RELATIVE PERFORMANCE OF FOUR TYPES OF TESTERS TO IDENTIFY ELITE INBRED LINES OF MAIZE (*Zea mays* L.)

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ABSTRACT

Breeders need more information on selecting testers to identify elite lines and need more methods to study general combining ability (GCA) and specific combining ability (SCA) of genotypes. Seven new white inbred lines were isolated from Giza-2 composite population and American Early Dent cultivar. Four testers were used to evaluate the topcross performance of the used seven lines, including Sd.7, SC.10, TWC.324 and NWP. The results showed that the differences among locations were significant for all studied traits. Significant differences were detected among the testers for the studied traits, except for late wilt susceptible. Also, significant differences were observed among the inbred lines for all traits. Significant differences were detected for line x tester interactions for the studied traits, except for grain yield. The topcrosses of Nb.11D, Nb.26D and Nb.51K inbred lines had the highest grain yield and did not significantly differ than the check hybrid, S.C.10, where, they yielded 8.21, 8.12 and 8.17 Mg ha^{-1}, respectively, while, the check hybrid yielded, 7.84 Mg ha^{-1}. In addition, these inbred lines had highly positive significant GCA effects. These results reflected that these inbred lines had favorable alleles for grain yield and contributed in obtaining good grain yields in the crosses involving these lines. For early maturity, thirteen topcrosses were significantly earlier than SC.10. All topcrosses of the tested inbred lines with Sd.7 were significantly earlier than the check hybrid, SC.10, except for Nb.51k x Sd.7. Topcrosses of Nb.3A, Nb.11D, Nb.12A and Nb.38 lines, with Sd.7 tester, were significantly shorter than SC.10. Also, topcrosses of the inbred lines, Nb.3A, Nb.12A and Nb.38, were significantly lower for ear height than the check hybrid, SC.10. Mean of topcrosses of the inbred lines, Nb.3A, Nb.38 and Nb.51K, were the smallest in late wilt susceptibility and had negative GCA effects. For the testers, Sd.7 was the best tester for grain yield, number of days to mid-silking, plant height and ear height, while, NWP tester was the bettest for late wilt susceptibility, which reflected that the narrow genetic base genotype was the best tester for identify the elite inbred lines, except for late wilt susceptibility, where the results showed that the broad genetic base tester was the best for selection among the new inbred lines for late wilt susceptibility. Also, the results showed that specific combining ability (SCA) effects were more important than general combining ability (GCA) effects in the inheritance of grain yield. Correlation relationships of grain yield with the other traits, in Sd.7 tester, were not significant, while, in NWP tester, it was significant for grain yield with number of days to mid-silking, plant height and late wilt susceptibility. Significant negative correlation was observed for number of days to mid-silking with plant height, ear height and late wilt susceptibility in NWP and TWC.324.

Key words: *Maize, Corn, Tester, Lines, GCA, SCA.*

Abbreviations: *Nb., Nubaria; SC, Single cross; TWC, Three-way cross; Sd., Sids; Mg ha^{-1}, Mega/hectare; NWP, Nubaria White Population; GCA, General combining ability; SCA, Specific combining ability; E, Environment; Cro, Crosses; Chk, Checks; Lin, Lines; Tes, Testers; Ent, Entries; C.V., Coefficient of variation; SE, Standard error;*

INTRODUCTION

Developing high yielding hybrids of maize depends on inbred lines with high general and specific combining abilities. Therefore, developing superior maize inbred lines is necessary for maize breeders to improve currently commercial hybrids or develop newer more productive hybrids. Breeders need more information on selecting testers to identify elite lines and need more user-friendly methods to study general combining ability (GCA) and specific combining ability (SCA) of genotypes (Narro *et al.*, 2003).

Topcross testing, as suggested by Davis (1927), with broad and/or narrow base tester was the most common procedure to evaluate the combining ability of inbred lines and to determine the usefulness of the lines for hybrids development.

The use of testers in a maize recurrent selection program has been well documented (Jenkins and Brunson, 1932; Matzinger, 1953; Rawlings and Thompson, 1962; Allison and Curnow, 1966; Hallauer, 1975; Hallauer and Miranda, 1988, Russell *et al.*, 1992; Menz *et al.*, 1999). These authors concluded that choice of a suitable tester should be based on simplicity in its use, its ability to classify the relative merit of lines, maximize genetic gain, and give the most accurate information on tested lines. However, it is difficult to identify tester, having all these characteristics. Allison and Curnow (1966) suggested use of low yielding varieties as testers. The use of a single-cross as a tester has been reported by Horner *et al.* (1976). The use of an inbred, as tester, was suggested by Russell and Eberhart (1975) and it has been widely used by breeders (Walejko and Russell, 1977; Darrah, 1985; Horner *et al.*, 1989). Castellanos *et al.* (1998) studied 21 maize inbreds and seven testers (five single crosses, one synthetic and one inbred line) to identify the best tester and concluded that the single cross was the best alternative in a breeding program oriented to generate superior three-way hybrids. Nature and number of testers was an issue to argue among scientists and there was no agreement on the best type of testers.

Both general (GCA) and specific (SCA) combining ability effects should be taken in consideration when planning the maize breeding

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programs to produce and release new inbred lines and crosses (Hallauer and Miranda, 1988). Also, GCA and SCA provide useful genetic information for selection strategies of choosing the suitable testers in maize breeding programs (Zhang *et al*, 2005).

The objectives of this study were: ***(i)*** to identify the relative performance of four types of testers to identify the elite inbred lines, ***(ii)*** to estimate the general (GCA) and specific (SCA) combining ability effects for seven white new lines and the resultant crosses and ***(iii)*** to identify the most superior line(s) to be utilized in the breeding program.

MATERIALS AND METHODS

Seven new white inbred lines were isolated in the breeding nursery at Nubaria Agriculture Research Station; five lines were isolated from Giza-2 composite population (Nb.3A, Nb.11D, Nb.12A, Nb.26D and Nb.38), while, Nb.48B and Nb.51K were isolated from American Early Dent cultivar and were used for the present study.

Four testers were used to evaluate the topcrosses performance of the used seven inbred lines, including Sids-7 (Sd.7) and single-cross hybrid Giza-10 (SC.10), as a narrow genetic base tester; Three-way cross hybrid-324 (TWC.324), as a moderate genetic base tester, while, Nubaria white population (NWP) was a broad genetic base tester.

In 2006 season, topcrosses were developed by using a mixture of pollen grains of male plants. At harvest, all ears from each topcross were bulk-shelled and a part of this seed was used for trial evaluation. The resultant 28 topcrosses were evaluated during 2007 season in three environments; i.e., Gemmiza, Nubaria and Mallawy Agriculture Research Station, representing Middle Delta, North West Delta and South Delta, respectively.

Two-factor experiment, as a randomized complete block design, with four replications, was used at each location. Plots consisted of one row, six meters long and 80 cm apart. Hand planting was used; hill spacing was 25 cm along the row. Two kernels/hill were sown and thinned later to one plant per hill to provide a population of, approximately, 55000 plants per hectare (55000 ha^{-1}). All cultural practices were applied as recommended at the proper time. Data were collected for number of days (d) from planting to mid-silking, plant and ear heights (cm), susceptibility to late wilt disease (%) and ears weight per plot. Ears were weighed in kg, shelled, adjusted to 15.5% grain moisture and converted to grain yield ton/hectare (Mg ha^{-1}). Data of late wilt susceptibility was transformed, using arcsine method, and was measured at Gemmeiza and Mallawy only.

Analysis of variance was carried out for each location, using proc ANOVA (SAS system, 2002), according to Steel and Torrie (1980). Homogeneity test, according to Steel and Torrie (1980), indicated no significant differences were observed among different locations, so, combined analysis was completed. The procedure of Singh and Chaudhary (1979) was used to estimate combining ability of lines and testers, using proc IML (SAS system, 2002). Lines and testers were considered as fixed effects, while locations were random effects.

RESULTS AND DISCUSSION

Analysis of variance:

Combined analysis of variance for the studied traits is presented in Table (1). The differences among environments were highly significant for all studied traits, indicating that these environments differed in their conditions. Highly significant differences were detected among the testers for the studied traits, except for late wilt susceptibility. Also, significant differences were observed among the inbred lines for all traits. Similar results were obtained by El-Itriby *et al* (1990), Soliman and Sadek (1999), Soliman (2000) and Habliza and Khalifa (2005), for all studied traits; Soliman *et al* (1995) and Shehata *et al* (1997) for grain yield and plant height; El-Hosary (1985), Salama *et al* (1995) and El-Zeir *et al* (2000) for grain yield, number of days to mid-silking and plant height.

Highly significant differences were detected for line x tester interactions for the studied traits, except for grain yield. Significant differences of locations x line interactions were observed for all studied traits, except for plant height, while, the locations x tester interactions were highly significantly different only for plant height. These interactions with locations indicated that the studied topcrosses differently performed at the three locations. These results, also, indicated that it would be worthwhile to evaluate topcrosses at many environments, especially for grain yield, which was regarded as a complex polygenic trait (Darrah and Hallauer, 1972).

Furthermore, highly significant differences were detected for locations x lines x testers interactions for grain yield, plant height and late wilt susceptibility, revealing that the crosses between lines and testers behaved, somewhat, differently from location to another. These results are in agreement with those obtained by El-Hosary (1985), El-Itriby *et al* (1990), Salama *et al* (1995), Soliman *et al* (1995), Uhr and Goodman (1995), Abdel-Aziz *et al* (1996), Mahgoub *et al* (1996), Shehata *et al* (1997), El-Zeir (1999), Soliman and Sadek (1999), Soliman (2000), Sadek *et al* (2000), Gado *et al* (2000), Sadek *et al* (2002) and Habliza and Khalifa (2005).

Mean performances and combining ability effects:

Grain yield:

Grain yield and general combining ability (GCA) for the studied inbred lines and testers, over the three locations, are presented in Table (2). The topcrosses of Nb.11D, Nb.26D and Nb.51K inbred lines had the highest grain yield and did not significantly differ from the check hybrid, S.C.10, where they yielded 8.21,

8.12 and 8.17 Mg ha^{-1}, respectively, while, the check hybrid yielded 7.84 Mg ha^{-1}. In addition, these inbred lines had highly positive significant GCA effects (Table 2). These results reflected that these inbred lines had favorable alleles for grain yield and contributed in obtaining good grain yields in the crosses involving these lines. On the other hand, Nb.3A inbred line gave the lower grain yield and was significantly lower than the check hybrid, SC.10 (6.74 Mg ha^{-1}), and, also, had highly significant negative GCA effects (Table 2).

For the testers, the highest frequency of the inbred lines within each tester, for grain yield, was observed as follows: Sd.7, SC.10, TWC.324 and NWP, respectively (Table 1), reflected that the narrow genetic base genotype was the best tester for differentiation among the new inbred lines. Therefore, topcrosses of these inbred lines, with Sd.7 and SC.10 testers, had the highest grain yield (8.66 and 7.78 Mg ha^{-1}) and also, had significant positive GCA values (Table 2), while, NWP had the lower grain yield and had a significant negative GCA value.

Comparison of grain yield and SCA effects of the 28 resultant topcrosses (Table 3) revealed that ten topcrosses had a significant grain yield more than the check hybrids, SC.10 and TWC.324. Out of them, three topcrosses; i.e., Nb.11D x Sd.7, Nb.26D x Sd.7 and Nb.51K x Sd.7, significantly yielded more than SC.10 (9.32, 9.25 and 9.55 Mg ha^{-1}, respectively, compared with 7.84 Mg ha^{-1}) and, at the same time, had significant positive SCA effects (0.574, 0.592 and 0.634 respectively). In addition, two topcrosses; i.e., Nb.26D x SC.10 and Nb.51K x SC.10, had a highly significant grain yield more than the check hybrid, TWC.324 (8.45 and 8.41 Mg ha^{-1}, compared with 7.41 Mg ha^{-1}) and, also, had significant positive SCA effects (0.366 and 0.369). Shehata and Dhawan (1975) and Sadek *et al* (2000) found that SCA effects were more important than GCA effects in the inheritance of grain yield.

Number of days to mid-silking:

Results in Table 1 showed that Sd.7 tester had the highest frequency of the tested inbred lines. Number of days from planting to mid-silking for the resultant topcrosses ranged from 56.1 (Nb.12A x Sd.7) to 62 d (Nb.51k x SC.10), as shown in Table 3. Out of the 28 resultant topcrosses, thirteen topcrosses were significantly earlier than SC.10 (Table 3). All topcrosses of the tested inbred lines with Sd.7 were significantly earlier than the check hybrid, SC.10, except for Nb.51k x Sd.7. Out of them (thirteen topcrosses), four topcrosses; i.e., Nb.12A x Sd.7, Nb.26D x NWP, Nb.38 x SC.10 and Nb.48B x Sd.7, were significantly earlier than the check hybrid, SC.10, and had significant negative SCA effects.

Nb.11D, Nb.12A, Nb.26D and Nb.38 inbred lines had significant negative GCA effects (Table 2) and its topcrosses were significantly earlier than the check hybrid, SC.10. These results indicated that these inbred lines had favorable alleles in direction of early maturity. In case of Sd.7 and NWP testers, they were significant earlier than SC.10 and had significant negative GCA effects.

Plant height:

The highest variations of the tested inbred lines within each tester, for plant height, were detected among Sd.7 tester (Table 1). Plant height of the resultant 28 topcrosses ranged from 215.9 (Nb.38 x Sd.7) to 267.7 cm (Nb.26D x SC.10), as shown in Table 4. Topcrosses of Nb.3A, Nb.11D, Nb.12A and Nb.38 lines, with Sd.7 tester, were significantly shorter than SC.10. Also, topcrosses of Nb.3A, with TWC.324 and NWP testers, were significantly shorter than the check hybrid, TWC.324, reflecting that Nb.3A line had favorable alleles for shortest plants.

Means of topcrosses of the inbred lines, Nb.3A, Nb.11D, Nb.12A and Nb.38, were significantly shorter than the check hybrid, SC.10 (Table 2), where, it had 231.7, 236.3, 230 and 229.9 cm values, respectively, compared with 257 cm. In addition, these inbred lines had significant negative GCA effects, except for Nb.11D, reflecting that these inbred lines had favorable alleles in direction of shortness. In the opposite, topcrosses of Nb.26D line, they gave the tallest plants and had significant positive GCA effects.

Ear height:

Considering ear height, presented in Table 1, results showed that the highest frequencies of the inbred lines were observed among Sd.7 and SC.10 testers. Means of topcrosses of Nb.3A, Nb.12A and Nb.38 gave the lowest ear height, as shown in Table 2 (126.3, 123.8 and 121.6 cm, respectively). At the same time, these inbred lines had significant negative GCA effects in direction of lower ear height. Topcrosses of Nb.26D and Nb.51K inbred lines were the highest in ear position and had significant positive GCA effects. For the testers, means of topcrosses of Sd.7 and NWP were the lowest in ear height and had significant negative GCA effects (Table 2).

Table 1. Mean squares for grain yield and other four characters of 28 topcrosses for combined data over three locations in 2007.

Source of variance	df	Grain yield	Number of days to mid-silking	Plant height	Ear height	Late wilt susceptibility
Environment (E)	2	27.84 **	489.34 **	81254.5 **	53089.2 **	952.3 **
Rep/ E	9	1.11	2.91	1524.4	1994.0	33.6
Entries	30	9.35 **	38.52 **	1799.5 **	929.5 **	42.6
Crosses (Cro.)	27	9.84 **	38.16 **	1758.1 **	960.3 **	43.4
Checks (Chk.)	2	5.41 **	7.19	3091.7	826.9	53.1
Cro. Vs. Chk.	1	4.03	110.95	332.4	303.6	0.05
Testers	3	53.36 **	181.15 **	4728.5 **	2303.9 **	21.7
Lines	6	16.21 **	49.59 **	3305.5 **	2195.9 **	50.4 *
Lin. X Tes.	18	0.46	10.51 **	747.2 **	324.5 **	44.6 **
Lin / Tes-1	6	6.83	30.60 **	2241.2 **	1107.1 **	46.3
Lin / Tes-2	6	4.45 **	16.10 *	1560.8 *	1279.9 *	10.0
Lin / Tes-3	6	3.37 *	22.91 *	979.8	382.4	53.4
Lin / Tes-4	6	2.95 *	11.51	765.5	399.9	74.6
E x Ent.	60	1.08 **	6.21 **	546.3 **	325.8 **	27.8 *
E x Cro.	54	1.13 **	6.15 **	527.2 **	326.3 **	27.3 *
E x Chk.	4	0.20	5.24 **	707.1 *	302.4	29.4
E x Cro. Vs. Chk.	2	1.63	9.99	740.7	359.3	39.6
E x Tes.	6	0.39	1.42	1192.0 **	248.8	15.4
E x Lin.	12	1.64 **	11.48 **	858.0	569.1 **	40.0 *
E x Lin. X Tes.	36	1.08 **	5.15 **	306.1	258.3 **	25.0
E x Lin / Tes-1	12	2.73 **	5.26 **	298.4	157.5	28.6
E x Lin / Tes-2	12	0.63	4.68 **	378.5	324.1 *	9.8
E x Lin / Tes-3	12	0.74	6.70 **	536.1 **	353.9 **	32.5
E x Lin / Tes-4	12	0.80 *	10.31 **	563.4 **	508.5 **	44.3 *
Error	270	0.39	1.09	212.7	147.2	18.6
C.V.		8.2	1.7	6.1	9.3	17.6

*, ** Significantly different at 0.05 and 0.01 levels of probability, respectively.

Table 2. Mean performance and general combining ability (GCA) for grain yield and other agronomic traits for seven lines topcrossed to four testers, and commercial checks evaluated at three locations in 2007.

	Grain yield		Number of days to mid-silking		Plant height		Ear height		Late wilt susceptibility	
	Mean (Mg ha^{-1})	GCA	Mean (d)	GCA	Mean (cm)	GCA	Mean (cm)	GCA	Mean (%)	GCA
Lines										
Nb.3A	6.74	- 0.878	59.2	- 0.021	231.7‡	- 6.413 **	126.3‡	- 3.979 *	0.63	- 1.009 **
Nb.11D	8.21	0.591 **	57.8‡	- 1.375 **	236.3‡	- 1.809	129.0	- 1.208	2.14	0.505
Nb.12A	7.52	- 0.097	58.8‡	- 0.354 *	230.0‡	- 8.039 **	123.8‡	- 6.396 **	2.03	0.395
Nb.26D	8.12	0.504 **	58.7*	- 0.500 **	251.1	13.024	137.8	7.625	1.68	0.047
Nb.38	7.05	- 0.568	58.8‡	- 0.375 *	229.9‡	- 8.101 **	121.6‡	- 8.604 **	1.13	- 0.506
Nb.48B	7.51	- 0.106	60.1	0.896	242.2	4.149	134.9	4.667	2.40	0.768
Nb.51K	8.17	0.555 **	60.9	1.729	245.3	7.190	138.1	7.896	1.44	- 0.200
Tester										
Sd.7	8.66	1.043 **	57.8	- 1.434 **	232.2‡	- 5.830 **	127.4‡	- 2.809 *	1.62	- 0.020
Sc.10	7.78	0.166 *	60.8	1.565	247.5	9.455	136.9	6.679	1.24	- 0.400
TWC.324	7.18	- 0.433	60.1	0.923	240.6	2.598	131.6	1.405	1.83	0.190
NWP	6.84	- 0.777	58.1	- 1.053 **	231.8‡	- 6.223 **	124.9‡	- 5.274 **	1.87	0.230
SE-L (g_i)		0.091		0.153		2.1		1.7		0.3
SE-L ($g_i - g_j$)		0.128		0.217		3.0		2.4		0.5
SE-T (g_i)		0.068		0.116		1.6		1.3		0.3
SE-T ($g_i - g_j$)		0.096		0.164		2.3		1.8		0.4

‡ Indicates significant differences than the check hybrid, SC.10.
*, ** Indicates significantly different at 0.05 and 0.01 levels of probability, respectively.

Mean performance of ear height of the resultant 28 topcrosses ranged from 112.9 (Nb.38 x Sd.7) to 151.7 cm (Nb.26D x SC.10), as shown in Table 4. Topcrosses of the inbred lines, Nb.11D, Nb.12A and Nb.38 with Sd.7 tester, were significantly lower in ear height than the check hybrid SC.10. Also, these inbred lines had negative SCA effects (Table 4). Topcrosses, which, also, had the shortest plants, had the lowest ear height; i.e., crosses of Nb.11D, Nb.12A and Nb.38 lines with Sd.7 (Table 4).

Table 3. Mean performance and specific combining ability (SCA) for grain yield and number of days to mid-silking for seven lines topcrossed to four testers, and commercial checks evaluated at three locations in 2007.

Line	Tester	Grain yield		Number of days to mid-silking	
		Mean (Mg ha^{-1})	SCA	Mean (d)	SCA
Nb.3A	Sd.7	7.65	0.212	58.1 **	0.413
	SC.10	6.81	0.007	61.1	0.330
	TWC.324	6.31	- 0.093	59.2	- 0.860 *
	NWP	6.17	- 0.126	58.2 *	0.116
Nb.11D	Sd.7	9.32 **	0.574 **	56.7 **	0.351
	SC.10	8.21 *	0.165	59.2 **	- 0.149
	TWC.324	7.83	- 0300	58.2	- 0.506
	NWP	7.47	-0.439	57.1 *	0.304
Nb.12A	Sd.7	8.57 *	0.310	56.1 **	- 1.253 **
	SC.10	7.54 *	0.145	60.7	0.247
	TWC.324	7.21	0.125	60.3	0.557
	NWP	6.75	- 0.580	58.2 *	0.449
Nb.26D	Sd.7	9.25 **	0.592 **	57.7 **	0.393
	SC.10	8.45 **	0.366 *	61.4	1.143
	TWC.324	7.53	- 0.453	59.0	- 0.631 *
	NWP	7.24	- 0.500	56.7 *	- 0.905 **
Nb.38	Sd.7	7.77	0.186	57.5 **	0.101
	SC.10	7.33	0.112	59.2 *	- 1.232 **
	TWC.324	6.63	0.018	60.5	0.744
	NWP	6.46	- 0.317	58.2 *	0.387
Nb.48B	Sd.7	8.49 *	- 0.367	57.1 **	- 1.586 **
	SC.10	7.74 *	0.161	61.8	0.163
	TWC.324	7.32	0.044	62.1	1.056
	NWP	6.49	- 0.572	59.4	0.366
Nb.51K	Sd.7	9.55 **	0.634 **	61.1	1.580
	SC.10	8.41 **	0.369 *	62.0	- 0.503
	TWC.324	7.44	- 0.494	61.5	- 0.360
	NWP	7.28	- 0.509	59.2	- 0.717 *
Checks					
Sc.10		7.84		61.4	
TWC.324		7.41		61.6	
LSD $_{(0.05)}$		0.85		2.0	
SE (S_{ij})			0.181		0.306
SE ($S_{ij} - S_{kl}$)			0.256		0.433

*, ** Significantly different than the check hybrid at 0.05 and 0.01 level of probability, respectively

Late wilt susceptibility:

The highest variations of the inbred lines, for late wilt susceptibility, were observed for NWP tester (Table 1), indicating that the broad genetic base tester was the best tester for selection of late wilt susceptibility among the new inbred lines. Overall mean performance of topcrosses of the inbred line, Nb.3A, Nb.38 and Nb.51K, were the lowest in late wilt susceptibility and had negative GCA effects (Table 2). Also, Sd.7 and SC.10 testers had the highest resistance to late wilt and had negative GCA effects.

Late wilt susceptibility ranged from zero (Nb.3A x NWP) to 4.22% (Nb.12A x NWP), as shown in Table 4. The results showed that all tested topcrosses had the lowest values of late wilt susceptibility (less than 4.22%), reflecting that these topcrosses were resistant to late wilt disease.

Table 4. Mean performance and specific combining ability (SCA) for different characters for seven lines topcrossed to four testers, and commercial checks evaluated at three locations in 2007.

Line	Tester	Plant height		Ear height		Late wilt susceptibility	
		Mean (cm)	SCA	Mean (cm)	SCA	Mean (%)	SCA
Nb.3A	Sd.7	236.3 *	10.49	131.4	7.96	0.69	0.088
	SC.10	249.7	8.54	134.7	1.72	0.76	0.530
	TWC.324	222.1*	- 12.18 **	121.0	- 6.68	1.05	0.239
	NWP	218.6*	- 6.86	118.0	- 2.99	0.00	- 0.858
Nb.11D	Sd.7	220.8 *	- 9.61 *	121.7 *	- 4.48	0.79	- 1.328
	SC.10	242.5	- 3.23	132.8	- 2.89	1.51	- 0.236
	TWC.324	244.4	5.55	133.1	2.64	3.68	1.352
	NWP	237.3	7.29	128.5	4.73	2.58	0.211
Nb.12A	Sd.7	218.0 *	- 6.21	118.4 *	- 2.63	1.82	- 0.188
	SC.10	233.4	- 6.08	126.9	- 3.62	1.08	- 0.549
	TWC.324	243.6	10.94	131.4	6.16	1.00	- 1.222
	NWP	225.2	1.35	118.7	0.09	4.22	1.959
Nb.26D	Sd.7	248.4	3.14	135.5	0.43	2.21	0.545
	SC.10	267.7	7.11	151.7	7.11	1.38	0.095
	TWC.324	247.8	- 5.87	138.3	- 0.95	2.39	0.517
	NWP	240.5	- 4.38	126.0	- 6.60	0.76	- 1.157
Nb.38	Sd.7	215.9 *	- 8.23	112.9 *	- 5.92	1.53	0.419
	SC.10	236.7	- 2.68	124.0	- 4.32	0.36	- 0.368
	TWC.324	238.9	6.34	128.2	5.20	0.38	- 0.942
	NWP	228.3	4.58	121.4	5.04	2.25	0.892
Nb.48B	Sd.7	241.4	5.02	135.8	3.73	3.88	1.501
	SC.10	251.2	- 0.52	140.5	- 1.09	2.13	0.131
	TWC.324	239.2	- 5.66	134.4	- 1.90	2.50	- 0.089
	NWP	237.2	1.16	128.9	- 0.73	1.09	- 1.543 *
Nb.51K	Sd.7	244.8	5.39	136.2	0.91	0.38	- 1.038
	SC.10	251.6	- 3.14	147.9	3.09	1.43	0.398
	TWC.324	248.7	0.88	135.1	- 4.47	1.77	0.144
	NWP	235.9	- 3.13	133.3	0.46	2.16	0.496
Checks							
SC.10		257.0		142.5		1.1	
TWC.324		241.9		130.0		1.0	
$LSD_{(0.05)}$		19.1		14.7		2.3	
SE (S_{ij})			4.2		3.4		0.7
SE ($S_{ij} - S_{kl}$)			6.0		4.9		1.0

*, ** Significantly different than the check hybrid at 0.05 and 0.01 level of probability, respectively.

Correlation among traits:

Generally, all correlation relationships of grain yield with the other traits in Sd.7 tester (narrow genetic base) were not significant, while, in NWP tester (broad genetic base), they were significant for grain yield with number of days to mid-silking, plant height and late wilt susceptibility (Table 5). A highly significant negative correlation between grain yield and number of days to mid-silking was observed in NWP tester, while, it was not significant within the other testers. Also, significant positive correlation was detected for grain yield and plant height in NWP tester, but, with the other testers, it was not significant.

All correlation relationships of number of days to mid-silking with plant height, ear height and late wilt susceptibility were negative and low values with narrow base genetic testers. With broad genetic testers (NWP and TWC.324), negative and nonconsiderable relationships were detected between number of days to mid-silking with plant and ear heights and late wilt susceptibility. Highly significant positive correlation of plant height with ear height was detected in four testers, while, no correlation was obtained between plant height and ear height with late wilt susceptibility.

From the previous results, it could be concluded that topcrosses of Nb.11D, Nb.26D and Nb.51K inbred lines had the highest grain yield and did not significantly differ from the check hybrid, S.C.10. Also, these inbred lines had highly positive significant GCA effects. These results reflected that these inbred lines had favorable alleles for grain yield and contributed in obtaining good grain yields in the crosses involving these lines. For early maturity, thirteen topcrosses were significantly earlier than SC.10. Topcrosses of Nb.3A, Nb.11D, Nb.12A and Nb.38 lines with, Sd.7 tester, were significantly shorter than SC.10. Means of topcrosses of the inbred lines, Nb.3A, Nb.11D, Nb.12A and Nb.38, were significantly shorter than the check hybrid, SC.10. Means of topcrosses of the inbred lines, Nb.3A, Nb.38 and Nb.51K were the lowest in late wilt susceptibility and had negative GCA effects. For the testers, Sd.7 was the best for grain yield, number of days to mid-silking, plant height and ear height, while, NWP tester was the best for late wilt susceptibility. The specific combining ability (SCA) effects were more important than the general combining ability (GCA) ones in the inheritance of grain yield. Correlation relationships of grain yield with the other traits, in Sd.7 tester, were not significant, while, in NWP tester, they was significant for grain yield with number of days to mid-silking, plant height and late wilt susceptibility. A significant negative correlation was observed for number of days to mid-silking with plant height, ear height and late wilt susceptibility in NWP and TWC.324.

Table 5. Correlation values of the studied traits for twenty-eight topcrosses within four testers.

Trait		Sd.7	SC.10	TWC.324	NWP
Grain yield					
	Number of days to mid-silking	0.061	- 0.173	- 0.124	- 0.378 **
	Plant height	0.005	0.056	0.097	0.253 **
	Ear height	0.015	0.071	0.095	0.177
	Late wilt susceptibility	0.039	0.229 *	0.396 **	0.278 **
Days to mid-silking					
	Plant height	- 0.211	- 0.182	- 0.522 **	- 0.417 **
	Ear height	- 0.243 *	- 0.222 *	- 0.572 **	- 0.293 **
	Late wilt susceptibility	- 0.342 **	- 0.194	- 0.256 *	- 0.283 **
Plant height					
	Ear height	0.951 **	0.857 **	0.919 **	0.918 **
	Late wilt susceptibility	0.137	0.016	0.120	0.202
Ear height					
	Late wilt susceptibility	0.153	0.198	0.133	0.185

*, ** Significantly different at 0.05 and 0.01 level of probability, respectively.

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الملخص العربى

الكفاءة النسبية لأربعة طرز مختلفة من الكشافات لتحديد سلالات الذره الشامية المرغوبة

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تم استنباط سبع سلالات من الذرة الشامية من العشيرة "جيزة-٢" والصنف "أمريكانى بدرى" فى برنامج تربية الذرة الشامية بمحطة البحوث الزراعية بالنوبارية. تم تكوين الهجن القمية مع اربعة كشافات مختلفة الطراز وهى: السلالة "سدس-٧" والهجين الفردى "جيزه-١٠" والهجين الثلاثى "جيزه-٣٢٤" وعشيرة النوبارية البيضاء لينتج ٢٨ هجينا قميا. وتم تقييم الهجن القمية الناتجة فى ثلاثة مواقع مختلفة شملت المحطات البحثية فى الجميزة والنوبارية ومالاوى موسم ٢٠٠٧.

أظهرت النتائج وجود فروق معنوية بين السلالات المختبره لكل الصفات تحت الدراسة وأيضا كانت الفروق معنوية بين الكشافات المختبرة لكل الصفات ، عدا صفة الاصابة بمرض الذبول المتأخر. وكان تفاعل السلالات مع الكشافات معنويا لكل الصفات تحت الدراسة ، عدا صفة محصول الحبوب.

أعطت الهجن القمية للسلالات "Nb.11D, Nb.26D, Nb.51K " أعلى محصول حبوب ولم تختلف معنويا عن صنف المقارنة "هجين فردى-١٠" حيث اعطت ٨،٢١ و ٨،١٢ و ٨،١٧ طن/هكتار بينما أعطى صنف المقارنة ٧،٨٤ طن/هكتار. كما أعطت هذه السلالات قيما موجبة ومعنوية لتأثيرات القدرة العامة على الائتلاف (GCA) ، مما يؤكد أن هذه السلالات احتوت على اليلات مرغوبة لمحصول الحبوب.

حقق ثلاثة عشر هجينا قميا – من اجمالى الهجن المختبرة – فروقا معنوية للتبكير فى موعد ظهور الحرابر عن صنف المقارنة ، كما حققت كل الهجن القمية المختبرة مع السلالة "Sd.7" المختبرة فروقا معنوية للتبكير فى موعد ظهور الحرابر عن صنف المقارنة ، عدا الهجين القمى " Nb.51K x Sd.7".

أعطت الهجن القمية للسلالات "Nb.3A,Nb.11D, Nb.12A, Nb.38 " مع السلالة "Sd.7" قيما معنوية لصفة انخفاض ارتفاع النبات عن هجين المقارنة. أيضا حققت الهجن القمية للسلالات "Nb.3A, Nb.12A, Nb.38" قيما معنوية لصفة انخفاض ارتفاع الكوز على النبات. كما اعطت الهجن القمية للسلالات" Nb.3A, Nb.51K Nb.38" قيما معنوية لصفة انخفاض الاصابة بمرض الذبول المتأخر.

كانت السلالة "Sd.7" أفضل الكشافات لصفات محصول الحبوب وعدد الأيام من الزراعة حتى منتصف التزهير وارتفاع النبات وارتفاع الكوز ، بينما كانت العشيرة "NWP" هى أفضل الكشافات لصفة الاصابة بمرض الذبول المتأخر مما يعكس أن الكشافات ضيقة القاعدة الوراثية هى أفضل الكشافات للانتخاب بين السلالات الجديدة لكل الصفات تحت الدراسة ، عدا صفة الاصابة بمرض الذبول المتأخر حيث يفضل استخدام كشاف ذو قاعدة وراثية عريضة.

أوضحت النتائج أن تاثيرت القدره الخاصة على الائتلاف (SCA) كانت أكثر اهمية لوراثة صفة محصول الحبوب عن القدرة العامة على الائتلاف (GCA). وأظهرت النتائج أن قيم التلازم بين محصول الحبوب والصفات الأخرى كانت غير معنوية مع الكشاف "Sd.7" بينما كان التلازم معنويا مع الكشافين "NWP و "TWC.324 لصفة محصول الحبوب مع عدد الأيام حتى منتصف التزهير وارتفاع النبات والحساسية لمرض الذبول المتأخر. وكان التلازم معنويا وسالبا لصفة عدد الأيام حتى منتصف التزهير مع ارتفاع النبات وارتفاع الكوز والحساسية لمرض الذبول المتأخر.