estimates of general combinding ability effects.

Parents	DF	PH	NPT	PL	PG	GW	GY
FEMALE PARENTS							
ICMA 91444A	0.7	-3.5	-0.2	0.1	-0.4*	0.1*	-5.2**
ICMA 92444A	-0.6*	-4.2	-0.3**	-1.5**	0.7**	-0.1*	2.2
ICMA 92666A	-0.8**	-1.2	0.3*	-1.7**	-0.1	0.03	-1.5
ICMA 92777A	-0.4	1.3	0.2	-0.7	0.7**	0.1**	1.0
851 A	0.6*	13.0**	0.1	3.8**	-0.3**	0.02	5.6**
852 A	0.9**	-3.4-	-0.1	-0.3	-0.1	0.1**	4.5**
302 A	-0.1	4.6*	-0.02	1.5**	0.0	-0.1*	-0.4
306 A	0.01	-0.1	-0.1	-1.5	0.3*	0.1	2.4
732 A	0.4	0.34	0.12	0.3	-0.2**	-0.2**	-4.1*
SE	0.2	1.6	0.09	0.32	0.16	0.02	1.13
CD (p=0.05)*	0.5	4.6	0.25	0.89	0.44	0.05	3.16
CD (p=0.01)**	0.7	6.04	0.33	1.19	0.59	0.07	4.18
MALE PARENTS							
PT5567	-0.5	-4.0	0.4**	-2.4**	-0.6**	-0.1**	0.1
PT5568	0.7*	0.3	-0.2	-0.2	0.5	-0.1**	0.1
PT5569	1.4**	0.5	0.2	-1.0*	0.1	-0.1	2.1
PT5570	1.4**	2.5	0.1	-0.6	-0.4	-0.01	4.1*
PT5571	1.7**	23.5	-0.1**	2.5**	0.3	-0.1*	-7.1**
PT5572	-1.0**	-4.6	0.1	0.4	0.1	0.2**	3.0
PT5573	1.9**	-5.9	-0.6	-0.2	-0.2	0.2**	4.4*
PT5574	-1.4**	-14.5**	-0.2	-0.2	-0.2	-0.1*	0.2
PT5575	-1.1**	-4.6	-0.2	0.5	-0.1	0.00	3.0
PT5576	0.6**	6.6	0.5**	1.2*	0.8**	-0.01	2.3
SE	0.2	1.73	0.09	0.34	0.17	0.02	1.2
CD(p=0.05)*	0.56	4.85	0.25	0.95	0.47	0.05	3.36
CD(p=0.01)**	0.74	6.41	0.33	1.26	0.63	0.07	4.44

DF: days to 50% flowering; PH: plant height (cm); NPT: number of productive tillers; PL: panicle length (cm); PG: panicle girth (cm); GW: 100 grain weight (g); GY: grain yield (g per plant); SE: standard error of the means.

high mean *per se* plant height and high gca can be advantageously utilised in pedigree breeding programmes depending on the need to develop tall varieties. The cross 851 A × PT5568 and 306 A × PT5570 recorded highest sca effect for plant height. The cross 851 A × PT 5568 showed significant heterobeltiosis and standard heterosis. Among the parents ICMA 92666 A, PT 5567 and PT 5576 showed significant gca effect for number of productive tillers. The positive gca effect of the tester PT 5567 was also associated with the high mean performance and it will be useful to evolve high tillering hybrids. The crosses ICMA 92777 A × PT 5576 and 302 A × PT 5572

showed significant sca effect for the number of productive tillers (Table 3). The crosses 851 A × PT 5576 and 302 A × PT 5572 recorded significant relative heterosis, heterobeltiosis and standard heterosis.

Table 3. Crosses showing significant specific combining ability effect for different characters.

Characters	Crosses
Days to 50% flowering	851A *X* PT 5570
	ICMA 92777A *X* PT 5572
	306A *X* PT 5567
Plant height (cm)	851 A *X* PT 5568
	306 A *X* PT 5570
	852 A *X* PT 5572
Number of productive tillers	ICMA 92777A *X* PT 5576
	302 A *X* PT 5572
	851 A *X* PT 5571
	306 A *X* PT 5567
	851 A *X* PT 5576
Panicle length (cm)	306 A *X* PT 5575
	851 A *X* PT 5576
	ICMA 92777A *X* PT 5568
Panicle girth (cm)	ICMA 92777A *X* PT 5569
	ICMA 95666A *X* PT 5575
	306 A *X* PT 5572
	732 A *X* PT 5570
100 Grain weight (g)	851 A *X* PT 5570
	851 A *X* PT 5568
	92444 A *X* PT 5573
	732 S *X* PT 5572
Grain yield (g per plant)	302 A *X* PT 5573
	95444A *X* P 5573
	ICMA 91444A *X* PT 5569
	306 A *X* PT 5571
	852 A *X* PT 5567

The parents such as 851 A, 302 A, PT 5575 and PT 5576 recorded highly significant gca effect for panicle length (Table 2). The highly significant positive effect observed in PT 5571, PT 5576 pollinators were also associated with high mean *per se* performance. Such parents could be utilized profitably to increase the earhead length which in turn will improve grain yield. The crosses 306 A × PT 5575 and 306 A × PT 5570 showed significant gca effects. The 306 A × PT 5575 cross recorded significance for all three types of heterosis (di, dii and diii).

Table 4. Crosses showing significant heterosis.

Ch.	Relative heterosis	Heterobeltiosis	Standard heterosis
DF	ICMA 92777A *X* PT 5572	ICMA 92666A *X* PT 5574	ICMA 92777A *X* PT 5572
	ICMA 92666 A *X* PT 5574	ICMA 62777A *X* PT 5572	ICMA 92666 A *X* PT 5574
	306 A *X* PT 5572	306A *X* PT 5578	851 A *X* PT 5570
PH	852 A *X* PT 5568	851 A *X* PT 5568	851 A *X* PT 5568
	851 A *X* PT 5572	306 A *X* PT 5572	851 A *X* PT 5570
	732 A *X* PT 5573	852 A *X* PT 5569	732 A *X* PT 5572
NPT	851 A *X* PT 5576	851 A *X* PT 5576	851 A *X* PT 5576
	851 A *X* PT 5572	302 A *X* PT 5572	302 A *X* PT 5567
	306 A *X* PT 5572	732 A *X* PT 5572	ICMA 92666A *X* PT 5576
PL	306 A *X* PT 5575	306 A *X* PT 5575	852 A *X* PT 5571
	851 A *X* PT 5576	852 A *X* PT 5572	306 A *X* PT 5572
	732 A *X* PT 5572	302 A *X* PT 5573	ICMA 92777A *X* PT 5569
PG	ICMA A 92777 *X* PT 5570	851 A *X* PT 5568	ICMA 92777A *X* PT 5569
	852 A *X* PT 5573	ICMA 92777A *X* PT 5569	852 A *X* PT 5571
	306 A *X* PT 5572	732 A *X* PT 5572	851 A *X* PT 5570
GW	851A *X* PT 5570	851 A *X* PT 5570	732 A *X* PT 5572
	732 A *X* PT 5572	732 A *X* PT 5572	851 A *X* PT 5570
	ICMA 92777A *X* PT 5568	852 A *X* PT 5572	306 A *X* PT 5573
GY	302 A *X* PT 5573	302 A *X* PT 5573	302 A *X* PT 5573
	851 A *X* PT 5568	732 A *X* PT 5572	851 A *X* PT 5570
	306 A *X* PT 5572	ICMA 92777A *X* PT 5576	306 A *X* PT 5572

DF: days to 50% flowering; PH : plant height (cm); NPT: number of productive tillers; PL: panicle length (cm); PG: panicle girth (cm); GW: 100 grain weight (g); GY: grain yield (g per plant); SE: standard error of the mean..

Among the parents ICMA 92444 A, ICMA 92777 A, 306 A, PT 5576 and PT 5568 showed high gca effects for panicle girth. These parents could be useful for evolving varieties with thicker earheads. The crosses ICMA 92777 A × PT 5569 and 306 A × PT 5572 recorded high sca effects. The cross ICMA 92777 A × PT 5569 performed better with a significant expression of relative heterosis, heterobeltiosis and standard heterosis.

For the character 100 grain weight, the parents ICMA 91444 A and PT 5573 recorded high positive significant gca effects coupled with high mean *per se* performance. The crosses 851 A × PT 5568, 732 A × PT 5572 and 92444 A × PT 5573 expressed high sca effect. The crosses 851 A × PT 5570 and 732 A × PT 5572 recorded high heterosis, for 100 grain weight character (Table 4).

The ultimate objective in any breeding programme is the improvement of grain yield and hence breeding procedures are to be focused and carefuly formulated in increasing the potentiality of this complex trait. Among the parents 851 A 852 A and PT 5570 possessed high gca effects associated with moderate per se grain yield. The crosses 302 A × PT 5573 showed high gca effect with significant heterosis. Theses crosses may be further utilized in the breeding programme for improving other desirable agronomical characters.

CONCLUSIONS

The parents such as 851 A, ICMA 92777 A, 852 A, PT 5576 and PT 5570 were the recommended parents for future crossing programme for improving the yield and yield contributing characters. The crosses 302 A × PT 5573, 851 A × PT 5570, 306 A × PT 5572, ICMA 92777 A × PT 5569, 306 A × PT 5575, 732 A × PT 5572, ICMA 92777 A × PT 5576 and 851 A × PT 5568 were considered as good performing hybrids.

REFERENCES

Burton, G.W. (1983). Breeding pearl millet. Pl. Breed. Rev. 1: 162-182.

Kempthorne, O. (1957). An Introduction to Genetic Statistics. John Wiley and Sons. Inc. New York.

Turner, A. (1953). A study of heterosis in upland cotton. I. Yield of hybrids compared with varieties. Agron. J. 45: 485-486.

Pethani, K.V. and Kapoor, R.L. (1995). Combining ability analysis for yield components in pearl millet. Gujarat Agrl. Uni. Res. J. 20: 87-93.