Genetic analysis to find suitable parents for development of tomato hybrids

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Abstract: Line x Tester analysis was used to identify the potential parents and their hybrids from a set of 12 crosses derived from three lines used as females LA-2661, LA-2662 and 017899 and four testers, including BL-1078, BL-1079, CLN-2413 and CLN-2418-A. Results showed that parents and F_1 hybrids differed significantly for general combining ability and specific combining ability effects. The values of general combining ability (GCA) and specific combining ability (SCA) variances depicted non-additive and additive gene action with predominance of non-additive gene action in the genetic determination of all characters except fruit yield per plant. Parent lines LA-2662 and CLN-2418A provided the best general combining ability effects in more than one yield contributing traits. Specific combining ability effects, heterosis and heterobeltiosis in desired direction were recorded in two crosses viz. "LA-2662 × CLN-2418A" and "LA-2662 × BL-1078". F_1 hybrid "LA-2662 × CLN-2418A" proved to be the best cross in overall performance and should be further exploited in breeding program for hybrid vigour and commercial utilization.

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1. Introduction:

Pakistan is an agriculture based country and to fulfill the food demand of ever increasing population, there is an urgent need to improve the yield potential of crops. Among the various crops grown in Pakistan, the importance of tomato as a food crop cannot be under estimated. Tomato *(Lycopersiconesculentum*L. 2n=2x=24) is considered the second important vegetable crop after potato in world and is also widely used in the country as raw and in industrial products. It plays an important role in human diet as major contributor of antioxidants like carotenoids, lycopene, phenolics, vitamin C and minor quantity of vitamin E (Rai*et al*., 2012). It also plays a vital role in nutrition improvement of poor masses as compared to milk, fruits, meat and other costly items. Recent studies suggest that tomatoes markedly reduce the risk of prostate cancer (Kucuk, 2001). It is reported that a hundred g tomato provides about 20% and 40% of the daily requirement of vit. A and C, respectively (Grierson and Kader, 1986). In many countries, its juice is also used as an alternate of orange juice in kids and also as a home remedy for children suffering from rickets. It helps in digestion of food and tomato sucking in the morning avoids the feeling of nausea and vomiting in expected mothers. In world, tomato is grown in 50 countries with overall production of 159 million tons on 4.7 million hectares. Currently, Pakistan ranks 35th in tomato production on the globe. During 2011, the area under tomato cultivation was 52.3 thousand hectare that was about 20% of the total vegetable area with production of 529.6 thousand tons (Govt. of Pakistan, 2011-12).

Average yield of tomato in Pakistan is very low comparing to other countries like India, Iran and Bangladesh due to lack of focus on its genetic improvement for yield contributing traits, secondary importance in crop husbandry and lack of good combiners to be used in crossing for the development of economic hybrids. To cope with this problem hybrid development is one of the best ways to meet the ever increasing demand and improving the yield potential of crops. As hybrid crop leads to several benefits like quick and convenient way of combining desirable characters, higher productivity, earliness, improved quality, resistance to biotic and abiotic stresses etc. But in Pakistan only one local tomato hybrid has been brought to market for commercial cultivation yet and all the available varieties have failed to get farmer attraction due to certain inferior traits and thus a huge amount of foreign exchange is spent on the import of tomato seeds every year. According to an estimate during the last two years, the import of tomato seed increased from 38 m.

tonnes to 57 m. tonnes that worth Rs. 83 to 185 million respectively (Anon., 2011). It exhibits the farmer's inclination towards hybrid seeds.

Therefore, the available germplasm must be replaced with newly evolved hybrids with attractive quality traits to attain high yield potential. Considering the present scenario, development of hybrid is inevitable to enhance the crop yield. For this purpose, choice of parents is an important step that promotes a well-planned hybridization programme. In this direction, Line ×Tester design proposed by Kempthorne (1957) helps the breeders to determine combining ability status of genotypes and nature of gene action, which places heterosis breeding on further scientific footing.

2. Materials and Methods:

The research work was carried out in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture Faisalabad. The plant material used for current study was produced by crossing seven tomato pure lines in line × tester mating fashion by keeping three varieties as lines and four as testers. Twelve F_1 hybrids were developed and evaluated alongwith seven parents in triplicated randomized complete block design (RCBD). Each entry contained a single row of 5.5 meter length with inter-row and intra-row distance of 125 cm and 50 cm, respectively. A single non-experimental row was planted on both sides of each plot to minimize experimental error due to border effects. Standard agronomic and plant protection measures were adopted to grow healthy crop. Data on the following traits was recorded as follow. Number of flower clusters per plant, number of fruits per plant, Fruit weight (g), Fruit length (cm), Fruit diameter (cm), Fruit yield per plant (kg), Fruit firmness (g/cm^2), No. of locules per fruit and Total soluble solids (meL^{-1}). The recorded data of all characters were analyzed statistically according to Steel *et al.* (1997). General and specific combining ability analysis and their effects were estimated following method described by Kempthorne (1957). Percent heterosis over mid parent and better parent was calculated after computing heterosis of respective parent by using formula proposed by Falconer and Mackay (1996).

3. Results and Discussion:

The mean performance of three lines and four testers used as parents in the present study indicated that there were highly significant differences among all genotypes for all the observed traits except flower clusters per plant which showed significant differences (Table 1). The testers showed non-significant differences for all the traits, except the significant differences for fruit firmness while the lines exhibited highly significant differences for fruit yield per plant, significant differences for fruit weight and fruit diameter and non-significant differences for theother traits. Highly significant differences were observed in all twelve hybrids for all traits. The significant differences results among parent crosses are in total accordance with the results reported by Chandha*et al.* (2001) and Dhaliwal*et al*. (2003).

General Combining Ability Effects of Parents:

Estimation of general combining ability (GCA) provides basic and important information for exploiting genetic potential of parents for development of superior and elite lines. As expression of significant and high GCA effects of a parent line reflects the presence of favorable additive genes with additive genetic effects that leads to selection in early generations for developing widely adapted hybrids (Roy *et al.* 2002).Estimation of GCA effects of lines and testers represented that no single line or tester exhibited good general combining ability for all the traits (Table 2). Among the lines, highest values of GCA effects were shown by the line 017899 for number of fruits per plant and number of locules per fruit and the line LA-2661 for fruit length while the line LA-2662 had highest GCA effects for all other traits. Similarly among the testers, BL-1079 had highest GCA effects for fruit length, CLN-2413 for fruit diameter and BL-1078 for (flower clusters per plant and number of fruits per plant while CLN-2418A exhibited the highest GCA effects for all other traits (Table 2).According to these results, line LA-2662 and the tester CLN-2418A showed maximum positive GCA effects for most of the traits so these parents could be successfully used in future breeding programs. High GCA effects are attributed to additive gene action and additive x additive gene interaction reported by Harer&Bapat (1982) and Premalatha*et al*. (2006).

Specific Combining Ability Effects of Hybrids: Accumulation of additive gene effects for desired characters is the basic need for hybrid development and hybrids with high SCA effects of various traits involving either one or both of the parents with good GCA indicating the preponderance of additive genetic effects. On the other hand, Hybrids with significant and positive SCA involving the parents with low or non-significant GCA showed the worth of non-additive genetic effects.Many hybrids present high significant SCA effects in high x low or high x high general combining combination due to the interaction of dominant alleles from good combiners and recessive alleles from poor combiner (Roy *et al.*, 2002). Significant superior SCA effects for all observed traits were not shown by a single hybrid. Cross LA-2662 × BL-1078 exhibited significant SCA effect for flower clusters per plant and fruit firmness while the hybrids LA-2661 × CLN-2413, O17899 × CLN-2418A, LA-2661 × BL-1079, LA-2661 × BL-1078, LA-2662 × CLN-2413, O17899 × BL-1079, LA-2662 × CLN-2418A showed the highest significant SCA effects for number of fruits per plant, fruit weight, fruit length, fruit diameter, fruit yield per plant, number of locules per fruit, fruit TSS, respectively (Table 3). SCA represents the deviation from additivity i.e. the dominant gene action ignoring the epistatic effect. Among all hybrids, only LA-2661 x BL-1078 exhibited significant SCA effects for seven characters except fruit length and fruit firmness. So this hybrid can be used in future breeding program. These results are also in accordance with the study of Sharma *et al.* (2002), Chisti*et al.* (2007) and Saleem*et al.*(2009).

Heterosis: Significant efforts have been made for exploitation of heterosis in different yield contributing traits to find the feasible cross for the production of F_1 hybrids. The hybrids showing high heterosis have good chances to identify desirable lines in succeeding generations as compared to hybrids having low heterotic effects (Sharif *et al.*, 2001). All the crosses exhibited significant mid parent heterosis in majority of the traits indicating a predominance of non-additive gene action in the genetic control of these traits. The highest mid parent heterosis were exhibited by the hybrids viz : LA-2662 × BL-1078, O17899 ×BL-1078, LA-2661 × CLN-2418A, LA-2661 × BL-1078, LA-2662 × CLN-2413, O17899 × CLN-2413, O17899 ×BL-1079 for traits including flower clusters per plant, number of fruits per plant, fruit weight, fruit length, fruit diameter, fruit firmness and number of locules per fruit respectively while the hybrid LA-2662 × CLN-2418A showed highest significant heterosis for fruit yield per plant and fruit TSS (Table 4).Similarly the highest better parent heterosis was found in hybrid LA-2661 × BL-1078 for number of fruits per plant and fruit length, cross LA-2662 × BL-1078 for flower clusters per plant and fruit firmness, hybrid LA-2662 × CLN-2418A for fruit diameter and fruit TSS and the hybrid LA-2662 × CLN-2413 for fruit weight, fruit yield per plant and number of locules per fruit (Table 5). Among all the hybrids,LA-2662 x CLN-2418A was the only cross that showed positive significant mid parent heterosis in all traits (Table 4) while the hybrid LA-2662 x CLN-2413 exhibited the positive significant heterobeltiosis for all traits except fruit length and number of fruits per plant (Table 5). Observed significant heterosis over better parent in the majority of the crosses for all traits indicated the involvement of non-additive gene action in the genetic control of that traits. Assuming that epistasis is absent, the cause of heterosis can only be attributed to the dominant gene action. This was in agreement with previous findings of Sharma *et al.* (1996), Padma *et al.* (2002), Patgaonkar*et al.* (2003), Premlakshmi et al. (2006), Sharma *et al.*(2006), Kumar *et al.* (2009) and Komori and Sharma (2011). The hybrids (H x H) involving both parents (male and female parents) showed overall high GCA status and hybrids (H x L) involving high (female) and low (male) produced hybrids with overall high (H) heterotic status. On the other hand, hybrids involving L x H and L x L had overall low (L) heterotic status. This clearly indicates the need for using parents having overall high GCA status or at least using the parents having high GCA status as female to produce hybrids with overall high heterotic status.

Table 1: Mean squares values for various yield related traits of tomato genotypes

CROSSES	FC/P	F/P	FW	FL	FD	FY/P	F.FR	Lo./F	F.TSS
Replications	0.063$^{N.S}$	6.089$^{N.S}$	0.376$^{N.S}$	0.002$^{N.S}$	0.005$^{N.S}$	0.004$^{N.S}$	27935.01$^{N.S}$	0.031$^{N.S}$	0.05$^{N.S}$
Genotypes	5.797**	886.8**	122.3**	0.409**	0.128**	0.936**	6141363**	1.09**	423.4**
Parents	1.623*	355.2**	37.26**	0.75**	0.063**	0.157**	1014343**	1.206**	80.24**
Crosses	6.599**	1185**	170.7**	025**	0.142**	1.381**	5891504**	0.854**	643.1**
P vs C	22.03**	791.2**	100.9**	0.115**	0.368**	0.729**	39651930**	2.995**	64.81**
Tester	6.22 $^{N.S}$	817$^{N.S}$	83.3$^{N.S}$	0.13$^{N.S}$	0.003$^{N.S}$	0.71$^{N.S}$	12310053*	0.44$^{N.S}$	413$^{N.S}$
Lines	1.57$^{N.S}$	584$^{N.S}$	554.7*	0.54$^{N.S}$	0.505*	5.86**	7408421$^{N.S}$	1.00$^{N.S}$	568$^{N.S}$
L * T	8.464**	1570**	86.33**	0.213**	0.091**	0.227**	2176590**	1.013**	783.2**
Error	0.505	6.734	1.156	0.008	0.011	0.005	11715.76	0.252	1.4
Total	2.19	289.6	40.07	0.137	0.048	0.304	1982539	0.513	137

** = Highly significant; * = Significant; N.S = Non significant

FC/P=Flower cluster per plant, F/P=No. Of fruits per plant, FW=fruit weight, FL=fruit length, FD=fruit diameter, FY/P=fruit yield per plant, F.FR=fruit firmness, Lo/F=No. of locules per fruit, F.TSS=fruit TSS

Table-2 General Combining Ability estimates of various yields related traits of lines and testers in tomato

PARENTS	FC/P	F/C	FW	FL	FD	FY/P	F.FR	Lo/F	F.TSS
LA-2661	-0.19	1.87	-3.3	0.24	-0.12	-0.63	-347.82	-0.08	0.22
LA-2662	2.03	5.85	7.82	-0.1	0.237	0.76	899.61	-0.24	6.77
O17899	-0.23	10.3	-4.5	-0.1	-0.12	-0.13	-551.78	0.313	-6.99
BL-1078	0.77	9.51	-1.3	-0	-0	-0.19	-1262	-0.23	-4.38
BL-I079	-0.12	-2.45	0.56	0.17	-0.02	0.22	135.84	-0.01	5.6
CLN-24I3	-1.12	-12.2	-3.2	-0.1	0.024	-0.29	-400.85	-0.06	-7.18
CLN-24I8A	0.47	5.16	3.94	-0.1	-0	0.26	1526.98	0.3	5.96

Table 3: Specific Combining Ability Effects for various yield related traits of crosses among parents

CROSSES	FC/P	F/C	FW	FL	FD	FY/P	F.FR	Lo/F	F.TSS
LA-2661 × BL-1078	0.35	5.22	2.56	-0.04	0.25	0.18	-645.6	0.52	6
LA-2661 × BL-1079	0.49	-11	4.69	0.394	0.03	0.17	52.6	-0.7	13.04
LA-2661 × CLN-2413	-1.42	28.84	-2.4	-0.03	-0.1	-0.17	10.8	-0.2	-12.1
LA-2661 × CLN-2418A	0.58	-23	-4.9	-0.32	-0.2	-0.18	582.2	0.41	-6.91
LA-2662 × BL-1078	1.83	12.01	0.51	0.041	-0.1	0.07	1375	0.19	-6.7
LA-2662 × BL-1079	-0.11	-9.26	-0.6	-0.1	-0.1	-0.37	-226.3	0.13	-14.1
LA-2662 × CLN-2413	-0.19	-15.9	3.32	-0.02	0.02	0.25	-652.5	0.02	-1.47
LA-2662 × CLN-2418A	-1.53	13.15	-3.2	0.08	0.1	0.06	-496.1	-0.3	22.28
O17899 × BL-1078	-2.19	-17.2	-3.1	0.003	-0.2	-0.25	-729.3	-0.7	0.7
O17899 × BL-1079	-0.38	20.28	-4.1	-0.29	0.03	0.2	173.7	0.57	1.07
O17899 × CLN-2413	1.62	-12.9	-0.9	0.045	0.07	-0.08	641.7	0.21	13.61
O17899 × CLN-2418A	0.95	9.88	8.1	0.242	0.1	0.13	-86.1	-0.1	-15.4

Table 4: Estimates of heterosis for various yield related traits in tomato

CROSSES	FC/P	F/C	FW	FL	FD	FY/P	F.FR	Lo/F	F.TSS
LA-2661 × BL-1078	19.3	13.92	4.41	38.2	9.5	-12.7	-35.22	13.51	3.32
LA-2661 ×BL-1079	15.6	11.83	34.83	9.64	1.29	1.82	37.58	-28.6	27.44
LA-2661 × CLN-2413	-14.8	-7.41	-26.5	23.3	2.54	-28.2	39.46	6.06	-21.7
LA-2661 × CLN-2418A	17	13.7	74.32	19.5	-3.55	-14.2	14.53	14.63	-4.47
LA-2662 × BL-1078	43.2	-16.4	28.96	13.9	7.49	27	84.33	16.13	0.88
LA-2662 × BL-1079	17.7	3.37	47.76	-1.06	5.8	24.4	75.09	5.56	4.69
LA-2662 × CLN-2413	6.85	-2.41	22.81	14.1	12.3	32.5	67.87	33.33	11.8
LA-2662 × CLN-2418A	3.45	11.51	33.56	16.7	11.7	35.1	15.81	2.86	53.47
O17899 × BL-1078	-0.92	17.21	-20.6	14.5	-2.39	-6.38	-29.2	10.34	-14.4
O17899 × BL-1079	13.3	-9.81	-6.55	4.08	2.48	26.5	74.14	47.06	0.22
O17899 × CLN-2413	26	4.54	-25.6	20.7	7.87	-1.37	115.3	8	6.42
O17899 × CLN-2418A	28.5	-8.1	51.86	21.9	5.73	19.2	18.62	39.39	-25.8

Table 5: Estimates of heterobeltiosis for various yield relating traits in tomato

CROSSES	FC/P	F/C	FW	FL	FD	FY/P	F.FR	Lo/F	F.TSS
LA-2661 × BL-1078	14.88	7.41	-2.28	12.46	5.73	-15.6	-39.49	0	2.13
LA-2661 × BL-1079	15.04	-5.61	18.48	-0.21	-3.36	-2.45	29.87	-28.6	26.08
LA-2661 × CLN-2413	-15.2	1.12	-20.2	4.28	0.71	-29	10.73	-16.7	-27.3
LA-2661 × CLN-2418A	11.29	-4.84	-17.2	-1.91	-7.08	-21.2	9.33	11.9	-7.28
LA-2662 × BL-1078	35.54	-7.87	21.83	-22.5	7	22.19	75.38	12.5	-4.31
LA-2662 × BL-1079	15.04	7.21	24.26	-22.6	4.03	20.81	68.38	-9.52	-0.78
LA-2662 × CLN-2413	5.41	-3.41	24.8	-26	10.9	24.78	35.25	20	10.57
LA-2662 × CLN-2418A	-3.23	-1.52	22.72	-22.3	11	33.02	10.67	-10	40.02
O17899 × BL-1078	-10.7	5.76	-25.6	0.28	-6.42	-12.5	-41.27	0	-15.4
O17899 × BL-1079	5.31	-10.8	-17.9	-26.4	-2.91	17.19	43.17	19.05	-0.8
O17899 × CLN-2413	18.02	-2.54	-19.3	-4.55	5.18	-5.81	112.2	7.87	-1.15
O17899 × CLN-2418A	14.51	-1.32	14.06	5.18	1.14	6.01	18.5	15	-95.7

4. Conclusion:

From this experiment it can be concluded that LA-2662 × CLN-2418A proved to be best cross for heterosis breeding and for the development of vigorous high yielding genotype from the succeeding progenies.

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References:

1. Anonymous. 2011. Establishment of Facilitation Unit for Participatory Seed and Nursery Program. Ministry of Food and Agriculture (MINFA), Islamabad.
2. Chandha, S., Kumar, J. and Vidyasagar. 2001. Combining ability over environments in tomato. Ind. J. Agric. Res. 35(3): 171-175.
3. Chishti, S. A. D., Khan, A.A., Sadia, B. and Khan, I.A. 2007. Analysis of combining ability for yield, yield components and quality characters in tomato (*Lycopersiconesculentum* mill.). J. Agric. Res. 46(4):325-332.
4. Dhaliwal, M.S., Singh, S. and Cheema, D.S. 2003. Line x tester analysis for yield and processing attributes in tomato. J. Res. 40(1): 49-53.
5. Falconer, D.S. and MacKay, T.F.C. 1996. Introduction to quantitative genetics.4th edition. Longman Green, Harlow, Essex, UK.
6. Govt. of Pakistan. 2011-12. Agricultural Statistics of Pakistan. Ministry of Food and Agricultural Division (Planning unit), Government of Pakistan, Islamabad.
7. Grierson, D. and Kader, A.A. 1986. Fruit ripening and quality. In: J. G. Atherton and J. Rudich (Eds.). The tomato crop, Chapman and Hall London. New York. pp: 265.
8. Harer, P.N. and Bapat, D.R. 1982.Line x tester analysis of combining ability in grain sorghum. J. Maharashtra Agric. Uni. 7: 230-232.
9. Kempthorne, D. 1957. An Introduction to Genetic Statistics. John Wiley and Sons. Inc., New York. pp: 458-471.
10. Komori S. and Sharma, M.K. 2011.Exploitation of heterosis for yield and its contributing traits in tomato (*Lycopersiconesculentum* L.). Int. J. Farm Sci.1: 45-55.
11. Kucuk, O. 2001. Phase II randomized clinical trial of lycopene supplementation before radical prostatectomy. Cancer Epidem.Biom.10**:** 861-868.
12. Kumar. K., Patel, S.S., Dharmatti, P.R., Byadagi, A.S., Kajjidoni, S.T. and Path, R.H. 2009. Estimation of heterosis for tospo virus resistance in tomato. Karnataka J. Agric. Sci. 22: 1073-1075.
13. Padma, E., Shekar, C.R. and Rao, B.V. 2002. Heterosis and combining ability in tomato (*Lycopersiconesculentum* L.). Andhra agric. J. l49: 285-292.
14. Patgaonkar, D.R., Ingavale, M.T., Mangave, K. and Kadam, D.D. 2003. Heterosis studies for fruit characters in heat tolerant lines of tomato (*Lycopersiconesculentum* L.). South. Ind. Hort. 51: 134-136.
15. Premalatha, N., Kumaravadivel, N. and

Veerabadhiran, P. 2006. Heterosis and combining ability for grain yield and its components in sorghum (*Sorghum bicolor* L.) Moench. Ind. J. Genet. 66(2): 123-126.
16. Premlakshmi, V., Thyagaraj, T., Veeraragavathatham, D. and Arumugam, T. 2006. Heterosis and combining ability analysis in tomato (*Lycopersiconesculentum* L.) for yield and yield contributing traits. Vegetable Sci. 33: 5-9.
17. Rai, G.K., Kumar, R., Singh, A.K., Rai, P.K, Rai, M., Chaturvedi, A.K. and Rai, A.B. 2012. Changes in antioxidant and phytochemical properties of tomato (*Lycopersiconesculentum* L.) under ambient condition. Pak. J. Bot., 44(2): 667-670.
18. Roy, N.C., Jettopujov, V.N., Solanik, N.M., 2002.Combining ability for some agronomic characters in alfalfa (*Medicago sativa* L.). Pak. J. Agric. Res., 17(4): 346-350.
19. Sharif, A., Bakhsh, A., Arshad, M., Haqqani, A.M. and Najma, S. 2001.Identification of genetically superior hybrids in chickpea (*Cicerarietinum* L.). Pak. J. Bot., 33(4): 403-409.
20. Saleem, M. Y., Asghar, M., Haq, M.A., Rafique, T., Kamran, A. and A. A. Khan, A.A. 2009. Genetic analysis of identify suitable parents for hybrid seed production in tomato (*Lycopersiconesculentum*mill.) Pak. J. Bot. 41(3):1107-1116.
21. Sharma, D.K., Chaudhary, D.R. and Sharma, P.P. 1996. Nature of gene action governing economic traits in tomato (*Lycopersiconesculentum* L.). Haryana J. Hort. Sci. 25: 225-229.
22. Sharma, H.R., Sharma, D. and Thakur, A.K. 2006.Studies on analysis of generic divergence in tomato (*Lycopersiconesculentum* L.). J. Hort. Sci. 1: 52-54.
23. Sharma, K. C., Verma, S. and Pathak, S. 2002. Combining ability effects and components of genetic variation in tomato (*Lycopersiconesculentum* Mill.). Ind. J. Agric. Sci. 72(8):496-497.
24. Steel, R.G.D., Torrie, J.H. and Dickney, D.A. 1997. Principles and procedures of statistics: A Biometrical Approach, 3rd ed. McGraw Hill Book Co. New York.

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