Minufiya J. Agric. Res. Vol.39 No. 1(1): 131 - 141 (2014) "http://www.mujar.net"

COMBINING ABILITY ANALYSIS OF SOME NEW YELLOW MAIZE (*Zea mays L.*) INBRED LINES

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(Received : Nov. 12 , 2013)

ABSTRACT: *Fourteen yellow maize inbred lines derived from different hetrotic group were used in this study. In 2011 growing season the fourteen inbred lines were topcrossed to each of two narrow base inbred testers i.e. Gz.650 and Mall 5013. In 2012 season, 28 topcrosses along with two commercial check hybrids i.e. SC 162 and SC 168 were evaluated in replicated yield trails conducted at Sakha and Mallawy. Data were recorded for days to 50% silking, plant and ear height (cm), ears per 100 plants, resistance to late wilt and grain yield.*

Combined analysis over the two locations showed that mean squares due to crosses and lines were significant for all the studied traits. Mean squares due to lines x testers were significant for days to 50% silking, ear height. Ears / 100 plants and grain yield, indicating that differed in their order of performance in crosses with each of the testers. Mean squares due to crosses x location and lines x location interaction were significant for all the studied traits, except no of days to 50% silking. Testers x location interaction were significant for the studied traits, except days to 50% silking and resistance to late wilt%. Mean squares due to lines x testers x locations interaction was significant for plant height, ear height and ears/100 plants. The magnitude of σ2 GCA was larger than that obtained for σ2 SCA for days to 50% silking, plant height, ear height and ears per 100 plants. The magnitude of σ2 SCA exceeded that of σ2 GCA for grain yield. For grain yield, two crosses i.e. (L-9 x Mall.5013) and (L-11 x Mall.5013) outyielded the check hybrid SC 162.

The best GCA effects were obtained from L-2, L-5, L-10, L-11 and L-12 for grain yield exhibited positive and significant GCA effects. The topcrosses L-5, L-10, L-13 and L-14 x Gz.650 and L-4, L-6 and L-9 X Mall.5013) had positive and significant SCA effects.

Key words: *Maize, topcross, line x tester, combining ability.*

INTRODUCTION

Maize (Zea mays L.) is one of the three most important cereal crops in the world together with wheat and rice. The topcross procedures suggested by Davis (1927) were used to evaluate the combining ability of inbred lines to determine the usefulness of the lines for hybrid development. Line x tester analysis is an extension of this method in which several testers are used Kempthorne (1957). Line x testers analysis provides information about general and specific combining ability of parents and at the same time it is helpful in estimating various type of gene action Singh and Chaudhary (1985). The concepts of general combining ability (GCA) and specific combining ability (SCA) defined by Sprague and Tatum (1942) have been used extensively in breeding of several economic crop species. For maize yield, they found that GCA was relatively more important than SCA for non selected inbred lines, whereas SCA was more important than GCA for previously selected lines. Rojas and Sprague (1952) compared estimates of the variances of GCA and SCA for yield and their interaction with locations and years. They stressed that the variance of SCA includes not only the non-additive deviations due to dominance and epistasis but also a considerable portion of the genotype x environment interaction. The concepts of GCA and SCA became useful for characterization of inbred lines in crosses and often have been included in the description of an inbred line Hallauer and Miranda (1988). Jayakumar and Sundaram (2007) reported that the specific combining ability variances were higher than the general combining ability variances for days to 50% silking, number of grains per row and grain yield. Abd El-Maksoud *et al.* (2003), Almanie *et al.* (2006), Todkar and Navale (2006), Dar *et al.* (2007) and Abd El-Moula and Abd El-Aal (2009) reported similar results.

The main objectives of this study were (1) identify the best inbred lines for general combining ability, (2) identify the best crosses regarding the specific combining ability for grain yield and other traits and (3) determined the different types of gene action involved in manifestation of grain yield and other studied traits.

MATERIALS AND METHODS

Fourteen yellow maize inbred lines derived from different hetrotic group through selection in disease nursery field at Mallawy Agricultural Research Station were used in this study. In 2011 growing season the fourteen inbred lines were topcrossed to each of the two narrow base inbred testers i.e. Gz. 650 and Mall.5013 at Mallawy Agric. Res. Station. In 2012 season, 28 topcrosses along with two commercial check hybrids i.e. SC 162 and SC 168 were evaluated in replicated yield trails conducted at Sakha (Kafr El-Sheikh governorate) and Mallawy (El-Minia governorate) Agric. Res. Stations. A randomized complete block design with four replications was used in each location at normal season. Plot size was one row, 6 m long and 80 cm apart and hills were spaced 25 cm along the row. All cultural practice for maize production was applied as recommended. Data were recorded for days to 50% silking, plant and ear height (cm), number of ears per 100 plants, resistance to late wilt disease% and adjusted grain yield at 15.5% grain moisture and converted to ardab per fed (ardab = 140 kg). Analysis of variance was performed for the combined data over locations according to Steel and Torrie (1980). Procedures of Kempthorne (1957) were performed to obtain valuable information about the combining ability of lines and testers as well as their topcrosses.

RESULTS AND DISCUSSION

Analysis of variance:

Combined analyses of variance over two locations for 28 topcrosses for the studied traits are presented in Table 1. Results showed highly significant differences between the two locations for all traits. These results revealed the presence of clear variations among the two locations in climatic and soil conditions. Mean squares due to crosses, lines and testers were significant or highly significant for all the studied traits except for late wilt resistance % of testers. Mean squares due to lines x testers were significant for days to 50% silking, ear height, No. of ears/100 plants and grain yield, indicating that differed in their order of performance in crosses with each of the testers. Similar results were obtained by Castellanos *et al.* (1998), Soliman and Sadek (1999), Soliman (2000), Venugopal *et al.* (2002), Amer *et al.* (2003), Abd El-Moula and Abd El-Aal (2009).

Mean squares due to crosses x location and lines x location interaction were significant for all the studied traits except for days to 50% silking. Mean squares due to testers x location interaction were significant or highly significant for plant and ear height, no. of ears/100 plants and grain yield. Mean squares due to lines x testers x locations interaction were significant for plant height, ear height and no. of ears/100 plants. These results are in good agreement with obtained by Shehata et al. (2001) they found that the interaction of lines x testers x locations was insignificant for No. of rows per ear. Mahmoud and Abd El-Azeem (2004), Abd El-Moula and Abd El-Aal (2009) found that the interaction of lines x testers x locations was highly significant for grain yield.

The magnitude of mean squares due to testers were higher than of lines for all the studied traits, except late wilt resistance%, indicating that the tester contributed much more in the total variation for most the studied traits. Also the mean squares due to testers x locations were higher than of lines x locations for all the studied traits, except days to 50% silking and late wilt

Table 1

resistance%, indicating that the testers were more affected by the environmental conditions than the lines. These results are in agreement with obtained by Gado *et al.* (2000), El-Morshidy *et al.* (2003), Abd El-Moula and Ahmed (2006) and Abd El-Moula and Abd El-Aal (2009).

Mean performance:

Mean performance of the 28 topcrosses for all the studied traits are presented in Table 2. For days to 50% silking all crosses were significantly earlier than the two check hybrids. The earliest crosses were L-1 x Mall.5013, L-13 x Mall.5013, L-14 x Mall.5013, and L-14 x Gz.650. While the latest crosses were L-2 x Gz.650 and L-6 x Gz.650. In general, the crosses involving inbred lines Mall.5013 as tester significantly flowered earlier than those involving tester inbred lines Gz.650. Regarding plant height, ranged from 238.8 for cross L-1 x Mall.5013 to 268.4 cm for cross L-12 x Gz.650. There were 18 crosses significantly shorter than check hybrid SC 168. For ear height, ranged from 127.8 for cross L-1 x Mall.5013 to 157.4 cm for cross L-2 x Gz.650. There were 7 crosses had significantly lower ear height than the check hybrid SC 168. The crosses involving the inbred tester Mall.5013 had short plant and low ear height comparing with the crosses, which involving the tester inbred lines Gz.650. Concerning No. of ears per 100 plants, two crosses i.e. L-4 x Gz.650 and L-6 x Gz.650 significantly increased than the check hybrid SC 162.

Also, result showed that the crosses involving the tester Gz.650 tended to have higher No. of ears per 100 plants than those of the tester Mall.5013. For resistance to late wilt disease, generally all crosses had high resistance to late wilt. Concerning grain yield, results showed that the crosses involving Mall.5013 as a tester tended to have higher values of grain yield than those of Gz.650 as a tester. Grain yield ranged from 16.3 for cross L-6 x Gz.650 to 36.7 ard/ fedd. For cross L-9 x Mall.5013. There were two crosses i.e. L-9 x Mall.5013 (36.7) and L-11 x Mall.5013 (33.3) outyielded the check hybrid SC 162. One of them (L-9 x Mall.5013) significantly out yielded the check hybrid SC 162. The two crosses were not significantly different with the check hybrid SC.168.

General and specific combining ability effects:

General combining ability effects are presented in Table 3. For days to 50% silking there was 6 inbred lines had significant GCA effects. Out of these inbred lines there were L-13 and L-14 exhibited negative and highly significant GCA effects. These inbred lines are considered best inbred lines for earliness. Concerning plant height, the inbred lines No. 1, 5, 8 and 14 manifested negative and significant GCA effects. Regarding ear height, only one inbred line L-1 had negative and significant GCA effects. For ears per 100 plants, L4 and L 6 had positive and significant GCA effects. Only one inbred lines L10 had positive and significant GCA effects for resistance to late wilt disease. Five inbred lines i.e. L-2, L-5, L-10, L-11 and L-12 possessed positive and significant or highly significant GCA effects for grain yield, indicating that they have favorable genes and are best combiners for grain yield.

Results showed that the tester inbred lines Mall.5013 were more favorable effect than inbred line Gz.650 for earliness, plant height, ear height and grain yield. The tester inbred line Mall.5013 had positive and highly significant GCA effects and could be considered as good combiners for grain yield.

Specific combining ability effects of 28 topcrosses for all the studied traits are presented in Table 4. Results showed that, four crosses (L-7 x Gz.650 and L-14 x Gz.650 and L-6 x Mall.5013) for days to 50% silking, had negative (desirable) and significant SCA effects. One cross (L-5 x Mall.5013) for ears/100 plant. For grain yield, there are seven crosses (L-5, L-10, L-13 and L-14 x Gz.650 and L-4, L-6 and L-9 X Mall.5013) had positive and significant or highly significant SCA effects with values of 2.355*, 3.004**, 2.850*, 2.776*, 3.604**, 5.536** and 7.003**, respectively.

Table 2

Table (3). General combining ability effects for grain yield and the other studied traits, data are combined over two locations in 2012 season.

Inbred lines	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ears/100 plants	Late wilt resistance %	Grain yield (ard/fed)
L-1	-0.437	-4.026*	-3.683*	-3.306	1.755	-1.153
L-2	0.937**	10.973**	8.691**	0.965	0.736	1.483*
L-3	-0.125	-2.526	-1.620	-3.416	0.667	1.301
L-4	0.937**	1.598	2.192	6.063**	0.667	-1.819*
L-5	-0.375	-4.401*	-3.120	-2.510	1.817	2.078**
L-6	0.750**	0.473	1.817	10.021**	-1.182	-3.838**
L-7	0.437	-3.089	-0.620	-2.827	2.724	0.302
L-8	-0.375	-5.901*	-3.495	-5.459*	1.273	-0.834
L-9	1.125**	6.098**	4.004*	0.660	-0.926	-0.185
L-10	-0.312	-2.526	-3.308	-0.450	4.892*	2.067**
L-11	0.062	3.598	2.066	0.099	1.773	2.065**
L-12	0.062	7.598**	4.254*	1.482	-1.489	2.016**
L-13	-0.562*	-0.776	-3.370	-1.839	-1.770	0.136
L-14	-2125**	-7.089**	-3.308	0.518	-10.938**	-3.619**
SE (g_i)	0.276	2.054	1.872	2.017	1.865	0.756
SE(g_i-g_i)	0.390	3.753	2.648	2.852	2.637	1.069
Testers						
Gz.650	1.446**	4.75**	5.013**	3.219**	0.009	-2.089**
Mall.5013	-1.446**	-4.75**	-5.013**	-3.219**	-0.009	2.089**
SE (g_i)	0.104	1.003	0.707	0.768	0.704	0.285
SE(g_i-g_i)	0.147	1.141	1.001	1.078	0.996	0.404

*' ** significant at 0.05 and 0.01 levels of probability, respectively.

Table 4

Variance components:

Estimates of combining ability variances σ2GCA for lines, σ2SCA for line x tester and their interactions with environments are presented in Table 5. The results showed that, σ2GCA-T was higher than σ2GCA-L for days to 50% silking, plant and ear height, resistance to late wilt disease and grain yield, indicating that most of GCA variance was due to testers for these traits. The magnitude of σ2GCA (average) was larger than that obtained for σ2SCA for days to 50% silking, plant height, ear height and ears per 100 plants, indicating that the additive gene action played an important role in the inheritance of these traits. The magnitude of σ2SCA exceeded that of σ2GCA (average) for grain yield, indicating that the dominance gene action played an important role in the inheritance of grain yield. Jayakumar and Sundaram (2007) reported that the specific combining ability variances were higher than the general combining ability variances for days to 50% silking, number of grains per row and grain yield. Abd El-Maksoud *et al.* (2003), Almanie *et al.* (2006), Todkar and Naval (2006), Dar *et al.* (2007) and Abd El-Moula and Abd El-Aal (2009) reported similar results. Furthermore, the magnitude of σ2 GCA x E interaction was higher than σ2 SCA x E for plant height, ear height and grain yield, indicating that the additive type of gene action was more affected than the additive type of gene action by environment in these traits. These results are in a good agreement with those obtained by El-Itriby *et al.* (1990), El-Zeir *et al.* (2000) and Soliman *et al.* (2001). On the other side, the magnitude of σ2SCA x E interaction was higher than σ2GCA x E for ears per 100 plants indicating that the additive type of gene action were more affected by environment than additive ones. These results are in a good agreement with those obtained by Sadek *et al.* (2000), Soliman *et al.* (2001), Abd El-Moula *et al.* (2004) and Amer and El-Shenawy (2007). They found that the magnitude of σ2SCA x E interaction was higher than that of σ2GCA x E interaction.

Table (5). Genetic parameters for grain yield and the other studied traits of 52 topcrosses and two testers over the two locations.

Parameters	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ears/100 plants	Late wilt resistance %	Grain yield (ard/fed)
$\sigma^2_{GCA\text{-}L}$	0.388	9.534	-1.398	7.448	-6.800	-7.040
$\sigma^2_{GCA\text{-}T}$	4.463	9.799	9.883	-1.374	-0.217	3.558
$\sigma^2_{GCA\ (average)}$	3.920	9.764	8.379	38.829	-1.095	2.145
σ^2_{SCA}	0.536	-16.371	0.381	1.978	2.734	19.688
$\sigma^2_{GCA\text{-}L\ x\ E}$	0.021	24.926	18.004	0.393	34.541	2.028
$\sigma^2_{GCA\text{-}T\ x\ E}$	-0.010	75.495	86.173	44.743	-0.396	8.564
$\sigma^2_{GCA\ (average)\ x\ E}$	-0.005	68.752	77.080	-0.198	4.262	7.692
$\sigma^2_{SCA\ x\ E}$	-0.140	31.855	15.528	16.578	-8.703	-0.903

All negative estimates of variance were considered equal zero.

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تحليل القدرة على التآلف فى بعض السلالات الجديدة من الذرة الشامية الصفراء

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الملخص العربى

تم إجراء التهجين بين 14 سلالة من الذرة الشامية الصفراء مرباة تربية داخلية بمحطة البحوث الزراعية بملوى مع كشافين عبارة عن السلالة النقية جيزة 650 و ملوي 5013 فى موسم 2011 . تم تقييم 28 هجين قمى مع هجينين مقارنة وهما الهجين الفردى 162 والهجين الفردى 168 فى محطتى البحوث الزراعية بسخا وملوى فى الموسم الزراعى 2012. تم اخذ القراءات على صفات عدد الايام حتى ظهور 50% من الحراير و ارتفاع النبات والكوز وعدد الكيزان لكل 100 نبات والمقاومة لمرض الذبول المتاخر ومحصول الحبوب (اردب/فدان).

اظهر التحليل المشترك اختلافات معنوية ناتجة من الهجن والسلالات لكل الصفات محل الدراسة. كما اظهر تباين تفاعل السلالات مع الكشافات اختلافات معنوية لصفات عدد الايام حتى ظهور % من الحراير , ارتفاع الكوز, عدد الكيزان لكل 100 نبات ومحصول الحبوب . كان تباين التفاعل بين كل من الهجن , السلالات x المواقع معنويا لجميع الصفات ما عدا صفة عدد الايام حتى ظهور 50% من الحراير وكان تباين تفاعل الكشافات x المواقع معنويا بالنسبة لكل الصفات محل الدراسة ماعدا صفة عدد الأيام حتى ظهور 50% من

الحراير والمقاومة لمرض الذبول المتاخر. اظهر التفاعل المشترك بين السلالات والكشافات والمواقع اختلافات معنوية لصفات ارتفاع النبات, ارتفاع الكوز وعدد الكيزان لكل 100 نبات .

كان تباين القدرة العامة على التآلف اكبر من تباين القدرة الخاصة على التآلف فى جميع الصفات عدا صفة محصول الحبوب. بينما كان تباين القدرة الخاصة على التآلف اكبر من تباين القدرة العامة على التآلف فى صفة محصول الحبوب. تفوق هجينان قميان على هجين المقارنة 162 وهى (السلالة-9 x ملوي 5013) و (السلالة-11 x ملوي 5013). أظهرت السلالات 2 و 5و 10 و 11 و 12 أفضل قدرة عامة على التآلف حيث كانت موجبة ومعنوية فى صفة محصول الحبوب. أما بالنسبة للقدرة الخاصة على التآلف فقد أظهرت الهجن القمية (السلالة- 5 و 10 و 13 و 14 x جيزة 650) والهجن (السلالة-4 و 6 و 9 x ملوي 5013) تأثيرات موجبة ومعنوية.

Table (1). Mean squares for grain yield and the other studied traits, for combined analysis over two locations in 2012 season.

S.O.V	DF	Days to 50% silking	Plant height (cm)	Ear height (cm)	Ears/100 plants	Late wilt resistance%	Grain yield (ard/fed)
Location (Loc)	1	486.16**	62712.07**	40635.21**	4381.98**	2446.62**	1158.79**
Rep/loc.	6	1.80	1045.61	527.79	36.50	104.72	23.09
Crosses	27	25.19**	461.76**	383.89**	277.55**	122.24**	146.82**
Lines	13	11.33**	461.11**	242.95**	260.09**	210.71**	66.62**
Testers	1	468.64**	5054.00**	5630.04**	2321.49**	0.02	978.37**
tester x Line	13	4.95**	109.16	121.28*	137.79*	43.18	163.04**
Crosses x Loc.	27	0.72	481.54**	353.54**	209.65**	153.59**	29.84**
Lines x Loc.	13	0.83	439.54**	262.26**	125.11*	297.64**	21.76**
testers x Loc.	1	0.16	4165.87**	4599.21**	2448.61**	0.72	450.87**
Lines x tester x Loc.	13	0.66	240.13*	118.23*	121.97*	21.31	5.54
Error	162	1.22	112.71	56.12	65.10	55.66	9.15
CV%		1.92	4.20	5.32	7.55	8.87	10.87

*' ** significant at 0.05 and 0.01 levels of probability, respectively.

Table (2). Mean performance for grain yield and other studied traits of the crosses between 14 inbred lines and two testers (Gz.650 and Mall.5013) over the two locations.

Inbred lines	Days to 50% silking		Plant height (cm)		Ear height (cm)		Ears/100 plants		Late wilt resistance%		Grain yield (ard/fed)	
	Gz.650	Mall.5013	Gz.650	Mall.5013	Gz.650	Mall.5013	Gz.650	Mall.5013	Gz.650	Mall.5013	Gz.650	Mall.5013
L-1	58.6	54.3	257.8	238.8	146.5	127.8	106.87	99.98	99.0	98.9	24.8	28.5
L-2	60.0	55.3	265.1	261.4	157.4	141.6	110.20	105.19	98.4	99.0	28.0	30.6
L-3	58.6	55.0	256.4	243.1	144.9	133.5	104.52	102.11	98.4	98.9	28.1	30.1
L-4	59.3	56.6	258.3	249.5	148.3	137.8	121.03	104.56	97.1	99.5	20.3	31.7
L-5	58.6	56.0	250.0	245.8	141.4	134.0	102.08	106.36	99.0	99.0	30.2	29.6
L-6	60.3	55.3	257.9	247.6	146.8	138.5	124.93	108.58	98.0	97.8	16.3	31.6
L-7	59.3	58.6	255.1	243.3	141.8	138.6	103.70	104.11	98.9	99.5	27.9	28.3
L-8	57.3	56.0	248.0	244.8	140.9	133.8	102.00	100.55	99.0	98.4	26.7	27.3
L-9	59.0	56.6	263.8	253.0	150.0	139.6	110.76	104.02	97.7	98.5	18.5	36.7
L-10	58.6	55.0	254.5	245.0	144.1	130.9	110.78	101.78	100.0	99.5	30.8	28.9
L-11	58.6	55.0	257.1	254.6	143.1	142.6	111.16	102.50	99.4	98.5	26.5	33.3
L-12	57.3	55.0	268.4	251.4	153.0	137.1	113.72	102.70	97.8	98.5	28.8	30.8
L-13	54.9	53.6	258.4	244.6	145.1	129.8	106.52	103.27	99.0	95.9	28.7	27.2
L-14	54.3	53.3	247.8	242.6	138.4	135.6	111.03	103.47	92.5	92.7	24.5	23.9
Mean	58.2	55.4	257.00	247.50	145.8	135.8	109.85	103.51	98.15	98.18	25.72	29.89
Check Sc 168	62.75		266.75		144.00		111.50		97.7		35.84	
Sc 162	63.50		278.00		148.00		115.27		97.1		32.13	
LSD 0.05%	1.08		10.40		7.34		7.90		7.31		2.95	

Table (4). Specific combining ability effects of 28 top crosses for grain yield and the other studied traits, data are combined of two locations in 2013 season.

Inbred lines	Days to 50% silking		Plant height (cm)		Ear height (cm)		Ears/100 plants		Late wilt resistance%		Grain yield (ard/fed)	
	Gz.650	Mall.5013	Gz.650	Mall.5013	Gz.650	Mall.5013	Gz.650	Mall.5013	Gz.650	Mall.5013	Gz.650	Mall.5013
L-1	0.616	-0.616	4.750	-4.750	4.361	-4.361	0.229	-0.229	0.053	-0.053	0.246	-0.246
L-2	0.366	-0.366	-2.875	2.875	2.861	-2.861	-0.714	0.714	-1.053	1.053	0.785	-0.785
L-3	0.553	-0.553	1.875	-1.875	0.674	-0.674	-2.015	2.015	-0.984	0.984	1.067	-1.067
L-4	-0.008	0.008	-0.375	0.375	0.236	-0.236	5.013	-5.013	-3.197	3.197	-3.604**	3.604**
L-5	-0.446	0.446	-2.625	2.625	-1.325	1.625	-5.589*	5.589*	-0.009	0.009	2.355*	-2.355*
L-6	0.928*	-0.928*	0.375	-0.375	-0.888	0.888	4.958	-4.958	1.403	-1.403	-5.536**	5.536**
L-7	-0.884*	0.884*	1.187	-1.187	-3.450	3.450	-3.423	3.423	-1.103	1.103	1.865	-1.865
L-8	-0.446	0.446	-3.125	3.125	-1.450	1.450	-2.492	2.492	0.484	-0.484	1.766	-1.766
L-9	-0.446	0.446	0.625	-0.625	0.174	-0.174	0.151	-0.151	-0.640	0.640	-7.003**	7.003**
L-10	-0.139	0.139	0.000	0.000	1.611	-1.611	1.281	-1.281	1.028	-1.028	3.004**	-3.004**
L-11	0.008	-0.008	-3.500	3.500	-4.763	4.763	1.112	-1.112	1.984	-1.984	-1.285	1.285
L-12	0.366	-0.366	3.750	-3.750	2.924	-2.924	2.290	-2.290	-1.190	1.190	1.072	-1.072
L-13	0.336	-0.366	2.125	-2.125	2.674	-2.674	-1.594	1.594	3.528	-3.528	2.850*	-2.850*
L-14	-0.821*	0.821*	-2.187	2.187	-3.638	3.638	0.558	-0.558	-0.303	0.303	2.376*	-2.376*
SE sij	0.390		3.753		2.648		2.852		2.637		1.069	
SE sij-ski	0.562		5.308		3.745		3.034		3.730		1.512	

*' ** significant at 0.05 and 0.01 levels of probability, respectively.