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Research Article

Line x Tester analysis for yield and its component traits in pumpkin (*Cucurbita moschata* Duch.Ex Poir)

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Abstract

Line x tester analysis was carried out involving twelve lines and three testers for assessing the combining ability for yield and its component characters in pumpkin (*Cucurbita moschata* Duch.ex Poir). The combining ability analysis revealed that highly significant differences among the treatments for all the parameters were exhibited by the genotypes. The variance due to *sca* was higher than the *gca* for all the characters indicating the predominance of non-additive gene effects. Out of 15 parents used in the study, the lines Vadhalagundu local followed by Kasi Harit were the best combiners for days to first female flower appearance, first female flowering node number, sex ratio, days to first harvest, fruit number per vine and quality characters *viz.*, carbohydrate content, total carotenoids content and fruit yield per vine as they expressed significant *gca* effect. Among the testers, CO 2 had significant *gca* effect for days to first female flower appearance, first female flowering node number, sex ratio, fruit number per vine, total carotenoids content and yield per vine and the tester Arka suryamukhi also expressed significant preferable *gca* value for days to first harvest, carbohydrate content and total carotenoids content. The cross Kasi Harit x Avinashi local were identified as good specific combiner for days to first female flower appearance, first female flowering node number, sex ratio, fruit number per vine, flesh thickness, total carotenoids content, and fruit yield per vine followed by Vadhalagundu local x CO 2 for first female flowering node number, sex ratio, carbohydrate content, total carotenoids content fruit number per vine and fruit yield per vine.

Key words

Pumpkin, Line x tester, combining ability, *gca* effect, *sca* effect

Introduction

Pumpkin (*Cucurbita moschata* Duch ex.Poir), originated from Central Mexico, is cultivated in tropical and subtropical region all over the world and an important cucurbitaceous vegetable crop of India and principal ingredient of several Indian dishes (Mohanty and Mohanty, 1998). Pumpkin is a monoecious crop and cross pollination is the general rule. Choice of parents is an important aspect in any breeding programme to improve the yield and its related attributes. The success of hybridization programme is generally depends upon the breeder to select suitable parents to obtain high proportion of desirable recombinations. Knowledge of various genetic parameters and gene action is essential in selecting the parents and breeding methods to be followed for the improvement of important traits. However, gene action varies with degree of diversity among parents and their genetic architecture. Hence it is necessary to evaluate the combining ability of genotypes for their utilization in hybridization. Combining ability analysis is a powerful tool in identifying the best combiners which may be hybridized either to exploit heterosis or to accumulate favourable genes and also helps the breeders to choose the suitable parents for formulating a breeding programme and provide valuable information regarding cross combinations to be exploited commercially. Thus the technique provides the space to classify the parental lines in terms of superiority in hybrid combination and to determine gene action involved in the inheritance of different characters. The line x tester mating design is very useful for preliminary evaluation of genetic studies through hybridization programme. Hence, the present investigation was undertaken to study the combining ability and degree of dominance for yield and other quantitative traits in pumpkin.

Materials and methods

The experimental material comprised fifteen diverse genotypes including twelve lines *viz.*, Pusa Vishwas,Punjab Samrat, Narendra Abhushan, Narendra Uphar, Ambili, Virudhachalam local, Chakor, Ashoka Farm Aids, Vadhalagundu local, Karamadai local, Karwar local and Kasi Harit and three testers *viz*., Arka Suryamukhi, Avinashi local , CO 2 which were used for developing thirty six hybrids adopting line x tester mating design. The fifteen parents and thirty six F_1 hybrids were evaluated along with the standard check "hybrid MPH-1" (from MAHYCO private Limited) in Randomized Block Design (RBD) with three replications at Department of Vegetable Crops, Tamil Nadu Agriculture University, Coimbatore - 641103 during 2009-10. The experimental material was planted in an inter-row spacing of 2.5 m and

intra row spacing of 2.5 m apart and observations were recorded on traits *viz*. vine length, days to first female flower appearance, node number to first female flower appearance, sex ratio, days to first harvest, fruit number per vine, fruit weight, flesh thickness, quality traits *viz.,* carbohydrate content, total carotenoids content and fruit yield per vine along with quality traits such as carbohydrate content, carotene content and crude fibre content of the fruit. The combining ability analysis was done using the line x tester method as described by Kempthrone (1957).

Results and discussion

Analysis of variance for combining ability indicated the presence of significant differences among lines and testers for all the characters studied (Table 1). The female x male interaction component also emerged significant for all the characters which precede the combining ability contribution heavily in the expression of these traits. The information regarding general combining ability effects of the parent is of prime importance as it helps in successful prediction of genetic potentiality of crosses, which yield desirable individuals in segregating population of cross pollinated crops. The significant variance of line × tester interaction indicated the importance of specific combining ability. The mean squares due to lines were of a larger magnitude than those of testers and line × tester for all the characters indicating greater diversity among the lines for combining ability.

The magnitude of specific combining ability variances was much greater than those of general combining ability variances for the yield and yield related characters, which indicated the preponderance of non-additive gene action for all the characters (Table 2). The ratio of *gca*: *sca* variance indicated higher magnitude for *SCA* variance than *GCA* variance for the following characters *viz.,* days to first female flower appearance, first female flowering node number, sex ratio, days for first harvest, number of fruits per vine, fruit weight, total carotenoid content, total carbohydrate content, crude fibre content of the fruit and fruit yield per vine implying the preponderance of non-additive gene action (Table 2). This indicated the limited scope of population improvement for these characters and heterosis breeding could be adopted for exploiting the genetic variations. Similar results in respect of these characters were obtained by Srinivasan (2003) and Jha *et al.* (2009) in pumpkin. Hence improvement of these yield related characters could be accomplished by selection at later filial generations.

The estimates of *gca* effects showed that the lines Vadhalagundu local followed by Kasi Harit were good general combiners for days to first female flower appearance, first female flowering node number, sex ratio, days to first harvest, fruit number per vine and fruit yield per vine (Table 3). Among the testers, CO 2 had significant *gca* effect for vine length, days to first female flower appearance, first female flowering node number, sex ratio and yield per vine followed by the tester Arka suryamukhi which could also be used to develop hybrids with earliness in terms of less days to first harvest. It was observed that performance of the parents had direct relation for their respective characters. The results are in close conformity with the findings of Ram et *al.* (2007) in sponge gourd and Maurya *et al.* (2005) in bottle gourd. Since, high *gca* effect is attributed to additive gene actions, these parents could be used in breeding programme for yield improvement through pedigree breeding.

The specific combining ability is the deviation from the performance predicted on the basis of general combining ability. The *sca* estimates of the cross Kasi Harit x Avinashi local was significant for days to first female flower appearance, first female flowering node number, sex ratio, fruit number per vine, flesh thickness, total carotenoids content and fruit yield per vine. It was followed by the cross Vadhalagundu local x CO 2, recorded significant *sca* effects for first female flowering node number, sex ratio, fruit number per vine, flesh thickness and fruit yield per plant .The performance of parents involved in these cross were also adjudged by their *gca* effects. To develop pumpkin fruits with early harvest, the cross Karamadai local x Arka Suryamukhi was the best one proved by the preferable *gca* effect of the male parent involved in this cross combination. Concomitant reports were also given by Vidya *et al.* (2002) in pumpkin.

The male parents CO 2 and Arka Suryamukhi were best for developing pumpkin hybrids with more fruit weight as evidenced by the *sca* values of cross combinations *viz*, Narendra Abhusan x CO 2 and Ambili x Arka Suryamukhi. However, the crosses involving one good combiner with other medium or poor combiner could produce desirable trangressive segregants if additive genetic system was operative is good combining parents and epistatic effect also act in the same direction. Non additive gene action was however preponderant for all the traits studied, indicating the need for heterosis breeding for improvement of these traits. The pre-dominant role played by non additive gene action in sponge gourd for fruit yield and yield component characters had also been reported by Mole *et al.* (2001).

From the foregoing discussion, it might be concluded that the parents Vadhalagundu local, Kasi Harit, CO 2 and Arka Suryamukhi was

considered as good combining parent for earliness, yield and yield component characters and could be utilized in breeding programme. Most of the high yielding crosses exhibiting desirable *sca* effects involved parents with high and low *gca* effects, indicating the influence of non-additive gene interactions in these crosses. These results indicated that the hybrids Kasi Harit × Avinashi Local and Vadhalagundu Local × CO 2 could be exploited through heterosis breeding to obtain higher yield.

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Table 1. Analysis of variance (sum of mean square) for combining ability of different traits of pumpkin

Source of variation	df	Vine length (m)	Days to first female flower appearance	First female flowering node number	Sex ratio	Days to first harvest	Fruit number per vine	Fruit weight (Kg)	Fruit equatorial diameter (cm)	Fruit polar diameter (cm)	Flesh thickness (cm)	Carbohydrate content (g/100 g)	Total carotenoid content (mg per 100 g)	Fruit yield per vine (kg)
Replications	2	0.02	2.20	2.91	1.14	0.88	0.006	0.16	0.004	0.59	0.19	0.0003	0.02	0.08
Hybrids	35	3.74	22.56	14.71	26.09	215.97	3.86	1.24	15.24	19.86	0.47	1.05	1.81	21.65
Lines	11	5.33	50.20	26.20	74.92	579.59	8.64	3.02	23.31	54.33	0.60	2.44	3.48	18.91
Testers	2	4.72	13.55	7.11	2.08	35.00	1.59	0.09	8.84	6.45	0.07	2.50	1.86	14.50
Line x Testers	22	2.85	9.56	9.66	3.85	50.61	1.68	0.45	11.78	3.85	0.44	0.23	0.97	23.66
Error	35	0.005	0.93	0.66	0.50	8.41	0.16	0.02	0.35	0.12	0.05	0.002	0.004	0.009

Table 2. Magnitude of genetic variance of yield and yield components of pumpkin parents and hybrids

Character	GCA variance	SCA variance	Ratio GCA:SCA
Vine length (m)			
Days to appearance of first female flower	0.3070	4.3151	0.07114
First female flowering node number	0.1194	4.4988	0.02654
Sex ratio	0.5251	0.6767	0.7759
Days to first harvest	3.9052	21.1021	0.1850
Fruit number vine	0.0516	0.7582	0.06805
Fruit weight (kg)	0.0186	0.2136	0.0870
Fruit equatorial diameter (cm)	0.0816	5.7175	0.0142
Fruit polar diameter (cm)	0.3782	1.8630	0.2030
Flesh thickness (cm)	0.0006	0.1972	0.003
Carbohydrate content(g/100 g)	0.0195	0.1145	0.17030
Total carotenoid content (mg per 100 g)	0.0199	0.4837	0.04114
Fruit yield per vine (kg)	-0.047	11.830	0.0039

GCA – General combining ability: SCA – Specific combining ability

Table 3. Estimation of general combining ability (gca) effects of parents for various traits in pumpkin

Parents	Vine length (m)	Days to first female flower appearance	First female flowering node number	Sex ratio	Days to first harvest	Fruit number per vine	Fruit weight (Kg)	Fruit equatorial diameter (cm)	Fruit polar diameter(cm)	Flesh thickness (cm)	Carbohydrate content (g/100 g)	Carotene content (mg per 100 g)	Fruit yield per vine (kg)
Lines													
Pusa Vishwas	-0.85 **	3.35**	-3.60**	-1.89 **	10.21**	-1.38 **	0.61 **	-0.42 ns	6.04 **	-0.28 **	-0.88 **	-0.59 **	-2.20 **
Punjab Samrat	-0.71 **	-0.53	0.02	-2.07 **	16.63**	0.62 **	0.01	1.18 **	1.18 **	-0.12	-0.38 **	-0.49 **	0.97 **
Narendra Abhushan	0.26 **	-2.28**	-1.52**	6.38 **	-8.54**	-0.80 **	-0.30 **	1.22 **	-0.89 **	-0.02	-0.45 **	-0.50 **	-1.70 **
Narendra Uphar	-1.52 **	-0.40	0.32	-1.30 **	-6.88**	-0.72 **	0.23 **	-0.86 **	-3.30 **	-0.35 **	-0.20 **	-0.42 **	0.22 **
Ambili	-0.37 **	0.18	-0.43	3.00 **	-1.33	-0.92 **	0.73 **	-0.65 **	-0.74 **	0.11	-0.60 **	-0.65 **	0.37 **
Virudhachalam local	0.60 **	4.22**	2.61**	6.89 **	18.17**	-1.76 **	0.94 **	2.67 **	5.27 **	0.37 **	-0.23 **	-0.44 **	-2.41 **
Chakor	0.26 **	3.56**	1.40**	-1.05 **	-1.63	0.49 **	0.61 **	3.26 **	0.38 *	0.39 **	-0.09 **	-0.33 **	3.13 **
Ashoka Farm Aids	2.09 **	0.43	2.82**	-1.17 **	-3.88**	-0.05	0.35 **	1.34 **	-0.03 ns	0.50 **	-0.26 **	-0.40 **	-0.37 **
Vadhalagundu local	-0.89 **	-3.44**	-2.43**	-3.12 **	-11.04**	2.03 **	-1.12 **	-1.89 **	-3.57 **	-0.44 **	0.38 **	1.23 **	1.68 **
Karamadai local	0.33 **	-2.61**	0.69*	-1.51 **	-2.67*	1.41 **	-0.55 **	-1.00 **	-1.44 **	0.10	0.52 **	0.18 **	0.55 **
Karwar local	0.37 **	2.14**	2.23**	-0.12	0.08	-0.34 *	-0.28 **	-1.31 **	-0.29 *	-0.36 **	1.01 **	1.08 **	-1.99 **
Kasi Harit	0.45 **	-4.61**	-2.10**	-4.02 **	-9.13**	1.41 **	-1.22 **	-3.56 **	-2.60 **	0.10	1.17 **	1.34 **	1.74 **
SEd	0.02	0.39	0.33	0.29	1.18	0.16	0.06	0.24	0.14	0.09	0.01	0.02	0.03
Testers													
Arka Suryamukhi	-0.48 **	0.06	0.11	0.09	-1.30*	-0.28 **	0.02	0.70 **	0.20 **	-0.04	-0.26 **	-0.31 **	-0.89 **
Avinashi local	0.10 **	0.72**	0.48**	0.24	-0.22	0.05	-0.07 *	-0.42 **	0.39 **	0.06	0.36 **	0.23 **	0.34 **
CO2	0.39 **	-0.78**	-0.59**	-0.33 *	-1.08	0.23 **	0.05	-0.28 *	-0.59 **	-0.02	-0.10 **	0.08 **	0.55 **
SEd	0.01	0.19	0.16	0.14	0.59	0.08	0.03	0.12	0.07	0.04	0.009	0.01	0.01

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

Table 4. Estimation of specific combining ability (sca) effects of crosses for various traits in pumpkin

Hybrids	Vine length (m)	Days to first female flower appearance	First female flowering node number	Sex ratio	Days to first harvest	Fruit number per vine	Fruit weight (Kg)	Fruit equatorial diameter (cm)	Fruit polar diameter (cm)	Flesh thick ness (cm)	Carbohydrate content (g/100 g)	Carotene content (mg per 100 g)	Fruit yield per vine (kg)
Pusa Vishwas x Arka Suryamukhi	-0.30 **	0.69	-1.82**	-0.71	-5.55*	1.15 **	-0.49 **	-2.52 **	-0.99 **	1.00 *	0.02	0.41 **	3.40 **
Pusa Vishwas x Avinashi local	-0.27 **	-0.22	-0.57	0.29	3.22	-0.42	0.45 **	-0.83	1.57 **	-0.33	-0.10 **	-0.23 **	-1.33 **
Pusa Vishwas x CO2	0.56 **	-0.47	2.38**	0.42	2.33	-0.73 *	0.05	3.34 **	-0.58 *	-0.67	0.08 *	-0.18 **	-2.07 **
Punjab Samrat x Arka Suryamukhi	-0.34 **	-0.18	-1.69**	-1.17 *	-5.84**	0.15	0.08	4.47 **	0.69 **	-1.83 **	0.01	0.25 **	1.00 **
Punjab Samrat x Avinashi local	-0.23 **	0.53	0.81	0.18	1.55	0.45	0.37 **	-0.92 *	0.31	0.96 *	0.09 **	0.10	3.11 **
Punjab Samrat x CO2	0.56 **	-0.35	0.88	1.00	4.29*	-0.61 *	-0.45 **	-3.56 **	-0.99 **	0.87	-0.10 **	-0.35 **	-4.11 **
Narendra Abhushan x Arka Suryamukhi	0.87 **	-0.68	-0.15	-1.09 *	0.32	0.44	-0.61 **	-1.78 **	0.27	-2.83 **	0.23 **	0.32 **	0.00
Narendra Abhushan x Avinashi local	-1.46 **	-0.22	2.48**	2.27 **	-1.28	-0.75 *	-0.30 *	0.09	-2.84 **	2.09 **	-0.32 **	-0.18 **	-3.16 **
Narendra Abhushan x CO2	0.58 **	0.90	-2.33**	-1.18 *	0.96	0.31	0.91 **	1.69 **	2.56 **	0.74	0.09 **	-0.14 **	3.16 **
Narendra Uphar x Arka Suryamukhi	1.31 **	1.32	-1.23*	0.04	-0.97	-0.76 *	-0.44 **	0.69	0.02	6.17 **	-0.08 *	0.08	-3.64 **
Narendra Uphar x Avinashi local	-0.60 **	-1.72*	1.27*	0.03	1.05	0.04	0.09	-0.66	1.24 **	-2.91 **	0.30 **	0.09	-0.31 **
Narendra Uphar x CO2	-0.71 **	0.40	-0.03	-0.06	-0.08	0.73 *	0.35 **	-0.04	-1.27 **	-3.26 **	-0.22 **	-0.17 **	3.96 **
Ambili x Arka Suryamukhi	0.09	0.74	-1.11	0.88	-2.89	0.32	0.53 **	-0.99 *	2.47 **	1.92 **	0.34 **	0.33 **	2.11 **
Ambili x Avinashi local	-0.87 **	1.32	0.39	-0.30	-0.86	-0.25	-0.36 **	-2.61 **	-0.43	-3.29 **	0.10 **	0.12 *	-2.19 **
Ambili x CO2	0.78 **	-2.60**	0.72	-0.58	3.75	-0.07	-0.17	3.61 **	-2.04 **	1.37 **	-0.45 **	-0.45 **	0.07
Virudhachalam local x Arka Suryamukhi	0.54 **	-3.06**	0.48	0.47	-2.64	0.28	0.09	-3.09 **	0.02	0.42	0.27 **	0.23 **	1.21 **
Virudhachalam local x Avinashi local	1.29 **	2.65**	0.65	0.72	3.39	-0.30	0.26 *	1.99 **	0.19	3.21 **	-0.13 **	0.03	-0.79 **
Hybrids	Vine length (m)	Days to first female flower appearance	First female flowering node number	Sex ratio	Days to first harvest	Fruit number per vine	Fruit weight (Kg)	Fruit equatorial diameter (cm)	Fruit polar diameter (cm)	Flesh thick ness (cm)	Carbohydrate content (g/100 g)	Carotene content (mg per 100 g)	Fruit yield per vine (kg)
Virudhachalam local x CO2	-1.83 **	0.40	0.17	-1.18 *	-0.75	0.02	-0.36 **	1.11 *	-0.21	-3.63 **	-0.14 **	-0.26 **	-0.42 **
Chakor x Arka Suryamukhi	1.33 **	3.36	-0.19	-0.24	5.78**	0.03	-0.49 **	-1.58 **	-1.56 **	-0.67	-0.15 **	0.18 **	-1.01 **
Chakor x Avinashi local	-0.52 **	-0.31	1.56**	0.02	-6.70**	-0.55	0.42 **	1.92 **	0.29	-1.68 **	0.06	-0.11 *	-0.30 **

Chakor x CO2	-0.80 **	-0.36**	-1.37*	0.23	0.92	0.52	0.07	-0.34	1.27 **	2.35 **	0.09 *	-0.07	1.31 **
Ashoka Farm Aids x Arka Suryamukhi	-2.31 **	-2.51**	1.27*	0.23	10.91**	0.07	0.52 **	0.69	0.54 *	0.04	0.23 **	0.15 **	0.95 **
Ashoka Farm Aids x Avinashi local	0.65 **	-1.06	-1.11	-0.73	-5.57**	0.37	-0.39 **	1.11 *	-0.59 *	1.21 *	0.03	0.10 *	1.32 **
Ashoka Farm Aids x CO2	1.66 **	3.57**	-0.16	0.50	-5.33**	-0.44	-0.13	-1.80 **	0.05	-1.26 *	-0.26 **	-0.25 **	-2.27 **
Vadhalagundu local x Arka Suryamukhi	0.27 **	0.11	1.64**	0.15	-0.80	-0.64 *	0.14	2.64 **	-0.06	1.25 *	-0.30 **	-1.17 **	-1.46 **
Vadhalagundu local x Avinashi local	-0.72 **	0.69	1.39*	1.11 *	2.47	-1.34 **	0.31 *	0.09	-0.05	-2.33 **	-0.32 **	-1.15 **	-4.81 **
Vadhalagundu local x CO2	0.45 **	-0.81	-3.03**	-1.25 *	-1.67	1.98 **	-0.44 **	-2.74 **	0.11	1.08 *	0.62 **	2.32 **	6.26 **
Karamadai local x Arka Suryamukhi	-0.08	0.40	0.64	-0.35	-5.93**	-0.01	0.39 **	-0.43	0.14	-0.79	0.04	0.19 **	0.78 **
Karamadai local x Avinashi local	1.44 **	-1.64*	-0.23	-0.28	5.59**	0.91 **	-0.45 **	-0.38	-0.17	-0.99 *	0.39 **	0.23 **	0.13
Karamadai local x CO2	-1.36 **	1.24	-0.41	0.64	0.33	-0.90 **	0.06	0.81	0.03	1.79 **	-0.43 **	-0.42 **	-0.90 **
Karwar local x Arka Suryamukhi	-0.79 **	-0.60	-0.52	-0.02	5.07*	0.11	0.46 **	1.29 **	-0.95	0.29	-0.58 **	-0.64 **	0.53 **
Karwar local x Avinashi local	0.43 **	2.86**	0.60	0.63	0.47	0.04	-0.45 **	-1.12 *	-0.35	-2.04 **	0.02	0.46 **	1.40 **
Karwar local x CO2	0.36 **	-2.26**	-0.08	-0.60	-5.54**	-0.15	-0.01	-0.16	1.30 **	1.74 **	0.56 **	0.18 **	-1.93 **
Kasi Harit x Arka Suryamukhi	-0.58 **	0.40	2.68**	1.83 **	2.53	-1.14 **	-0.17	0.62 ns	-0.60 *	-4.96 **	-0.02	-0.34 **	-3.86 **
Kasi Harit x Avinashi local	0.85 **	-2.89**	-5.94**	-3.92 **	-3.32	1.79 **	0.05	1.31 **	0.82 **	6.09 **	-0.12 **	0.54 **	6.92 **
Kasi Harit x CO2	-0.27 **	2.49**	3.26**	2.09 **	0.79	-0.65 *	0.12	-1.93 **	-0.23	-1.13 *	0.15 **	-0.20 **	-3.05 **
SEd	0.05	0.68	1.88	0.50	2.05	0.29	0.11	0.42	0.25	0.16	0.03	0.04	0.06

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