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Estimates of Combining Ability Effects to New Yellow Maize (*Zea mays* L.) Inbred Lines and Its Topcrosses

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ABSTRACT

Twelve yellow maize inbred lines isolated from five different sources at maize breeding nursery of Nubaria Agriculture Research Station were used for the present study. These lines were topcrossed to two testers; Cim.325 and Gm.1002. The 24 resultant topcrosses and the commercial check hybrid SC.162 were evaluated in replicated yield trials conducted at two locations; i.e., Nubaria and Sids. Data were recorded for ears weight per plot(kg), number of days to mid-silking (d) and plant and ear heights (cm). Ears were weighed in kg/plot, shelled, adjusted to 15.5% grain moisture and converted to grain yield in Mg ha-1.

Significant differences were detected among locations, lines and testers for the studied traits at each location and their combined data except grain yield of testers at Nubaria and combined data, and also number of days to mid-silking of lines at combined data. The most superior crosses for grain yield were Nb.603b x Cim.325, Nb.556 x Cim.325, Nb.659a x Gm.1002, Nb556 x Gm.1002, Nb601 x Cim.325 and Nb.603b x Gm.1002, which yielded 10.55, 10.06, 10.06, 9.93, 9.70 and 9.68 Mg ha-1, across the tested locations, respectively. Inbred lines Nb.603b and Nb.556 had significant GCA effects for grain yield, in addition, these lines had favorable alleles for early maturity, short plants and low ear placement. These lines are the most superior inbred line and may be recommended for further test. For the testers, Cim.325 lines had favorable alleles for grain yield, earliness, short plants and low ear placement, therefore, Cim.325 was recommended as a good tester for determining the superior crosses. Regarding SCA effects, the topcrosses of Nb.516c x Cim.325, Nb.575 x Gm.1002 and Nb.545 x Gm.1002 possessed high negative SCA values. Results showed that both GCA and SCA effects should be taken into consideration when planning maize breeding programs for developing new inbred lines and crosses.

Key words: Maize, Topcross, Testcross, Combining Ability, GCA, SCA.

INTRODUCTION

The increased demand for yellow maize grain to provide the needs of the growing poultry industry and animal feed has emphasized the importance of breeding new yellow maize inbred lines to develop superior yellow grain maize hybrids.

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 to study general combining ability (GCA) and specific combining ability (SCA) of genotypes (Narro *et al*., 2003).

Successful development of superior maize hybrids is dependent upon accurate evaluation of inbred lines when crossed. The identification of parental inbred lines that form superior hybrids is the most costly and time-consuming phase in maize hybrid development.

Performance of inbred lines per se doesn't provide enough information about their behavior in hybrid combination (Hallauer and Miranda, 1988). The topcross procedure has been widely used to evaluate lines for combining ability. Topcross testing, as suggested by Davis (1927) with broad and/or narrow base tester is the most common procedure to evaluate the combining ability of inbred lines and to determine their usefulness for hybrid development.

Hallauer and Miranda (1988) stated that both general combining ability (GCA) and specific combining ability (SCA) effects should be taken into consideration when planning the maize breeding programs to produce and release new inbred lines and crosses. Also, Zhang *et al.* (2005), Habliza and Mousa (2008), Habliza and Gabr (2009) and Habliza (2011) reported that GCA and SCA provide useful genetic information to help plant breeders for identify the best hybrids.

The objectives of this study were: (***i***) to estimate the general (GCA) and specific (SCA) combining ability effects for new twelve yellow maize inbred lines and their resultant top-crosses, using two testers, (***ii***) to identify the most superior line(s) to be utilized in the national maize breeding program, (***iii***) to study the interaction of the new hybrid over two divergent locations (Nubaria and Sids).

MATERIALS AND METHODS

Twelve new yellow maize inbred lines were isolated from five different genetic sources from the maize breeding nursery at Nubaria Agriculture Research Station are presented in Table 1. In 2013 growing season, these lines were topcrossed to two testers; Cimmyt-325 (Cim.325) and Gemmiza1002 (Gm.1002). In 2014, the 24 resultant topcrosses and the commercial check hybrid Single Cross Giza-162 (SC.162) were evaluated in replicated yield trials conducted at two locations; i.e. Nubaria and Sids Agric. Res. Stations, representing North West Delta and South Delta, respectively.

A randomized complete block design, with four replications, was used at each location. Plot size was one row, six meter long and 80 cm apart. Sowing was made in hills evenly spaced at 25 cm along the row. Seedlings were thinned, three weeks after planting, to one plant per hill to provide a plant population density of approximately 55000 plants/hectare. All cultural practices were performed as recommended for maize cultivation. Data were recorded for number of days from planting to mid-silking (d), plant and ear heights (cm), and grain yield. For grain yield, ears were weighed in kg/plot, shelled, and grain weight was adjusted to 15.5% moisture content then converted to grain yield (Mg ha^{-1}).

Analysis of variance was calculated out for each location and their combined data, using Proc ANOVA (SAS software, 1997) according to Steel and Torrie (1980) followed by the procedure of Singh and Chaudhary (1979) using proc IML (SAS software, 1997) to estimate combining ability of inbred lines and testers. Homogeneity of error was tested using Hartly method of maximum F (1955), and the two errors were homogeneous, therefore the combined analysis was done. Testers and lines were considered fixed while location was random effect.

RESULTS AND DISCUSSION

Variance analysis for the studied traits at each location and across locations (combined) are presented in Table(2). Results showed that the differences were highly significant among locations, indicating that the tested locations differed in their environmental conditions. Highly significant differences were detected among inbred lines for the studied traits at each location and their combined data, except for days to mid-silking at combined data. Also, significant and highly significant differences were detected between the two testers for the studied traits at each location and their combined data, except for grain yield at Sids and combined data. Similar results were obtained by El-Itriby *et al.* (1990), for all studied traits; Shehata *et al* (1997) and Habliza and Mousa (2008) for grain yield and plant height; Salama *et al* (1995) and El-Zeir *et al.* (2000) for grain yield, number of days to mid-silking and plant height. Significant and highly significant differences were detected between lines x testers interaction at each location and their combined analysis except for grain yield at combined data, plant height at Nubaria and combined data and ear height at Nubaria. Highly significant differences were observed between locations x testers interaction for number of days to mid-silking. Meanwhile the interaction of locations with lines was highly significant for all the studied traits. These interactions with locations indicated that the studied testcrosses performed differently at the tested locations. These results, also, indicated that it would be worthwhile to evaluate testcrosses at several environments, especially for grain yield, which is regarded as a complex polygenic trait (Darrah and Hallauer, 1972)**.**

Significant and highly significant differences were observed between locations and testers x lines interaction for grain yield and plant height. These results revealed that the crosses (lines and testers) performed, differently from location to another. These results are in agreement with those obtained by El-Itriby *et al.* (1990), Salama *et al.* (1995), Uhr and Goodman (1995), Abdel-Aziz *et al.* (1996), Mahgoub *et al.* (1996), Shehata *et al.* (1997), El-Zeir (1999), Gado *et al* (2000), and Habliza and Mousa (2008).

Table 1: Name and genetic source of the twelve inbred lines and two testers were used in the study.

Line	Source
Nb.516c	CIMMYT population-29 , (Mexico)
Nb.530	CIMMYT population-29, (Mexico)
Nb.545	F_2-population-22 (Yugoslavia)
Nb.556	Drought tolerant line-256 (Yugoslavia)
Nb.575	F_2-Population-40-12 (Egypt)
Nb.592a	F_2-Population-40-54 (Egypt)
Nb.593	F_2-Population-40-55 (Egypt)
Nb.601	F_2-Population-40-85 (Egypt)
Nb.603a	F_2-Population-40-93a (Egypt)
Nb.603b	F_2-Population-40-93b (Egypt)
Nb.651	Nubaria high oil population-1 (Egypt)
Nb.659a	Nubaria high oil population-24 (Egypt)
Testers	
Cim.325	CIMMYT line-325 (Mexico)
Gm.1002	Modified type of Line Gm.102 (Egypt)

Table 2. Mean square for grain yield and other characters of 12 yellow lines topcrossed to two Testers for each location in 2014 season.

S.O.V	Df	Grain yield	Days to mid-silk	Plant Height	Ear Height
NUBARIA					
Replicates	3	0.21	4.09	514.51	111.18
Testers (Tes)	1	5.25**	114.84**	4732.04**	1926.04**
Lines (Lin)	11	6.06**	8.12**	828.79**	556.04**
Tes x Lin	11	2.78*	5.96*	114.93	115.04
Error	69	0.70	0.81	66.35	74.91
C.V.		11.6	1.6	3.9	7.8
SIDS					
Replicates	3	0.32	0.84	163.37	199.57
Testers (Tes)	1	0.01	17.51**	4718.01**	2490.84**
Lines (Lin)	11	8.41**	2.12**	1014.85**	598.53**
Tes x Lin	11	2.32**	1.87*	276.67**	135.23*
Error	69	0.93	0.75	73.89	57.25
C.V.		9.0	1.5	3.4	5.6
COMBINED					
Locations (Loc)	1	597.98**	266.02**	79992.50**	29526.88**
Replicates/Loc	6	0.27	2.47	338.94	155.37
Testers (Tes)	1	2.70	111.02*	9450.03**	4398.76**
Lines (Lin)	11	10.97**	7.19	1728.39**	1051.96**
Tes x Lin	11	2.07	6.15*	272.58	189.74*
Loc x Tes	1	2.56	21.33**	0.01	18.3
Loc x Lin	11	3.50**	3.05**	115.24**	102.62*
Loc x Tes x Lin	11	3.03*	1.44	119.02**	60.53
Error	138	0.82	0.78	70.12	66.09
C.V.		10.1	1.5	3.6	6.6

*, ** Significant and highly significant differences at 0.05 and 0.01 levels of probability.

Grain yield

Grain yield performance of the studied twelve inbred lines topcrosses (topcrossed to two testers) is given in Table (3) for each location and their combined data. As the locations-by-lines interaction was significant, different means of the twelve single crosses for each location were composed under each location, independently. For Nubaria, Cim.325 x Nub.603b was the top yield hybrid and outyield the check hybrid SC.162. Highly significant differences were detected between the tested locations, where the overall means of grain yield were 10.75 and 7.22 Mg ha^{-1} for Sids and Nubaria, respectively, reflecting that the tested locations differed in their environmental conditions. Four inbred lines were significantly high in grain yield than the check hybrid SC.162 (Table 3). These lines are in a descending order according to yield, Nb.556, Nb.603a, Nb.603b, and Nb.659a**.**

Topcrosses of Nb.556 and Nb.603b lines had the highest grain yield and were significantly different than the check hybrid, which yielded 10.06, 9.93, 10.55 and 9.68 Mg ha^{-1}, respectively with the used testers, while the check hybrid SC.162 yielded 9.24 Mg ha^{-1} (Table 3). In addition these inbred lines had highly significant positive values of GCA effects, (1.01 and 1.13, respectively) as showed in Table (4). These results indicated that these inbred lines had favorable alleles for grain yield and contributed in obtaining good yields in the crosses involving these lines. On the other hand, inbred lines Nb.530, and Nb.545 yielded the lowest grain yield (7.54 and 7.82 Mg ha^{-1}, respectively), and had significant negative GCA effects (-1.44 and -1.16, respectively (Tables 3 and 5). Comparison of SCA effects for grain yield indicated that the superior crosses were of Nb.545 x Cim.325, Nb.603a x Gm.1002 and Nb.603b x Cim.325 (Table 6), which had highest grain yield and also had high values of SCA effects (0.60, 0.45 and 0.31, respectively). Shehata and Dhawan (1975) showed that SCA effects were more important than GCA effects in the inheritance of grain yield.

In case of the testers; the highest significant differences of lines within each tester, for grain yield, were detected for Cim.325 at Nubaria, while no differences were detected between the two testers at Sids and combined data. Also, Cim.325 tester had positive GCA effects for grain yield (0.12). These results reflected the superiority of Cim.325 as a good combiner tester.

Number of days to mid-silking

Number of days to mid-silking for the topcrosses ranged from 56.0 (Nb.603a x Cim.325) to 61.9 d (Nb.516c x Gm.1002) Table (4).

Table 3: Mean performance of grain yield (Mg ha^{-1}) for 12 inbred lines topcrossed to two testers, and the commercial check (SC.162) for each location and combined data in 2014.

Line	Tester	Grain yield (Mg ha^{-1})			
		NUBARIA	SIDS	COMBINED	Mean
Nb.516c	Cim.325	6.67	11.35**	9.01	
	Gm.1002	6.84	9.65	8.25	8.63
Nb.530	Cim.325	6.73	8.39	7.56	
	Gm.1002	5.86	9.17	7.51	7.54
Nb.545	Cim.325	5.89	11.19**	8.54	
	Gm.1002	4.80	9.40	7.10	7.82
Nb.556	Cim.325	7.78	12.36**	10.06**	
	Gm.1002	7.53	12.33**	9.93**	10.00**
Nb.575	Cim.325	5.99	9.69	7.84	
	Gm.1002	7.39	10.02	8.71	8.27
Nb.592a	Cim.325	8.66**	10.56**	9.61	
	Gm.1002	5.68	11.61**	8.65	9.13
Nb.593	Cim.325	6.71	11.17**	8.93	
	Gm.1002	7.22	10.58*	8.90	8.20
Nb.601	Cim.325	8.31*	11.08**	9.70**	
	Gm.1002	7.49	10.36	8.93	9.31
Nb.603a	Cim.325	8.20*	10.03	9.11	
	Gm.1002	7.62	11.92**	9.77**	9.44**
Nb.603b	Cim.325	9.44**	11.66**	10.55**	
	Gm.1002	7.67	11.69**	9.68**	10.12**
Nb.651	Cim.325	7.89	9.40	8.65	
	Gm.1002	7.78	10.05	8.92	8.78
Nb.659a	Cim.325	7.17	12.15**	9.67	
	Gm.1002	7.96*	12.16**	10.06**	9.86*
Mean		7.22	10.75		8.97
Testers					
Cim.325		7.45	10.75	9.10	
Gm,1002		6.98	10.74	8.87	
Check					
Sc.162		7.93	10.53	9.24	
LSD $_{0.05}$ (Lin.)		1.2	1.3	1.5	
LSD $_{0.05}$ (Tes.)		1.2	1.3	1.5	
LSD $_{0.05}$ (Loc.)		----	----	0.73	

* significantly different than check hybrid at 0.05 level of probability.

All of the 24 tested topcrosses were significantly earlier than the check hybrid SC.162. The overall mean of inbred lines ranged from 57.4 (Nb.575) to 59.7 (Nb.516c) with an average of 58.0 days. Results of Table (5) showed that the earlier topcrosses were of Nb.575, Nb.601 and Nb.603b lines, which had highly negative GCA effects (-0.56, -0.50 and -0.30), meanwhile topcrosses of Nb.516c, and Nb.659a lines were the latest and had highly significant positive GCA effects (1.69, and 0.88, respectively). The topcrosses of the testers Cim.325 were significantly earlier than the topcrosses of Gm.1002 tester (-0.76). Results of Table (6) showed that only Nb.516c x Cim.325 topcross had significantly negative SCA values.

Plant height

Results of Table (4) showed that all the topcrosses were shorter than the check hybrid, except those crosses of lines Nb.601, Nb.659a, with the two testers and Nb.516c, Nb.556 and Nb.651 with Gm.1002 tester. Plant height ranged from 198.0 (Nb.530 x Cim.325) to 257.2 (Nb.659a x Gm.1002 with an average of 229.0 cm. Data over the testers showed that plant height ranged from 206.0 (Nb.530) to 248.3 cm (Nb.659c). Generally, the shortest plants were obtained for topcrosses of Cim.325 tester (222.0 cm), compared with 236.0 cm of Gm.1002 tester (Table 4).

Results in Table (5) showed that the shorter topcrosses were of Nb.530, Nb.575 and Nb.593 lines which had highly significant and significant negative GCA effects (-23.01, -6.20 and -5.95, respectively). While topcrosses of Nb.659a and Nb.601 lines were the tallest and had highly significant positive GCA effects. At the same time, the topcrosses of Cim.325 and Gm.1002 testers were shortest than SC.162, but Cim.325 tester only had significant negative GCA effects (-7.02).

Table 4: Mean performance of 12 inbred lines topcrossed to tow testers, and the commercial check for number of days to mid-silking, plant height and ear height over two locations in 2014.

Lines	Tester	Number of days to mid-silking (d)		Plant height (cm)		Ear Height (cm)	
		value	mean	value	mean	Value	mean
Nb.516c	Cim.325	57.5**		217.4**		115.6**	
	Gm.1002	61.9**	59.7	249.1**	233.2	138.7	127.2
Nb.530	Cim.325	57.0**		198.0**		96.6**	
	Gm.1002	59.0**	58.0	214.0**	206.0	111.6**	104.1
Nb.545	Cim.325	57.2**		229.9**		127.0**	
	Gm.1002	58.0**	57.6	230.4**	230.1	128.0**	127.5
Nb.556	Cim.325	57.2**		222.2**		120.0**	
	Gm.1002	58.9**	58.1	240.6	231.4	132.4	126.2
Nb.575	Cim.325	57.1**		219.5**		118.2**	
	Gm.1002	57.8**	57.4	226.1**	222.8	115.7**	117.0
Nb.592a	Cim.325	58.1**		224.5**		118.5**	
	Gm.1002	58.2**	58.2	235.5**	230.0	133.5	126.0
Nb.593	Cim.325	56.7**		219.5**		116.1**	
	Gm.1002	58.4**	57.6	226.6**	223.1	121.2**	118.7
Nb.601	Cim.325	57.0**		237.7		127.6**	
	Gm.1002	58.0**	57.5	244.9	246.3	134.5	131.1
Nb.603a	Cim.325	56.0**		219.1**		115.5**	
	Gm.1002	59.2**	57.6	237.2**	228.2	129.9	122.3
Nb.603b	Cim.325	56.5**		216.5**		114.1**	
	Gm.1002	58.5**	57.5	230.1**	223.3	122.0**	118.1
Nb.651	Cim.325	57.6**		220.2**		120.7**	
	Gm.1002	58.2**	57.9	240.5	230.4	127.7**	124.3
Nb.659a	Cim.325	58.7**		239.4		130.5	
	Gm.1002	59.0**	58.9	257.2	248.3	141.1	135.8
Mean			58.0		229.0		123.1
Testers							
Cim.325		57.2**		222.0**		118.4**	
Gm.1002		58.8**		236.0**		127.9**	
Check							
Sc.162		65.2		249.5		140.7	
LSD $_{0.05}$		1.2		11.9		12.0	

* Significantly different than check hybrid at 0.05 level of probability.

Ear height

Regarding ear height, all topcrosses had lower ear placement than the check hybrid, except those of inbred lines Nb.659a with the two testers, in addition Nb.516c, Nb.556, Nb.592, Nb.601 and Nb.603a with Gm.1002 tester (Table 4). Ear height of topcrosses ranged from 96.6 cm (Nb.530 x Cim.325) to 141.1 cm (Nb.659a x Gm.1002) with an average of 123.1 cm. The lowest ear placement among inbred lines was for topcrosses of Nb.530 (104.1 cm), while the highest was for topcrosses of Nb.659a line (135.8 cm). Also, the lowest ear placement among testers was for topcrosses of the tester Cim.325 (118.4 cm)**.**

Results in Table (5) showed that the topcrosses of Nb.530 and Nb.575 lines had the lowest ear height and had highly significant negative GCA effects (-19.04 and -6.17, respectively). Topcrosses of inbred lines Nb.659a and Nb.601 had highly significant positive GCA effects (12.64 and 7.89). Also, topcrosses of the Cim.325 tester were in general of low ear placement and had high negative GCA effects.

Regarding SCA effects, data in Table (6) showed that topcrosses of Nb.516c x Cim.325, Nb.575 x Gm.1002 and Nb.545 x Gm.1002 possessed high negative SCA values (-6.77, -6.04 and -4.28, respectively), which is desirable for developing new hybrids with low ear height.

Finally, it may be concluded that the most superior crosses for yield were Nb.603b x Cim.325, Nb.556 x Cim.325 and Nb.659a x Gm.1002. Inbred lines Nb.603b and Nb.556 were the most superior and may be utilized in developing new yellow maize hybrids. For the testers, inbred line Cim.325 has favorable alleles for yield and earlier silking emergence. Both GCA and SCA effects should be taken into consideration when planning the maize breeding programs to produce new inbred lines and crosses.

Table 5. General combining ability (GCA) effects of the 11 inbred lines for grain yield and the other studied traits across the two locations in 2014.

Genotype	Grain Yield	Number of days to mid-silking	Plant height	Ear Height
Lines				
Nb.516c	-0.36	1.69**	4.23	4.02
Nb.530	-1.44**	0.01	-23.01**	-19.04**
Nb.545	-1.16**	-0.37	1.11	4.33
Nb.556	1.01**	0.06	2.42	3.02
Nb.575	-0.71*	-0.56	-6.20*	-6.17*
Nb.592a	0.14	0.18	0.98	2.83
Nb.593	-0.07	-0.44	-5.95	-4.48
Nb.601	0.32	-0.50	12.29**	7.89*
Nb.603a	0.46	-0.37	-0.83	-0.98
Nb.603b	1.13**	-0.50	-5.70	-5.10
Nb.651	-0.20	-0.06	1.36	1.08
Nb.659a	0.88*	0.88**	19.29**	12.64**
Testers				
Cim.325	0.12	-0.76*	-7.02*	-4.78
Gm.1002	-0.12	0.76*	7.02*	4.78
SE lines (g_i)	0.32	0.31	2.96	2.87
($g_j - g_l$)	0.45	0.44	4.18	4.06
SE testers (g_i)	0.13	0.12	1.21	1.17
($g_i - g_l$)	0.18	0.18	1.71	1.66

*, ** significantly different from zero at 0.05 and 0.01 level of probability, respectively.

Table 6: Specific combining ability (SCA) effects of 12 inbred lines for grain yield, number of days to mid-silking, plant and ear heights across two locations in 2014.

Lines	Tester	Grain Yield	Days to mid-silking	Plant height	Ear Height
Nb.516c	Cim.325	0.26	-1.43**	-8.86*	-6.77
	Gm,1002	-0.26	1.43**	8.86*	6.77
Nb.530	Cim.325	-0.10	-0.24	-0.98	-2.71
	Gm,1002	0.10	0.24	0.98	2.71
Nb.545	Cim.325	0.60	0.38	6.76*	4.28
	Gm,1002	-0.60	-0.38	-6.76*	-4.28
Nb.556	Cim.325	-0.05	0.05	-2.17	-1.40
	Gm,1002	0.05	0.05	2.17	1.40
Nb.575	Cim.325	-0.55	0.45	3.70	6.04
	Gm,1002	0.55	-0.45	-3.70	-6.04
Nb.592a	Cim.325	0.36	0.70	1.51	-2.71
	Gm,1002	-0.36	-0.70	-1.51	2.71
Nb.593	Cim.325	-0.10	-0.05	3.45	2.22
	Gm,1002	0.10	0.05	-3.45	-2.22
Nb.601	Cim.325	0.27	0.26	3.45	1.35
	Gm,1002	-0.27	-0.26	-3.45	-1.35
Nb.603a	Cim.325	-0.45	-0.86	-2.04	-1.90
	Gm,1002	0.45	0.86	2.04	1.90
Nb.603b	Cim.325	0.31	-0.24	0.20	0.85
	Gm,1002	-0.31	0.24	-0.20	-.85
Nb.651	Cim.325	-0.25	0.45	-3.11	1.28
	Gm,1002	0.25	-0.45	3.11	-1.28
Nb.659a	Cim.325	-0.32	0.63	-1.92	-0.52
	Gm,1002	0.32	-0.63	1.92	0.52
SE (s_{ij})		0.45	0.44	4.18	4.06
($s_{ij} - s_{kl}$)		0.64	0.62	5.92	5.74

*, ** significantly different from zero at 0.05 and 0.01 level of probability, respectively.

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الملخص العربى

تقديرات القدرة على التآلف للسلالات الجديده والهجن القميه لها من الذره الشاميه الصفراء

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هجنت قميا ١٢ سلالة نقية صفراء من الذره الشامية – مستنبطة من مصادر وراثية مختلفة – مع اثنين من الكشافات (السلالات Cim.325 and Gm.1002) وذلك فى موسم ٢٠١٣. تم تقييم الـ ٢٤ هجينا قميا بالاضافة الى هجين المقارنة(هجين فردى ١٦٢) فى تصميم قطاعات عشوائية كاملة في أربع مكررات ونفذت التجربة في محطتين بحثيتين هما: النوبارية وسدس خلال موسم ٢٠١٤. تم قياس صفات محصول الحبوب وعدد الأيام من الزراعة حتى ظهور ٥٠% من الحراير وارتفاعى النبات والكوز.

أوضحت النتائج ما يلى:

- وجود فروق معنوية بين المواقع والسلالات والكشافات لكل الصفات تحت الدراسة فى كل موقع على حدة وكذلك للتحليل المجمع للمواقع عدا صفه محصول الحبوب للكشافات فى موقع النوباريه والتحليل المجمع وايضا عدد الايام اللازمه لظهور ٥٠% من الحرائر للسلالات فى التحليل المجمع.
- تفوقت بعض الهجن الناتجة فى المحصول مثل Nb.603b x Cim.325, Nb.556 x Cim.325, Nb.659a x Gm.1002, Nb556 x Gm.1002, Nb601 x Cim.325 and Nb.603b x Gm.1002, حيث حققت محصولا ١٠,٥٥، ١٠,٠٦، ١٠,٠٦، ٩,٩٣، ٩,٧٠ و٩,٦٨ ميجا/ هكتار كمتوسط لكل المواقع على الترتيب.
- أعطت السلالات Nb.603b and Nb.556 قيما موجبة وعالية المعنوية لتأثيرات GCA لصفة محصول الحبوب بالاضافه انها تحمل اليلات مرغوبة لصفات التبكير وانخفاض ارتفاعى النبات والكوز.
- أفضل الكشافات هى السلالة Cim.325 حيث تحمل اليلات مرغوبة لصفة محصول الحبوب وكذلك التبكير وانخفاض ارتفاعى النبات والكوز.
- أعطت الهجن Nb.516c x Cim.325, Nb.575 x Gm.1002 and Nb.545 x Gm.1002 أفضلية بالنسبة لتأثيرات SCA لصفة المحصول وأيضا للصفات الأخرى.
- يجب الأخذ فى الاعتبار كل من تأثيرات GCA و SCA عند التخطيط لبرامج تربية الذره الشامية لانتاج سلالات وهجن جديدة.