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Assessment of Combining Ability in Some Newly Maize Inbred Lines for Grain Yield and Late Wilt Resistance

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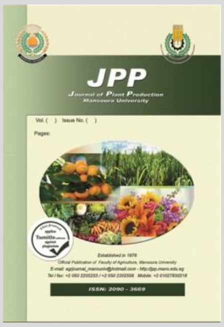

ABSTRACT

Twenty new yellow maize inbred lines were crossed to two testers (Sk-3 and SC 177) during 2017 season. The resulting forty crosses and two checks (SC168 and TWC 368) were evaluated in two trials during 2018 season. The first trial for grain yield, days to 50% silking and plant height traits was conducted at Sakha and Sids Research Stations, the second trial in nursery late wilt field under two nitrogen levels (60 and 120 unit) at Sakha Research Station. The mean squares due to lines (L), testers (T), lines x tester (L x T) and their interaction with locations in the first trial and nitrogen levels in the second trial were significant for most traits. The non-additive gene effects were the most important component control the inheritance of all studied traits except days to 50% silking. The best inbred line for general combining ability effects was L-7 for days to 50% silking, L-19 for taller plants and grain yield while, inbred line L-5 was the best for late wilt resistance. The desirable hybrids for specific combining ability effects were L-20 x Sk-3 and L-16 x SC 177 for grain yield and late wilt resistance. Two single crosses L-10 x Sk-3 and L-20 x Sk-3 were significantly out-yield compared to the check SC 168. Meanwhile, one three-way cross L-5 × SC 177 was significant out-yield than check TWC 368. These hybrids could be considered as promising crosses in the hybrids breeding program and require further testing.

Keywords: Line × tester, Combining ability, Late wilt, Maize

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in Egypt, in terms of cultivated area, total production and cash value. The soil borne vascular wilt pathogen *Cephalosporium maydis* is the most economical disease of maize in Egypt. The disease was first identified in the early sixties by Samra *et al.* (1962 and 1963). It recorded as single or infected plants in a restricted area (Sabet *et al.* 1962). Later on, it has been spread out over all growing areas with variable percentage depending on maize genotype and pathogen. The best technique to control this disease is through developing genetically resistance genotypes. The late wilt disease causes severe losses in yield of susceptible maize cultivars. So, resistance to late wilt disease is one of the most important evaluation tests to restriction hybrids in Egypt. Fertilization is a vital tool to increase grain yield and resistance to diseases in maize. Mosa *et al.* (2010) reported that the low and high nitrogen levels exhibited the lowest values for resistance to late wilt disease, while the optimum nitrogen level was coupled with the highest values of resistance. Information on the combining ability among maize genotypes is vital in increasing the effectiveness of hybrid development. The conception of general and specific combining ability was suggested by Sprague and Tatum (1942). Information about type of gene action is so important for the breeder to design the breeding program. Nair *et al.* (2004) and Abd El-Kareem (2013) found that additive gene effects played a vital role in the inheritance of resistance to late wilt and grain yield, while Amer *et al.* (2002), Abd-Elaziz (2010), Osman (2014) and Mosa *et al.* (2016) illustrated that non-additive gene effects were predominant in the inheritance of late wilt disease and grain yield. Barakat and Osman (2008) found that non-additive gene effects played an important role in the inheritance of days to 50% silking, plant height and resistance to late wilt disease, While, additive gene effects played an important role in the inheritance of grain yield. Mosa *et al.* (2017) found that non-additive gene effects were the most important component in the inheritance of grain yield and late wilt resistance. The objectives of this study are-: 1) Estimate general and combining ability effects for days to 50% silking, plant height, grain yield and resistance to late wilt disease. 2) Determine the effect of nitrogen fertilization on resistance to late wilt disease. 3) Identify the superior hybrids in grain yield and resistance to late wilt disease.

MATERIALS AND METHODS

Twenty new yellow maize inbred lines, derived from diverse genetic sources by self-pollination, visual selection for agronomic traits and pest resistance of the lines *per se* among and within ear to row progenies in breeding field at Sakha (SK) Research Station. In 2017 growing season, the 20 new yellow inbred lines were crossed with two testers; one inbred line Sk-3 and one single cross SC 177. The resulting forty crosses and two commercial cross SC 168 and three way-cross TWC 368 were evaluated in two trials during 2018 season. The first trial was conducted at Sakha and Sids Research Stations. Randomized complete block design (RCBD) with four replications was used at both locations. The plot size was one ridge, 6 m length, 80 cm apart and 25 cm between hills. Two kernels were planted

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per hill then thinned to one plant per hill before the first irrigation. All agricultural practices were applied as recommended at the proper time. Data were recorded on number of days to 50% silking, plant height (cm) and grain yield ardab/feddan (ard/fed) (One ardab= 140 kg, one feddan = 4200 m^2) adjusted to 15.5% grain moisture content. The second trial for resistance to late wilt disease was performed in two separate trials under two nitrogen levels 60 and 120 kg N/fed, respectively in disease nursery under artificial soil inoculation by the pathogen *Cephalosporium maydis* at Sakha Research Station in 2018 season. Annually in same place, different isolates of *Cephalosporium maydis* were used to reinfection disease nursery to increase the efficiency of selection. RCBD with four replications was also used. Plot size was one row, 2 m length, 80 cm width, 20 cm between hills and two seeds were planted per hill – thinned later to one plant per hill before the first irrigation. Data were taken on percentage of resistance to late wilt disease after 35 days from flowering. The nitrogen fertilizer was applied in two equal doses, at the first and the second irrigation in the late wilt trial. Combined analysis across two locations in the first trial and across two nitrogen levels in the second trial was performed when homogeneity of variance was detected according to Snedecor and Cochran (1980). Combining ability analysis was computed according to line x tester analysis procedure of Kempthorne (1957).

RESULTS AND DISCUSSION

The combined analysis of variance for days to 50% silking, plant height and grain yield across two locations are presented in Table 1. Mean squares due to the locations (loc.) were highly significant for days to 50% silking, plant height and grain yield, indicating that these traits were influenced by different environment conditions in different locations. Crosses(C) and interaction C x Loc. mean squares were highly significant for previous traits. Thus, crosses varied in these traits and the crosses were differed from one location to another.

Table 1. Combined analysis of variance for days to 50% silking, plant height and grain yield across two locations.

SOV	df	Mean squares		
		Days to 50% silking	Plant height	Grain yield
Locations(Loc.)	1	142.74**	140835.2**	12221.84**
Rep/Loc.	6	14.31	96.94	16.99
Crosses (C)	41	13.95**	496.58**	64.68**
C × Loc.	41	6.39**	449.03**	21.33**
Error	246	1.32	101.27	11.01

**** Significant at the 0.01 levels of probability.**

Table.2, showed that the mean squares due to nitrogen level (N) was highly significant for late wilt resistant, indicating that the nitrogen dose effect on resistance to late wilt disease.

Table 2. Combined analysis of variance for late wilt resistant across two nitrogen levels.

SOV	df	Late wilt resistance %
Nitrogen levels (N)	1	720.42**
Rep/N	6	2.94
Crosses (C)	41	8.74**
C × N	41	2.77*
Error	246	1.72

***, ** Significant at the 0.05 and 0.01 levels of probability, respectively.**

This result is agreement with Mosa *et al*. (2010). Crosses mean squares were highly significant and the mean squares of the interaction C x N was significant. This implied that the resistance of crosses differed by the different nitrogen levels.

The line × tester analysis for days to 50% silking, plant height and grain yield across the two locations are presented in Table 3. The mean squares due to lines (L), testers (T) and L x T interaction were highly significant for these traits except for (T) for grain yield and L x T for days to 50% silking, indicating the presence of wide diversity among lines and testers for these traits and line performance differed from one tester to another. The mean squares due to L × Loc was highly significant for days to 50% silking, plant height and grain yield proving the point that lines performance was affected by change locations. T x Loc and L x T x Loc mean squares were significant for plant height and grain yield, respectively.

Table 3. Line x tester analysis of 40 crosses for three traits over two locations.

SOV	Df	Mean squares		
		Days to 50% silking	Plant height	Grain yield
Lines (L)	19	23.92**	509.91**	98.17**
Testers (T)	1	13.61**	4255.90**	23.43
L xT	19	1.52	207.79**	26.18**
L x Loc.	19	11.66**	662.24**	22.77**
T x Loc.	1	3.61	3373.50**	28.34
L x T x Loc.	19	1.47	96.94	18.13*
Error	234	1.30	100.64	10.70

***, ** Significant at the 0.05 and 0.01 levels of probability, respectively.**

In Table 4, the mean squares due to L, T, L x T and L x N were significant or highly significant for resistance to late wilt disease.

Table 4. Line x tester analysis of 40 crosses for late wilt resistant across two nitrogen levels.

SOV	df	Late wilt resistance %
Lines (L)	19	11.69**
Testers (T)	1	24.75**
L xT	19	3.76**
L x N	19	2.97*
T x N	1	0.03
L x T x N	19	2.27
Error	234	1.66

***, ** Significant at the 0.05 and 0.01 levels of probability, respectively.**

The assessment of genetic components for days to 50% silking, plant height and grain yield across two locations are presented in Table.5. The additive gene effects (K^2 GCA) were important component controlling inheritance of days to 50% silking. While, the non-additive gene effects (K^2 SCA) was the most important in inheritance plant height and grain yield. The magnitudes of the K^2 SCA x Loc interaction was larger than K^2 GCA x Loc for grain yield, indicating that the non-additive gene effects influenced more by changing locations than additive gene effects for this trait. Meanwhile, the reverse was obtained for days to 50% silking and plant height. Meanwhile in Table. 6, the result showed that, the non-additive gene effects (K^2 SCA) were more important than additive gene effect (K^2 GCA) in the inheritance of resistance to late wilt disease. The interaction K^2 SCA x N were larger than K^2 GCA x N, meaning that non-additive gene effects were more influenced by nitrogen level than additive gene effects. Similar results were obtained by El-Itriby *et al.* (1984), Mahmoud and Abd El-Azeem (2004), Abd-Elaziz (2010), Osman (2014), Mosa *et al.* (2016) and Mosa *et al.* (2017) .

Table 5. Genetic components for three traits over two locations.

Genetic components	Days to 50% silking	Plant height	Grain yield
K^2 GCA	0.12	2.89	0.31
K^2 SCA	0.01	13.85	1.00
K^2 GCA x Loc	0.13	43.64	0.16
K^2 SCA x Loc	0.04	0.92	1.85

Table 6. Genetic components for late wilt resistance across two nitrogen levels.

Genetic components	Late wilt resistance %
K^2 GCA	0.16
K^2 SCA	0.18
K^2 GCA x N	0.01
K^2 SCA x N	0.15

Mean performance of 40 crosses (20 single crosses and 20 three-way crosses) and two checks (SC 168 and TWC 368) across two locations for days to 50% silking, plant height and grain yield and late wilt resistance across two nitrogen levels are presented in Table 7.

Table 7. Mean performance of crosses and two checks for days to 50%silking, plant height and grain yield across two locations and late wilt resistance across two nitrogen levels.

Lines	Days to 50% silking		Plant height (cm)		Grain yield (ard/fed)		Late wilt resistance %	
	Sk 3	SC 177	Sk 3	SC 177	Sk 3	SC 177	Sk 3	SC 177
L-1	62.2	60.9	265.3	262.1	30.1	29.4	88.9	88.6
L-2	63.3	59.8	269.0	258.1	30.6	27.0	88.8	89.6
L-3	61.0	61.9	257.3	260.4	23.9	26.7	90.9	90.0
L-4	59.4	59.0	258.0	256.6	26.2	25.8	90.0	89.9
L-5	61.4	61.6	260.5	259.6	25.6	33.8	90.4	87.4
L-6	62.4	60.1	268.1	246.8	26.4	26.2	90.3	89.4
L-7	59.8	61.8	247.9	261.1	25.7	30.7	89.5	88.4
L-8	59.3	59.8	253.8	247.6	26.9	26.2	89.5	89.4
L-9	61.1	62.6	264.9	268.4	32.2	25.7	87.9	90.4
L-10	61.9	61.0	267.8	258.4	35.7	30.2	86.5	88.1
L-11	62.1	60.8	263.9	257.5	27.8	25.9	89.6	90.1
L-12	63.6	60.6	270.5	261.1	25.8	29.9	90.5	88.6
L-13	62.0	62.1	273.3	272.4	25.0	25.7	90.8	90.8
L-14	59.1	59.6	264.6	266.3	25.7	26.9	90.1	90.0
L-15	60.5	61.0	269.0	271.5	26.7	30.2	90.1	88.9
L-16	63.4	61.3	262.4	258.5	26.3	30.2	90.1	88.3
L-17	60.8	62.1	258.6	277.1	25.2	27.6	90.4	90.3
L-18	59.4	61.0	260.5	270.0	24.4	26.9	90.8	90.0
L-19	62.0	63.1	265.5	276.9	29.5	30.7	89.0	89.1
L-20	62.5	61.6	277.9	260.0	35.1	28.8	88.1	89.3
Check SC 168	63.6		254.4		31.5		84.3	
Check TWC 368	63.3		278.5		29.8		87.3	
LSD 0.05	1.1		9.9		3.3		1.3	
LSD 0.01	1.5		13.0		4.3		1.7	

Days to 50% silking, 16 single crosses were significantly early than the check SC 168 while 18 three way-crosses were significantly early than the check TWC 368. The earliest single cross was L-14 x Sk-3 (59.1 days) and the earliest three-way cross was L-4 x SC 177 (59.0 days). For plant height, single crosses ranged from 247.9 cm for L-7 x Sk-3 to 277.9 cm for L-20 x Sk-3. While, three-way crosses ranged from 246.8 cm for cross L-6 x SC 177 to 277.1 cm for cross L-17 x SC 177. For grain yield, single crosses means ranged from 23.9 ard/fed for cross L-3 x Sk-3 to 35.7 ard/fed for cross L-10 x Sk-3. While for three-way crosses means ranged from 25.7 ard/fed for crosses L-9 x SC 177 and L-13 x SC 177 to 33.8 ard/fed for cross L-5 x SC 177. Two single crosses (L-10 x Sk-3 and L-20 x Sk-3) were significantly out-yield compared to the check SC 168. Meanwhile, one three-way cross (L-5 × SC 177) was significant out-yield than check TWC 368. The percentage of late wilt resistance for single crosses ranged from 86.5% (L-10 x Sk-3) to 90.9% (L-3 x Sk-3), the best single crosses for resistance were L-3 x Sk-3, L-13 x Sk-3 and L-18 x Sk-3 while, three-way crosses ranged from 88.1% (L-10 x SC 177) to 90.8% (L-13 x SC 177), the best three-way crosses were L-3 x SC 177, L-9 x SC 177, L-13 x SC 177 and L-17 x SC 177. These hybrids could be considered as promising crosses in the hybrids breeding program and require further testing.

General combining ability for the studied inbreeds and testers for the four traits are illustrated in Table 8.

Table 8. Estimates of general combining ability effects of twenty inbred lines and two testers for days to 50% silking, plant height and grain yield across two locations and late wilt resistance across two nitrogen levels.

Inbred line		Days to 50% silking	Plant height	Grain yield	Late wilt resistance%
L-1		1.15**	1.34	1.04	-0.21
L-2		-0.41	-3.41	-0.30	-0.08
L-3		2.21**	6.53**	0.29	0.17
L-4		-1.04**	-3.60	0.49	-0.33
L-5		0.28	2.02	-3.50**	1.35**
L-6		0.78**	3.15	-1.72*	0.92**
L-7		-1.98**	-1.91	-1.98*	0.60
L-8		-1.91**	-1.78	-1.58	0.48
L-9		-0.29	1.53	-1.82*	0.79*
L-10		0.09	2.34	3.61**	-1.33**
L-11		1.65**	2.03	-1.56	0.73*
L-12		-0.54	-10.60**	0.29	-0.65*
L-13		-0.98**	-9.97**	-2.52**	0.48
L-14		0.71*	5.90*	1.22	-0.15
L-15		-1.91**	-6.10*	-2.32**	0.67*
L-16		-0.85**	-4.41	-1.37	0.23
L-17		0.34	1.97	2.91**	-1.02**
L-18		1.65**	9.40**	0.28	0.29
L-19		0.96**	9.59**	6.96**	-2.15**
L-20		0.09	-4.03	1.58	-0.77*
LSD g_i	5%	0.55	4.91	1.60	0.63
	1%	0.73	6.47	2.10	0.83
LSD g_i-g_j	5%	0.79	6.95	2.26	0.89
	1%	1.04	9.15	2.98	1.17
Tester					
Sk-3		-0.23**	-3.65**	0.27	-0.28**
SC 177		023**	3.65**	-0.27	0.28**
LSD g_i	5%	0.17	1.55	0.50	0.19
	1%	0.23	2.04	0.66	0.26
LSD g_i-g_j	5%	0.25	2.19	0.71	0.28
	1%	0.32	2.89	0.94	0.37

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

The desirable general combining ability effects (GCA) for days to 50% silking were found in inbred lines L-4, L-7, L-8, L-13, L-15, L-16 and tester Sk-3. Inbred lines L-3, L-14, L-18, L19 and Tester SC 177 showed positive significant GCA for taller plants, so these genotypes are good for breeding to silage yield while, L-12, L-13 and tester Sk-3 showed negative significant GCA for plant height. Theses inbred lines are good for breeding to short plants. The positive significant GCA for grain yield was obtained in L-10, L-17 and L-19, so these inbred lines are good general combiners for grain yield. For late wilt resistance, five inbred lines L-5, L-6, L-9, L-11, L-15 and tester SC 177 showed desirable positive significant GCA and could be used in breeding program for late wilt resistance.

The desirable crosses of specific combining ability effects for three traits over two locations and late wilt over two nitrogen levels are in Table. 9. The desirable crosses for specific combining ability effects were L-4 x Sk-3, L-17 x Sk-3, L-18 x Sk-3, L-1 x SC 177, L-2 x SC 177 and L-10 x SC 177 for earliness, L-5 x Sk-3, L-8 x Sk-3, L-17 x Sk-3, L-1 x SC 177, L-7 x SC 177 and L-16 x SC 177 for short plant height, L-2 x Sk-3, L-10 x Sk-3, L-20 x Sk-3, L-5 x SC 177, L-12 x SC 177 and L-16 x SC 177 for grain yield and L-7 x Sk-3, L-12 x Sk-3, L-20 x Sk-3, L-3 x SC 177, L-4 x SC 177 and L-16 x SC 177for resistance to late wilt disease. General, the desirable crosses for specific combining ability effects were L-20 x Sk-3 and L-16 x SC 177 for grain yield and late wilt resistance.

Table 9. The desirable crosses for days to 50% silking, plant height and grain yield across two locations and late wilt resistance across two nitrogen levels.

Days to 50% Silking	Plant height	Grain yield	Late wilt resistance%
L-4 x SK-3	L-5 x SK-3	L-2 x SK-3	L-7 x SK-3
L-17 x SK-3	L-8 x SK-3	L-10 x SK-3	L-12 x SK-3
L-18 x SK-3	L-17 x SK-3	L-20 x SK-3	L-20 x SK-3
L-1 x SC 177	L-1 x SC 177	L-5 x SC 177	L-3 x SC 177
L-2 x SC 177	L-7 x SC 177	L-12 x SC 177	L-4 x SC 177
L-10 x SC 177	L-16 x SC 177	L-16 x SC 177	L-16 x SC 177

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تقدير القدرة الائتلافية لبعض سلالات الذرة الشامية الصفراء لمحصول الحبوب والمقاومة للذبول المتأخر

عباس عبدالحى الشناوى، محمد عرفة على حسن، سعيد محمد أبو الحارس ومحمد عبد العزيز عبد النبى عبد العزيز

قسم بحوث الذرة الشامية – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية

تم التهجين بين ٢٠ سلالة جديدة صفراء من الذرة الشامية مع اثنين من الكشافات (سلالة سخا ٣ وهجين فردى ١٧٧) خلال موسم ٢٠١٧. قيمت الهجن الـ٤٠ الناتجة وكذلك الهجين الفردى التجارى ١٦٨ والهجين الثلاثى التجارى ٣٦٨ فى تجربتين خلال موسم ٢٠١٨. التجربة الأولى لمحصول الحبوب وقيمت فى موقعين بمحطتى بحوث سخا وسدس ، التجربة الثانية لتقييم المقاومة لمرض النبول المتأخر تحت معدلين من التسميد النتروجينى(٦٠ كجم نتروجين/فدان و١٢٠ كجم نتروجين للفدان) فى حقل معدى صناعيا بالمرض فى محطة بحوث سخا. تم عمل التحليل المشترك للموقعين للتجربة الاولى ولمعدلى التسميد النتروجينى للتجربة الثانية ويمكن تلخيص النتائج كما يلى: وجد أن هناك معنوية للتباين الراجع للسلالات والكشافات والتفاعل بينهما لمعظم الصفات.كانت تأثيرات الفعل الغيرمضيف للجينات هو المتحكم فى وراثة جميع الصفات تحت الدراسة ماعدا صفة عدد الايام حتى ظهور ٥٠% حريرة. أظهرت السلالة ل-٧ أفضل قدرة عامة على الائتلاف لصفة عدد الايام حتى ظهور ٥٠% حريرة والسلالة ل-١٩ لصفتى طول النبات ومحصول الحبوب والسلالة ل-٥ لصفة المقاومة لمرض الذبول المتأخر. أفضل الهجن فى القدرة الخاصة على الائتلاف هو ل-٢٠ × سخا ٣ و ل-١٦ × هـ ف ١٧٧ لصفة محصول الحبوب و المقاومة لمرض الذبول المتأخر. اعطى الهجينين ل-١٠× سخا٣ و ل-٢٠× سخا٣ زيادة معنوية فى محصول الحبوب عن هجين المقارنة هـ ف ١٦٨ وأيضا الهجين الثلاثى ل-٥× هـ ف ١٧٧ زيادة معنوية عن هجين المقارنة هـ ث ٣٦٨. ويمكن اعتبار هذه الهجن مبشرة وتصعد لإختبارات أخرى لإمكانية التسجيل.