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Combining ability and superiority of new white maize (*Zea mays* L.) inbred lines using line by tester analysis over three locations

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UNDERSTANDING genetic variability and combining ability is essential for improving maize programs. Inbred line Sd 7 and single cross SC. Sk 187 were used as testers in the top crossing of 15 different white maize inbred lines during 2021 season. The produced 30 crosses and four checks were assessed throughout 2022 season in Sakha, Sids, and Nubaria Agricultural Research Stations in Egypt. All traits except days to 50% silking of Cr x Loc, showed significant mean squares owing to locations, crosses, and their interaction. The majority of the qualities under study showed substantial to extremely significant mean squares resulting from lines (L), testers (T), and (L x T) and their interaction with locations. Although non-additive gene impact is more significant in grain production inheritance, additive genetic effects were more prominent in days to 50% silking, plant height, and ear height inheritance. Two single crossings (SC. Sk5003/11 x Sd7 and SC. Sk5004/19 x Sd7) and one three-way cross (TWC Sk5002/8 x SC Sk 187) showed considerably better grain yield performance and superiority compared to checks. The inbred lines Sk 5001/4 and Sk 5003/13 exhibited negative, favorable, significant GCA impacts for days to 50% silking, height of plant, and ear height. Sk 5002/8, Sk 5003/10, Sk 5003/11, and Sk 5004/19, four inbred lines, demonstrated considerable favorable GCA benefits for grain yield. For SCA effects, Sk 5003/11 x Sd 7 were the best crosses, Sk 5004/19 x Sd 7, Sk 5001/1 x SC Sk187 and Sk 5002/8 x SC Sk187 for grain yield.

Keywords: Additive gene effect, Non-additive gene effect, *Zea mays* L., Cross, General combining ability (GCA), Specific combining ability (SCA).

Introduction

The most extensively dispersed crop in the world is maize. Under irrigated to semi-arid circumstances, it is grown in tropical, subtropical, and temperate climates up to 50° and from sea level to 4000 m. Grain color, texture, and other characteristics vary greatly among the kinds that mature in 85 days to more than 200 days. The terms general combining ability (GCA) and special combining ability (SCA) are helpful for describing the inbred lines in their crosses, according to Sprague and Tatum (1942). The line × tester analysis is a technique used in maize breeding to assess the heterotic patterns and the ability to combine inbred lines for yield of grain and associated variables. Testers (male) are crossed with various inbred lines (female) to analyze the performance of the resulting hybrids and ascertain the specific combining ability (SCA) of the hybrids and the general combining ability (GCA) of the inbred lines. Whereas the SCA shows the unique performance of a certain combination of lines, the GCA shows the average performance of a line when crossed with other lines. This method aids in locating superior parent lines for creating adaptable and high-yielding maize cultivars.

Numerous studies were conducted to assess the performance of maize hybrids and to calculate the GCA and SCA for key parameters including grain yield. Dinesh *et al.* (2016), for instance, used two testers to evaluate 290 hybrids created by crossing 145 inbred lines of tropical maize. Yield of grain, days to silking, height of plant, and height of ear all exhibited significant differences in the mean squares for lines, tester, and line x tester. The ratio of GCA to SCA indicated that non-additive gene action predominated in the features' inheritance. According to Meseka *et al.* (2018) and Mutimamba *et al.* (2020), additive gene activity was more crucial for grain yield than non-additive gene action. As per Keimeso *et al.* (2020), the GCA was comparatively greater than the SCA, indicating that additive gene action was primarily responsible for regulating plant and ear heights, the yield of grain, and the inheritance of days to 50% silking. According to Kustanto and Hendrayana (2023), the mean square resulting from lines, testers, and their interaction was significant for grain yield, days to 50% silking,

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and plant and ear height. According to Mosa *et al.* (2024), when it came to the inheritance of grain yield, additive gene impacts were more significant compared to non-additive gene impacts. A number of techniques are commonly employed in the categorization of maize heterotic groups since identifying the heterotic group among inbred lines is crucial to the success of a maize hybrid program Barata and Carena (2006), Fan *et al.* (2009), Badu-Apraku *et al.* (2016).
This study aimed to: 1) Determine the maize inbred lines' combining abilities and their crosses and 2) Identify superior single and three way-crosses relative to commercial hybrids.

Materials and Methods

This investigation used about 15 white inbred lines that were divergent in isolation sources developed at Sakha Agricultural Research Station, viz., Sk5001/1, Sk5001/2, Sk5001/4, Sk5001/5, Sk5001/7, Sk5002/8, Sk5003/9, Sk5003/10, Sk5003/11, Sk5003/12, Sk5003/13, Sk5003/14, Sk5003/16, Sk5004/18, and Sk5004/19, used as female parents. Using two tester types as male parents, specifically the single cross SC. Sk 187 (T2) and the inbred line Sd 7 (T1), as well as four checks, which include two single crosses (SC.10) and Hytech SC. 2031, two three-way crosses (TWC 321), and Pioneer TWC Fadda. During the summer of 2021, at Sakha Agricultural Research Station, 15 female parents and 2 male testers were crossed using a line x tester design to produce 30 crosses. The resulting 30 crosses, along with the four commercial hybrids checks, were assessed at Egypt's Sakha, Sids, and Nubaria Agricultural Research Stations during the 2022 summer season. The experiment was laid out as a randomized complete block design with three replications in each location. Each entry is one 6 m long row, with hills 25 cm apart and rows spaced 80 cm apart. All recommended cultural practices were performed in the field as optimum crop production.
Recoded data were the number of days to 50% silking, height of plant (cm), height of ear (cm), and yield of grain in ardab/feddan (ard/fed) adjusted to 15.5% moisture of grain.

Statistical analysis

Combined analysis of variance (ANOVA) across three locations conducted after homogeneity test according to Snedecor and Cochran (1989). Calculation of variances analysis was carried out by using computer application of Statistical Analysis System (SAS, 2008). Combining ability effects of studied traits were computed according to line by tester the method presented by Kempthorne (1957) when the crosses mean squares were significant. Fan *et al.* (2009) calculated the Heterotic Group Specific and General Combining Ability (HSGCA) method to group inbred lines into heterotic groups.

Results and Discussion

Table (1) shows the combined analysis of variance for plant height, ear height, days to 50% silking, and grain yield across three locations. All traits showed highly significant differences among three locations (Loc.), showing that these traits are highly affected by the environmental conditions prevalent in these locations. Mean squares due to crosses (Cr) and their interaction with locations (Cr x Loc) were highly significant for every trait that was studied, with the exception of Cr x Loc of days to 50% silking, indicating that crosses had a wide genetic diversity among themselves for those traits providing opportunity for selection. Similar results founded by Mosa *et al.* (2008), Mousa (2014), Abu Shosha *et al.* (2020) and Mousa *et al.* (2021).

Table 1. A combined analysis of variance for days to 50% silking, plant height, ear height, and grain yield over three locations.

SOV	df	Days to 50% silking	Plant height	Ear height	Grain yield
Locations (Loc.)	2	1136.90**	206955.20**	72533.00**	7729.00**
Rep/Loc.	6	20.00	1212.20	427.70	38.30
Crosses (Cr)	33	15.70**	2568.20**	1069.80**	64.30**
Loc. X Cr	66	1.85	285.60**	222.90**	41.00**
Error	198	1.57	188.40	103.40	8.80

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

Table (2) shows the mean performance of crosses and checks for plant height, ear height, and days to 50% silking across three locations. One single cross (Sk5004/18 x Sd 7) was considerably earlier than the checks SC 10 and SC 2031, with days to 50% silking ranging from 64.7 days for Sk5004/18 x Sd 7 to 67.9 days for Sk5003/11 x Sd 7. When compared to the earliest check, TWC 321, the three-way crossovers were more timely, ranging from 61.8

days for Sk5004/18 x SC SK187 to 66.3 days for Sk5001/5 x SC SK187. According to these findings, the earliest single and three-way crosses were produced by the inbred line Sk5004/18. Two single crossings (Sk5003/9 x Sd 7) and (Sk5003/13 x Sd 7) were considerably shorter than the shortest check SC.2031, with plant heights ranging from 232.6 cm for Sk5003/9 x Sd 7 to 277.6 cm for Sk5004/18 x Sd 7. Ten three-way crosses were much shorter than the shortest check, TWC Fadda, with plant heights ranging from 207.4 cm for Sk5003/9 x SC. Sk187 to 257.3 cm for Sk5001/1 x SC. Sk187, Sk5003/9 x Sd 7 had a significantly different ear position than the check SC 2031, with ear heights ranging from 112.3 cm for Sk 5003/9 x Sd 7 to 149.1 cm for Sk5002/8 x Sd 7. The TWC Sk 5003/9 x SC. SK 187 had an ear height of 101.9 cm, while the TWC Sk 5001/1 x SC SK 187 had an ear height of 135.1 cm. The best check TWC Fadda was taller than nine three-way-crosses. The inbred line Sk 5003/9 produced the shortest single and three-way crossings for plant and ear heights based on the results above

Table 2. Mean performance of crosses, as well as checks for days to 50% silking, plant height, and ear height, across three locations.

Inbred line	Days to 50% silking		Plant height		Ear height	
	Sd 7	SC SK187	Sd 7	SC SK187	Sd 7	SC SK187
Sk5001/1	67.8	65.9	270.2	257.3	142.6	135.1
Sk5001/2	66.3	65.0	259.0	233.0	133.0	117.6
Sk5001/4	66.4	63.1	250.1	221.0	125.6	116.3
Sk5001/5	66.4	66.3	267.6	243.9	141.7	129.3
Sk5001/7	66.2	65.3	259.6	239.7	136.7	122.0
Sk5002/8	66.6	66.1	276.6	249.4	149.1	131.1
Sk5003/9	66.1	65.0	232.6	207.4	112.3	101.9
Sk5003/10	67.3	66.0	261.0	235.7	138.4	122.7
Sk5003/11	67.9	65.4	263.1	238.7	137.1	116.6
Sk5003/12	67.6	66.0	274.4	244.3	144.1	121.0
Sk5003/13	65.8	63.0	244.0	220.2	125.8	111.0
Sk5003/14	66.6	64.9	260.2	238.0	139.8	126.1
Sk5003/16	66.4	64.1	258.9	236.9	140.2	124.6
Sk5004/18	64.7	61.8	277.6	242.4	138.9	122.0
Sk5004/19	66.3	65.3	265.0	232.0	138.1	118.0
Check SC10	66.3		263.8		136.7	
Check SC2031	66.3		258.2		131.8	
Check TWC321	66.7		258.0		133.4	
Check TWC Fadda	66.8		253.8		132.1	
LSD 0.05	1.16		12.68		9.40	
0.01	1.52		16.69		12.37	

Table 3 shows the mean and superiority of 30 crosses over checks for grain yield. Two single crosses (Sk5003/11 x Sd7 35.1 ard. /fed.) and (Sk5004/19 x Sd7 32.8 ard. /fed.) significant out produced two checks (SC 10 and SC 2031), with percentages of superiority of 20.2% and 19.0% and 12.3% and 11.2%, respectively. Single crosses ranged from 24.6 ard/fed for (Sk5003/13 x Sd7) to 35.1 ard/fed for (Sk 5003/11 as well). Additionally, the Sk5002/8 x Sd7 cross was noteworthy for excellence in comparison to check SC 10. Three-way crosses' grain yields, meanwhile, varied from 22.1 ard/fed for Sk5003/9 x SC SK 187 to 35.0 ard/fed for Sk5002/8 x SC.SK 187. The two checks (TWC 321 and TWC Fada) were significantly outperformed by one three-way cross (Sk5002/8 x SC Sk 187 (35.0 ard. /fed.); the corresponding superiority percentages were 27.7% and 24.1%. For supremacy relative check TWC 321, the two-way crosses (Sk 5003/10 x SC.Sk 187) and (Sk 5003/11 x SC.Sk 187) were significant. This study recommends one three-way cross (TWC Sk5002/8 x SC. Sk 187) and two single crosses (SC. Sk5003/11 x Sd7 and SC. Sk5004/19 x Sd7) for large-scale evaluation in maize breeding programs.

Table 3. Mean performance and superiority of crosses along with checks for grain yield across three locations.

Inbred line	Grain yield(ard/fed)		Superiority SC		Superiority TWC	
	Sd 7	SC 187	SC 10	SC 2031	TWC 321	TWC Fedda
Sk5001/1	25.0	29.2	-14.4**	-15.3**	6.6	3.5
Sk5001/2	30.3	28.6	3.8	2.7	4.4	1.4
Sk5001/4	29.0	26.8	-0.7	-1.7	-2.2	-5.0
Sk5001/5	30.2	28.2	3.4	2.4	2.9	0.0
Sk5001/7	27.5	27.5	-5.8	-6.8	0.4	-2.5
Sk5002/8	31.9	35.0	9.2*	8.1	27.7**	24.1**
Sk5003/9	24.7	22.1	-15.4**	-16.3**	-19.3**	-21.6**
Sk5003/10	31.8	30.5	8.9	7.8	11.3*	8.2
Sk5003/11	35.1	30.7	20.2**	19.0**	12.0*	8.9
Sk5003/12	29.1	28.3	-0.3	-1.4	3.3	0.4
Sk5003/13	24.6	27.9	-15.8**	-16.6**	1.8	-1.1
Sk5003/14	29.6	27.1	1.4	0.3	-1.1	-3.9
Sk5003/16	29.7	30.1	1.7	0.7	9.9*	6.7
Sk5004/18	28.9	28.7	-1.0	-2.0	4.7	1.8
Sk5004/19	32.8	28.7	12.3**	11.2*	4.7	1.8
Check SC10	29.2					
Check SC2031	29.5					
Check TWC321	27.4					
Check TWC Fadda	28.2					
LSD 0.05	2.74					
0.01	3.61					

The line × tester analysis results for the three locations' days to 50% silking, height of plant, ear height, and yield of grain are shown in Table (4). For every trait, with the exception of grain yield (T), the testers' (T) and lines' (L) mean squares were very significant. Days to 50% silking and grain yield showed significantly significant mean squares for the L x T interaction. For days to 50% silking, ear height, and grain yield, mean squares resulting from L × Loc were significant. The mean squares resulted from T x Loc and L x T x Loc were significant or very significant for height of plant, ear height, and yield of grain Meaning that the lines, testers and crosses differed in their order from location to another, also indicated that it would be worthwhile to evaluated test crosses under multi environments, especially for grain yield, which was regarded as a complex polygenic trait Mousa *et al*. (2021). These results are consistent with those published by Mosa *et al*. (2004), Motawei *et al*. (2019) and Abd-Elaziz *et al*. (2021).

Table 4. Variance analysis of days to 50% silking, plant height, ear height, and grain yield across three locations.

S.O.V	df	Days to 50% silking	Plant height	Ear height	Grain yield
Lines (L)	14	18.15**	2582.5**	1260.7**	116.3**
Testers (T)	1	189.2**	43269.3**	15610.4**	34.8
L x T	14	3.89**	130.6	82.4	30.6**
L x Loc.	28	2.47*	229.8	272.0**	46.4**
T x Loc.	2	0.11	842.3**	354.5*	429.0**
L x T x Loc.	28	1.38	305.0**	177.1**	14.8*
Error	174	1.62	167.1	99.1	9.0

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

Table (5) while the K^2SCA, or non-additive gene effects, were crucial in determining grain yield inheritance, the K^2GCA, or additive gene effects, were the most significant factor governing the inheritance of 50% silking days, plant height, and ear height. According to Abd-Elaziz *et al.* (2021), additive gene action was primarily responsible for the days to 50% silking inheritance, plant height, and ear height, while non-additive gene action was primarily responsible for the inheritance of grain yield. These findings are consistent with those of numerous other researchers. Ismail *et al*. (2023) and Tabu *et al*. (2023) discovered that both additive and non-additive gene effects control days to 50% silking, height of plant, ear height, and the yield of grain, although additive gene effects predominate in the inheritance of these characteristics. Singh *et al*. (2017), Mosa et al. (2017), Motawei *et al*. (2019), and Ali *et al*. (2020) found that the main role influencing grain yield inheritance was non-additive gene action.

Table 5. Estimates of general (K^2GCA) and specific (K^2SCA) combining ability effects for grain yield across three locations.

Genetic component	Days to 50% silking	Plant height	Ear height	Grain yield
K^2GCA	1.33	297.50	108.97	0.87
K^2SCA	0.25	0.01	0.01	2.40

Table (6) shows the general combining ability effects of 15 inbred lines and two testers for days to 50% silking, plant height, ear height, and grain production across the three locations. Sk 5001/4, Sk 5003/9, and Sk 5003/13 were the best inbred lines for GCA effects; Sk 5002/8, Sk 5003/10, Sk 5003/11, and Sk 5004/19 were the best for grain yield; and Sk 5001/4, Sk 5003/13, and Sk 5004/18 were the best for earliness. According to the data above, the inbred lines Sk 5001/4 and Sk 5003/13 had desired GCA effects for short plant and ear height as well as earliness. In the meantime, Sd 7 for grain yield and SC 187 for earliness, short plant, and ear heights were the preferred testers for GCA effects.

Table 6. Effects of 15 inbred lines and two testers on general combining ability for days to 50% silking, plant height, ear height, and grain yield in the three locations.

Inbred line	Days to 50%	Plant height	Ear height	Grain yield
Sk5001/1	1.11**	15.12**	10.21**	-1.91**
Sk5001/2	-0.06	-2.66	-3.34	0.46
Sk5001/4	-0.95**	-13.10**	-7.67**	-1.10
Sk5001/5	0.66*	7.06*	6.88**	0.22
Sk5001/7	0.05	0.95	0.71	-1.46*
Sk5002/8	0.61*	14.34**	11.49**	4.47**
Sk5003/9	-0.17	-28.66**	-21.51**	-5.59**
Sk5003/10	0.94**	-0.33	1.94	2.19**
Sk5003/11	0.94**	2.23	-1.79	3.91**
Sk5003/12	1.05**	10.73**	3.94	-0.30
Sk5003/13	-1.34**	-16.55**	-10.23**	-2.72**
Sk5003/14	0.01	0.45	4.33	-0.66
Sk5003/16	-0.45	-0.77	3.77	0.94
Sk5004/18	-2.50**	11.34**	1.83	-0.21
Sk5004/19	0.11	-0.16	-0.56	1.75*
Tester Sd7	0.84**	12.66**	7.60**	0.36
Tester SC SK187	-0.84**	-12.66**	-7.60**	-0.36
LSD gi L 0.05	0.59	5.97	4.60	1.39
0.01	0.77	7.86	6.05	1.82
LSD gi T 0.05	0.21	2.18	1.68	0.51
0.01	0.28	2.87	2.21	0.67

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

Table (7) shows the best cross overs of particular combining abilities for the four qualities under study in the three locations. Sk 5001/1 x Sd7, Sk 5001/5 x Sd7, Sk 5004/18 x SC Sk187, and Sk 5004/19 x SC. Sk187 for low plant height and Sk 5001/5 x Sd7, Sk 5002/8 x Sd7, Sk 5001/4 x SC Sk187, and Sk 5004/18 x SC. Sk187 for earliness showed the strongest SCA effects. Sk 5001/4 x Sd7, Sk 5003/12 x SC. Sk187, and Sk 5004/19 x SC. Sk187 are used for ear placement, whereas Sk 5001/1 x SC. Sk187, Sk 5002/8 x SC. Sk187, and Sk 5003/11 x Sd 7 are used for yield of grain.

The promising crosses Sk 5003/11 x Sd 7, Sk 5004/19 x Sd 7 and the three-way cross Sk 5002/8 x SC. Sk187 had high for both means and Grain yield effects of SCA. This study recommended the future use of these crossing in maize breeding program.

Table 7. The best crosses of specific combining abilities for four traits under study across the three locations.

Days to 50% silking	Plant height	Ear height	Grain yield
Sk 5001/5 x Sd7	Sk 5001/1 x Sd7	Sk 5001/1 x Sd7	Sk 5003/11 x Sd 7
Sk 5002/8 x Sd7	Sk 5001/5 x Sd7	Sk 5001/4 x Sd7	Sk 5004/19 x Sd 7
Sk 5001/4 x SC. Sk187	Sk 5004/18 x SC. Sk187	Sk 5003/12 x SC. Sk187	Sk 5001/1 x SC.
Sk 5004/18 x SC. Sk187	Sk 5004/19 x SC. Sk187	Sk 5004/19 x SC.	Sk 5002/8 x SC.

Table (8) displays heterotic group estimations for grain yield according to special and general combining ability impacts (HSGCA). A heterotic grouping technique based on special and general combining ability effects (HSGCA) was presented by Fan *et al*. (2009). Inbred lines were categorized into the following groups: In step one, every tested inbred line was put in the same heterotic group as its tester. In the second step, the inbred lines were eliminated from the other heterotic groups and retained with the heterotic group where their HSGCA impacts had the biggest negative value. Step 3: It will be careful to ascribe the inbred line to any heterotic group if it showed positive HSGCA effects with all representative tests, as the line may be a member of a heterotic group that is distinct from the testers that were employed in the study.

Table 8. Heterotic group estimates for grain yield across three locations utilizing the specific and general combining ability (HSGCA) method.

Line	HSGCA	
	Sd7	SC Sk187
Sk5001/1	-4.39#	0.57
Sk5001/2	0.98	-0.05#
Sk5001/4	-0.39	-1.81#
Sk5001/5	0.88	-0.44#
Sk5001/7	-1.81#	-1.11
Sk5002/8	2.55	6.38
Sk5003/9	-4.62	-6.57#
Sk5003/10	2.48	1.90
Sk5003/11	5.77	2.06
Sk5003/12	-0.30	-0.31#
Sk5003/13	-4.74#	-0.70
Sk5003/14	0.22	-1.53#
Sk5003/16	0.37	1.50
Sk5004/18	-0.49#	0.07
Sk5004/19	3.46	0.04

≠ means that this inbred line belongs to tester group.

First heterotic group (tester Sd7) contained the inbred lines Sk5001/1, Sk5001/7, Sk5003/13 and Sk5004/18 meanwhile second heterotic group (tester SC. Sk 187) contained the inbred lines Sk5001/2, Sk5001/4, Sk5001/5, Sk5003/9, Sk5003/12 and Sk5003/14. Nevertheless, this approach was unable to classify the inbred lines Sk5002/8, Sk5003/10, Sk5003/11, Sk5003/16 and Sk5004/19

The above results for heterotic grouping might be used in breeding programs to select the best parents for developing high-heterosis crossings. Vasal *et al*. (1992), Lee (1995), Menkir *et al*. (2004), and Legesse *et al*. (2009), Mosa *et al*. (2017), and Mosa *et al*. (2024) classified inbred lines into heterotic groups for grain yield and reported that classifying inbred lines into heterotic groups makes it easier to exploit heterosis in maize, which may enhance hybrid performance.

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القدرة على التالف والتفوق لسلالات جديدة بيضاء من الذرة الشامية باستخدام تحليل الهجن القمية في ثلاث مواقع

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من المهم معرفة التباين الوراثي والقدرة القدرة على الائتلاف في برامج تحسين الذرة الشامية. تم تهجين ١٥ سلالة مرباه داخليا من الذرة الشامية البيضاء مع اثنين من الكشافات سلاسة سدس ٧ وهجين فردى سخا ١٨٧ خلال موسم ٢٠٢١. الهجن الثلاثين الناتجة مع اربعة هجن مقارنة تم تقييمها فى ثلاث محطات بحثيه وهي سخا وسدس والنوبارية فى موسم ٢٠٢٢. كان متوسط مربع الانحرافات للجهات والهجن والتفاعل بينهم عالي المعنوية لكل صفات الدراسة ماعدا التفاعل لصفة عدد الايام حتى ظهور حريرة ٥٠% في النباتات كان التباين الراجع للسلالات والكشافات وتفاعلهما كذلك التفاعل لهم مع المواقع معنوي الى عالي المعنوية في معظم الصفات تحت الدراسة. اظهر هجينين فرديين وهجين ثلاثي معنوية في متوسط المحصول والتفوق عن هجن المقارنة. كانت التأثيرات الاضافية للجينات لها التأثير الاكبر في توريث صفات عدد الايام حتى ٥٠% حريرة وارتفاع النبات وارتفاع الكوز بينما كان التأثيرات الغير إضافية للجينات لها التأثير الاكبر فى توريث صفة محصول الحبوب. اظهرت السلالتين سخا ٤/٥٠٠١ وسخا ١٣/٥٠٠٣ قدرة على الائتلاف مرغوبة لصفات عدد الايام حتى ظهور حرائر ٥٠% من النباتات وارتفاع النبات وارتفاع الكوز. بينما اظهرت أربع سلالات سخا٨/٥٠٠٢و ١٠/٥٠٠٣و سخا ١١/٥٠٠٣ وسخا ١٩/٥٠٠٤ قدرة ائتلافية عامة عالية لمحصول الحبوب ويوصى باستخدامها في برنامج انتاج الهجن الجديدة بيضاء الحدود من الذرة الشامية. اظهرت اربعة هجن Sk 5003/11 x Sd 7و Sk 5004/19 x Sd7 Sk 5001/1 x SC Sk187, Sk 5002/8 x SC Sk187 افضلية لتأثيرات القدرة الخاصة على التالف لصفة محصول الحبوب.

الكلمات الدالة: تأثير الجين المضيف، تأثير الجين غير المضيف، الذره الشاميه.، تهجين، القدرة العامة التآلف، القدرة الخاصه على التآلف.