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Development of heteroitic hybrids for quality, yield and its architectural traits in pearl millet [*Pennisetum glaucum* (L.) R. BR.]

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Abstract
An experiment comprised five cytoplasmic male sterile lines and ten inbreds of pearl millet along with their 50 hybrids was conducted during *kharif,* 2011 to study the gene action, combining ability and heterosis for quality, yield and its architectural traits. The lines ICMA 04777, ICMA 88004, ICMA 92666 and the testers PT 6324, PT 6238 and PT 6330 possessed higher *per se* and positive *gca* effects for most of the quality and yield traits. The hybrid ICMA 04777 x PT 6328 recorded high *sca* coupled with heterosis and *per se* performance for quality and yield traits. Among the 50 hybrids ICMA 04777 x PT 6328, ICMA 04777 x PT 6330, ICMA 92666 x PT 6328, and ICMA 04777 x PT 6250 were selected as best crosses since they expressed high standard heterosis over standard hybrid (TNAU Cumbu Hybrid CO 9) for most of the traits related to grain yield.

Keywords: *GCA,* Heterosis, Pearl millet, *SCA*

Introduction
Pearl millet (*Pennisetum glaucum* (L.) R. Br.) is a stable diet for majority of poor farmers and also forms an important fodder crop for livestock population in arid and semi-arid regions of India (Yadav and Manjit, 2012). In India it is the fifth most important grain crop next to rice, wheat, maize and sorghum (Singh *et al.,* 2008). It is a highly cross-pollinated crop with protogyny and wind borne pollination mechanism fulfills the essential biological requirements for hybrid development. It has 8.6-17.4 per cent protein, 61.5-89.1 per cent carbohydrate and 292 mg phytate phosphorus (Hulse *et al.,* 1980). Improvement of nutritional quality is presently being emphasized and considerable progress has been made towards genetic improvement of quality in pearl millet. The yield has been increased in pearl millet during the past ten years mainly through development of hybrids by the utilization of cytoplasmic genetic male sterility system. For the development of effective heterosis breeding programme in pearl millet, one needs to have information about genetic architecture and estimated prepotency of parents in hybrid combinations (Jain and Nagar, 2007). Selection made on phenotypic performance alone does not lead to expected success in hybrid breeding. The choice of parents should be based on combining ability, gene action and expressions of heterosis, for quality, grain yield and its components. The present investigation was carried out to study gene action, combining ability and heterosis in pearl millet genotypes with a view to identify the best combination of parents and F_1 hybrid combinations for quantitative and qualitative traits.

Materials and Methods
Experimental materials and design: In the present study five male sterile lines and ten inbreds of pearl millet were chosen. Crosses were effected by using Line × Tester mating design during *kharif*, 2011 at the experimental farm of Department of Millets, Tamil Nadu Agricultural University, Coimbatore. Fifty hybrids along with their parents and standard check (TNAU Cumbu Hybrid CO 9) were raised in Randomized Block Design (RBD) with three replications during *rabi*, 2011. Each parent and the F_1 hybrids were accommodated in a single row of 4 m length with a spacing of 45 cm between rows and 15 cm between plants. Recommended agronomic practices were followed.

***Biometrical and qualitative traits*:** Observations were recorded on five randomly selected plants for four quantitative characters *viz.,* days to 50 per cent flowering, plant height (cm), 1000 grain weight (g), grain yield per plant (g) and for three qualitative characters *viz.,* starch (Anthrone reaction method by Hodge and Hofreiter (1962), crude protein (Micro-Kjeldahl method; Humphries, 1956) and phytic acid (Wheeler and Ferrel, 1971).

Statistical analysis: The mean values of observations were subjected to statistical analysis and the line x tester analysis was carried out according to Kempthrone (1957).

Results and Discussion

Analysis of variance: The analysis of variance for yield and its components indicated that the variances due to genotypes were highly significant for all the characters studied indicating considerable amount of genetic variability present among the genotypes. Analysis of variance for combining ability (Table 1) revealed that the higher *sca* variance than the *gca* variance for all the characters studied exhibiting preponderance of non-additive gene action which justifies heterosis breeding for rapid improvement of quality and biometrical traits in pearl millet.

Per se performance: The *per se* performance of hybrids were significant from that of parents for days to 50 per cent flowering, plant height, grain yield per plant, 1000 grain weight, starch, crude protein and phytic acid content, emphasized the need of selecting morphologically diverse parents for maximization of hybrid vigour for seed yield and its contributing characters.

General combining ability effects: The estimates of *gca* effects of parents for various characters are presented in table 2. The line ICMA 04777 and ICMA 92777 were found to be general combiners for days 50 per cent flowering and plant height. The lines, ICMA 04777 and ICMA 88004 can be utilized for evolving early maturing hybrids through pedigree breeding as they exhibited high *per se* performance and high *gca* effect for earliness. Among testers, PT 6324 and PT 6328 were good general combiners for plant height, 1000 grain weight, starch, crude protein and grain yield per plant. The tester, PT 6330 emerged as good general combiner by registering significant *gca* effects for plant height, starch, crude protein, grain yield per plant.

Specific combining ability effects: While considering the *per se* performance, specific combining ability effects and standard heterosis for seed yield and its attributes, revealed that top most heteroitic hybrid (Table 3) ICMA 04777 x PT 6328 and ICMA 04777 x PT 6330 (high x high) exhibited high *per se* performance and significant *sca* effects in desired direction for 1000 grain weight, crude protein and grain yield per plant. These hybrids also recorded significant heterosis over standard check for most of the characters. This result was in accordance with the studies (Izge *et al.,* 2007; Lakshmana, 2011; Dangariya *et al.,* 2009; Bhadalia *et al.,* 2014). In general, the hybrids showing high *per se* performance also displayed high *sca* effects suggesting that *per se* performance of the crosses was a good indicator of their *sca* effects.

Besides the hybrid ICMA 92666 x PT 6328 (low x high) also exhibited high *per se* performance and positive significant *sca* effects for four characters including grain yield per plant and exhibited significant standard heterosis for plant height and grain yield per plant. ICMA 88004 x PT 6324 showed high *sca* effects and exhibited significant standard heterosis for grain yield per plant.

Table 1. Analysis of variance for combining ability of yield and quality traits in pearl millet

Source of variation	df	Mean sum of squares						
		Days to 50 % flowering	Plant height (cm)	1000 grain weight (g)	Starch (g)	Crude protein (g)	Phytate Phosphorous (mg)	Grain yield per plant(g)
Replication	2	27.74	3.24	0.17	0.12	1.01	0.60	24.88
Hybrids	49	12.57**	1181.42**	9.68**	121.29**	13.23**	4101.46**	1707.78**
Lines	4	45.56**	4089.28**	7.03**	559.05**	30.65**	7987.03**	4706.03**
Testers	9	12.23**	2230.76**	11.93**	53.32**	12.83**	5028.22**	2322.36**
L x T	36	8.99**	595.98**	9.41**	89.64**	11.39**	3438.04**	1220.98**
Error	98	2.21	4.17	0.03	0.26	0.07	0.65	5.08
GCA		0.05	8.65	0.00	046	0.02	9.80	7.19
SCA		2.26	197.26	3.12	29.79	3.77	1145.70	405.30
GCA/SCA		0.02	0.04	0.00	0.01	0.005	0.008	0.01

*,** Significant at P<0.05 and P<0.01 level, respectively

Table 2. Estimates of general combining ability effects (*gca*) for yield and quality characters in pearl millet

Parents	Days to 50% flowering	Plant height (cm)	1000 grain weight (g)	Starch (g)	Crude protein (g)	Phytate Phosphorous (mg)	Grain yield per plant (g)
Lines							
ICMA 04777	1.25 **	14.71 **	0.27 **	-1.52 **	1.06 **	-27.52 **	21.76 **
ICMA 88004	-2.02 **	-11.41 **	0.71 **	-6.54 **	0.98 **	4.10 **	-8.38 **
ICMA 92666	0.15	1.24 **	-0.51 **	2.16 **	-0.04	15.45 **	-3.37 **
ICMA 92777	0.65 *	7.40 **	-0.22 **	4.87 **	-0.93 **	0.81 **	-1.66 **
ICMA 92888	-0.02	-11.93 **	-0.24 **	1.04 **	-1.07 **	7.17 **	-8.35 **
SE	0.27	0.37	0.03	0.09	0.05	0.14	0.41
Testers							
PT 6064	0.31	2.34 **	0.91 **	0.06	-0.03	16.39 **	-7.24 **
PT 6067	1.38 **	-7.79 **	0.59 **	-2.85 **	1.14 **	-21.34 **	-9.14 **
PT 6238	-1.35 **	-14.91 **	0.55 **	-0.18	-1.56 **	10.77 **	-20.52**
PT 6250	-0.49	-19.23 **	0.07	-1.07 **	0.23 **	-32.00 **	-7.86 **
PT 6311	-0.02	13.49 **	-0.11 *	3.54 **	-1.24 **	11.03 **	-1.44 *
PT 6316	-1.22 **	-6.55 **	-1.79 **	-2.70 **	-0.20 **	-3.92 **	-0.27
PT 6324	1.31 **	16.82 **	0.39 **	0.70 **	0.87 **	-12.14 **	13.86 **
PT 6328	-0.15	11.33 **	0.95 **	0.50 **	1.05 **	3.45 **	22.64 **
PT 6330	0.18	6.38 **	-1.09 **	1.26 **	0.34 **	-1.45 **	1.99 **
PT 6333	0.05	-1.86 **	-0.45 **	0.74 **	-0.58 **	29.23 **	7.97 **
SE	0.38	0.52	0.04	0.13	0.07	0.20	0.58

*,** Significant at P<0.05 and P<0.01 level, respectively.

Table 3. Specific combining ability (*sca*), standard heterosis (SH) and *per se* performance for top five promising hybrids

Crosses		Days to 50 % flowering	Plant height (cm)	1000 grain weight (g)	Starch (g)	Crude protein (g)	Phytate Phosphorous (mg)	Grain yield per plant (g)
ICMA04777 x PT6328	Per se	48.33	170.93	14.10	69.93	16.44	98.47	146.42
	sca	1.22	4.71**	1.47**	10.25**	2.49**	-70.92**	26.58**
	SH	-3.33	9.48**	65.23**	4.84**	85.07**	-13.05**	45.60**
ICMA04777 x PT6330	Per se	49.00	167.4	13.23	61.65	15.57	198.4	122.1
	sca	1.55	6.19**	2.65**	1.21 **	2.34 **	33.95**	22.89**
	SH	-2.00	7.26**	55.08**	-7.57**	75.27**	75.23**	21.39**
ICMA92666 x PT6328	Per se	44.67	160.3	12.67	57.87	10.48	236.4	117.4
	sca	-1.35	7.55**	0.82**	-5.49**	-2.38**	24.04**	22.72**
	SH	-10.67**	2.67*	48.44**	-13.2**	17.97**	108.7*	16.76**
ICMA04777 x PT6250	Per se	50.00	144.3	11.47	59.31	13.70	134.3	110.1
	sca	3.22**	8.70**	-0.28 *	1.21 **	0.58 **	0.44	20.79*
	SH	0.00	-7.54**	34.38**	-11.1**	54.26**	18.66**	9.50**
ICMA88004 x PT6324	Per se	46.00	130.83	11.63	61.03	13.50	160.5	104.57
	sca	0.69	-14.77**	-0.88**	6.17 **	-0.18	-24.88**	23.65**
	SH	-8.00**	16.20**	36.33**	-8.50**	51.97**	41.76**	3.98*

*, ** Significant at P<0.05 and P<0.01 level, respectively

The hybrids ICMA 04777 x PT 6250 exhibited high *sca* effects for grain yield per plant. ICMA 04777 x PT 6250 had standard heterosis for crude protein and grain yield per plant. These hybrids were derivatives of high x low parental combinations. The hybrid ICMA 88004 x PT 6250 was found to be the most promising combination for developing short duration hybrid, since they showed highly significant negative standard heterosis (Table 3). Similar results for days to 50 per cent flowering were obtained by Lakshmana (2011) and Vetriventhan *et al*. (2008). These hybrids can be effectively utilized in hybridization programme for the commercial exploitation of grain yield.

Conclusion

The expectation of the pearl millet farmers is mainly focused on level of superiority of newly released hybrids than the local standard hybrids. Hence there is a need for the breeder to evaluate the newly developed hybrids for yield and other desirable characters. Lines ICMA 04777, ICMA 88004, ICMA 92666 and the testers PT 6324, PT 6238 and PT 6330 possessed higher *per se* and positive *gca* effects for most of the quality and yield traits. Among the 50 hybrids generated in the present investigation, the hybrid ICMA 04777 x PT 6328, ICMA 04777 x PT 6330, ICMA 92666 x PT 6328 and ICMA 04777 x PT 6250 were identified as the best hybrids, since they possessed high *per se* performance, *sca* effect and heterosis for grain yield per plant and important yield attributing characters over standard hybrid (TNAU Cumbu Hybrid CO 9). Hence, these hybrids could be effectively utilized to exploit heterosis for commercial cultivation.

References

Bhadalia, A. S., K. K. Dhedhi, H. J. Joshi and J. S. Sorathiya. 2014. Combining ability studies through diallel analysis in pearl millet [*Pennisetum glaucum* (L.) R. Br.]. *International Journal of Agricultural Science* 10: 57-60.

Dangariya, C. J., J. M. Chotalia, J. J. Savaliya, B. K. Davda and A. G. Pansuriya. 2009. Combining ability analysis in pearl millet (*Pennisetum glaucum* (L.) R. Br.). *Agricultural Science Digest* 29: 287-290.

Hodge, J. E. and B. T. Hofreiter. 1962. In: R. L. Whistler and J. N. Be Miller (eds). *Methods in Carbohydrate Chemistry.* Academic Press, New York.

Hulse, J. H., E. M. Laing and O. E. Pearson. 1980. *Sorghum and Millets, their Composition and Nutritive Value.* New York Academy Press. pp. 997.

Humphries, E. S. 1956. *Modern Methods of Plant Analysis*. Springer Verlag. Berlin. pp. 468-502.

Izge, A. U., A. M. Kadams and A. A. Sajo. 2007. Heterosis and inheritance of quantitative characters in a diallel cross of pearl millet (*Pennisetum glaucum* L.). *Agronomy Journal* 6: 275-285.

Jain, R. K and R. Nagar. 2007. Stability analysis in dual purpose bajra [*Pennisetum glaucum* (L.) R.Br.]. *Range Management and Agroforestry* 28: 311-313.

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

Lakshmana, D., B. D. Biradar, D. Madaiah and R. B. Joli. 2011. Combining ability studies on A1 source of cytoplasmic male sterility system in pearl millet. *Indian Journal of Agricultural Research* 45: 45-51.

Singh, A. K., O. N. Srikant, Mathur and L. D. Sharma. 2008. Hybrid potential of seed parental lines of pearl millet under arid/semi-arid regions of India. *Research on Crops* 9: 155-158.

Vetriventhan, M., A. Nirmalakumari, S. Ganapathy. 2008. Heterosis for Grain Yield Components in Pearl Millet [*Pennisetum glaucum* (L.) R. Br.]. *World Journal of Agricultural Science* 4: 657-660.

Wheeler, E. L. and R. E. Ferrel. 1971. A method for phytic acid determination in wheat and wheat fractions. *Cereal Chemistry* 48: 312-320.

Yadav, O. P. and S. Manjit. 2012. Pearl millet stover productivity in crop-livestock farming system of arid zone: current status and opportunities for enhancement. *Range Management and Agroforestry* 33: 102-111.