EVALUATION OF NEW MAIZE HYBRIDS FOR GRAIN YIELD AND RESISTANCE TO DOWNY MILDEW DISEASE

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ABSTRACT

A number of 36 hybrids obtained directly from crossing among nine white inbred lines in a half diallel system and two commercial hybrids were evaluated in 2009 season in two experiments: The first (yield experiments) was planted in the normal season (May) at Sakha and Mallawy Agric. Res. Sta. to evaluate grain yield. The second (disease experiments) was carried out under three nitrogen levels, i.e. 60, 120 and 180 kg N/fed in late season (July) in the disease nursery under artificial infection by downy mildew disease at Sakha Station to evaluate resistance to downy mildew disease. The results showed that the differences among locations were highly significant for grain yield, while the differences among nitrogen levels were not significant for resistance to downy mildew disease. The non-additive gene action was most responsible for controlling the inheritance of grain yield. While, additive gene action was controlling resistance to downy mildew disease. The non-additive gene action interacted more with the environment than the additive gene action for grain yield. Significant desirable general combining ability effects were detected in inbred line Sk5140 for grain yield and inbred Sk5058 for resistance to downy mildew. While desirable specific combining ability effects were shown in hybrid Sk5058 x Sk8238 for grain yield. Two hybrids, i.e. Sd7 x Sk5058 and Sk5058 x Sk5140 showed high resistance to downy mildew and insignificantly outyielded the commercial hybrids, SC10 and SC129, while hybrid Sk5058 x Sk8238 exhibited high resistance to downy mildew disease and significantly outyielded SC10 and SC129. This study suggests using the above three hybrids as good hybrids for grain yield and resistance to downy mildew especially in Delta region in Egypt.

Key words: ***Downy mildew, Maize, Peronosclerospora sorghi, Combining ability.***

INTRODUCTION

One of the main objectives of national maize program in Egypt is releasing high yielding hybrids and of resistance to the major diseases. Downy mildew (*Peronsclerospora sorghi*) as one of the most destructive diseases of maize in Egypt, especially in Delta Region caused by late planting date and planting sudan grass and sorghum beside maize. The best way of controlling this disease is through developing genetically resistant maize hybrids. However, natural disease resistance mechanisms can be enhanced by plant nutrients. Yamada and Aday (1977) reported that only nitrogen independently of phosphorus and potassium was effective for seedling to cause infection of Philippine downy mildew and that susceptibility of a resistant matrial was hardly affected by the application of three elements, in any amount and in any combination. Orangel and Borges (1987) found that the crosses between the resistant and the susceptible lines showed intermediate disease reaction to sorghum downy mildew in maize. Both additive and non-additive gene effects were present. However, additive gene effects were clearly more important in controlling disease reaction. Sadoma (1995) studied the maize resistance to downy mildew disease. The genotypes were categorized as highly resistant (0-5% incidence), resistant (5.1-10%), moderately resistant (10.1-20%), moderately susceptible (20.1-30%), susceptible (30.1-50%) and highly susceptible (50.1-100%). Patil *et al* (1983), El-Shenawy (1995), Al-Naggar *et al* (1997), Nair *et al* (2004) and El-Shenawy and Mosa (2005) reported that additive gene effects were predominant in the inheritance of downy mildew disease. While, El-Shenawy and Tolba (2001) and Mosa *et al* (2009) found that non-additive gene effects were the major portion of the genetic variance conditioning for downy mildew. Inheritance of grain yield was studied by many investigators. Nevado and Jhnso (198?), Hamid *et al* (1995) and Mosa and Motawei (2005) found that additive gene effects play an important role in the inheritance of grain yield. While Debnath *et al* (1988), Turgut *et al* (1995) and Mosa *et al* (2010) found that non-additive gene effects played a major role in the expression of grain yield. The main objectives of this study were: to estimate general and specific combining ability effects and nature of inheritance for resistance to downy mildew disease and grain yield and to identify the superior crosses for resistance to downy mildew disease and grain yield.

MATERIALS AND METHODS

Nine white maize inbred lines, i.e. Sk5, Sd7, Sk9, L63b, Sk5058 this inbred resistant to downy mildew disease, Sk5140, Sk5215, Sk8238 and Gm 18 were crossed in all possible combinations in a half diallel system in 2008 season at Sakha Agric. Res. Sta. In 2009 season, the 36 F_1 hybrids and two commercial hybrids, i.e. SC10 and SC129 were evaluated in two types of experiments. The first (yield experiments) was planted in the normal season (May) at Sakha and Mallawy Agric.Res. Sta. Randomized complete block design (RCBD), with four replications was used at all locations. The plot size was one row, 6 m long, 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 taken on grain yield in ardab/feddan (ard/fed) adjusted to 15.5% grain moisture. The second (disease experiments) was planted in the late season (July) in the disease nursery under artificial infection by downy mildew disease at Sakha. Annually this field was previousely planted by sudan grass as a source of infection, 30 days prior to planting of test genotypes. Spreader rows (sudan grass) were alternatively planted with maize rows in a ratio of 1:3, respectively. The 36 hybrids and two checks were evaluated in three separate experiments under three nitrogen levels, i.e. 60, 120 and 180 kg N/fed. The nitrogen fertilizer was applied in two equal doses the first at planting and the second at first irrigation in Urea form. RCBD with four replications was used, Plot size was one row, 4 m long, 80 cm apart, and 25 cm between hills. Two kernels were planted per hill and left without thinning. Percentage of resistance to downy mildew disease was taken after 40 days from planting. (The data were transformed by using arcsine scale for analysis of variance. However, means of non transformed values were also given for purpose of comparison between hybrids). Statistical analysis was done according to Steel and Torrie (1980). Hybrid and nitrogen levels were considered fixed while location were considered random in the analysis of variance. Combining ability was computed according to Griffing (1956), method-4, model-1.

RESULTS AND DISCUSSION

Mean squares due to general and specific combining ability and their interactions with locations for grain yield are presented in Table (1). Locations (L) mean squares were highly significant, indicating overall differences between Sakha location (north Egypt) and Mallawy location (south Egypt) for grain yield.

Mean squares due to hybrids (H) and their partitioning into general and specific combining ability (GCA and SCA) were highly significant. This indicated that the hybrids varied from each other. Also it is evident that both additive and non-additive gene effects were involved in determining the grain yield. The magnitude of GCA to SCA indicated that the non-additive gene action was more responsible for controlling the inheritance of grain yield. Baktash *et al* (1985), Turgut *et al* (1995), Rameeh *et al* (2000) and Mosa *et al* (2010) found that SCA was more important than GCA for grain yield.

Table 1. Mean squares of general and specific combining ability and their interactions with locations for grain yield.

SOV	df	SS	MS
Locations (Loc)	1	16746.71	16746.71**
Rep/Loc	6	324.96	54.16
Hybrids (H)	35	5310.07	151.71**
GCA	8	1995.28	249.41**
SCA	27	3314.79	122.77**
H x Loc	35	1050.39	30.01*
GCA x Loc	8	232.56	29.07
SCA x Loc	27	817.79	30.29*
Error	222†	4044.84	18.22
K^2GCA / K^2SCA			0.34
σ^2 GCA x Loc / σ^2 SCA x Loc			0.13

*,** Significant at 0.05 and 0.01 levels of probability, respectively.
† including checks.

The partitioning of variation among H x Loc. interaction to GCA x Loc and SCA x Loc. interactions (Table 1), exhibited that SCA x Loc was significant, indicating that the non-additive gene action interacted more with the environment than the additive gene action for grain yield. These results agreed with Mosa *et al* (2010).

Differences among the three nitrogen levels (N) were found to be not significant for resistance to downy mildew disease (Table 2), indicating that resistance to downy mildew disease was not affected by nitrogen level. The mean squares due to hybrids and one from their partitions (GCA) were highly significant, indicating that only additive gene action acts in the genetic control of resistance to downy mildew disease. This result supports the finding of Orangel and Borges (1987) and Al-Naggar *et al* (1997).

The interaction between GCA and SCA with nitrogen levels was not significant.

Table 2. Mean squares of general and specific combining ability and their interactions with nitrogen levels for resistance to downy mildew.

SOV	Df	SS	MS
Nitrogen levels (N)	**2**	**297.46**	**148.73**
Rep/N	**9**	**2257.74**	**250.86**
Hybrids (H)	**35**	**14286.39**	**408.18****
GCA	**8**	**10051.44**	**1256.43****
SCA	**27**	**4234.95**	**156.85**
H x N	**70**	**6086.46**	**86.94**
GCA x N	**16**	**971.04**	**60.69**
SCA x N	**54**	**5115.42**	**94.73**
Error	**333†**	**34209.09**	**102.73**
K^2GCA / K^2SCA			**3.04**
K^2 GCA x N / K^2 SCA x N			**0.00**

** Significant at 0.01 level of probability.
† including checks.

Mean performance of 36 hybrids and two checks for grain yield across locations and resistance to downy mildew disease across nitrogen levels are given in Table (3). For grain yield, the mean values for hybrids ranged from 18.18 ard/fed for hybrid Sk5215 x Sk 8238 to 36.01 ard/fed for hybrid Sk5058 x Sk8238. The highest hybrids for grain yield were Sd 7 x Sk 5140 (35.76 ard/fed), Sk 5058 x Sk8038 (36.01 ard/fed) and Sk5140 x Gm18

(35.77 ard/fed). These three hybrids were significantly different from the commercial hybrids SC10 and SC129. Hence it could be concluded that these hybrids offer good possibility for improving grain yield of maize. For resistance to downy mildew, mean values for hybrids ranged from 78.46% for hybrid Sk5 x Sk5215 to 98.14 % for hybrid L 63 b x Sk5058, the highly resistant hybrids were Sd7 x Sk5058 (95.03%), Sk 9 x Sk5058 (95.93%), L63b x Sk5058 (98.14%), Sk5058 x Sk5140 (97.67%) and Sk5058 x Sk8238 (96.23%). While the resistance hybrids were Sk5 x Sk5058 (94.6%), Sk5 x Sk 5140 (90.78%), Sk9 x Sk5215 (93.21%), Sk9 x Sk8238 (90.92%), L63 b x Sk8238 (91.87%), L63 b x Gm 18 (92%), Sk5058 x Sk5215 (93.06%), Sk 5058 x Gm 18 (94.33%), Sk 5215 x Sk8238 (90.68%) and Sk 5215 x Gm 18 (93.16%). These previous hybrids offer good possibility for improving resistance to downy mildew disease.

Table 3. Mean performance of 36 hybrids and two checks for grain yield across locations and resistance to downy mildew across nitrogen levels.

Hybrid	Grain yield (ard/fed)	Downy mildew resistance %	Hybrid	Grain yield (ard/fed)	Downy mildew resistance %
Sk5 x Sd7	32.33	86.27	Sk9 x Sk8238	29.04	90.92
Sk5 x Sk9	31.95	89.32	Sk9 x Gm18	29.92	88.19
Sk5 x L63b	27.74	86.83	L63b x Sk5058	23.12	98.14
Sk5 x Sk5058	28.54	94.60	L63b x Sk5140	32.57	85.37
Sk5 x Sk5140	32.59	90.78	L63b x Sk5215	26.59	85.66
Sk5 x Sk5215	32.04	78.46	L63b xSk8238	22.95	91.87
Sk5 x Sk8238	29.36	88.71	L63b x Gm18	21.80	92.00
Sk5 x Gm18	23.61	81.62	Sk5058 x Sk5140	31.04	97.67
Sd7 x Sk9	20.45	81.48	Sk5058 x Sk5215	31.33	93.06
Sd7 x L63b	29.04	82.22	Sk5058 x Sk8238	36.01	96.23
Sd7 x Sk5058	30.39	95.03	Sk5058 x Gm18	24.99	94.33
Sd7 x Sk5140	35.76	87.14	Sk5140 x Sk5215	32.23	88.90
Sd7 x Sk5215	31.55	84.73	Sk5140 x Sk8238	34.29	86.76
Sd7 x Sk8238	27.67	78.92	Sk5140 x Gm18	35.77	86.87
Sd7 x Gm18	32.11	86.54	Sk5215 x Sk8238	18.18	90.68
Sk9 x L63b	27.68	88.38	Sk5215 x Gm18	31.10	93.16
Sk9 x Sk5058	26.40	95.93	Sk8238 x Gm18	31.26	86.98
Sk9 x Sk5140	34.25	85.58	SC10 (Check)	29.97	89.64
Sk9 x Sk5215	30.08	93.21	SC129 (Check)	30.23	88.14
LSD 0.05				5.52	7.08
0.01				7.40	9.31

In general, the previous mentioned indicated that all hybrids which showed high resistance to downy mildew disease included inbred line Sk 5058 (all self pollination and selection in all segregating generations for this inbred were under artificial infection by downy mildew disease at Sahka Res. Sta.). Also, the results exhibited that the hybrids, Sd 7 x Sk 5058 and Sk 5058 x Sk 5140 showed high resistance to downy mildew disease and insignificantly outyielded checks SC10 and SC129, while hybrid Sk 5058 x Sk8238 showed high resistance to downy mildew and significantly outyielded SC10 and SC129. It could be concluded that the three hybrids could be used as good hybrids in maize breeding programs.

Estimates of general combining ability effects of the nine inbred lines for grain yield across locations and resistance to downy mildew across nitrogen levels are presented in Table (4). Significant desirable GCA effects were detected in the inbred line Sk5140 for grain yield and inbred Sk5058 for resistance to downy mildew disease. These two inbreds can be used for developing high yielding and high resistant hybrids to downy mildew , respectively.

Table 4. Estimates of general combining ability effects for grain yield across locations and resistance to downy millew across nitrogen levels.

Inbred line	Grain yield	Downy mildew resistance
Sk 5	0.529	-2.645*
Sd 7	0.597	-4.635*
Sk 9	-0.665	0.026
L 63b	-3.277*	-0.204
Sk 5058	-0.375	9.484*
Sk 5140	4.759*	-0.814
Sk 5215	-0.190	-0.417
Sk 8238	-0.812	-0.499
Gm18	-0.564	-0.293
LSD g_i 0.05	1.56	2.04
LSD g_i-g_j 0.05	2.34	3.06

*, Significant at 0.05 level of probability.

Estimates of specific combining ability effects of 36 hybrids for grain yield across locations and resistance to downy mildew across nitrogen levels are presented in Table (5).

The desirable specific combining ability effects were obtained for grain yield in cross Sk5058 x Sk8238. This hybrid can be used for improving grain yield.

Table 5. Estimates of specific combining ability effects of 36 hybrids for grain yield across locations and resistance to downy mildew across nitrogen levels.

Hybrid	Grain yield	Downy mildew resistance	Hybrid	Grain yield	Downy mildew resistance
Sk5 x Sd7	1.90	3.874	Sk9 x Sk5215	1.63	4.70
Sk5 x Sk9	2.78	1.162	Sk9 x Sk8238	1.21	2.066
Sk5 x L63b	1.18	1.518	Sk9 x Gm18	1.85	-1.590
Sk5 x Sk5058	-0.92	0.803	L63b x Sk5058	-2.53	1.038
Sk5 x Sk5140	-2.01	3.035	L63b x Sk5140	1.79	-3.905
Sk5 x Sk5215	2.39	-7.336*	L63b x Sk5215	0.76	-3.610
Sk5 x Sk8238	0.33	1.321	L63b x Sk8238	-2.27	3.031
Sk5 x Gm18	-5.66*	-4.376	L63b x Gm18	-3.66*	4.441
Sd7 x Sk9	-8.78*	-3.731	Sk5058 x Sk5140	-2.65	2.106
Sd7 x L63b	2.42	-3.300	Sk5058 x Sk5215	2.59	-3.982
Sd7 x Sk5058	0.86	2.402	Sk5058 x Sk8238	7.89*	-0.484
Sd7 x Sk5140	0.42	3.834	Sk5058 x Gm18	-3.45*	-1.156
Sd7 x Sk5215	1.84	-0.362	Sk5140 x Sk5215	-1.64	1.625
Sd7 x Sk8238	-1.42	-4.71	Sk5140 x Sk8238	1.04	-1.776
Sd7 x Gm18	2.77	1.922	Sk5140 x Gm18	2.20	-2.266
Sk9 x L63b	2.32	0.788	Sk5215 x Sk8238	-10.12*	3.219
Sk9 x Sk5058	-1.86	-0.726	Sk5215 x Gm18	2.55	5.763
Sk9 x Sk5140	0.85	-2.653	Sk8238 x Gm18	3.33	-2.738
LSD S_{ij} 0.05				3.45	6.08
LSD $S_{ij}-S_{ik}$ 0.05				5.22	7.50
LSD $S_{ij}-S_{kl}$ 0.05				4.76	6.85

*, Significant at 0.05 level of probability.

REFERENCES

Al-Naggar, A. M., H.Y. El-Sherbieny and A.I. Gabr (1997). Inheritance of resistance to sorghum downy mildew disease caused by *Peronosclerospora sorghi* in maize. Egypt, J. plant Breed. 1:47-60.

Baktash, F.Y., M.A. Younis; A.H. AL-Younis and B.A. AL-Ithawi. (1985). Diallel crosses of corn inbred lines for grain yield and ear characters. Iraqi J. Agric. Sci. ZANCO 3:29-45.

Debnath, S.C., K.R. Sarkar and D. Singh (1988). Combining ability estimates in maize (*Zea mays* L.). Annals of Agric. Res. India 9:37-42.

El-Shenawy, A.A. (1995). Breeding for disease resistance in maize. Ph.D. Thesis, Fac. Agric., Menufia University Egypt.

El- Shenawy, A. A. and H.E. Mosa (2005). Evaluation of new single and three way maize crosses for resistance to downy mildew disease and grain yield under different environments. Alex. J. Agric. Res. 50: 35-43.

El-Shenawy, A.A. and S.A.E. Tolba. (2001). General and specific combining ability and reciprocal crosses effects in complete diallel set of maize inbreds. J. Agric. Sci., Mansoura Univ. 26 : 1271-1279.

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. Aust. J. Biol. Sci. 9: 463-493.

Hamid, F., M. Saleem, A. Ahmad and A. Naveed (1995). Combining ability for grain yield and its components in maize (*Zea mays* L.). Pak. J. Agric. Sci. 32: 168-171.

Mosa, H.E. and A.A. Motawei (2005). Combining ability of resistance to late wilt disease and grain yield and their relationships under artificial and natural infections in maize. J. Agric. Sci. Mansoura Univ. 30:731-742.

Mosa, H.E, A.A. Motawei and A.A. El-Shenawy (2009). Selection of new single crosses of maize for grain yield and resistance to downy mildew disease under different locations and potassium fertization. J. Agric. Res. Kafr El-Sheikh Univ. 35:522-536.

Mosa H.E., A.A. Motawei and A.M.M. Abd El-Aal (2010). Nitrogen fertilization influence on combining ability for grain yield and resistance to late wilt disease in maize. Agric. Res. Kafr El-Sheikh Univ. 36:278-291.

Nair, S.K., B.M. Prosanna, R.S.Rathore, T.A.S. Setty, R. Kumar and N.N. Singh (2004). Genetic analysis of resistance to sorghum downy mildew and rajasthan downy mildew in maize (*Zea mays* L.). Field Crops Res. 89: 379-387.

Nevado, M.E. and K.M. Jhnso (1989). Combining ability related to reduce gene flow among maturity groups with maize populations. Crop Sci. 29:928-932.

Orangel, L. and F. Borges (1987). Diallel analysis of maize resistance to sorghum downy mildew. Crop. Sci. 27:178-180.

Patil, S.H., S.J. Patil, K.H. Anahosur and J.V. Goud (1983). Evaluation of maize genotype to sorghum downy mildew caused by *Peronosclerospora sorghi*. Nadu Agric. Univ. Karnataka, India, 5:25-27.

Rameeh, V., A. Rezai and A. Arzani (200( ). Estimates of genetic parameters for yield and yield components in corn inbred lines using diallel crosses. J. Sci. and Technol. Agric. and Natural Resources 4: 95-104.

Sadoma, M.T. (1995). Studies on downy mildew disease of maize in Egypt. M. Sc. Thesis, Fac. Agric., Minufiya Univ., Egypt

Steel, R.G.D. and J.H. Torrie (1980). Principles and Procedures of Statistics. A Biometrical Approach. 2nd Ed. Mc Graw Hill, N.Y. USA.

Turgut, I., S. Yuces and M. Altinbas (199( ). Inheritance of some agronomic traits in a diallel cross of maize inbreds. Torla. Bitkileri Bolumu, Zireat Fakultesi, Akdeniz Univ., Antlya Turkey Anadolu, 5:74-92.

Yamada, M. and B.A. Aday (1977). Fertilizer conditions affecting susceptibility to downy mildew disease, *Sclerospora philippinensis* Weston, in resistant and susceptible materials of maize. Ann. Phytopath. Soc. Japan 43:291-293.

تقييم هجن جديدة من الذرة الشامية لمحصول الحبوب والمقاومة لمرض البياض الزغبى

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تم تقييم ٣٦ هجين فردى ناتجة من التهجين بين ٩ سلالات من الذرة الشامية البيضاء بنظام الهجن التبادلية الغير كاملة واثنين من الهجن التجارية فى موسم ٢٠٠٩ فى نوعين من التجارب . أولا تجارب محصولية

حيث زرعت الهجن في الميعاد المناسب في مايو في موقعين سخا وملوى وذلك لتقدير صفة محصول الحبوب.
ثانيا: تجارب العدوى بالمرض حيث زرعت الهجن في ميعاد زراعة متاخر (يوليو) تحت ثلاثة من معدلات التسميد النيتروجيني (٦٠، ١٢٠ و ١٨٠ كجم نيتروجين/فدان) في حال العدوى الصناعية بمرض البياض الزغبي بسخا وذلك لتقدير نسبة المقاومة لهذا المرض.

كانت الاختلافات بين المواقع عالية المعنوية لصفة المحصول بينما الاختلافات بين مستويات التسميد النتروجيني غير معنوية لصفة المقاومة لمرض البياض الزغبي. الفعل غير المضيف للجين هو الاكثر اهمية في وراثة صفة المحصول بينما الفعل المضيف للجين هو المتحكم في وراثة المقاومة لمرض البياض الزغبي. الفعل الوراثي غير المضيف للجين اكثر تاثرا بالبيئة بالمقارنة بالفعل المضيف للجين لصفة المحصول. افضل السلالات في تاثيرات القدرة العامة على الائتلاف كانت السلالة سخا ٥١١٠ لصفة المحصول والسلالة سخا ٥٠٥٨ لصفة المقاومة لمرض البياض الزغبي. افضل الهجن في تاثيرات القدرة الخاصة على الائتلاف كان سخا٥٠٥٨ × سخا٨٢٣٨ لصفة المحصول.

اظهرت النتائج ان الهجن سدس٧ × سخا ٥٠٥٨ وسدا ٥٠٥٨ × سخا٥١٤٠ تمتلك مقاومة عالية لمرض البياض الزغبي و محصولها لا يختلف معنويا عن الهجن التجارية هـ.ف١٠ و هـ.ف١٢٩ بينما اظهر الهجين سخا٥٠٥٨ × سخا٨٢٣٨ مقاومة عالية لمرض البياض الزغبي ومحصوله يزيد معنويا عن هـ.ف١٠ و هـ.ف١٢٩ ولذلك توصي هذه الدراسة باستخدام الثلاث هجن السابقة كهجن عالية المحصول و مقاومة لمرض البياض الزغبي خاصة بمنطقة الدلتا بمصر.