Advances in Crop Science and Technology

Singh and Sharma, Adv Crop Sci Tech 2014, 2:4
http://dx.doi.org/10.4172/2329-8863.1000147

Research Article Open Access

Assessment of Combining Ability in Pearl Millet Using Line x Tester Analysis

Jagendra Singh[1] and Ravi Sharma[2]*

[1]Research Scholar Senior Research Fellow Directorate of Research Services, RVSKVV Race Course Road, Gwalior 474002, MP, India
[2]Ex-Principal ESS College, Dr B.R. Ambedkar University (formerly Agra University), Dayalbagh, Agra, India

Abstract

Present experiment was conducted at Raya, Mathura (U.P.) during the kharif season of 2008, 2009 and 2010 with four male sterile lines (female parents) and nine inbreds used as testers (male parents) of pearl millet in line x tester fashion. In general combining ability analysis GIB 144 found maximum g.c.a. effects for yield, stem thickness, leaf area, panicle length, panicle-girth, and 1000-grain weight, dry weight per plant and harvest index followed by ICMA 93222, GIB 3346 and ICMA 95333. None of the parents showed significant positive g.c.a. effects for number of nodes per main stem and number of leaves per main stem. In specific combining ability analysis seven crosses viz., ICMA 93222 x GIB 78, ICMA 96111 x GIB 129, ICMA 93222 x GIB 144, ICMA 93222 x GIB 129, ICMA 97333 x GIB 157, ICMA 97333 x GIB 135 and ICMA 95333 x GIB 157 were identified as the best specific combiners for yield and major yield components. Analysis of s.c.a. effects revealed that good combining parents yield better hybrids, because parents with significant positive g.c.a. effects were involved more in selected crosses than those with non-significant g.c.a. effects and negative g.c.a. effects. In the present study, the involvement of at least one good general combiner was found essential for obtaining combinations with high specific effects. Combining ability studies revealed that both general and specific combining ability variances were important but the estimates of s.c.a. variance were higher in magnitude for all the characters. Thus, indicating the predominance of non-additive gene action.

Keywords: Kharif; Inbreds; Pearl; Millet; Line x Tester Analysis

Introduction

Pearl millet is being grown in arid and semi-arid regions of the world including West Africa, India and Pakistan with the rainfall ranging from 150-700 mm. India is a major pearl millet producing country with 43.3 per cent of the world area and 42 per cent of world production. It is mainly cultivated in the states of Rajasthan, Maharashtra, Gujarat, Madhya Pradesh, Karnataka, Andhra Pradesh, Uttar Pradesh and Tamil Nadu on a total area of 9.16 million hectare with the production of 8.01 million tonnes. The national average productivity is 850 kg/ha [1]. Pearl millet (*Pennisetum glaucum*) belonging to family Poaceae is a major crop of semi-arid tropics and possesses tetraploid (2n=4x=28) chromosomes. It is a monocotyledonous and cross-pollinated annual C_4 crop species. Its protogynous nature of flowering can be used to make hybrids. The principal aim of any breeding Programme is to increase the yield potential. The yield is a complex character comprising of a number of components each of which is genetically controlled and susceptible to environmental fluctuations. The concept of combining ability is gaining importance in plant breeding as it provides valuable genetic information about the parents and the characters under study. It helps in assessing the breeding value of parental lines in terms of their superiority in hybrid combinations and also provides the information regarding the nature and extent of gene action involved in controlling the inheritance of characters in question, like yield and yield attributing characters, thus helps in deciding upon the future breeding strategy. Hence the present investigation based on '*line* x *tester*' analysis was designed, to collect the information regarding the genetic composition of various quantitatively inherited yield contributing traits including grain yield in pearl millet.

Materials and Methods

The present study was brought from author's Ph.D. thesis. The experiment was conducted during the *kharif* season of 2008, 2009 and 2010 and recommended package of practices were applied. The material comprised of four male sterile lines (female parents) and nine inbreds used as testers (male parents) of pearl millet. During the year 2008 the experimental material was generated by crossing four male sterile lines to nine testers in line x tester fashion resulting in 36 F_1s. During the year 2009, the 36 F_1 crosses along with four lines and nine testers constituting a total of 49 treatments were grown in a randomized block design (RBD) with three replications, each entry represented by a single row of four meter length, with row to row and plant to plant spacing being 50 cm and 15 cm respectively. During the year 2010 the experiments were again repeated as in the year 2009. The observations for 14 quantitative characters [*viz.*, Plant height, Stem thickness, Number of nodes per main stem, Number of leaves per main stem, Leaf area, Flag leaf length, Number of productive tillers per plant, Panicle length, Panicle-girth, Grain density, 1000-grain weight, Grain weight per plant (economical yield), Dry weight per plant (Biological yield), Harvest Index (%)] were recorded on ten competitive plants, selected randomly from each row in each replication during 2009 and 2010 and averaged. Combining ability analysis was computed using line x tester procedure developed by Kempthorne [2].

Result and Discussion

Analysis of variance for combining ability

The results of analysis of variance for combining ability indicated that the mean squares due to lines were found to be highly significant for plant height , leaf area, flag leaf length, panicle length, panicle-girth,

***Corresponding author:** Ravi Sharma, Ex-Principal ESS College, Dr B.R. Ambedkar University (formerly Agra University), Dayalbagh, Agra, India, Tel: 05626455901; E-mail: drravisharma327@yahoo.com

Received: September 21, 2014; **Accepted:** October 20, 2014; **Published:** November 27, 2014

Citation: Singh J, Sharma R (2014) Assessment of Combining Ability in Pearl Millet Using Line x Tester Analysis. Adv Crop Sci Tech 2: 147. doi:10.4172/2329-8863.1000147

grain density, 1000- grain weight, grain yield per plant, dry weight per plant and harvest index (Table 1). In case of testers significant values were obtained for all the characters except for number of nodes per main stem, number of leaves per main stem and flag leaf length, whereas the mean squares due to line x tester were found highly significant for all the characters under study.

Estimates of general combining ability effects

The estimates of general combining ability (g.c.a.) effects of parents for all the characters have been given in Table 2. General combining ability effects suggested that GIB 144, ICMA 93222, GIB 3346 and ICMA 95333 were found to be the best general combiners for yield and some of its attributes. GIB 144 showed maximum g.c.a. effects for yield, stem thickness, leaf area, panicle length, panicle-girth, 1000-grain weight, dry weight per plant and harvest index, hence was considered most desirable. ICMA 93222 was fond to be good general combines for grain yield, number of productive tillers per plant, grain density and dry weight per plant while GIB 3346 proved to be good general combiner for yield, stem thickness, leaf area, flag leaf length and dry weight per plant. Similarly ICMA 95333 was identified as good general combiner for yield, stem thickness, leaf area, flag leaf length, panicle length and dry weight per plant. None of the parents showed significant positive g.c.a. effects for number of nodes per main stem and number of leaves per main stem.

Estimates of specific combining ability effects

The specific combining ability estimates revealed that no cross combination was consistently superior for all the characters under study as reported by Upadhyay and Murthy [3], Pokhriyal et al. [4] and Basavraju et al. [5]. Seven crosses viz., ICMA 93222 x GIB 78, ICMA 96111 x GIB 129, ICMA 93222 x GIB 144, ICMA 93222 x GIB 129, ICMA 97333 x GIB 157, ICMA 97333 x GIB 135 and ICMA 95333 x GIB 157 were identified as the best specific combiners for yield and major yield components (Table 3). Analysis of s.c.a. effects revealed that good combining parents yield better hybrids, because parents with significant positive g.c.a. effects were involved more in selected crosses than those with non-significant g.c.a. effects and negative g.c.a. effects. In the present study, the involvement of at least one good general combiner was found essential for obtaining combinations with high specific effects. For example in the case of hybrid ICMA 93222 x GIB 78, parent ICMA 93222 was a good general combiner for most of the characters while parent GIB 78 was a low combiner, whereas in the hybrid ICMA 93222 x GIB 144 both the parents were high combiners. Several workers Singh et al., Mathur and Mathur and Dass et al. [6-8] have also made similar observations in pearl millet.

S.N.	Source	d.f.	Plant height (cm)	Stem thick-ness (mm)	No. of nodes / main stem	No. of leaves / main stem	Leaf area (cm^2)	Flag leaf length (cm)	No. of product-ive tillers / plant	Panicle length (cm)	Panicle-girth (mm)	Grain density / cm^2	1000-grain weight (gm)	Grain weight / plant (gm)	Dry weight / plant (gm)	Harvest index (%)
1.	Replication	2	14.25	130.01	1.14	0.41	3420.00	36.42	0.00	1.21	3.98	4.59	0.02	0.48	5.89	4.04
2.	Lines	3	829.16**	5.27	0.42	0.28	5654.63**	94.84**	0.09	9.89**	233.18**	8.50**	3.94**	188.28**	2047.72**	36.66**
3.	Testers	8	205.42**	8.54**	0.38	0.37	1678.58**	27.75	0.18**	14.68**	78.28**	5.61**	3.46**	117.09**	366.06**	44.69**
4.	Line x Tester	24	439.50**	8.82**	1.55**	1.44**	2706.51**	86.08**	0.21**	29.48**	210.07**	13.63**	3.17**	79.28**	576.67**	51.42**
5.	Error	70	22.01	2.15	0.38	0.32	561.59	13.46	0.06	1.65	23.53	1.22	0.01	13.56	41.29	5.72

** Significant at 1% level.

Table 1: Analysis of Variance for combining ability for 14 characters in pearl millet (Mean sum of squares).

S. N.	Parents	Plant height (cm)	Stem thick-ness (mm)	No. of nodes / main stem	No. of leaves /main stem	Leaf area (cm^2)	Flag leaf length (cm)	No. of productive tillers / plant	Panicle length (cm)	Panicle-girth (mm)	Grain density / cm^2	1000-grain weight (gm)	Grain weight / plant (gm)	Dry weight / plant (gm)	Harvest index (%)
	Lines (Females)														
1.	ICMA 93222	1.78**	0.24	0.10	0.03	1.03	- 0.05	0.07**	0.23	-3.64**	0.64**	- 0.26	2.76**	7.62**	-0.20
2.	ICMA 95333	2.78**	0.47*	0.11	0.12	19.83**	2.56**	- 0.00	0.38*	0.10	0.01	- 0.23**	1.21	6.77**	-1.44**
3.	ICMA 96111	3.64	-0.21	- 0.10	-0.10	- 7.56*	-0.62	- 0.00	0.28	-0.00	0.05	- 0.06	- 0.60	- 4.07**	1.36**
4.	ICMA 97333	-8.23	-0.50*	- 0.11	-0.05	-13.29**	-1.88**	-0.06*	-0.90**	3.55**	-0.72**	0.55**	- 3.37**	-10.33**	0.27
5.	SE (g_i)	0.67	0.20	0.08	0.08	3.38	0.52	0.03	0.18	0.69	0.15	0.01	0.52	0.97	0.34
	SE (g_i - g_j)	0.94	0.282	0.112	0.112	4.765	0.733	0.042	0.253	0.972	0.211	0.014	0.733	1.283	0.479
	Testers (Males)														
1.	GIB 1	- 5.89**	- 1.06**	- 0.24	0.31	- 4.95	- 0.28	0.23**	-1.45**	-2.60*	-0.92**	-0.49**	1.59	6.46**	- 0.54
2.	GIB 77	4.42**	0.10	0.10	0.12	- 4.70	0.66	- 0.02	1.66**	-0.01	0.15	0.07**	- 0.40	- 3.53*	0.81
3.	GIB 78	5.23**	- 0.06**	- 0.10	-0.17	2.77	1.31	- 0.02	-0.29	-3.52**	-0.42	-0.72**	- 2.90**	- 5.03**	- 1.50**
4.	GIB 129	- 2.68*	- 0.16	0.10	0.10	-19.56**	- 2.23*	0.05	0.74*	-0.01	0.90**	-0.13	-3.82**	- 6.78**	- 1.78**
5.	GIB 135	- 3.33**	0.17	0.07	0.17	- 4.09	-1.20	- 0.14**	0.45	-1.06	0.99**	-0.34**	- 1.99**	- 3.87*	0.51
6.	GIB 144	5.13**	1.52**	- 0.15	0.07	19.95**	1.61	- 0.18**	1.04**	5.23**	0.07	1.03**	6.25**	8.54**	4.06**
7.	GIB 157	- 2.28*	- 0.56	0.27	0.12	- 2.57	-0.76	0.03	-1.58**	0.49	-0.59*	0.13**	-1.82*	0.37	- 1.94**
8.	GIB 8436	- 1.90	0.26	-0.19	- 0.19	- 2.72	-1.12	0.08	-0.65*	-0.50	0.40	0.53**	0.84	- 1.45	1.67**
9.	GIB 3346	1.30	0.80*	0.13	0.07	15.89**	2.01*	- 0.03	0.07	1.99	-0.59*	- 0.07**	2.25*	5.29**	- 0.27
	SE (g_i)	1.09	0.34	0.14	0.13	5.52	0.85	0.05	0.30	1.13	0.25	0.03	0.85	1.49	0.55
	SE (g_i - g_j)	1.53	0.479	0.197	0.183	7.783	1.198	0.070	0.423	1.593	0.352	0.042	1.198	2.100	0.775

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

Table 2: Estimates of General combining ability effects of Parents for 14 characters in Pearl millet.

S. N.	Crosses	Plant height (cm)	Stem thick-ness (mm)	No. of nodes / main stem	No. of leaves / main stem	Leaf area (cm^2)	Flag leaf length (cm)	No. of productive tillers / Plant	Panicle length (cm)	Panicle-girth (mm)	Grain density / cm^2	1000-grain weight (gm)	Grain weight / plant (gm)	Dry weight / plant (gm)	Harvest index (%)
1.	ICMA 93222 x GIB 1	- 11.75**	- 0.68	0.67	0.64**	- 6.04	- 0.79	- 0.24	0.68	- 7.42**	1.85**	-0.82**	-1.51	-15.12**	4.23**
2.	ICMA 95333 x GIB 1	5.72**	- 0.39	- 0.53	- 0.51	34.04**	8.67**	- 0.11	1.58**	12.00**	-1.23**	0.50**	1.14	-2.79	2.52**
3.	ICMA 96111 x GIB 1	- 0.42	0.20	- 0.32	- 0.35	- 11.78	- 3.48*	- 0.05	- 0.80	3.18	0.35	-0.09	-4.35**	-11.29**	-0.39
4.	ICMA 97333 x GIB 1	- 20.98**	0.08	- 0.33	- 0.30	- 7.80	- 3.84*	0.07	- 5.07**	- 1.12	0.01	0.81**	-4.76**	-15.21**	0.60
5.	ICMA 93222 x GIB 77	10.14**	1.20*	0.49*	0.49*	12.41	- 0.36	- 0.12	1.72**	- 6.67**	2.26**	- 0.54**	-0.26	8.20**	-2.98**
6.	ICMA 95333 x GIB 77	8.74**	- 0.67	- 0.93**	- 0.80**	14.32	7.77**	- 0.01	2.99**	8.29**	-1.14*	0.37**	-1.18	5.45*	- 3.73**
7.	ICMA 96111 x GIB 77	- 5.23**	0.68	- 0.23	- 0.32	- 17.45	- 4.40**	- 0.17	- 0.95	- 0.50	0.18	0.04	-3.43*	-0.71	-3.52**
8.	ICMA 97333 x GIB 77	- 4.41*	- 2.31**	- 0.10	- 0.06	-19.44**	- 2.41	0.23*	- 1.17*	- 2.77	-1.14*	0.07	1.56	12.45**	-2.72**
9.	ICMA 93222 x GIB 78	18.20**	1.87**	1.30**	1.22**	1.75	- 1.14	0.42**	1.02	- 4.93*	-1.14*	-0.34**	12.81**	19.03**	5.98**
10.	ICMA 95333 x GIB 78	13.76**	- 0.05	0.20	-0.04	46.88**	7.51**	- 0.15	0.71	6.11**	-1.51**	-0.19**	-2.96*	-10.27**	0.61
11.	ICMA 96111 x GIB 78	- 3.35	1.57**	0.05	0.05	-24.28*	- 5.82**	- 0.40	-2.02**	- 1.23	-2.26	-0.02	-5.96**	-4.94	- 4.76**
12.	ICMA 97333 x GIB 78	- 21.76**	- 2.96**	- 0.39	- 0.31	-47.78**	- 4.31**	0.43**	-5.61**	- 1.82	-0.01	0.50**	-2.12	0.22	-2.14*
13.	ICMA 93222 x GIB 129	16.18	- 0.55	1.12**	1.07**	- 16.95	-1.58	0.22*	0.19	-11.40**	2.98**	0.91**	5.12**	16.63**	-0.01
14.	ICMA 95333 x GIB 129	-10.09**	0.83	-0.51*	-0.46*	17.55	2.10	-0.04	1.02	5.64**	-0.76	-0.17**	0.28	- 4.94	2.03*
15.	ICMA 96111 x GIB 129	0.10	2.28**	0.38	0.30	29.41**	-1.18	-0.06	3.70**	5.88**	-2.51**	-1.53**	9.70**	26.63**	-0.63
16.	ICMA 97333 x GIB 129	- 2.64	- 0.75	-0.44	-0.21	-28.13**	-0.33	0.37**	-2.04**	-8.78**	-0.51	0.14**	1.45	- 4.19	3.05**
17.	ICMA 93222 x GIB 135	7.61**	0.08	0.42	0.43	-11.15	-2.78	-0.00	3.02**	-12.85**	5.14**	-2.36**	-4.21**	- 11.36**	-0.51
18.	ICMA 95333 x GIB 135	0.19	- 0.46	-0.83**	-0.83**	34.44**	6.35**	-0.35**	1.01	12.44**	-0.51	1.48**	-1.29	- 7.77**	2.37*
19.	ICMA 96111 x GIB 135	- 2.98	0.37	-0.84**	-0.61**	-23.21*	- 4.72**	0.10	-0.17	2.75	0.11	-0.06	-0.48	15.90**	-6.38**
20.	ICMA 97333 x GIB 135	- 13.18**	- 1.80**	-0.46	-0.38	-27.83**	-3.95**	0.49**	-2.30	-0.88	0.36	1.10**	4.51**	2.24	4.12**
21.	ICMA 93222 x GIB 144	12.88**	1.23*	0.81**	0.91**	11.85	-0.66	-0.07	0.83	-9.00**	0.94*	-0.59**	5.35**	10.40**	1.55
22.	ICMA 95333 x GIB 144	1.50	-1.19*	-0.59*	-0.56*	24.08*	6.12**	-0.17	2.26**	7.77**	-1.38**	0.21**	-2.06	0.15	-3.33**
23.	ICMA 96111 x GIB 144	- 1.08	0.73	-0.03	-0.16	-17.00	2.86	-0.04	-0.23	1.42	-1.80**	-0.17**	-1.56	-13.09**	3.58**
24.	ICMA 97333 x GIB 144	- 4.34*	- 0.48	-0.06	-0.19	-23.12*	-4.12**	-0.03	-4.75**	-0.20	3.44**	-1.06**	-6.14**	-26.50**	5.06**
25.	ICMA 93222 x GIB 157	15.90**	1.90**	1.30**	1.34**	27.50**	3.32*	-0.22*	4.23**	-4.34	0.11	-0.01	0.93	15.32**	-5.07**
26.	ICMA 95333 x GIB 157	5.35**	1.83**	0.03	-0.13	46.93**	9.92**	-0.01	1.48**	7.99**	-1.55**	0.80**	3.60*	6.49*	0.72
27.	ICMA 96111 x GIB 157	-14.05**	-2.60**	-0.15	-0.20	-19.19*	-3.08	-0.02	-1.35*	-5.50**	-0.22	-0.21**	-4.14**	-10.92**	-0.25
28.	ICMA 97333 x GIB 157	0.96	0.36	-0.03	0.00	-17.62	-2.00	0.29**	-1.22**	-1.40	-0.44	1.08**	4.96**	9.50**	1.53
29.	ICMA 93222 x GIB 8436	10.81**	0.62	0.94**	0.84**	13.07	1.08	0.02	2.73**	-9.88**	3.13**	-1.58**	0.29	5.50*	-1.88
30.	ICMA 95333 x GIB 8436	9.30**	1.52**	-0.10	-0.23	47.71**	8.44**	-0.31**	5.53**	7.65**	-1.27**	0.18**	1.12	0.66	0.98
31.	ICMA 96111 x GIB 8436	3.30	1.66**	-0.18	-0.20	0.67	-0.75	-0.11	2.61**	4.74*	-1.61**	-0.10*	1.71	-1.58	2.73**

32.	ICMA 97333 x GIB 8436	1.03	-2.77**	0.04	0.12	-12.96	1.12	0.21*	-2.51**	-0.40	0.30	0.90**	1.54	9.83**	-2.62**
33.	ICMA 93222 x GIB 3346	-4.49*	-1.12	0.61*	0.69**	-20.61*	-2.46	0.12	-1.94**	-13.96**	0.22	-0.85**	-2.37	-5.58**	-0.69
34.	ICMA 95333 x GIB 3346	-8.01**	-1.83**	-0.61*	-0.80**	18.08	1.41	0.03	-1.23*	7.63**	0.22	-0.17**	1.04	-10.41**	5.54**
35.	ICMA 96111 x GIB 3346	-8.56**	0.39	-0.35	-0.24	-16.33	-4.72**	-0.21*	-3.33**	7.63**	-0.44**	1.48**	-0.95	-7.58**	2.51*
36.	ICMA 97333 x GIB 3346	-4.34*	1.18*	-0.31	-0.18	-17.00	-2.12	-0.03	-0.68	-2.00	1.88**	-0.93	-7.37**	-0.33	-8.10**
SE (Sij)		1.89	0.59	0.25	0.22	9.57	1.48	0.10	0.52	1.96	0.44	0.05	1.48	2.59	0.96
SE (Sij-Sij)		2.664	0.831	0.352	0.310	13.49	2.086	0.141	0.733	2.763	0.620	0.070	2.086	3.651	1.353

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

Table 3: Estimates of specific combining Ability effects of crosses for 14 characters in Pearl millet.

Combining ability studies revealed that both general and specific combining ability variances were important but the estimates of s.c.a. variance were higher in magnitude for all the characters. Thus, indicating the predominance of non-additive gene action.

Acknowledgements

First author is thankful to the Head Department of Botany and the Principal K.R. College, Mathura for permission to work for his PhD in the Department of Botany K.R. College, Mathura 281001 (Dr B.R. Ambedkar University formerly Agra University, Agra) UP India.

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Citation: Singh J, Sharma R (2014) Assessment of Combining Ability in Pearl Millet Using Line x Tester Analysis. Adv Crop Sci Tech 2: 147. doi:10.4172/2329-8863.1000147