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Combining ability analysis for fruit yield and quality traits across environments in tomato (*Solanum lycopersicum* L.)

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Abstract
Twelve parental lines were crossed in line x tester fashion comprising 8 lines and 4 testers at Vegetable Research Scheme, Regional Horticulture Research Station (R.H.R.S.), Navsari to estimate combining ability in tomato for fruit yield, yield components and fruit quality traits. Combining ability analysis revealed that both additive and non additive gene actions were important for fruit yield and its related traits. However, magnitude of additive gene action was comparatively larger than that of non additive gene action for fruit yield and its component traits. None of the parents exhibited desirable gca effects for all the traits in individual as well as in pooled over environments. However, overall ranking of genotypes revealed that the parents *viz.,* AVTO-7, AVTO-5, JTL-12-12, GT-2 and JT-3 were good general combiners for fruit yield and its contributing characters. The cross AVTO-5 x GT-2 having the maximum *sca* effect for fruit yield also had high *sca* effect for titrable acidity and non-reducing sugar per cent.

Keywords: tomato, combining ability, yield and quality traits

Introduction
Tomato (*Solanum lycopersicum* L., 2n = 24) a member of solanaceae family, is one of the most important vegetable crops both because of its special nutritive value and also due to its worldwide cultivation. Besides, fresh consumption, tomato ranks first among processed vegetables in the world given by Dhaliwal *et al*. (2000) [8]. Information pertaining to different types of gene action, relative magnitude of genetic variance and combining ability estimates are important and vital parameters to mould the genetic makeup of tomato crop. This important information could prove an essential strategy to tomato breeders in the screening of better parental combinations for further enhancement of desired traits. Combining ability studies provide useful information for the selection of suitable genotypes for an effective hybridization and at the same time elucidate the nature and magnitude of different types of gene action. The entire genetic variability observed in the analysis for each trait was partitioned into its components, *i.e.* general (GCA) and specific combining ability (SCA) by Sprague (1966) [26]. GCA effects were due to additive type of gene action and SCA effects were due to non-additive (dominant or epistatic) gene action. Several studies of combining ability for yield components are available in many species. Some researchers found the predominancy of GCA to be more important than that of SCA reported by Khan *et al.* (1991) [12]; Yaqoob *et al.* (1997) [28], while others suggested that SCA was more important reported by Ortiz and Golmirzaie (2004) [16], Biswas *et al.* (2005) [7]. The present investigation was carried out to analyze tomato genotypes to ascertain the relative performance regarding combining ability effects for yield and its components.

Materials and Methods
The basic materials consisted of twelve diverse genotypes of tomato among them 8 lines *viz.,* AVTO- 6 (L_1), AVTO- 7 (L_2), NTL- 50 (L_3), AVTO- 4 (L_4), AVTO - 5 (L_5), JTL-12-15 (L_6), JTL-12-08 (L_7) and JTL-12-12 (L_8) was crossed with 4 testers *viz.,* Arka Abha (T_1), GT-2 (T_2), JT-3 (T_3) and AT-3 (T_4) in line x tester fashion to obtain 32 F_1 hybrid combinations in *rabi* 2013 at the Vegetable Research Scheme, Regional Horticulture Research Station, Navsari Agricultural University, Navsari (Gujarat). The final experimental materials consisting of twelve parents and thirty two F_1 crosses were evaluated during *kharif* 2014-15 at three locations. Vegetable Research Scheme, Regional Horticulture Research Station, Navsari (E_1);

Main Cotton Research Station, Surat (E_2) and Cotton Wilt Research Station, Hansot, Dist. Bharuch (E_3). These Stations falls in the tropical zone characterized by fairly hot summer, moderately cold winter and warm monsoon. At each location, the experiment was laid out in completely randomized block design with three replications. The row to row and plant to plant spacing was maintained at 75cm x 60 cm. Recommended package of practices were adopted to raise a healthy crop at all the locations. The observations were recorded on five randomly selected plants in each replication at all locations. The observations were recorded on the following characters: days to 50 % flowering, plant height at final harvest, number branches per plant at final harvest, number of clusters per plant, number of fruits per plant, average fruit weight, fruit yield per plant, pericarp thickness, total soluble solids, titrable acidity, ascorbic acid, lycopene content, total sugar, reducing sugar and non-reducing sugar per cent. In order to obtain information on the influence of genotype x environment interaction on combining ability estimates, pooled analysis of variance for combining ability over the environments was carried-out. The statistical model in this case would be as follows:

$$Y_{ijkl} = \mu + g_i + g_j + s_{ij} + e_l + r_{kl} + (ge)_{Il} + (ge)_{jl} + (se)_{Ijl} + \in_{Ijkl}$$

Results and Discussion

The results of analysis of variance are presented in Table 1. The magnitude of *gca* variance due to females were comparatively higher than males in majority of the characters which indicated greater diversity among females for these components. Similar views have also been expressed by Ahmad *et al*., (2009) [2]. Mean squares due to females x locations were found to be significant for number of fruits per plant, average fruit weight, fruit yield per plant, pericarp thickness and reducing sugar which indicated that *gca* variance of females were highly influenced by the environments for this trait. While mean squares due to males x locations were found to be non-significant for all the characters except number of cluster per plant, fruit yield per plant and total soluble solids under study which indicated that males were not influenced by locations. The *sca* variances were more sensitive to the environmental fluctuations as evident by the significance of mean squares due to females x males x locations for only four studied characters *viz.*, number of branches per plant at final harvest number of clusters per plant, number of fruits per plant and non-reducing sugar.

In present study, both *gca* and *sca* variances were found to be significant for days to 50 % flowering, plant height at final harvest, number of fruits per plant, average fruit weight, fruit yield per plant, pericarp thickness, total soluble solids, ascorbic acid and lycopene content (Table 1). This suggested that both additive and non-additive variances were important in the inheritance of these characters. Significant of both variances have been reported by Singh *et al.* (2010) [24] for days to 50 % flowering; Asati *et al*. (2007) [4] and Singh *et al.* (2010) [24] for plant height at final harvest; Premalakshme *et al.* (2006), Singh *et al.* (2010) [24] and Asati *et al.* (2007) [4] for number of fruits per plant, Singh *et al.* (2008) [10-25] for average fruit weight; Bhatt *et al.* (2000) [6] and Singh *et al.* (2010) [24] for fruit yield per plant; Himanshu *et al.* (2008) [10] for pericarp thickness; Singh *et al.* (2005) [23] and Joshi and Kohli (2006) [11] for total soluble solids; Bhatt *et al.* (2001) [5] for ascorbic acid.

The *sca* variances were greater than *gca* variances for most of the characters (except days to 50 % flowering, fruit yield per plant, pericarp thickness and total soluble solids) indicated predominance role of non-additive type of gene action (Table 1). Almost identical findings have been reported by Ahmad *et al.* (2009) [2], Farzane *et al.* (2012) [9] and Mali and Patel (2014) [13] for plant height at final harvest; Angadi *et al.* (2012) [3] and Narasimhamurthy and Gowda (2013) [15] for number of branches per plant at final harvest; Angadi *et al.* (2012) [3] for number of clusters per plant; Angadi *et al.* (2012) [3] and Yadav *et al*. (2013) [27] for number of fruits per plant; Yadav *et al.* (2013) [27], Shankar *et al.* (2013) [21], Saleem *et al.* (2013) [20] and Agarwal *et al.* (2014) [1] for average fruit weight; Shende *et al*. (2012) [22] for titrable acidity; Joshi and Kohli (2006) [11], Pandey *et al.* (2006) [17] for ascorbic acid; Narasimhamurthy and Gowda (2013) [15] for reducing sugar content and for lycopene content; Mondal *et al.* (2009) [14] and Rattan and Vidyasagar (2009) [19] for total sugar content and Rattan and Vidyasagar (2009) [19] for non-reducing sugar content.

The *gca* variances were greater than *sca* variances for days to 50 % flowering, fruit yield per plant, pericarp thickness and total soluble solids indicated predominance role of additive type of gene action (Table 1). Almost identical findings have been reported by Ahmad *et al.* (2009) [2] for days to 50 % flowering, Farzane *et al.* (2012) [9], Narasimhamurthy and Gowda (2013) [15] and Mali and Patel (2014) [13] for fruit yield per plant (kg); Singh *et al.* (2008) [10-25] and Mondal *et al.* (2009) [14] for pericarp thickness and Ahmad *et al.* (2009) [2] and Narasimhamurthy and Gowda (2013) [15] for total soluble solids.

Nature and magnitude of combining ability effects provide guidelines for identifying parents and their utilization in hybridization programme. In the present study, significant *gca* effects were observed for most of the characters (Table 2). Among the parents AVTO-5 (L_5), AVTO-7 (L_2), JTL-12-12 (L_8), GT-2 (T_2) and JT-3 (T_3) were good general combiner for fruit yield per plant and some of its direct components. The females *viz.*, AVTO-4 (L_4), JTL-08-16 (L_6) and JTL-08-15 (L_7) were found to be poor general combiner for fruit yield as well as yield attributing characters. Among males, Arka Abha (T_1) was found to be poor general combiner for most of the traits followed by AT-3 (T_4). The estimates of *gca* effect further revealed that the parental lines showing high *gca* effects for fruit yield also exhibited high to average *gca* effects for one or more yield components. Among parents, high *gca* effect for fruit yield per plant was found in AVTO-5 (L_5), AVTO-7 (L_2) and GT-2 (T_2) which associated with positive and significant *gca* effects for average fruit weight. Almost identical result have been reported by Himanshu *et al.* (2008) [10], Ahmad *et al*. (2009) [2], Farzane *et al.* (2012) [9], Narasimhamurthy and Gowda (2013) [15].

Increase in yield, accompanied by a good standard of quality characters *viz.,* total soluble solids and ascorbic acid is always desirable. In the present investigation, the parents *viz.,* AVTO-6 (L_1), AVTO-5 (L_5), GT-2 (T_2) and JT-3 (T_3) could be spotted out as good general combiners for these traits (Table 2). Thus, by using these parents in breeding programme, there is a good scope for increasing yield without loss in quality characters.

Specific combining ability effects (SCA) of different crosses are given in (Table 3). Normally SCA effects do not contribute much to the improvements of self-pollinated crops. The crosses identified having high *sca* effect for fruit yield also had high *sca* effect for titrable acidity and non-reducing sugar per cent. The components like plant height at final harvest, number of branches per plant, number of clusters per plant, number of fruits per plant and average fruit weight showed association with fruit yield, thereby it increase the utility of those characters in identifying superior cross combination.

Table 1: Pooled analysis of variance for combining ability over environments

Source	d. f.	Traits						
		D50	**PH**	**NBP**	**NCP**	**NFP**	**AFW**	**FYP**
Environments	2	270.69**	2321.04**	57.66**	67.86**	3041.07**	1311.79**	45.78**
Replications	2	2.89	121.85	0.89	7.13	42.35	112.74	0.34
Hybrids	31	70.89**	974.82**	23.65**	34.36**	89.50**	1913.63**	1.50**
Female (F)	7	167.06**	1644.19*	25.31	50.74	161.50**	5368.39**	2.29*
Male (M)	3	233.26**	2441.82*	61.38*	54.95	385.65**	1628.30	5.15**
Female (F) x Male (M)	21	15.64**	542.12**	17.71**	25.96**	23.19**	802.80**	0.72**
Hybrids x Environments	62	7.95*	68.19	3.37**	4.02**	19.47**	111.37**	0.32**
Female (F) x Environments	14	10.21	87.13	3.94	2.75	49.98**	263.04**	0.67**
Male (M) x Environments	6	5.70	90.28	3.96	9.70*	13.70	99.66	0.53*
(F x M) x Environments	42	7.52	58.72	3.10**	3.63**	10.13	62.48	0.17
Pooled error	186	5.66	49.68	1.50	1.53	9.01	48.95	0.13
Estimates								
σ^2 Environments		2.01**	17.21**	0.43**	0.50*	22.97**	9.57*	0.35**
σ^2 Females		4.48**	44.29*	0.66	1.37	4.24*	147.76**	0.06
σ^2 Males		3.16**	33.22*	0.83*	0.74	5.23**	21.94	0.07*
σ^2 gca		3.60**	36.91*	0.77	0.95	4.90**	63.88**	0.07**
σ^2 sca		1.11*	54.72**	1.80**	2.71**	1.58*	83.76**	0.06**
σ^2 gca/ σ^2 sca		3.24	0.67	0.43	0.35	3.10	0.76	1.17
σ^2 Females x Environments		0.38	3.12	0.20	0.10	3.41**	17.84**	0.05**
σ^2 Males x Environments		0.00	1.69	0.10	0.34*	0.20	2.11	0.02*
σ^2 gca x Environments		0.13	2.17	0.14	0.26	1.27**	7.36**	0.03**
σ^2 sca x Environments		0.62	3.01	0.53**	0.70**	0.37	4.51	0.01

* and ** Significant at 5 % and 1 % levels of probability, respectively.

Cont…Table 1: Pooled analysis of variance for combining ability over environments

Source	d. f.	Traits							
		PT	**TSS**	**TA**	**ASC**	**LC**	**TS**	**RS**	**NRS**
Environments	2	20.28**	22.69**	1.13**	311.31**	22.54**	116.11**	48.44**	15.80**
Replications	2	0.14	0.03	0.00	12.02	1.14	0.17	0.04	0.05
Hybrids	31	2.39**	1.93**	0.03**	29.10**	1.95**	5.22**	2.49**	0.83**
Female (F)	7	5.46**	2.85**	0.02	56.86*	2.77	7.03	2.67	1.56*
Male (M)	3	5.55**	8.46**	0.05	38.85	4.33*	6.06	2.22	1.12
Female (F) x Male (M)	21	0.92**	0.69**	0.03**	18.46**	1.34**	4.49**	2.47**	0.55**
Hybrids x Environments	62	0.52**	0.17	0.00	5.15	0.44	0.54*	0.38	0.20**
Female (F) x Environments	14	1.28 **	0.21	0.01	5.75	0.41	0.80	0.64*	0.29
Male (M) x Environments	6	0.13	0.43**	0.00	0.86	0.07	0.50	0.18	0.12
(F x M) x Environments	42	0.32	0.13	0.00	5.57	0.50	0.46	0.32	0.18**
Pooled error	186	0.27	0.16	0.00	4.08	0.36	0.36	0.30	0.07
Estimates									
σ^2 Environments		0.15**	0.17**	0.01**	2.33**	0.17**	0.88**	0.36**	0.12**
σ^2 Females		0.14*	0.07**	0.001	1.47*	0.07	0.19	0.07	0.04
σ^2 Males		0.07**	0.12**	0.001	0.48	0.06*	0.08	0.03	0.01
σ^2 gca		0.10**	0.10**	0.001	0.81*	0.06*	0.11	0.04	0.02
σ^2 sca		0.07**	0.06**	0.003**	1.60**	0.11**	0.46**	0.24**	0.05**
σ^2 gca/ σ^2 sca		1.43	1.67	0.33	0.51	0.54	0.24	0.17	0.40
σ^2 Females x Environments		0.08**	0.00	0.00	0.14	0.00	0.04	0.03*	0.02
σ^2 Males x Environments		-0.01	0.01**	0.00	-0.13	-0.01	0.01	-0.01	0.00
σ^2 gca x Environments		0.02*	0.01*	0.00	-0.04	-0.01	0.02	0.01	0.01
σ^2 sca x Environments		0.01	-0.01	0.00	0.50	0.05	0.03	0.01	0.04**

* and ** Significant at 5 % and 1 % levels of probability, respectively

D50= Days to 50% flowering
PH= Plant height at final harvest (cm)
NBP= Number of branches/plant at final harvest
NCP= Number of clusters/plant
NFP= Number of fruits/plant
AFW= Average fruit weight (g)
FYP= Fruit yield/plant (kg)
PT= Pericarp thickness (mm)
TSS= Total soluble solids (ºBrix)
TA= Titrable acidity (%)
ASC= Ascorbic acid (mg/100g)
LC= Lycopene content (mg/100g)
TS= Total sugar (%)
RS= Reducing sugar (%)
NRS= Non-reducing sugar (%)

Table 2: Estimates of general combining ability effects of lines (L) and testers (T) over environments

Traits	D50	PH	NBP	NCP	NFP	AFW	FYP	PT	TSS	TA	ASC	LC	TS	RS	NRS
Lines (L)															
L_1	-1.74**	-1.31	-0.67**	-0.70**	-2.49**	9.94**	0.07	-0.14	0.45**	-0.02*	1.01**	-0.46**	-0.22*	-0.05	-0.17**
L_2	-1.18**	1.16	0.87**	0.62**	1.17*	10.69**	0.21**	0.24**	0.07	-0.02	-1.42**	0.09	0.19	0.00	0.19**
L_3	-1.57**	-3.45**	-0.52*	-0.95**	-1.56**	-12.36**	-0.06	-0.11	-0.11	0.02*	-1.98**	0.01	-0.47**	-0.29**	-0.19**
L_4	-0.07	6.75**	0.17	-0.22	-0.85	-4.38**	-0.16**	-0.28**	-0.09	0.03**	-0.06	0.03	-0.13	0.03	-0.16**
L_5	-1.90**	8.04**	1.30**	2.25**	2.90**	13.05**	0.35**	0.55**	0.33**	-0.02	1.13**	0.31**	0.23*	0.14	0.09*
L_6	-0.01	5.95**	0.48*	-0.75**	3.07**	-15.81**	-0.30**	-0.63**	-0.44**	-0.03**	1.42**	-0.37**	-0.59**	-0.35**	-0.24**
L_7	2.51**	-6.08**	-1.12**	-1.21**	-0.75	-11.47**	-0.33**	-0.07	-0.05	0.02*	0.59	0.15	0.23*	-0.02	0.25**
L_8	3.96**	-11.05**	-0.50*	0.97**	-1.50**	10.35**	0.22**	0.43**	-0.16*	0.01	-0.69*	0.25*	0.77**	0.54**	0.23**
S.E.gi	0.40	1.17	0.20	0.21	0.50	1.17	0.06	0.09	0.07	0.01	0.34	0.10	0.10	0.09	0.04
Testers (T)															
T_1	0.92**	-7.03**	-1.07**	-1.25**	-2.42**	-5.38**	-0.32**	-0.29**	-0.30**	-0.03**	0.30	-0.30**	0.02	-0.03	0.05
T_2	-2.69**	6.89**	1.19**	0.53**	2.74**	6.18**	0.29**	0.35**	0.41**	0.01	0.90**	0.26**	0.38**	0.23**	0.16**
T_3	1.03**	-1.48	-0.12	0.66**	0.99**	0.02	0.13**	0.07	0.15**	0.00	-0.60*	0.12	-0.08	0.00	-0.09**
T_4	0.75**	1.62	0.00	0.07	-1.31**	-0.83	-0.11*	-0.13*	-0.26**	0.003**	-0.60*	-0.08	-0.32**	-0.20**	-0.12**
S.E.gi	0.28	0.83	0.14	0.15	0.35	0.82	0.04	0.06	0.05	0.01	0.24	0.07	0.07	0.06	0.03

*, ** Significant at 5% and 1% levels respectively.

Table 3: Estimates of specific combining (sca) ability effects of crosses over environments

Hybrids	D50	PH	NBP	NCP	NFP	AFW	FYP	PT	TSS	TA	ASC	LC	TS	RS	NRS
$L_1 \times T_1$	-0.03	1.17	-0.10	0.61	0.45	-5.94*	0.01	0.05	-0.29*	0.04	2.37**	0.16	0.10	0.18	-0.08
$L_1 \times T_2$	-0.53	10.81**	-0.63	-0.23	-0.02	-0.27	0.23	0.41*	0.27*	-0.03	1.17	-0.02	-0.33	-0.32	-0.01
$L_1 \times T_3$	-0.36	-6.17**	-0.85*	-1.01*	-1.45	-9.19**	-0.45**	-0.31	0.04	0.00	-1.89**	-0.14	-0.09	-0.10	0.02
$L_1 \times T_4$	0.92	-5.82*	1.58**	0.64	1.02	15.40**	0.21	-0.16	-0.02	-0.01	-1.65*	-0.01	0.31	0.24	0.07
$L_2 \times T_1$	-0.58	-10.83**	-0.96*	-0.42	-2.32*	-6.04*	-0.13	-0.27	-0.05	0.02	0.39	-0.13	1.32**	0.97**	0.35**
$L_2 \times T_2$	-0.53	6.58**	-3.02**	-2.10**	2.09*	5.44*	0.23	0.38*	0.18	-0.02	-1.07	0.07	-0.20	-0.14	-0.06
$L_2 \times T_3$	0.53	16.13**	2.73**	3.08**	0.49	14.42**	0.12	-0.30	-0.10	0.00	0.23	0.33	-0.64**	-0.54**	-0.10
$L_2 \times T_4$	0.58	-11.88**	1.24**	-0.57	-0.26	-13.82**	-0.23	0.19	-0.03	0.01	0.46	-0.26	-0.49*	-0.30	-0.19*
$L_3 \times T_1$	0.69	5.49*	1.28**	0.97*	0.71	4.47	0.03	0.04	0.00	0.02	-0.84	-0.04	0.13	-0.06	0.20*
$L_3 \times T_2$	-0.25	-6.78**	-0.17	-0.60	-0.75	-4.25	-0.16	-0.48**	-0.43**	-0.07**	-0.51	-0.05	-0.52**	-0.26	-0.26**
$L_3 \times T_3$	1.25	1.55	-0.08	-0.09	-0.60	0.27	0.06	0.16	0.41**	0.01	0.43	-0.58**	0.20	0.25	-0.06
$L_3 \times T_4$	-1.69*	-0.26	-1.03*	-0.28	0.64	-0.49	0.08	0.28	0.02	0.05*	0.93	0.66**	0.19	0.07	0.12
$L_4 \times T_1$	-1.58	0.10	-0.74	1.09**	0.02	6.52**	0.32**	0.25	0.13	-0.04	-0.96	0.19	-0.68**	-0.47*	-0.21*
$L_4 \times T_2$	1.25	-1.68	1.89**	-1.09**	-0.62	-6.96**	-0.28*	-0.23	-0.43**	0.08**	0.22	-0.48*	-1.06**	-0.92**	-0.14
$L_4 \times T_3$	0.75	-7.44**	-0.69	1.04*	-1.03	-4.94*	-0.23	-0.08	0.01	0.08**	1.73*	0.51*	1.21**	0.80**	0.41**
$L_4 \times T_4$	-.0.42	9.02**	-0.46	-1.04*	1.63	5.39*	0.19	0.06	0.28*	-0.11**	-0.99	-0.22	0.53**	0.59**	-0.06
$L_5 \times T_1$	1.81*	-1.83	0.06	-2.58**	-0.16	-5.41*	-0.32**	-0.26	-0.15	-0.03	-2.05**	-0.18	-0.54**	-0.12	-0.42**
$L_5 \times T_2$	-0.36	3.35	0.24	2.15**	0.59	5.25*	0.39**	0.17	0.20	0.12**	1.23	0.41*	1.09**	0.64**	0.45**
$L_5 \times T_3$	-1.53	-7.29**	-0.53	-2.37**	1.65	-11.26**	0.23	0.53**	0.13	-0.04	1.71*	-0.62**	-0.25	-0.36*	0.11
$L_5 \times T_4$	0.08	5.77*	0.23	2.80**	-2.08*	11.42**	-0.30*	-0.44*	-0.18	-0.06**	-0.90	0.40*	-0.30	-0.16	-0.14
$L_6 \times T_1$	-0.31	0.68	0.15	0.38	-1.36	8.71**	0.09	0.20	0.37**	-0.02	1.12	0.34	0.38	0.22	0.16
$L_6 \times T_2$	-2.03*	1.89	1.08**	0.74	0.21	-1.14	-0.29*	-0.09	-0.41**	-0.03	0.36	-0.44*	-0.29	-0.05	-0.24**
$L_6 \times T_3$	-0.19	-4.20	-0.38	-1.19**	2.40*	-3.63	0.07	-0.22	-0.08	-0.05*	-1.23	0.06	-0.43*	-0.29	-0.13
$L_6 \times T_4$	2.53**	1.63	-0.84*	0.07	-1.25	-3.94	0.13	0.11	0.11	0.11**	-0.26	0.03	0.34	0.13	0.21*
$L_7 \times T_1$	-0.50	-0.15	0.83*	0.75	2.09*	4.77*	0.23	0.14	-0.04	-0.01	0.72	-0.16	-0.53**	-0.39*	-0.15
$L_7 \times T_2$	0.89	-4.76*	-1.45**	-0.06	-2.88**	-4.68*	-0.30*	-0.37*	0.19	-0.02	-0.04	0.22	1.07**	0.81**	0.26**
$L_7 \times T_3$	-0.39	4.11	0.37	-1.18**	0.20	1.78	-0.11	0.03	-0.14	-0.01	-0.80	0.17	-0.37	-0.16	-0.21*
$L_7 \times T_4$	0.00	0.80	0.25	0.50	0.59	-1.87	0.18	0.21	-0.01	0.04	0.12	-0.23	-0.17	-0.26	0.09
$L_8 \times T_1$	0.50	5.36*	-0.52	-0.80	0.57	-7.08**	-0.23	-0.15	0.02	0.02	-0.75	-0.19	-0.19	-0.33	0.15
$L_8 \times T_2$	1.56	-9.42**	2.05**	1.18**	1.38	6.62**	0.19	0.22	0.42**	-0.02	-1.37*	0.29	0.24	0.23	0.01
$L_8 \times T_3$	-0.06	3.32	-0.57	1.71**	-1.66	12.55**	0.30*	0.18	-0.27	0.01	-0.18	0.27	0.36	0.41*	-0.04
$L_8 \times T_4$	-2.00*	0.73	-0.96*	-2.09**	-0.28	-12.09**	-0.26*	-0.25	-0.17	-0.02	2.29**	-0.37	-0.41*	-0.30	-0.11
S.E.sij	0.79	2.35	0.41	0.41	1.00	2.33	0.12	0.17	0.14	0.02	0.67	0.20	0.20	0.18	0.09

*, ** Significant at 5% and 1% levels respectively.

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