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ESTIMATES OF COMBINING ABILITY FOR GRAIN YIELD AND OTHER ATTRIBUTES IN MAIZE

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ABSTRACT: *Twelve yellow maize inbred lines in the S_3 generation were topcrossed to three inbred line testers, viz. Gz638, Gz650, and Gm1021 in 2007 season. Thirty-six entries topcrosses in addition to two check hybrids; SC.155 and SC.162 were evaluated at Sakha, Gemmeiza, and Sids Agric. Res. St, ARC in 2008 for no. of days to 50% silking, plant and ear height, resistance to late wilt disease and grain yield. Mean squares due to crosses, lines (L) and testers (T) were significant for all traits studied across locations, except for days to 50%silking of testers and ear height of lines, revealing that great diversities were existed among testers and lines. Mean squares of the lines x testers interaction were significant for all the traits studied, indicating that the lines (females) had differed in order of performance in crosses with each of the testers (males). Highly significant differences were detected among locations for all traits studied, indicating that the three locations differed in their environmental conditions. The interactions of locations (environments) with crosses, lines and testers were significant for all the traits studied, except for ear height of L x Loc and days to 50%silking and resistance to late wilt of T x Loc. These significant interactions with locations are mainly attributed to the different ranking of genotypes from location to another. The interaction of L x T x Loc was significant for all the traits studied except of days to 50% silking and resistance to late wilt. These results revealed that the crosses between lines and testers were different from one location to another.The highest GCA effects for grain yield were recorded for lines L5 and L12. These lines should be utilized in breeding programs to be used as sources for developing high yielding hybrids Crosses L1 x GZ650 , L2 x GZ638 , L3 x GM1021 , L5 x GZ638 and L11 x GZ650 showed significant positive SCA effects for grain yield. The σ^2_{SCA} variances was larger than that of σ^2_{GCA} for days to 50%silking, plant height and late wilt resistance. These results indicate that the non-additive gene effects were more important than additive gene effects in the inheritance of these traits. But σ^2_{GCA} was larger than σ^2_{SCA} for ear height and grain yield. Furthermore, the magnitude of σ^2_{SCA} x Loc. interaction was greater than σ^2_{GCA} x Loc interaction for all the traits studied except, for days to 50% silking, indicating that the non-additive gene action interacted more with the environmental conditions than the additive component for this trait.*

Key words: *Maize, Topcrosses, Combining ability, Gene action.*

INTRODUCTION

Developing high yielding maize hybrids which had good performance and produce high yield are considered among the ultimate goals of the National Maize Research Program (NMRP).

Topcross (test cross) method using broad and/or narrow testers is widely used to evaluate new improved lines for combining ability in maize hybrid breeding programmes. The choice of a tester to test the developed inbred lines is an important decision. In this respect, Matzinger (1953) found that a narrow genetic base tester contributes more to line x tester interaction than does a heterogeneous one. Lonnquist and Lindsey (1964) reported that the use of common tester parent reduced the range of traits expression among the progenies being evaluated. Russell *et al* (1973) and Walejko and Russell (1977) stated that the inbred testers are effective for determining general and specific combining ability effects. Hallauer and Miranda (1981) found that the low performing testers gave a better idea of GCA of the lines than high performing testers. Ali and Tepora (1986) found that the inbred line as a narrow genetic base exhibited the highest genetic variation in the test crosse progenies for general combining ability effects for grain yield. Topcross procedure was the first suggested by Davis (1927) as an early testing to determine the usefulness of the lines for hybrid development programs. The concept of general (GCA) and specific (SCA) combining ability was firstly defined by Sprague and Tatum (1942). They and other investigators (Hassaballa *et al* 1980, ElMorshidy and Hassaballa 1982, Mahmoud 1996, Konak *et al* 1999, Zelleke 2000 and Abd ElMoula and Abd ElAzeem2008) reported that the variance components due to SCA for grain yield and other agronomic traits was larger than that due to GCA, indicating the importance of nonadditive type of gene action in the inheritance of these traits. Mathur *et al* (1998) obtained significant GCA variances for days to 50% silking. On the other hand, the environment x GCA interaction for grain yield was significant for both lines and testers (Hede *et al* 1999, Nass *et al* 2000, ElZeir *et al* 2000, ElMorshidy *et al* 2003 and Abd ElMoula et al 2004). However, Soliman and Osman (2006) revealed that the additive component of gene action had the major role in the inheritance of grain yield and other traits compared with the non-additive ones.

The main objectives of this investigation were 1) to evaluate of 36 yellow maize inbred lines in topcrosses with three testers, 2) to determine the important type of gene action., and 3) to identify the most superior line(s) and single crosses to be utilized in hybrid maize breeding program.

MATERIALS AND METHODS

Twelve selected yellow maize lines in S_5 generation derived from Pop45 (EV3) through selection from segregating generations in the disease nursery field at Sids Agricultural Research Station were used for the purpose of this study. In 2007 summer season, the 12 inbred lines were top crossed to three narrow base inbred testers, *i.e.* Gz638, Gz650 and Gm1021 at Sids Experimental Station. The three testers were developed by Maize Research Program and are being used in seed production of commercial single and three-way cross hybrids. In 2008 summer season, the obtained 36 top crosses (12 lines x 3 testers) with the two commercial check hybrids, SC 155 and SC162 were evaluated in replicated yield trials conducted at Sakha, Gemmeiza and Sids Agric Res Stns. The experimental design was randomized complete block design with four replications. Plot size was one row, 6 m long and 80 cm apart and hills were spaced 25 cm along the row. Two grains were planted per hill and thinned later to one plant per hill to provide a population density of approximately 21000 plants/feddan (One Feddan = 4200 m^2). All cultural practices for maize production were applied as recommended. Data were recorded for number of days to 50% silking, plant height (cm), ear height (cm), resistance to late wilt and grain yield $feddan^{-1}$ adjusted to 15.5% grain moisture. Analysis of variance was performed for the combined data over locations according to Steel and Torrie (1980), and Kempthorne (1957) procedure as explained by Singh and Chaudhary (1979) was followed to obtain information about the combining ability of the lines and the testers as well as estimate types of gene effects controlling grain yield and other traits studied of the tested lines.

RESULTS AND DISCUSSION

Analysis of variance

Combined analysis of variance for all the traits studied is presented in Table (1). Significant and/or highly significant differences were detected among locations for all traits studied. These results revealed the presence of markedly variations among three locations in climatic and soil conditions. Mean squares among crosses were highly significant for all traits. Partitioning of sum of squares due to crosses into its components showed that mean squares due to lines and testers were significant for all traits except, number of days to 50%silking of testers and ear height of lines, revealing that great diversity existed among testers and lines. At the same time, mean squares of the lines x testers interaction were significant for all the traits studied, indicating that the lines (females) differed in order of performance in crosses with each of the testers (males).

The interactions of locations (environments) with crosses, lines and testers were found to be significant for all the traits studied except, ear height of L x Loc, number of days to 50% silking and resistance to late wilt of T x Loc. These significant interactions with locations are mainly attributed to the different ranking of genotypes from location to another. The interaction of L x T x Loc were significant for all the traits studied except for number of days to 50% silking and resistance to late wilt. These results revealed that crosses between lines and testers behaved somewhat differently from location to another.

The magnitude of the variance due to testers for all the traits studied was higher than variances of lines, except for number of days to 50% silking, and resistant to late wilt indicating that testers contributed much more to the total variation. The magnitude of the variance due to T x Loc was higher than that of L x Loc for all traits except, number of days to 50% silking, revealing that testers were affected more by the environmental conditions than lines. Similar results were obtained by Shehata *et al* (1997), Soliman and Sadek (1999), ElZeir *et al* (2000), Soliman (2000); ElMorshidy *et al* (2003) and Abd ElMoula *et al* (2004). However, Amer and ElShenawy (2007) obtained significant interaction between locations, lines and testers for silking date, ear height and grain yield. Also, Gado *et al* (2000), Soliman (2000), and ElMorshidy *et al* (2003) added that testers were affected much more by the environmental conditions than lines.

Table 1: Mean squares and degrees of freedom for grain yield and other traits studied, data of combined over three locations.

S.O.V	df	MS				
		Days to 50% silking	Plant height (cm)	Ear height (cm)	Resistance to late wilt	Grain yield (ard/fed)
Loc.	2	1518.527**	151904.182**	63915.655**	3036.493**	8951.124**
Rep/loc	9	19.469	1022.310	570.196	28.935	24.127
Crosses	35	11.354**	2522.215**	1125.777**	131.758**	68.297**
Lines	11	29.652**	3754.019**	1046.759**	231.831**	55.915**
Testers	2	1.548	12366.182**	9158.918**	228.306**	369.866**
L x T	22	3.096**	1011.407**	434.999**	27.945**	47.072**
C x Loc	70	2.315**	255.816**	103.043**	64.399**	24.610**
L x Loc	22	4.636**	370.923**	56.932	112.879**	20.534**
T x Loc	4	1.138	643.662**	239.224**	28.252	79.922**
L x T x Loc	44	1.262	163.004**	113.718**	43.446	21.619**
Pooled error	315	1.293	76.811	51.941	17.234	6.565
CV%		1.908	3.713	5.589	4.354	10.198

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

Mean performance

Mean performance of topcrosses across the three locations for the traits studied of the are shown in Table 2. Results showed that the earliest cross was L10 x GM1021 (57.58 days), while the latest cross was L9 x Gm1021 (61.42 days). Six topcrosses were significantly earlier than the check SC155. Concerning plant height, the shortest cross was L6 x GZ638 (207.58 cm) while the tallest cross was L2 x GZ638 (264.67 cm). Twenty seven crosses was significantly shorter than the check SC155. The lowest ear height value was recorded for the cross L4 x GZ638 (111 cm) while the highest value was observed for the cross L7 x Gm1021 (146.92 cm). Thirty crosses had significantly lower ear placement than the check SC155.Regarding grain yield, the lowest value was detected for the cross L1 x GZ638 (20.16 ard/fed.), while the highest values was recorded for cross L3 x Gm1021 (30.52 ard/fed.). Fourteen crosses exceeded the check SC155. Seven crosses i.e. L3 x GZ638, L3 x Gm1021, L5 x GZ638, L5×Gm1021, L9 x Gm1021, L10x Gm1021 and L12 x Gm1021,were superior in termes of grain yield (ard/fed) than the check hybrid SC155 and one of the crosses, L3 x Gm1021 surpassed the check hybrid SC162. Therefore, these crosses could be considered as promising hybrids due to their superior grain yield and desirable values for resistance to late wilt disease. These results suggests that these crosses are out standing hybrids and would be fruitful to be used in maize breeding program and could be evaluated as new promising maize hybrids.

General (g_i) and specific (s_{ij}) effects:

General combining ability effects of lines and testers for all the traits studied are shown in Table 3. Desirable and significant values of GCA effects were obtained by lines L5, L6 , L7 , L10 and L12 for days to 50%silking, L4 , L6 , L7 , L9 and L11 for plant height, L3, L4 and L6 for ear height , L3, L9 , L11 and L12 for resistance to late wilt and L5 and L12 for grain yield. Furthermore, the best lines for combining ability had accumulated favorable alleles were L5 for earliness and grain yield, L6 for earliness, shortest plants and lower ear placement and L12 for earliness, resistance to late wilt and grain yield.

Values of GCA effects of inbred testers GZ638 and GZ650 were a good general combiner for days to 50% silking, plant height, ear height. While, tester Gm-1021 had favorable alleles for resistance to late wilt and grain yield.

Specific combining ability effects for all the top crosses (Table 4), pointed out that the crosses L3 x Gm1021 and L9 x GZ650 had negative and significant SCA effects for days to 50% silking. Crosses L1 x GZ638 , L4 x GZ638 , L2 x Gm1021 , L5 x GZ650, L7 x GZ638 , L8 x GZ650 , L11 x Gm1021 and L12 x Gm1021 for plant height and the crosses L1 x GZ638 , L1 x Gm1021 , L2 x Gm1021 , L3 x GZ638 , L4 x GZ638 , L7 x GZ638 , L11 x GZ638 and L12 x GZ650 for ear height hade negative and significant SCA effects. Positive and significant SCA effects were obtained for the crosses L 4x Gm1021 , L5 x GZ638 , L6 x GZ650 , L6 x Gm1021 and L11 x GZ650 for resistance to late wilt and crosses L1 x GZ650 , L2 x GZ638 , L3 x Gm1021 , L5 x GZ638 and L11 x GZ650 for grain yield.

Table (2): Mean performance of (12 lines x 3 testers) for grain yield and other attributes, data of combined over the three locations, 2008 season.

Lines	Days to 50% silking (days)			Plant height (cm)			Ear height (cm)			Resistance to late wilt			Grain yield (ard/fedd)		
	Gz638	Gz650	Gm1021	Gz638	Gz650	Gm1021	Gz638	Gz650	Gm1021	Gz638	Gz650	Gm1021	Gz638	Gz650	Gm1021
L1	60.33	59.92	60.75	218.17	231.33	256.25	115.83	124.50	143.50	95.77	91.95	91.95	20.16	23.66	24.84
L2	60.08	60.50	59.67	264.67	242.92	248.67	141.58	130.17	134.33	96.57	94.68	94.68	27.96	23.52	25.72
L3	61.25	61.33	60.08	236.67	244.50	258.58	113.83	125.33	137.50	98.52	96.27	96.27	24.29	21.09	30.52
L4	60.00	59.67	59.25	214.17	225.42	240.50	111.00	121.50	132.58	95.18	92.16	92.16	23.87	23.47	27.29
L5	58.50	59.00	60.00	243.83	228.92	253.67	130.92	125.00	135.08	97.88	92.95	92.95	28.25	24.46	28.17
L6	58.42	59.08	59.25	207.58	210.42	227.08	111.92	119.00	125.75	85.06	94.03	94.03	22.34	23.73	24.50
L7	58.50	59.67	58.58	221.25	220.83	252.67	120.75	133.25	146.92	90.83	89.18	89.18	21.15	24.58	27.25
L8	59.33	60.00	60.67	239.58	228.58	250.33	127.25	130.67	142.33	92.61	91.82	91.82	24.23	25.44	25.05
L9	61.17	60.42	61.42	229.25	223.33	243.50	124.33	123.50	140.00	98.97	97.14	97.14	24.13	24.04	28.98
L10	59.00	59.08	57.58	233.17	228.08	252.42	121.25	125.67	144.58	94.43	92.40	92.40	24.33	23.68	28.05
L11	59.33	59.42	59.50	213.33	242.00	232.83	112.92	132.25	133.42	96.18	100.00	100.00	22.23	26.63	24.90
L12	57.92	58.08	59.00	249.50	238.92	244.25	137.58	128.00	138.08	100.00	97.28	97.28	27.10	26.40	28.40
Means	59.48	59.68	59.64	230.93	230.44	246.73	122.43	126.57	137.84	95.17	94.15	94.15	24.17	24.22	26.97
Check SC155		59.58			253.75			144.42			98.8			25.30	
SC162		64.75			265.58			148.96			96.4			27.89	
LSD 0.05		0.90			7.01			5.76			3.32			2.05	

Table 3: Estimates of GCA effects for grain yield and other attributes, data of the combined over the three locations.

Traits / Lines	Days to 50% silking	Plant height	Ear height	Resistance to late wilt	Grain yield
L1	0.729**	0.783	1.002	0.626	2.237**
L2	0.479*	16.050**	6.414**	0.318	0.612
L3	1.284**	10.550**	3.391*	1.997*	0.178
L4	0.035	9.338**	7.252**	0.452	0.244
L5	0.437*	6.106**	1.386	0.152	1.836**
L6	0.687**	21.004**	10.057**	3.520**	1.598**
L7	0.687**	4.449**	4.692*	4.208	0.796
L8	0.395*	3.467*	4.469*	1.701	0.216
L9	1.396**	4.004**	0.331	3.375**	0.594
L10	0.576**	0.865	0.613	1.726	0.346
L11	0.187	6.643**	2.752	3.051**	0.533
L12	1.743**	10.912**	7.775**	3.074**	2.060**
Tester (T)					
GZ638	0.118	5.102**	6.516**	0.160	0.954**
GZ650	0.076	5.594**	2.377*	1.171**	0.896**
Gm1021	0.042	10.696**	8.893**	1.331**	1.850**
SE gi L	0.189	1.460	1.698	0.691	0.427
SE gi T	0.094	0.730	0.849	0.345	0.213

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

Table 4: Estimates of SCA effects for grain yield and other attributes, data of the combined over the three locations.

Crosses	Days to 50% silking	Plant height (cm)	Ear height (cm)	Resistance to late wilt	Grain yield
L1 x GZ638	0.118	11.981**	5.594*	1.227	1.774*
L2x GZ638	0.118	17.685**	12.738**	1.722	3.174**
L3 x GZ638	0.479	4.815	5.206*	1.358	0.057
L4 x GZ638	0.479	7.426**	4.178*	0.436	0.052
L5 x GZ638	0.548	6.796*	7.099**	2.559*	2.240**
L6 x GZ638	0.382	2.342	0.456	6.585**	0.233
L7 x GZ638	0.298	5.231*	6.372**	0.125	2.218**
L8 x GZ638	0.548	5.185*	0.349	0.854	0.273
L9 x GZ638	0.285	2.324	1.571	0.427	0.637
L10 x GZ638	0.090	3.101	0.567	0.988	0.187
L11 x GZ638	0.034	10.954**	6.761**	2.037	1.400
L12 x GZ638	0.173	7.657**	7.377**	1.756	0.871
L1 x GZ650	0.493	1.678	1.067	1.576	1.672*
L2 x GZ650	0.340	3.571	2.817	0.8433	1.312
L3 x GZ650	0.368	3.511	2.155	0.116	3.316**
L4 x GZ650	0.049	4.317	2.182	2.450*	0.506
L5 x GZ650	0.243	7.627**	2.956	1.359	1.601*
L6 x GZ650	0.090	0.984	2.488	3.399**	1.105
L7 x GZ650	0.674*	5.155*	1.988	0.768	1.148
L8 x GZ650	0.076	5.322*	0.373	0.635	1.434
L9 x GZ650	0.659*	3.099	3.400	0.389	0.776
L10 x GZ650	0.021	.1.488	0.289	0.025	0.892
L11 x GZ650	0.076	18.206**	8.432**	2.790*	2.934**
L12 x GZ650	0.145	2.432	6.344**	0.056	0.110
L1 x Gm1021	0.375	10.303**	6.662**	0.349	0.102
L2 x Gm1021	0.458	14.113**	9.921**	2.565*	1.862*
L3 x Gm1021	0.8 47*	1.303	3.050	1.474	3.373**
L4 x Gm1021	0.430	3.10C	1.995	2.886*	0.559
L5 x Gm1021	0.791*	0.831	4.143	1.199	0.639
L6 x Gm1021	0.291	1.358	2.072	3.186**	0.872
L7x Gm1021	0.375	10.386**	4.384*	0.894	1.069
L8 x Gm1021	0.625	0.136	0.023	1.490	1.708*
L9 x Gm1021	0.375	0.775	1.828	0.037	1.413
L10 x Gm1021	0.069	1.613	0.856	0.962	1.079
L12 x Gm1021	0.319	5.224*	1.032	1.812	0.982
L11 x Gm1021	0.041	7.252**	1.671	0.753	1.534*
SE (s_{ij})	0.328	2.530	2.080	1.198	0.739

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

Variance components

Estimates of the variance components of lines and testers (σ^2_{GCA}) and of crosses (σ^2_{SCA}) for grain yield and other agronomic traits across locations are presented in Table (5). Results revealed that values of σ^2_{GCA} for lines (L) were higher than those of σ^2_{GCA} for testers (T) for number of days to 50% silking and resistance to late wilt. These results indicate that most of the total variance was due to GCA of the lines. While, values of σ^2_{GCA} for testers (T) were higher than those of σ^2_{GCA} for lines (L) for plant and ear height and grain yield. These results indicate that most of the total variance was due to GCA of the testers of these traits. The variance interaction of σ^2_{GCA} testers x Loc. was larger than σ^2_{GCA} lines x Loc. for ear height and grain yield, indicating that σ^2_{GCA} for testers was more affected by environmental conditions than that for lines. On the other hand the magnitude of variance interaction of σ^2_{GCA} lines x Loc. was larger than that of σ^2_{GCA} testers x Loc for number of days to 50% silking, plant height and resistance to late wilt. The σ^2_{SCA} variances were larger than that of σ^2_{GCA} for days to 50%silking, plant height and late wilt resistance. These results indicate that the non-additive gene effects were more important than additive gene effects in the inheritance of these traits. While the σ^2_{GCA} variances was larger than those of σ^2_{SCA} for ear height and grain yield. Furthermore, the magnitude of σ^2_{SCA} x Loc. interaction was greater than σ^2_{GCA} x Loc interaction for all the traits studied except, for number of days to 50% silking, indicating that the non-additive gene action interacted more with the environmental conditions than the additive component for these trait. These results are in agreement with the findings of several investigators who reported that specific combining ability variance was more sensitive to environmental changes than general combining ability variance (Gilbert, 1958). Also, Shehata and Dhawan (1975) and Sadek *et al* (2000 and 2002) also found that the non-additive genetic effects interacted more with the environment than the additive component. On the other hand, El-Itriby *et al* (1990), and Soliman *et al* (2001) reported that the additive types of gene action were more affected by the environment than non-additive ones.

Table 5. Estimates of general (σ^2_{GCA}) and specific (σ^2_{SCA}) combining ability variances for grain yield and other plant traits combined over three locations.

Parameters	Traits				
	Days to 50% silking	Plant height (cm)	Ear height (cm)	Resistance to late wilt	Grain yield
σ^2_{gca} (lines)	0.737	76.183	16.993	4.413	0.245
σ^2_{gca} (testers)	0.10	78.852	60.582	1.078	2.242
σ^2_{gca} x Loc (lines)	0.281	17.326	4.732	5.786	0.090
σ^2_{gca} x Loc (testers)	0.002	10.013	2.614	0.316	1.214
σ^2_{gca}	0.125	77.062	53.258	2.011	7.312
σ^2_{gca} x Loc	0.037	0.789	0.623	0.623	0.641
σ^2_{sca}	0.150	77.883	31.921	4.642	3.375
σ^2_{sca} x Loc	0.008	21.548	15.444	6.553	3.763

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تقدير القدرة على التآلف لمحصول الحبوب وبعض الصفات الأخرى في الذرة الشامية

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الملخص العربي

هجنت ١٢ سلالة فى الجيل الاخصابى الذاتى الثالث(S_3) من الذرة الشامية الصفراء مع ٣ كشافات (سلالات تربية داخلية) مختلفة هي : جيزة٦٣٨ وجيزة ٦٥٠ وجميزة ١٠٢١ وذلك بمحطة البحوث الزراعية بسدس في موسم ٢٠٠٧ . وفي موسم ٢٠٠٨ تم تقييم ٣٦ هجين قمي مع هجن للمقارنة (هـ. ف. ١٥٥ ، هـ. ف. ١٦٢ في كل من محطة البحوث الزراعية بسخا والجميزة ، وسدس وذلك لصفات عدد الأيام من الزراعة حتى ظهور ٥٠ % من الحراير ، ارتفاع كل من النبات والكوز، المقاومة لمرض الذبول المتأخر ، محصول الحبوب بالأردب للفدان. وقد وجدت اختلافات معنوية بين الهجن القمية , السلالات , الكشافات لكل الصفات المدروسة ما عدا صفة عدد الأيام من الزراعة حتى ظهور ٥٠ % من الحراير للكشافات و صفة ارتفاع الكوز للسلالات ومعنوية لتباين تفاعل السلالات × الكشافات لكل الصفات موضع الدراسة . كذلك وجدت اختلافات معنوية بين المواقع لجميع الصفات المدروسة مما يدل عل ان المواقع مختلفة في الظروف البيئية. وكان تباين التفاعل بين المواقع والهجن القمية والسلالات والكشافات معنويا لجميع الصفات المدروسة ما عدا صفة ارتفاع الكوز للسلالات و صفة عدد الأيام من الزراعة حتى ظهور ٥٠ % من الحراير للكشافات .. كما كان تباين التفاعل بين السلالات × الكشافات × المواقع معنوي لصفات ارتفاع النبات والكوز ومحصول الحبوب. أظهرت السلالات رقم ١و ١٢ أحسن قدرة عامة (مرغوبة) لصفة المحصول وقد اظهرت ٣

هجـن قميـة هـي L1x GZ650 , L2 x GZ638 , L3 x GM1021 , L5 x GZ638 and L11 x GZ650) أحسن تأثيرات للقدرة الخاصـة علـى التـالف لـصفة المحـصول. كان تباين القدرة العامة على التآلف عاليـا لـصفات التزهيـر والمحـصول. وكـان التبـاين الراجع لتفاعل القدرة الخاصة على التآلف مع المواقـع أعلـى مـن تبـاين تفاعـل القـدرة العامة على الائتلاف مع المواقع لجميع الصفات المدروسـة عـدا صـفة عـدد الايـام حتـى ظهور ٥٠% من الحراير، مما يدل على ان الفعـل الجينـي غيـر المـضيف لتلـك الـصفات اكثر تاثرا بالمواقع عن الفعل المضيف.