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Combining Ability Analysis of Morpho-Physiological Traitsin Maize (*Zea mays* L.) inbred lines

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A B S T R A C T

Combining ability analysis for yield and its component traits was performed with 8lines, 3 testers and the resulting 24 crosses using Line×Tester analysis. The analysis of variance indicated significant differences among parents, lines, testers, crosses, and parents *vs.* crosses for almost all the traits. The ratio of sca/gca variance revealed that there was preponderance of non additive gene action in the expression of all the traits. Inbred lines *viz.*, JML-109, CML-161, JML 112 and V25 were good general combiners for yield and yield attributing characters, Tester VQL1 was high combiner for grain yield. Among the hybrids, CML-161 X CM 212, JML-109 X VQL1 and JM-112 X V341exhibited highest significant sca effects for yield and yield attributing traits.

Introduction

Maize is an extensively investigated crop for heterosis breeding and occupies the pride place in launching the first hybrid breeding programme in the country under auspicious of all India Co-ordinated Maize Improvement Project. Maize acreage and production have an increasing tendency with the introduction of hybrids due to its high yield potential. The nature and magnitude of gene action is an important factor in developing an effective breeding programme. Combining ability analysis is useful to assess the potential inbred lines and also helps in identifying the nature of gene action involved in various quantitative characters. This information is helpful to plant breeders for formulating hybrid breeding programmes. A wide array of biometrical tools is available to breeders for characterizing genetic control of economically important traits as a guide to decide upon an appropriate breeding methodology to involve in hybrid breeding. The present investigation was carried out to determine breeding value of genotypes, nature and magnitude of gene action for various yield and other important traits in maize (*Zea mays* L.). Line×tester mating design developed by Kempthorne (1957), which provides reliable information on the general and specific combining ability effects of parents and their hybrid combinations was used to generate the information. The design has been widely used in maize by several workers and continues to be applied in quantitative genetic studies in maize (Joshi *et al.,* 2002; Sharma *et al.,* 2004).

Materials and Methods

Eight lines and three testers were mated in aline×tester design during *kharif*2013. The resulting 24 F1s and their parents were grown in a Randomized Complete Block Design with two replications at farm of division of Plant Breeding and Genetics, SKUAST-J, chatha maintaining spacing between rows 60 cm and between plants25 cm and one plant per hill. Observations were recorded on twelve yield and yield attributing traits viz., days to 50 per cent pollen shed, days to 50 per cent silking, days to 75 per cent brown husk plant height (cm), ear placement height (cm), Leaf width (cm), ear length (cm), ear girth (cm), Kernel rows per year, Kernels per row Test weight (g) and Grain yield plant^{-1} (g). The data were subjected for analysis of variance for all the characters studied as per the method suggested by Panse and Sukhatme (1961). The variance of combining ability was estimated as per the procedure developed by Kempthorne (1957). The mean squares for GCA and SCA were tested against desired error variance.

Results and Discussion

Analysis of variance for line x tester revealed significant differences for line for all the characters, mean squares due to testers were significant in characters grain yield and ear girth. Variance components due to line x tester interaction showed significant in characters *viz.*, ear placement height and leaf width (where variance due to lines was more). It has been generally reported that in relatively selected material non-additive gene action was more important than additive gene action (Sprague and Tatum, 1942 and Hayman, 1957). The experimental material generated from the crosses revealed the predominance of non-additive gene action for grain yield. Similar study confirms the findings of the workers (Divan *et al.,* 2013; Kamara *et al.,* 2014; Kanagrasu *et al.,* 2010; Musa abadi *et al.,* 2011). The analysis of variance for combining ability revealed that mean squares due to lines, testers and line×testers were significant for all the characters except days to 75% brown husk, ear placement height and test weight (Table 1). General combining ability effects for grain yield per plant, parents V358, JML-109, CML-161 and V341, JML-112 for Days to 50% pollen shed, CML-161 for days to 50% silking, V358 for width, JML-109 and CML-161 for ear length and ear girth JML-109, V25 and VQL1 for kernel per row were found to be good combiners this is in accordance with the studies of Divan *et al.,* (2013) and Shah *et al.,* (2015) days to 75% brown husk, LTP-1.

Therefore, the parent V358 showed significant GCA effects for grain yield per plant and days to75% brown husk; the parent JML-109 showed significant GCA effects for grain yield per plant, ear length and kernels per row; parent CML-161 showed significant GCA effects for grain yield per plant and ear girth; parent V358 showed significant GCA effects for grain yield per plant, days to 50% silking, days to 75% brown husk; parent V 341 showed significant GCA effects for Grain yield per plant and kernel rows per year (Table 2).

Among twelve characters studied all manifested higher degree of sca variance as compared to gca variance. The higher sca variance revealed the predominance of non additive genetic variance. Contrarily, importance of additive gene effects was reported by Alamnie *et al.,* (2006). The per cent contribution of line x tester interaction appeared high to the bulk of the variation observed in hybrids.

Table.1 Mean sum of squares in lines x testers design for 12 morpho-physiological traits in maize (*Zea mays* L.)

Source of variation	d.f	Grain Yield (gm)	Days to 50% Pollen Shed	Days to 50% Silking	Days to 75% Brown Husk	Plant Height (cm)	Ear Placement Height (cm)	Leaf Width (cm)	Ear Length (cm)	Ear Girth (cm)	Kernel Rows per Ear	Kernels per Row	Test Weight (gm)
Replication	2	7.35	1.81	6.62	16.58	11.67	12.36	0.02	0.95	0.14	0.13	13.53	252.23
Treatment	34	483.68**	5.38*	4.67*	12.42**	3549.83**	930.50**	0.46**	5.97**	1.04**	1.34**	41.68**	455.16*
Parents	10	231.69**	5.03	5.11	8.84	132.79*	55.19	0.40**	5.79*	1.23*	0.28	15.09	301.30
Parents (lines)	7	159.63**	5.10	5.33	7.52	173.39*	18.39	0.30*	6.06*	1.00	0.211	14.61	294.81
Parents (tester)	2	589.82**	4.44	5.10	9.16	55.98	8.191	0.15	7.62	2.24*	0.64	13.44	474.67
Parents (L vs T)	1	19.89	5.77	3.67	17.37	2.14	406.78**	1.61**	0.22	0.84	0.02	21.70	0.065
Parents vs. crosses	1	7421.16**	81.97**	42.96**	175.97**	110376.17**	28027.30**	7.25**	79.47**	7.36**	16.82**	496.01**	5058.14**
Crosses	23	291.61**	2.20	2.82	6.86	390.88**	132.96**	0.19	2.85	0.68	1.13**	33.49**	321.93
Error	**68**	**31.24**	**2.88**	**2.75**	**6.07**	**64.65**	**44.33**	**0.13**	**2.48**	**0.52**	**0.36**	**8.89**	**235.38**

Table.2 Estimates of General combining ability effects of lines and testers for different characters in maize (*Zea mays* L.)

Source	Grain Yield (gm)	Days to 50% Pollen Shed	Days to 50% Silking	Days to 75% Brown Husk	Plant Height (cm)	Ear Placement Height (cm)	Leaf Width (cm)	Ear Length cm	Ear Girth cm	Kernel Rows per Ear	Kernels per Row	Test Weight (gm)
Line												
JML-109	7.49**	-0.35	-0.04	-0.58	-3.11	-1.17	0.02	1.41*	0.39	0.40	2.85**	3.74
CML-161	5.38**	-0.42	-1.18*	0.29	5.59	0.21	-0.06	-0.02	0.64*	0.16	-3.27**	-2.08
V25	-10.54**	0.53	0.90	0.51	-0.57	-1.33	0.18	0.72	0.26	-0.12	2.63*	-0.49
HKI-161	-0.55	1.04	0.84	0.96	3.57	3.54	-0.04	-0.59	-0.11	-0.17	1.38	0.97
JML-120	-9.39**	-0.14	0.46	-0.47	-3.03	-1.94	-0.07	-0.48	-0.40	-0.43*	-0.42	-9.48
LTP-1	-4.85*	0.25	-0.21	0.44	15.61**	6.42**	0.11	-0.73	-0.36	0.35	-1.25	1.18
JML-112	0.01	-1.31*	-0.20	0.73	-4.19	1.01	-0.14	-0.67	-0.44	-0.45*	-2.40*	-0.36
V358	12.47**	0.40	-0.57	-1.87*	-13.86**	-6.74**	0.00	0.37	0.01	0.26	0.48	6.52
S.E.gi(line)	**1.89**	**0.57**	**0.56**	**0.82**	**2.68**	**2.22**	**0.12**	**0.52**	**0.24**	**0.20**	**0.99**	**5.11**
S.E.gi-gj(line)	**2.67**	**0.80**	**0.79**	**1.16**	**3.79**	**3.13**	**0.17**	**0.74**	**0.34**	**0.29**	**1.40**	**7.23**
Tester												
V341	2.83*	0.02	-0.50	-0.09	1.97	-0.30	-0.16*	-0.11	0.05	0.31*	-0.97	5.93
CM212	-1.03	-0.04	0.47	0.54	1.68	1.90	0.00	0.13	0.13	0.00	-0.55	-5.76
VQL1	-1.80	0.02	0.04	-0.45	-3.65*	-1.60	0.16*	-0.01	-0.18	-0.30*	1.51*	-0.17
S.E.gi(tester)	**1.15**	**0.35**	**0.34**	**0.50**	**1.64**	**1.36**	**0.08**	**0.32**	**0.15**	**0.12**	**0.61**	**3.13**
S.E.gi-gj(tester)	**1.63**	**0.49**	**0.48**	**0.71**	**2.32**	**1.92**	**0.10**	**0.46**	**0.20**	**0.18**	**0.86**	**4.42**

***, ** significant at 5% and 1% level, respectively**

Table.3 Estimates of Specific combining ability effects of crosses for different traits of (3x8) line x tester analysis

Crosses	Grain Yield (gm)	Days to 50% Pollen Shed	Days to 50% Silking	Days to 75 % Brown Husk	Plant Height (cm)	Ear placement Height (cm)	Leaf Width (cm)	Ear Length (cm)	Ear Girth (cm)	Kernel Rows per Ear	Kernels per Row	Test Weight (gm)
JML-109 xV341	-0.98	0.52	-0.21	-0.32	-10.32*	-9.22*	-0.25	0.18	0.20	0.48	-4.01*	-2.99
JML-109 xCM212	-9.15**	-1.32	-0.24	0.28	16.96**	11.62**	-0.25	-1.25	-0.21	0.77*	1.91	1.72
JML-109 X VQL1	10.12**	0.79	0.45	0.04	-6.64	-2.40	0.50*	1.06	0.01	-1.25**	2.09	1.27
CML-161x V341	-10.03**	-0.23	-0.31	2.84	1.05	-0.81	0.16	0.24	-0.08	-0.52	1.96	3.83
CML-161x CM212	13.13**	-0.47	-0.04	0.64	-6.60	-1.63	0.05	-0.26	-0.10	-0.20	0.19	-6.35
CML-161X VQL1	-3.10	0.70	0.35	-3.47*	5.56	2.43	-0.21	0.02	0.18	0.72*	-2.15	2.52
V25xV341	-0.48	0.24	-1.35	-0.05	11.63*	5.33	-0.14	0.12	-0.53	-0.33	2.55	13.44
V25xCM212	-1.35	0.01	0.41	-0.15	-9.08	-7.07	-0.14	-0.55	0.08	-0.28	0.21	-6.68
V25 x VQL1	1.82	-0.25	0.94	0.20	-2.55	1.74	0.28	0.43	0.45	0.61	-2.76	-6.76
HKI-161xV341	6.53	0.13	0.10	-0.60	7.67	7.43	-0.08	-0.61	-0.31	-0.36	-1.95	-0.05
HKI-161xCM212	-5.07	0.60	-0.37	-0.50	-8.72	-7.98*	0.12	0.26	0.33	0.28	1.96	-11.23
HKI-161x VQL1	-1.47	-0.73	0.26	1.09	1.05	0.55	-0.03	0.35	-0.02	0.08	-0.01	11.28
JML-120 xV341	-1.50	-0.06	0.76	-0.03	6.40	1.40	-0.10	-0.13	0.03	-0.06	-2.46	11.66
JML-120 xCM212	2.50	0.64	-0.44	0.10	1.85	2.07	0.09	0.04	-0.08	0.22	-0.99	-0.42
JML-120 xVQL1	-1.00	-0.58	-0.32	-0.07	-8.25	-3.47	0.00	0.10	0.05	-0.16	3.45	-11.24
LTP-1 xV341	0.77	-0.21	0.80	-1.54	-1.44	0.69	0.08	-0.42	0.09	0.26	-0.13	-8.83
LTP-1 xCM212	-0.17	0.12	-0.11	-0.07	-5.53	-4.61	-0.08	0.28	-0.01	-0.58	-3.48*	4.39
LTP-1 xVQL1	-0.60	0.09	-0.69	1.62	6.97	3.92	0.00	0.14	-0.08	0.32	3.61*	4.44
JML-112xV341	9.91**	0.09	0.62	-0.60	-10.74*	-8.13*	0.14	-0.12	0.16	0.25	0.49	-5.89
JML-112xCM212	-4.84	-0.18	0.01	0.77	5.91	8.57*	0.11	1.39	0.27	-0.11	0.83	1.99
JML-112 X VQL 1	-5.06	0.09	-0.63	-0.17	4.84	-0.44	-0.24	-1.26	-0.43	-0.14	-1.32	3.90
V358xV341	-4.22	-0.49	-0.42	0.30	-4.24	3.32	0.20	0.74	0.45	0.29	3.53*	-11.17
V358xCM212	4.94	0.61	0.78	-1.06	5.21	-0.98	0.10	0.11	-0.28	-0.11	-0.64	16.58
V 358xVQL 1	-0.72	-0.12	-0.36	0.76	-0.96	-2.33	-0.30	-0.84	-0.16	-0.18	-2.90	-5.41
S.E.(sij)	**3.26**	**0.98**	**0.96**	**1.42**	**4.64**	**3.84**	**0.20**	**0.91**	**0.42**	**0.35**	**1.72**	**8.86**
S.E.sij-skl	**4.60**	**1.38**	**1.35**	**2.01**	**6.57**	**5.44**	**0.29**	**1.29**	**0.59**	**0.49**	**2.43**	**12.53**

*, ** significant at 5% and 1% level, respectively

High yield cross combination CML-161 X CM 212 showed significant SCA effects for grain yield per plant, days to 50% pollen shed and days to 50% silking; the cross JML-109 X VQL1 showed significant SCA effects for grain yield per plant and leaf width; the cross JM -112 X V341 showed significant SCA effects for grain yield per plant. Good specific combiners (Table 3) were exhibited by crosses viz., CML-161 X CM 212, JML-109 X VQL1 and JML-112 X V341 for grain yield; CML-161 X VQL1 for days to 75% brown husk; JML-109 X CM 212 and V25 X V341 for plant height; JML-109 X CM 212 and JML-112 X CM 212 for ear placement height; LTP-1 X VQL1 and V358 X V341for Kernels per row. Therefore crosses viz., CML-161 X CM 212, JML-109 X VQL1 and JM-112 X V341 involved at least one parent as good general combiner indicated the superiority due to non additive gene action. These results are in agreement with Alamnie *et al.,* (2003), Kamara *et al.*, (2014), Mahesh *et al.*, (2013) and Chandel and Mankotia (2014). Prasad and Pramod Kumar (2003), Subramaniyan and Subbraman (2006), Jayakumar and Sundram (2007), Vijayabharathi *et al.*, (2009) reported that specific combining ability (SCA) variances were higher than general combining ability variances (GCA) for all the characters which indicated preponderance of non-additive gene action for all the characters.

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