J. Plant Production, Mansoura Univ., Vol. 8 (1): 97 - 102, 2017

Evaluation and Classification of Maize Inbred Lines by Line X Tester Analysis for Grain Yield, Late Wilt and Downy Mildew Resistance

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ABSTRACT

Twenty five new yellow inbred lines of maize were mated to two inbred lines(Sk11 and Sk2) as testers during 2014 season. The resulting 50 hybrids and the check hybrid SC168 were evaluated in three trials during 2015 season. The first for grain yield (t/ha) was conducted at Sakha and Sids research stations, the second and the third for late wilt and downy mildew resistance, each one was performed in two trials under two nitrogen levels(143 and 286 kg N/ha), respectively in two separate disease nurseries at Sakha Research Station. The first nursery under artificial soil inoculation by late wilt disease and the second nursery under artificial infection by downy mildew disease. The results were combined analysed across the two locations in the first trial and across two nitrogen levels in the second and third trials. Mean squares due to lines, testers and their interaction were significant for all traits, except for the interaction between lines x testers for late wilt resistance. The interactions lines, testers and lines x testers with locations were significant for grain yield, while their interactions with nitrogen levels were not significant for late wilt and downy mildew resistance. The non-additive gene effects were the most important component controlling the inheritance of all studied traits. The best inbred line for general combining ability effects was L6 for grain yield and downy mildew resistance and L10 for late wilt resistance. The best hybrid for specific combining ability effects was L22 x Sk2 for gain yield, L20 x Sk2 for late wilt resistance and L13 x Sk2 for downy mildew resistance. The hybrid L6 x Sk11 had high grain yield (>check) and high resistance to both late wilt and downy mildew. The 25 inbred lines were classified into the following two heterotic groups using HSGCA: for grain yield: group 1 (SK11): L_9, L_{10}, L_{11}, L_{12}, L_{15}, L_{19}, L_{22} and L_{23} and group 2 (SK2): L_1, L_2, L_3, L_5, L_{14}, L_{16}, L_{17}, L_{21}, L_{24} and L_{25} , for late wilt resistance: group 1 (SK11): L_3, L_{15}, L_{16}, L_{19}, L_{20}, L_{21} and L_{25} and group 2 (SK2): L_1, L_4, L_6, L_7, L_{11}, L_{12}, L_{13} and $_{L14}$. For downy mildew resistance: group 1 (SK11): L_1, L_2, L_{13}, L_{15} and L_{21} and group 2 (SK2): L_3, L_4, L_7, L_{12}, L_{14}, L_{17} and L_{25}. These groups could be used in breeding programs for selecting the best parents in making crosses.

Keywords:*Combining ability, Additive effects, Non-additive effects, Heterotic groups, Heterotic pattern.*

INTRODUCTION

The main goal of the Egyptian national maize program is to develop new hybrids with high yielding and diseases resistance. Late wilt, caused by *Cephalosporium maydis* is one of the most economical diseases of maize in Egypt. The first record of late wilt as a vascular wilt disease in Egypt was in 1960. *Cephalosporium maydis* is known as a soil and/or seed born pathogen. This fungus reproduces asexually and no perfect stage has been identified. Moreover, it was mentioned that Egyptian isolates of *C. maydis* differed in their morphology, pathogenicity and mode of infection. In naturally infested fields with *C. maydis,* infection reached up to 80% in susceptible cultivars and the yield losses reached up to 40%. Mosa *et al.* (2010) found 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. Sorghum downy mildew (*Peronosclerospora sorghi*) as one of the most destructive disease of maize in Egypt, especially in Delta region is caused by late planting date and planting sudan grass and sorghum beside maize. This fungus induces systemic infection in plant and some causes local lesions as well. The systemic form of the disease is caused by infection of seedliness by oospores of the fungus born in the soil. The localized form of the disease is caused from foliar infection by conidia oospores. Yamada and Aday (1977) reported that only nitrogen independently of phosphorus and potassium was effective for seedling to cause infection of the Philippine downy mildew. Sadoma (1995) studied the maize resistance to downy mildew disease and found that the genotypes were categorized as highly resistant (0-5%) incidence infection, resistant (5.1-10%), moderately resistant (10.1-20%), moderately susceptible (20.1-30%), susceptible (30.1-50%) and highly susceptible (50.1-100%). The information of the type of gene actions is very important for the breeder in making decisions for the collocation resources and expected response to selection for resistance to this disease. Nawar and Salem (1985), Rameeh *et al.* (2000), Nair *et al.* (2004), El-Shenawy and Mosa (2005), Mosa and Motawei (2005), Mosa *et al.* (2010), Mosa (2011) and Abd el-Kareem (2013) found that additive gene effects played a major role in the expression of resistance to late wilt, downy mildew diseases and grain yield, while El-Itriby *et al.* (1984), Turgut *et al.* (1995), Amer *et al.* (2002), and Mosa *et al.* (2016) reported that non additive gene effects were predominant in the inheritance of late wilt, downy mildew and grain yield. Heterotic groups and patterns are extremely important in hybrid breeding.Melchinger and Gumber (1998) defined a heterotic group as a group of related or unrelated genotypes from the same or different populations, which display similar combining ability and heterotic response when crossed with genotypes from other genetically distinct germplasm groups. Fan *et al.* (2009) reported that heterotic groups using specific and general combining ability (HSGCA) method is a practical and easy to follow procedure to classify maize inbred lines into known heterotic groups.The new method was more reliable and efficient than traditional maize heterotic group classification methods that the use of SCA-GY and molecular markers. The main objectives of this study were to estimate general and specific combining ability effects, nature of inheritance for grain yield, late wilt and downy mildew resistance, identify the superior hybrids in grain yield and high resistance to both two diseases ($\geq$95%) and classifying the inbred lines into heterotic groups using specific and general combining abilities (HSGCA method) derived from line x tester analysis.

MATERIALS AND METHODS

The materials used in this study were the twenty five new yellow maize inbred lines, L_1 (SK5002/38), L_2 (SK5002/39), L_3 (SK5002/40), L_4 (SK5002/41), L_5(SK5002/42), L_6 (SK5002/43), L_7 (SK5002/44), L_8 (SK5002/45), L_9 (SK5003/46), L_{10} (SK5003/47), L_{11} (SK5003/48), L_{12} (SK5003/49), L_{13} (SK5003/50), L_{14} (SK5003/51), L_{15} (SK5003/52), L_{16} (SK5004/53), L_{17} (SK5004/54), L18 (S5004/55), L_{19} (SK5004/56), L_{20} (SK5004/57), L_{21} (SK5004/58), L_{22} (SK5004/59), L_{23} (SK5004/60), L_{24} (SK5004/61) and L_{25} (SK5004/63) derived from the S_5 segregating of 3 different genetic sources by self pollination, visual selection for plant and ear traits and pest resistance of the lines *per se* among and within ear to row progenies in breeding field at Sakha Research Station starting from 2009 season. In 2014 growing season, 25 inbred lines were crossed with two different genetic sources as testers; inbred line SK11 and inbred line Sk2. The resulting crosses (50) and one commercial cross (SC168) were evaluated in three trials during 2015 growing season. The first trial (for grain yield) was conducted at Sakha and Sids Research Stations. A randomized complete block design (RCBD) with four replications was used at both locations. The plot size was one row, 6 m length, 80 cm apart and 25 cm between hills. Two kernels were planted per hill then thinned to one plant per hill before the first irrigation. All cultural practices were applied as recommended at the proper time. Data were recorded on grain yield ton per hectare(t/ha) adjusted to 15.5% moisture content. The second experiment (for resistance to late wilt) was performed in two separate trials under two nitrogen levels (143 and 286 kg N/ha), respectively in disease nursery under artificial soil inoculation by the pathogen *Cephalosporium maydis* at Sakha Research Station. Annually in same place, different isolates of *Cephalosporium maydis* were used to re-infect disease nursery to increase the efficiency of selection. RCBD with two 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 flowring. The third (for resistance to downy mildew) was carried out in two separate trials under two nitrogen levels (143 and 286 kg N/ha), respectively in the late season (July) in the disease nursery under artificial infection by downy mildew disease caused by *Peronosclerospora sorghi* at Sakha Research Station. Annually in the same place , this field was previously planted by sudan grass as a source of infection, 30 days prior to planting of tested genotypes. Spreader rows (sudan grass) were alternatively planted with maize rows in a ratio of 1:3, respectively. RCBD with two replications was also used; plot size was one row, 2 m long, 80 cm apart and 20 cm between hills. Two kernels were planted per hill and left without thinning. Percentage of resistance to downy mildew disease was recorded after 40 days from planting. The nitrogen fertilizer was applied in two equal doses, at the first and the second irrigation in the late wilt trial and at the planting and the first irrigation in downy mildew trial. Combined analysis across two locations in the first trial and across two nitrogen levels in the second and third trials was performed when homogeneity of variance was detected. Combining ability analysis was computed according to line x tester analysis procedure of Kempthorne (1957). Heterotic groups using specific and general combining ability (HSGCA) were made according to Fan *et al*. (2009).

RESULTS AND DISCUSSION

The combined analysis of variance of line x tester mating design for grain yield across two locations is presented in Table (1). Highly significant differences were shown between the two locations (Loc), indicating that grain yield was affected by environmental conditions prevailed in different locations. While, the mean squares due to nitrogen levels were not significant for late wilt and downy mildew resistance (Table 2), indicating that the late wilt and downy mildew resistance were not affected by nitrogen fertilization. Results in Tables (1 and 2) showed that the mean squares due to hybrid (H) and their partitioning into lines (L), testers (T) and (L x T) interaction were significant or highly significant for all studied traits, except for L x T was not significantfor late wilt resistance. The interaction mean squares of H x Loc and their portioning into L x Loc, T x Loc and L x T x Loc were significant or highly significant for grain yield, while the interaction mean squares of H x N and their portioning into L x N, T x Nand L x T x N were not significant for late wilt and downy mildew resistance.

Table 1. Combined analysis of variance of line x tester mating design for grain yield(t/ha) across two locations.

S.O.V	d.f	Mean squares Grain yield (t/ha)
Locations (Loc)	1	927.111**
Rep./Loc.	6	4.332
Hybrids (H)	49	6.29**
Lines (L)	24	8.05**
Testers (T)	1	37.30**
L x T	24	3.23**
H x Loc	49	3.54**
L x Loc	24	5.39**
T x Loc	1	5.53**
L x T x Loc	24	1.60*
Error	294	0.91

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

Table 2. Combined analysis of variance of line x tester mating design for late wilt and downy mildew resistance across two nitrogen levels.

S.O.V	d.f	Mean squares	
		Late wilt resistance (%)	Downy mildew resistance (%)
Nitrogen (N)	1	312.62	1017.92
Rep/N	2	309.35	1008.80
Hybrids (H)	49	248.16**	512.88**
Lines (L)	24	298.90**	620.82**
Testers (T)	1	808.02*	1764.18**
L x T	24	174.10	352.81**
H x N	49	56.37	54.95
L x N	24	55.80	62.05
T x N	1	10.58	0.20
L x T x N	24	59.22	50.13
Error	98	133.24	83.52

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

The estimates of combining ability variance components for grain yield, late wilt and downy mildew resistance are presented in Table (3). The K^2SCA or non-additive gene effects were the most important component controlling in the inheritance of grain yield, late wilt and downy mildew resistance. This result support the findings of El-Itriby *et al.* (1984), Turgut *et al.* (1995), Amer *et al.* (2002), Mosa (2011) and Mosa *et al.* (2016).

Table 3. Estimates of combining ability variance components for grain yield, late wilt and downy mildew resistance.

Estimate	Grain yield (t/ha)	Late wilt resistance (%)	Downy mildew resistance%
K^2GCA	0.143	7.77	20.53
K^2SCA	0.203	10.22	67.32
K^2GCA/K^2SCA	0.70	0.76	0.30

Mean performance of inbred lines in their crosses for grain yield across two locations, late wilt and downy mildew resistance across two nitrogen levels is presented in Table (4). The results showed that SK11 tester had the highest grain yield with the L_8, L_6 and L_5 inbred lines (11.33, 10.85, and 10.65 t/ha, respectively), while L_1 and L_{22} had the lowest grain yield with the same tester (7.76 and 8.16 t/ha, respectively). Meanwhile, SK2 tester had the highest grain yield with the L_6, L_7 and L_{10} inbred lines (10.78, 10.43 and 10.11 t/ha, respectively), while L_1 and L_{21} inbred lines had the lowest grain yield with the same tester (6.79 and 7.84 t/ha, respectively).

Table 4. Mean performance of inbred lines in their crosses for grain yield across two locations, late wilt and downy mildew resistance across two nitrogen levels.

Inbred line	Grain yield (t/ha)		Late wilt resistance %		Downy mildew resistance %	
	SK11	**SK2**	**SK11**	**SK2**	**SK11**	**SK2**
L_1	7.76	6.79	82.00	85.25	69.01	87.00
L_2	9.96	8.77	97.50	95.00	59.37	91.96
L_3	10.37	9.17	83.50	95.50	79.42	79.20
L_4	10.14	9.66	100.00	92.50	85.24	87.20
L_5	10.65	8.65	100.00	100.00	86.53	95.81
L_6	10.85	10.78	95.50	86.50	96.68	98.81
L_7	10.51	10.43	83.75	85.00	81.92	79.23
L_8	11.33	10.05	95.30	97.75	90.80	95.66
L_9	9.39	8.96	100.00	100.00	93.18	95.00
L_{10}	9.05	10.11	100.00	100.00	96.87	95.34
L_{11}	9.78	9.80	91.00	90.50	90.83	98.91
L_{12}	9.58	9.75	95.00	85.00	80.15	60.09
L_{13}	10.49	9.42	93.00	86.50	51.99	96.87
L_{14}	9.55	7.90	84.25	86.25	95.00	90.00
L_{15}	9.25	9.75	88.75	100.00	81.14	100.00
L_{16}	10.60	8.73	86.50	100.00	98.75	94.76
L_{17}	9.87	8.85	97.75	97.75	77.67	72.02
L_{18}	10.57	9.69	93.25	100.00	88.92	94.98
L_{19}	9.44	9.36	72.25	86.50	96.22	98.61
L_{20}	10.11	9.59	68.00	93.25	93.93	100.00
L_{21}	9.16	7.84	78.75	100.00	69.31	91.46
L_{22}	8.16	9.83	93.25	100.00	87.50	94.60
L_{23}	9.51	9.42	100.00	97.75	92.61	97.18
L_{24}	10.08	8.63	97.75	97.75	96.28	93.75
L_{25}	10.15	9.13	81.50	100.00	97.22	96.25
Check (SC168)	10.30		93.25		95.25	
LSD 0.05	1.84		15.99		12.66	
LSD 0.01	2.42		21.05		16.67	

Out of 50 hybrids evaluated, ten hybrids (L_3 x SK11, L_5 x SK11, L_6 x SK11, L_7 x SK11, L_8 x SK11, L_{13} x SK11, L_{16} x SK11, L18 x SK11, L_6 x SK2 and L_7 x SK2) did not significantly outyield the check SC168 (10.3 t/ha). Out of the superior ten hybrids, the new hybrids (L_8 x SK11) (11.33 t/ha) and L_6 x SK11 (10.85 t/ha) outyielded all the hybrids under study. It could be concluded that these inbred lines and crosses could be immediately utilized by corn breeders to develop new hybrids with high yield potentiality. For late wilt resistance, the results showed that SK11 tester had 100% resistance for its hybrids with the inbred lines L_4, L_5, L_9, L_{10} and $L_{23}$and SK2 tester exhibited the same result (100% resistance) with inbred lines L_5, L_9, L_{10}, L_{15}, L_{16}, L_{18}, L_{21}, L_{22} and L_{25}.From, the above results, the inbred lines L_5, L_9 and L_{10} gave 100% resistance with the two testers. The high resistant hybrids (>95%) were L_2 x SK11, L_4 x SK11, L_5 x SK11, L_6 x SK11, L_8 x SK11, L_9 x SK11, L_{10} x SK11, L_{17} x SK11, L_{23} x SK11, L_{24} x SK11, L_3 x SK2, L_5 x SK2, L_8 x SK2, L_9 x SK2, L_{10} x SK2, L_{15} x SK2, L_{16} x SK2, L_{17} x SK2, L18 x SK2, L_{21} x SK2, L_{22} x SK2 L_{23} x SK2, L_{24} x SK2 and L_{25} x SK2; all these hybrids were more resistant than the check SC168 (93.25%). It could be concluded that these inbred lines and hybrids are good materials for resistance to late wilt disease. For downy mildew resistance, the results exhibited that the SK11 tester had high resistance (>95%)for its hybrids with the inbred lines L_6, L_{10}, L_{16}, L_{19}, L_{24} and L_{25}, also SK2 tester showed 100% resistance in hybrids with the inbred lines L_{15} and L_{20} and high resistance (>95%) with L_5, L_6, L_8, L_{10}, L_{11}, L_{13}, L_{19}, L_{23} and L_{25}. From above results, the inbred lines L_6, L_{10}, L_{19} and L_{25} showed high resistance to downy mildew in hybrids with the two testers SK11 and SK2. The high resistant hybrids (>95%) and higher resistance than check SC168 (95.25%) were L_6 x SK11, L_{10} x SK11, L_{16} x SK11, L_{19} x SK11, L_{24} x SK11, L_{25} x SK11, L_5 x SK2, L_6 x SK2, L_8 x SK2, L_{10} x SK2, L_{11} x SK2, L_{13} x SK2, L_{15} x SK2, L_{19} x SK2, L_{20} x SK2, L_{23} x SK2 and L_{25} x SK2. These inbred lines and their hybrids could be utilized in the breeding programs for resistance to downy mildew disease.

In general, hybrid L_6 x SK11 had high grain yield and high resistance to both of late wilt and downy mildew diseases, hybrids L_5 x SK11, and L_8 x SK11 had high grain yield and high resistance to late wilt disease, hybrid L_6 x SK2 had high grain yield and high resistance to downy mildew disease and hybrids L_3 x SK11, L_7 x SK11, L_{13} x SK11, L18 x SK11 and L_7 x SK2 had high grain yield (> check).

Estimates of general combining ability effects of 25 inbred lines and two testers for grain yield across two locations, late wilt and downy mildew resistance across two nitrogen levels are presented in Table (5).

Table 5. Estimates of general combining ability effects of 25 inbred lines and two testers for grain yield across two locations, late wilt and downy mildew resistance across two nitrogen levels

Inbred line	Grain yield (t/ha)	Late wilt resistance (%)	Downy mildew resistance (%)
L_1	-2.271**	-8.715*	-10.45**
L_2	-0.183	3.910	-12.825**
L_3	0.219	-2.840	-9.075**
L_4	0.355	3.900	-2.200
L_5	0.102	7.660*	2.675
L_6	1.253**	-1.340	9.300**
L_7	0.920**	-7.965*	-7.825*
L_8	1.139**	4.035	4.800
L_9	-0.374	7.660*	5.675
L_{10}	0.037	7.67*	7.800*
L_{11}	0.244	-1.590	6.425*
L_{12}	0.115	-2.340	-18.075**
L_{13}	0.406	-2.590	-14.075**
L_{14}	-0.819**	-7.090	4.050
L_{15}	-0.051	2.035	2.175
L_{16}	0.114	0.910	8.300*
L_{17}	-0.190	5.410	-13.450**
L_{18}	0.581*	4.285	3.425
L_{19}	-0.146	-12.965**	8.925**
L_{20}	0.301	-11.715**	8.550**
L_{21}	-1.048**	-2.965	-8.200*
L_{22}	-0.521*	4.285	2.675
L_{23}	-0.082	6.535	6.425*
L_{24}	-0.195	5.410	6.675*
L_{25}	0.093	-1.590	-8.300*
Testers:SK11	0.31**	-2.01	-0.97**
SK2	-0.31**	2.01	0.97**
Lines: LSD g_i 0.05	0.46	7.66	6.33
0.01	0.61	10.52	8.33
LSD g_i-g_j 0.05	0.66	11.31	8.95
0.01	0.87	14.89	11.78
Testers: LSD g_i 0.05	0.13	2.26	1.79
0.01	0.17	2.97	2.35
LSD gi-gj 0.05	0.186	3.19	2.53
0.01	0.246	4.21	3.33

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

The desirable general combining ability effects (GCA) of inbred liens were obtained by L_6, L_7, L_8 and L_{18} for grain yield, L_5, L_9 and L_{10} for late wilt resistance and L_6, L_{10}, L_{11}, L_{16}, L_{19}, L_{20}, L_{23} and L_{24} for downy mildew resistance. From above results, the inbred line L_6 had the highest value for GCA effects for grain yield and downy mildew resistance. The best tester for GCA effects was SK11 for grain yield and SK2 for late wilt and downy mildew resistance.

The results in Table (6), showed that the best hybrids for specific combining ability effects were L_5 x SK11, L_{10} x SK2, L_{16} x SK11 and L_{22} x SK2 for grain yield, L_{20} x SK2 and L_{21} x SK2 for resistance to late wilt disease and L_2 x SK2, L_{12} x SK11 and L_{13} x SK2 for resistance to downy mildew disease. These hybrids could be utilized in maize breeding programs.

Estimates of heterotic groups based on specific and general combining ability effects (HSGCA) for grain yield, late wilt and downy mildew resistance are presented in Table (7). Fan *et al.* (2009) proposed that the method of heterotic groups based on specific and general combining ability (HSGCA).The inbred lines were divided into groups according to the following; Step1, place all inbred lines (the 25 inbred lines)in the same heterotic group as their tester. Step 2, keep the inbred line with the hterotic group, where its HSGCA effects had the smallest value (or largest negative value) and remove it from other heterotic groups. Step 3, if the inbred line had positive HSGCA effects with all representative testers, it will be cautious to assign that line to any heterotic group because the line might belong to a heterotic group different from the testers used in the investigation.

For grain yield, group 1 (tester SK11) included L_9, L_{10}, L_{11}, L_{12}, L_{15}, L_{19}, L_{22} and L_{23}, while group 2 (tester SK2) included L_1, L_2, L_3, L_5, L_{14}, L_{16}, L_{17}, L_{21}, L_{24} and L_{25}. However, the method was not able to classify the inbred lines L_4, L_6, L_7, L_8, L_{13}, L_{18} and L_{20}. For late wilt resistance, group 1 (tester SK11) included L_3, L_{15}, L_{16}, L_{19}, L_{20}, L_{21} and L_{25}, while group 2 (tester SK2) included L_1, L_4, L_6, L_7, L_{11}, L_{12}, L_{13} and L_{14}. However, the method was not able to classify the inbred lines L_2, L_5, L_8, L_9, L_{10}, L_{17}, L18, L_{22}, L_{23} and L_{24}. For downy mildew resistance, group 1 (tester SK11) included L_1, L_2, L_{13}, L_{15}, and L_{21} while group 2 (tester SK2) included L_3, L_4, L_7, L_{12}, L_{14}, L_{17} and L_{25}. Meanwhile, the method was not able to classify the inbred lines L_5, L_6, L_8, L_9, L_{10}, L_{11}, L_{16}, L_{18}, L_{19}, L_{20}, L_{22}, L_{23} and L_{25}. The above results could be recommended for breeding programs in selecting the best parents for making crosses. Bernard (2001) reported that the heterotic group comprises a set of inbreds that have a similar performance when crossed with inbreds from another heterotic group. The inbreds within a heterotic group are often related due to advanced cycles of breeding. Two heterotic groups that complement each other comprise a heterotic pattern. Lee (1995) stated that a heteotic group is a collection of closely related inbred lines which tend to result in vigorous hybrids when crossed with lines from a different heterotic group, but not when crossed to other lines of the same heterotic group.

Table 6. Estimates of specific combining ability effects of 50 hybrids for grain yield across two locations, late wilt and downy mildew resistance across two nitrogen levels

Inbred line	Grain yield (t/ha)		Late wilt resistance (%)		Downy mildew resistance (%)	
	SK11	SK2	SK11	SK2	SK11	SK2
L_1	0.179	-0.179	0.385	-0.385	-6.030	6.030
L_2	0.291	-0.291	3.260	-3.260	-13.405**	13.405**
L_3	0.295	-0.295	-3.990	3.990	3.095	-3.095
L_4	-0.062	0.062	5.760	-5.760	1.970	-1.970
L_5	0.695*	-0.695*	2.010	-2.010	-1.655	1.655
L_6	-0.254	0.254	6.510	-6.510	1.970	-1.970
L_7	-0.269	0.269	1.385	-1.385	4.345	-4.345
L_8	0.331	-0.331	0.635	-0.635	0.470	-0.470
L_9	-0.087	0.087	2.010	-2.010	2.095	-2.095
L_{10}	-0.835*	0.835*	2.010	-2.010	3.720	-3.720
L_{11}	-0.315	0.315	2.260	-2.260	-1.155	1.155
L_{12}	-0.386	0.386	7.010	-7.010	13.095**	-13.095**
L_{13}	0.230	-0.230	5.260	-5.260	-19.655**	19.655**
L_{14}	0.522	-0.522	1.010	-1.010	5.470	-5.470
L_{15}	-0.554	0.554	-3.615	3.615	-6.405	6.405
L_{16}	0.634*	-0.634	-4.740	4.740	4.970	-4.970
L_{17}	0.205	-0.205	2.010	-2.010	5.720	-5.720
L_{18}	0.134	-0.134	-1.365	1.365	0.095	-0.095
L_{19}	-0.263	0.263	-5.115	5.115	1.845	-1.845
L_{20}	-0.044	0.044	-10.615	10.615	-0.030	0.030
L_{21}	0.357	-0.357	-8.615	8.615	-8.030	8.030
L_{22}	-1.168**	1.168**	-1.365	1.365	-0.655	0.655
L_{23}	-0.257	0.257	3.135	-3.135	0.595	-0.595
L_{24}	0.422	-0.422	2.010	-2.010	4.095	-4.095
L_{25}	0.200	-0.200	-7.240	7.240	3.470	-3.470
LSD s_{ij} 0.05	0.63		11.31		8.95	
0.01	0.87		14.89		11.78	
LSD sij-skl 0.05	0.96		15.99		12.66	
0.01	1.26		21.05		16.67	

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

Table 7. Estimates of heterotic groups using specific and general combining ability (HSGCA) for grain yield, late wilt and downy mildew resistance

Inbred line	Grain yield (t/ha)		Late wilt resistance (%)		Downy mildew resistance (%)	
	SK11	SK2	SK11	SK2	SK11	SK2
L_1	-2.092	-2.45	-8.33	-9.1	-16.148	-4.42
L_2	0.108	-0.474	7.17	0.65	-26.23	0.58
L_3	0.514	-0.076	-6.83	1.15	-5.98	-12.17
L_4	0.291	0.415	9.66	-1.86	-0.23	-4.17
L_5	0.797	-0.593	9.67	5.65	1.02	4.33
L_6	0.999	1.507	5.17	-7.85	11.27	7.33
L_7	0.651	1.189	-o.58	-9.35	-3.48	-12.17
L_8	1.47	0.808	4.67	3.4	5.27	4.33
L_9	-4.61	-0.287	9.67	5.65	7.77	3.58
L_{10}	-0.798	0.872	9.67	5.65	11.52	4.08
L_{11}	-0.071	0.559	0.67	-3.85	5.27	7.58
L_{12}	-0.27	0.501	4.67	-9.35	-4.98	-31.17
L_{13}	0.636	0.176	2.67	-7.85	-33.73	5.58
L_{14}	-0.297	-1.341	-6.08	-8.10	9.52	-1.42
L_{15}	-0.605	0.503	-1.58	5.65	-4.23	8.58
L_{16}	0.748	-0.520	-3.83	5.65	13.27	3.33
L_{17}	0.015	-0.395	7.42	3.40	-7.73	-19.17
L_{18}	0.715	0.447	2.92	5.65	3.52	3.33
L_{19}	-0.409	0.117	-18.08	-7.85	10.77	7.08
L_{20}	0.257	0.345	-22.33	-1.1	8.52	8.58
L_{21}	-0.691	-1.405	-11.58	5.65	-16.23	-0.17
L_{22}	-1.688	0.648	2.92	5.65	2.02	3.33
L_{23}	-0.339	0.175	9.66	3.39	7.02	5.83
L_{24}	0.227	-0.617	7.42	3.40	10.77	2.58
L_{25}	0.293	-0.107	-8.83	5.65	-4.83	-11.77

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تقييم وتقسيم سلالات من الذرة الشامية عن طريق تحليل السلالة × الكشاف لصفات المحصول والمقاومة لمرضى الذبول المتأخر والبياض الزغبى

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تم التهجين بين ٢٥ سلالة صفراء من الذرة الشامية واثنين من الكشافات (سلالة سخا ١١ وسلالة سخا ٢) خلال موسم ٢٠١٤. قيمت الهجن الـ٥٠ الناتجة وكذلك الهجين الفردى التجارى ١٦٨ فى ثلاث تجارب خلال موسم ٢٠١٥. التجربة الأولى لمحصول الحبوب (طن/هكتار) وقيمت فى موقعين بمحطتى بحوث سخا وسدس ، التجربتين الثانية والثالثة لتقييم المقاومة لمرض الذبول المتأخر ومرض البياض الزغبى ،على التوالى. كل مرض قييم فى تجربتين منفصلتين تحت معدلين من التسميد النتروجينى(١٤٣ كجم نتروجين/هكتار و٢٨٦ كجم نتروجين للهكتار) على التوالى فى حقلين منفصلين للعدوى الصناعية. تم عمل التحليل المشترك للموقعين للتجربة الاولى ولمعدلى التسميد النتروجينى للتجربة الثانية والثالثة ويمكن تلخيص النتائج كما يلى: وجد ان هناك معنوية للتباين الراجع للسلالات والكشافات والتفاعل بينهما لجميع الصفات ماعدا التفاعل بين السلالات والكشافات لصفة المقاومة لمرض الذبول المتأخر وكذلك تباين تفاعل السلالات والكشافات والسلالات × الكشافات مع المواقع معنويا لصفة المحصول بينما تباين تفاعلهم مع مستويات النتروجين لم يكن معنويا لصفتى المقاومة لمرض الذبول المتأخر والبياض الزغبى. تأثيرات الفعل الغيرمضيف للجينات هو المتحكم فى وراثة جميع الصفات تحت الدراسة. أظهرت السلالة ل٦ أفضل قدرة عامة على الائتلاف لصفتى المحصول والمقاومة لمرض البياض الزغبى والسلالة ل١٠ لصفة المقاومة لمرض الذبول المتأخر. أعلى هجين فى القدرة الخاصة على الائتلاف هو ل٢٢ × سخا ٢ لصفة المحصول ول٢٠ × سخا ٢ لصفة المقاومة لمرض الذبول المتأخر ول١٣ × سخا ٢ لصفة المقاومة لمرض البياض الزغبى. أعطى الهجين ل٦ × سخا١١ محصول اعلى من هجين المقارنة ومقاومة عالية لمرض الذبول المتأخر ومرض البياض الزغبى. تم تكوين مجموعات متباعدة وراثيا بإستخدام تأثيرات القدرتين العامة والخاصة على الائتلاف حيث قسمت السلالات إلى إثنين من المجاميع المتباعدة وراثيا هى: لصفة المحصول المجموعة الأول (للكشاف سخا ١١) وتضم السلالات ل٩ ، ل١٠ ، ل١١ ، ل١٢ ، ل١٥ ، ل١٩ ، ل٢٢ ، ل٢٣ والمجموعة الثانية (للكشاف سخا ٢) وتضم السلالات ل١ ، ل٢ ، ل٣ ، ل٥ ، ل١٤ ، ل١٦ ، ل١٧ ، ل٢١ ، ل٢٤ ، ل٢٥ ولصفة المقاومة للذبول المتأخر المجموعة الأولى(للكشاف سخا١١) تضم السلالات ل٣ ، ل١٥ ، ل١٦ ، ل١٩ ، ل٢٠ ، ل٢١ ، ل٢٥ والمجموعة الثانية(للكشاف سخا ٢)تضم ل١ ، ل٤ ، ل٦ ، ل٧ ، ل١١ ، ل١٢ ، ل١٣ ، ل١٤و لصفة المقاومة للبياض الزغبى . تضم المجموعة الاولى (للكشاف سخا ١١)السلالات ل١ ، ل٢ ، ل١٣ ، ل١٥ ، ل٢١ والمجموعة الثانية (للكشاف سخا ٢) تضم ل٣ ، ل٤ ، ل٧ ، ل١٢ ، ل١٤ ، ل١٧ ، ل٢٥. هذه المجاميع يمكن أن يستفاد منها فى انتخاب افضل السلالات لعمل الهجن