Electronic Journal of Plant Breeding, 5(3): 445-450 (Sep 2014)
ISSN 0975-928X

Research Article

Combining ability analysis and gene action in pearl millet [*Pennisetum glaucum* (L.) R. Br.]

S.G. Khandagale[1*], Vijay Sharma[1], R.P.Lone[2], V.G.Khandagale[3] and Kumara Swamy R.V[4]

[1]Department of Genetics and Plant Breeding, MPUAT, Udaipur- 313 001, India;
[2]Department of Genetics and Plant Breeding, VNMKV, Parbhani- 413 403, India;
[3]Department of Agricultural Biotechnology, VNMKV, Parbhani- 413 403, India;
[4]Department of Agricultural Biotechnology, MPUAT, Udaipur- 313 001, India.
*E-mail: sgkhandagale@yahoo.com

(Received: 02 May 2014; Accepted:21 Jul 2014)

Abstract

The experiment was conducted with 50 hybrids which were developed through Line x Tester mating design using five male sterile lines and ten restorers as parental material along with two standard check hybrids, *viz*., Pratibha-1666 and Shradha. . The parents, hybrids and two standard checks were evaluated during *kharif* 2012 season for ten characters. Significant differences were observed for all the ten characters studied. Among females, 732A was found best general combiner for grain yield and had significant GCA effects for days to 50% flowering, days to maturity, 1000-grain weight and plant height while, in male parent, PT 4801 was the best general combiner followed by PT 4108 and PT4563 for grain yield per plant. The cross ICMA 88004 x PT 4639 was the best specific combiner for grain yield per plant followed by ICMA 91222 x PT 4520 and ICMA 99222 x PT 4801. They produced significant and desirable SCA effects for most of the traits studied, indicating potential for exploiting hybrid vigour in breeding programme.

Key words:
Peral millet, GCA, SCA, gene action, Grain yield.

Introduction:

Among the cereals, Pearl millet (*Pennisetum glaucum* (L) R. Br.) is a stable diet for the vast majority of poor farmer and also an important fodder crop for livestock population in arid and semi-arid regions of India. It is an annual tillering diploid (2n=2x=14) crop, belongs to family *Poaceae,* subfamily *Panicoidae* and believed to be originated in Africa, where the greatest diversity of morphological types exists. In India, Pearl millet occupies an area of 9.61 million hectares with production of 10.37 million tones and productivity of 1079 kg/ha in 2011-12 (Anonymous, 2012).

Combining ability provides useful information regarding the selection of suitable parents for effective hybridization programme and at the same time elucidates the nature and magnitude of different types of gene action. Since, the nature of gene action varies with genetic architecture of population involved in hybridization, it is necessary to evaluate the parents for their combining ability. This information enables the breeder to evaluate and classify selected parental material for their utility in development of high yielding F_1 hybrids in pearl millet, where hybrids are being cultivated on commercial scale.

Keeping the above fact in mind, the present investigation was conducted to assess the combining ability for yield and contributing traits, to determine the nature and magnitude of gene actions in a line × tester mating design with a view to identify good combiners including CMS lines and restorers.

Material and methods

The present investigation was carried at Department of Agril. Botany Research Farm, College of Agriculture, Latur-413 512 during *Kharif* season of 2012. The experimental material consisting of five male sterile lines *viz.,* 732A, ICMA 99222, ICMA 91222, ICMA 95333 and ICMA 88004 (female parents) and ten testers *viz.*, PT 3999, PT 4046, PT 4108, PT 4139, PT 4160, PT 4657, PT 4639, PT 4520, PT 4563 and PT 4801 (male parents) which were obtained from Tamil Nadu Agricultural University Coimbatore. All these fifteen parents were crossed to produce 50 F_1 hybrids according to the line × tester mating design developed by Kempthorne (1957). A total of 67 treatments comprising 5 male sterile lines (female parents), 10 restorers (male parents), 50 F_1's and 2 check hybrids viz., Pratibha-1666, Shradha were grown in a randomized block design with two replication. Each entry was planted in a 3 meter long row with inter and intra row spacing of 50 × 15 cm. Two row of each entry was planted in each replication. Five competitive plants were randomly selected to record the observations on 10 character *viz.,* days to 50 per cent flowering, days to maturity, plant height (cm), total number of tillers per plant, number of effective tillers per plant, 1000-grain weight (g), ear head girth (cm), ear head length (cm), grain yield per plant (g) and fodder yield per plant (g) were recorded for statistical analysis. Data was subjected to analysis of variance to find significant differences among genotypes for the recorded data. After obtaining the significant differences, data recorded on parents and their F_1 s were subjected to combining ability analysis and the testing of significance of different genotypes was based on the procedure given by Kempthorne (1957).

Result and discussion

Analysis of variance for combining ability**:** Analysis of variance for combining ability was done for ten characters and presented in Table 1. The mean squares due to line were significant for all the traits except days to 50 % flowering, number of tillers per plant and ear head girth. Variations due to tester were significant for plant height, ear head length, fodder yield per plant, grain yield per plant and number of tillers per plant. Mean squares due to Line x Tester were significant for all the traits except days to 50 % flowering, number of tillers per plant, days to maturity and 1000 seed weight. Significant differences were found among the parents for all the traits indicating that the materials selected were diverse and also resulted in creation of substantial genetic variability in the crosses.

Combining ability analysis revealed that GCA was highly significant for ear head length and significant for days to 50 % flowering, days to maturity, total number of tillers per plant and 1000 grain weight, indicated that additive variance is predominant for the characters. These results were in conformity with Lakshmana *et al.,* (2003) and Patil *et al.,* (2005). While, SCA were highly significant for grain yield per plant, fodder yield per plant, plant height, ear head girth, ear head length and significant for total number of tillers per plant, number of effective tillers per plant and 1000-grain weight, indicated that dominance and epistatic variance are predominant for the characters. Similar results were also reported by Yadav *et al.,* (2002), Rathore *et al.,* (2004) and Patel *et al.,* (2008).

Analysis also revealed higher magnitude of mean sum of squares for SCA than GCA for all characters, indicated the preponderance of non-additive gene action to control these characters (Dhuppe *et al.,* 2006) and therefore, heterosis breeding will be rewarding.

General and Specific combining ability: The estimate of GCA effects and SCA effect for ten characters are presented in Table 2 and Table 3, respectively. In the present investigation parent, 732A showed significant positive GCA effect for grain yield and effective tillers per plant, and desirable negative GCA effect for days to maturity. Therefore, 732A proved to be good general combiner for grain yield per plant, effective tillers per plant and days to maturity. Parents ICMA 99222 and PT 4139 were showed good general combiner for days to 50% flowering, days to maturity and ear head length. In addition to above, PT 4139 was also a good general combiner for number of tillers per plant and effective tillers per plant, whereas ICMA 99222 was also a good general combiner for fodder yield per plant.

Parents PT 4563 and PT 4801 were showed good general combiner for ear head length and fodder yield per plant. In addition to above, PT 4563 and PT 4801 were also good general combiners for days to maturity and days to 50% flowering. Parents ICMA 88004 and PT 4639 proved to be good general combiner for days to 50% flowering and ear head girth. In addition to above, ICMA 88004 and PT 4639 were also good general combiner for effective tillers per plant and 1000 seed weight. ICMA 91222 was a good general combiner for number of tillers per plant, effective tillers per plant, 1000 seed weight and fodder yield per plant. Parent PT 3999 proved to be good general combiners for days to maturity, effective tillers per plant and ear head girth. Parent PT 4108 was showed good general combiner for days to maturity, 1000 seed weight and fodder yield per plant. Parent ICMA 95333 and PT 4520 were showed good general combiners for 1000 seed weight and ear head length, respectively. Parent PT 4046 proved to be a good general combiner for ear head girth and fodder yield per plant.

The data on GCA effects indicated that the effects varied significantly for different characters and in different parents. The good general combiners had fixable component of variance like additive and additive × additive epistasis component; therefore, parent viz., 732A offered the best possibilities of exploitation for development of improved high yielding lines in pearl millet.

Sprague and Tatum (1942) reported that the SCA effect is due to non-additive genetic proportion. It is an important parameter for judging and selecting superior cross combinations, which might be exploited through heterosis breeding programme. The crosses which showed highest significant positive SCA effects for grain yield per plant presented in Table 3. Among the hybrids, Crosses ICMA-88004 x PT-4639 showed highest positive SCA effect for grain yield per plant and fodder yield per plant. Crosses ICMA-91222 x PT-4520 and ICMA-99222 x PT-4801 showed significant SCA effects in negative direction for days to 50 % flowering, days to maturity, plant height; and significant SCA effects in positive direction for ear head length, fodder yield per plant and grain yield per plant show. Similar results were also reported by Rathore *et al.*, (2004) and Bhanderi *et al.,* (2007). While, the crosses ICMA-91222 x PT-4046 showed positive significant SCA effect for ear head length, fodder yield per plant and grain yield per plant.

In the present investigation, 732A showed significant positive GCA effect for grain yield. Therefore, it offered the best possibilities for development of improved high yielding lines. The cross ICMA-88004 x PT-4639 was the best specific combiner for grain yield per plant followed by ICMA-91222 x PT-4520 and ICMA-99222 x PT-4801. They produced significant and desirable SCA effects and heterosis for most of the traits studied indicating potential for exploiting hybrid vigour in breeding programme.

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Electronic Journal of Plant Breeding, 5(3): 445-450 (Sep 2014)
ISSN 0975-928X

Table 1. Analysis of variance for combining ability for ten characters in pearl millet

Source of variation	d.f.	Days to 50 % flowering	Days to maturity	Plant height (cm)	Number of tillers per plant	Effective tillers per plant	1000 seed weight (g)	Ear head girth (cm)	Ear head length(cm)	Fodder yield per plant (g)	Grain yield per plant (g)
Lines	4	1.690	3.410**	292.19**	0.308	0.1733*	3.193*	0.4900	6.4716**	45.64**	23.571**
Testers	9	2.813	1.410	177.29**	0.404*	0.0602	2.594	0.9645	7.493**	55.906**	17.726**
L x T	36	2.062	1.8155	249.26**	0.2674	0.1518*	2.531	1.157*	4.415**	51.278**	29.909*
Error	49	1.593	1.402	4.947	0.156	0.07458	1.306	0.5574	0.0306	2.569	5.179
δ^2 GCA	-	0.054*	0.075*	15.33	0.014*	0.003	0.106*	0.018	0.460**	3.194	1.032
δ^2 SCA	-	0.309	0.263	122.23**	0.059*	0.039*	0.615*	0.0347**	2.170**	24.296**	12.37**

* Significant at 5 % probability level, ** Significant at 1 %probability level. δ^2 GCA and δ^2 SCA- variance due to GCA and SCA, respectively

Table 2. Estimates of General Combining Ability (GCA) effects of Lines and testers for ten characters in Pearl millet

S. No.	Parents	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of tillers per plant	Effective tillers per plant	1000 seed weight (g)	Ear head girth (cm)	Ear head length (cm)	Fodder yield per plant (g)	Grain yield per plant (g)
Lines											
1.	732A	0.155	-0.590**	2.770**	-0.087**	0.038**	-0.243**	0.205*	-0.079**	-0.349**	1.045**
2.	ICMA 99222	-0.245**	-0.190**	1.670*	-0.071**	-0.075**	-0.018**	-0.145**	0.906**	1.616**	-0.375**
3.	ICMA 91222	-0.095**	0.160	-6.430**	0.211**	0.107**	0.427*	-0.114**	-0.019**	1.429**	0.125
4.	ICMA 95333	0.430*	0.510**	-0.530**	-0.067**	-0.118**	0.354*	-0.074**	- 0.669**	-1.916**	-1.653**
5.	ICMA 88004	-0.245**	0.110	2.520**	0.014	0.047**	-0.521**	0.129*	-0.139**	-0.781**	0.858
	S.Em. ±	0.2686	0.2339	0.4898	0.0867	0.0608	0.2550	0.1523	0.0615	0.3664	0.5084
Tester											
1.	PT 3999	0.455	-0.290**	1.07	-0.132**	0.127**	-0.493*	0.245*	-0.269 **	0.676	0.37
2.	PT 4046	0.055	0.11	-2.730 **	0.058	-0.098**	0.432	0.202*	-1.139 **	3.801 **	1.68
3.	PT 4108	0.555	-0.39***	-4.430 **	-0.112**	-0.008**	0.682*	0.053	-0.309 **	1.226 *	-1.040 **
4.	PT 4139	-1.045**.	-0.69***	0.97	0.499 **	0.137**	-0.133**	-0.153**	0.541 **	-1.064**	1.72
5.	PT 4160	0.255	0.11	2.370 **	-0.021**	-0.013**	0.242	-0.032**	-0.109**	-2.283 **	-1.370 **
6.	PT 4657	0.355	0.11	1.470 *	-0.182**	-0.025**	0.162	-0.124**	0.171**	-2.094 **	-1.840 **
7.	PT 4639	-0.545**	0.21	8.770 **	0.049	0.008	0.698*	0.33*	-1.479 **	-0.254**	-0.705 **
8.	PT 4520	0.105	0.61*	-0.63**	0.043	-0.003**	-0.608**	-0.763 **	1.041 **	-3.924 **	0.985
9.	PT 4563	0.355	-0.09**	-0.13**	-0.212**	-0.043**	-0.493**	0.074	0.291 **	2.136 **	-0.950 **
10.	PT 4801	-0.545**	0.31	-6.730 **	0.008	-0.083**	-0.488**	0.167	1.261 **	1.776 **	1.15
S.Em. ±		0.3798	0.3591	0.6927	0.1226	0.0860	0.3606	0.2153	0.0870	0.5182	0.7190

* Significant at 5 % probability level, ** Significant at 1 %probability level.

Electronic Journal of Plant Breeding, 5(3): 445-450 (Sep 2014)
ISSN 0975-928X

Table 3. Estimates of specific combining ability (SCA) effect for ten characters in Pearl millet

Crosses	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Effective tillers per plant	1000 seed weight (g)	Ear head girth (cm)	Ear head length (cm)	Fodder yield per plant (g)	Grain yield per plant (g)
732A x PT-3999	-0.055	-0.71	-3.270 *	-0.414	0.052	-1.487	0.76	0.919 **	0.904	0.03
ICMA-99222 x PT-3999	-1.155	0.39	-12.170 **	0.472	0.065	-0.487	-0.617	-0.416 *	2.939 *	0.325
ICMA-91222 x PT-3999	0.195	0.04	24.930 **	-0.311	0.183	1.968 *	0.816	-1.741 **	-5.699 **	1.65
ICMA-95333 x PT-3999	-0.58	-1.31	0.03	-0.033	-0.142	0.041	-0.06	1.109 **	2.871 *	1.152
ICMA-88004 x PT-3999	1.595	1.59	-9.520 **	0.286	-0.157	-0.034	-0.898	0.129	-1.014	-3.158
732A x PT-4046	-1.655	-0.11	-27.470 **	-0.253	-0.223	-1.112	-1.081 *	-1.161 **	-3.971 **	-3.405 *
ICMA-99222 x PT-4046	1.245	0.49	6.130 **	-0.319	0.29	0.413	0.996 *	-0.546 **	2.439 *	-1.785
ICMA-91222 x PT-4046	0.095	0.14	5.730 **	0.649 *	-0.167	0.018	0.397	1.179 **	5.926 **	4.965 **
ICMA-95333 x PT-4046	-0.43	-0.71	14.830 **	0.176	0.133	1.491	-0.478	-0.271	-1.404	1.942
ICMA-88004 x PT-4046	0.745	0.19	0.78	-0.254	-0.032	-0.809	0.166	0.799 **	-2.989 *	-1.718
732A x PT-4108	0.345	-0.61	10.230 **	-0.234	0.037	0.488	0.481	-0.441 *	-4.721 **	4.315 **
ICMA-99222 x PT-4108	1.245	0.49	-0.67	-0.048	-0.3	-0.712	0.674	-0.926 **	-2.361 *	2.36
ICMA-91222 x PT-4108	-1.155	0.64	-1.57	-0.181	0.243	1.968 *	-0.3	1.049 **	6.676 **	-3.840 *
ICMA-95333 x PT-4108	-0.43	0.79	-5.470 **	0.596 *	0.293	-1.384	-0.458	0.699 **	2.621 *	-0.337
ICMA-88004 x PT-4108	-0.005	-1.31	-2.52	-0.134	-0.272	-0.359	-0.396	-0.381	-2.214	-2.498
732A x PT-4139	-0.055	1.19	8.830 **	0.506	0.392 *	2.178 **	1.158 *	-1.641 **	9.144 **	3.305 *
ICMA-99222 x PT-4139	-1.655	-0.71	-2.07	-0.058	0.105	-0.072	0.077	2.724 **	-4.096 **	3.325 *
ICMA-91222 x PT-4139	0.445	-1.06	-6.970 **	0.109	-0.077	-0.942	-1.193 *	2.099 **	-1.434	4.075 *
ICMA-95333 x PT-4139	0.42	0.59	-0.87	-0.364	-0.302	0.081	0.161	-2.451 **	0.311	-7.648 **
ICMA-88004 x PT-4139	0.845	-0.01	1.08	-0.194	-0.117	-1.244	-0.204	-0.731 **	-3.924 **	-3.058
732A x PT-4160	0.145	0.89	-3.570 *	-0.324	0.292	-0.547	1.037 *	3.059 **	1.363	-0.805
ICMA-99222 x PT-4160	1.045	1.49	7.530 **	-0.188	-0.245	0.303	0.454	-2.026 **	-0.502	-2.285
ICMA-91222 x PT-4160	-0.605	-0.86	4.630 **	-0.371	-0.427 *	-1.067	-0.843	-0.451 *	4.940 **	0.265
ICMA-95333 x PT-4160	-0.63	-2.210 **	-0.27	0.256	0.248	0.856	-0.191	-1.001 **	-3.095 *	2.443
ICMA-88004 x PT-4160	0.045	0.69	-8.320 **	0.627 *	0.133	0.456	-0.457	0.419 *	-2.705 *	0.382
732A x PT-4657	1.045	-0.61	0.33	0.337	-0.483 *	0.083	-1.697 **	0.179	3.774 **	0.765
ICMA-99222 x PT-4657	-0.555	-0.51	-0.57	0.171	0.242	0.058	-0.049	-0.856 **	-1.116	-3.065
ICMA-91222 x PT-4657	0.045	0.64	-16.470 **	-0.261	0.085	-0.112	0.663	-0.481 *	-3.104 *	-0.665
ICMA-95333 x PT-4657	0.02	0.79	6.630 **	-0.033	0.11	-1.239	0.525	0.719 **	2.941 *	3.713 *
ICMA-88004 x PT-4657	-0.555	-0.31	10.080 **	-0.214	0.045	1.211	0.558	0.439 *	-2.494 *	-0.747
732A x PT-4639	0.945	-0.21	10.030 **	0.056	0.271	0.622	0.203	1.229 **	5.084 **	-5.720 **
ICMA-99222 x PT-4639	1.345	0.39	-6.870 **	-0.309	-0.511 *	1.397	0.126	-0.406 *	-4.131 **	0.9
ICMA-91222 x PT-4639	0.195	0.04	-4.770 **	-0.141	-0.098	-1.818 *	0.522	-1.081 **	-6.369 **	-3.700 *
ICMA-95333 x PT-4639	-0.08	0.69	-2.67	-0.263	-0.173	0.625	0.011	0.469 *	-5.349 **	-0.273
ICMA-88004 x PT-4639	-2.405 **	-0.91	4.280 **	0.657 *	0.512 *	-0.825	-0.862	-0.211	10.766 **	8.793 **
732A x PT-4520	-0.705	-0.61	3.430 *	0.212	-0.218	-0.197	-0.901	-1.741 **	-6.396 **	1.44
ICMA-99222 x PT-4520	0.195	-0.01	19.530 **	0.047	0.095	-0.222	-0.578	-0.026	-6.461 **	-4.290 *
ICMA-91222 x PT-4520	-0.205	-0.36	-14.370 **	0.489	0.313	0.383	0.045	2.649 ***	4.476 **	5.760 **

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ISSN 0975-928X

Table 3. Contd..

Crosses	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of tillers per plant	Effective tillers per plant	1000 seed weight (g)	Ear head girth (cm)	Ear head length (cm)	Fodder yield per plant (g)	Grain yield per plant (g)
ICMA-95333 x PT-4520	0.27	0.79	-8.270 **	-0.109	-0.112	0.406	0.633	-0.451 *	4.221 **	-1.188
ICMA-88004 x PT-4520	0.445	0.19	-0.32	-0.639 *	-0.077	-0.369	0.801	-0.431 *	4.161 **	-1.723
732A x PT-4563	0.045	-0.41	1.93	0.117	0.172	-1.012	-0.326	0.059	-0.956	2.275
ICMA-99222 x PT-4563	-0.555	-1.31	-8.470 **	-0.049	0.185	-0.887	-0.297	0.674 **	7.704 **	-0.605
ICMA-91222 x PT-4563	0.045	0.84	-3.870 *	0.119	-0.297	0.993	0.15	-1.101 **	-4.834 **	-4.255 *
ICMA-95333 x PT-4563	-0.23	-0.01	-7.770 **	0.097	0.078	-0.059	0.249	-0.751 **	-3.739 **	-2.177
ICMA-88004 x PT-4563	0.695	0.89	18.180 **	-0.284	-0.137	0.966	0.223	1.119 **	1.826	4.763 **
732A x PT-4801	-0.055	1.19	-0.47	-0.004	-0.288	0.983	0.366	-0.461 *	-4.221 **	-2.2
ICMA-99222 x PT-4801	-1.155	-0.71	-2.37	0.282	0.075	0.208	-0.787	1.804 **	5.589 **	5.120 **
ICMA-91222 x PT-4801	0.945	-0.06	12.730 **	-0.101	0.243	-1.387	-0.257	-2.121 **	-0.574	-4.255 *
ICMA-95333 x PT-4801	1.67	0.59	3.830 *	-0.324	-0.132	-0.814	-0.393	1.929 **	0.621	2.372
ICMA-88004 x PT-4801	-1.405	-1.01	-13.720 **	0.146	0.103	1.011	1.071 *	-1.151 **	-1.414	-1.037
S.Em. ±	0.8493	0.8229	1.5490	0.2741	0.1922	0.8064	0.4815	0.1945	1.1587	1.6077