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LINE x TESTER ANALYSIS IN SESAME

Rehab H.A. Abd El-Rhman[1] and Wafaa W.M. Shafi [2]

1. Oil Crop Res. Dept. Field Crop Res. Inst., ARC, Giza, Egypt.
2. Central Laboratory for Design & Statistical Analysis Res. Center, Giza, Egypt

ABSTRACT

The aim of this investigation was to study combining ability and heterotic effects for seed yield and its components through line x tester mating design. Six lines and three testers were crossed to produce eighteen crosses. The magnitude of SCA was greater than GCA for most studied traits, indicating the importance of non-additive gene effect. Among lines, Shandaweel-3 genotype recorded desirable GCA effects for plant height, length of fruiting zone, seed weight plant^{-1}, 1000-seed weight and seed yield fed^{-1}. Among testers, Shandaweel-8 genotype was the best general combiner for plant height, length of fruiting zone and number of branches plant^{-1}. However, line 141-1 proved to be a good combiner for seed weight plant^{-1}, 1000-seed weight and seed yield fed^{-1}. Hence, these genotypes could be utilized as doner parents in hybridization programs for transferring desirable traits. Two crosses (L1 x T2 and L5 x T3) showed the best SCA efects for plant height, length of fruiting zone, seed yield plant^{-1}, 1000-seed weight and seed yield fed^{-1}.

Key words: ***Sesamum, GCA, SCA, Heterotic effect***

INTRODUCTION

Sesame (*Sesamum indicum* L.) is a source of edible oil. Seeds contain 50 - 60% oil and 25% protein. Sesame oil is also more stable compared to other edible oils mainly due to the presence of antioxidants like sesamin, sesamol and sesamolinol. Average of sesame seed yield in Egypt is around 1440 kg ha^{-1}. The genetic diversity or allelic divergence among genotypes is very important in selecting parents for hybridization program, identifying heterotic cross-combination and obtaining desirable recombinants in the segregating generations to improve productivity. In that respect an early study on the diversity among 55 local and introduced genotypes of sesame in Egypt was done by Shabana and Abu-Hagaza (1984). Due to the yield plateau around four ardabs per feddan (i.e., ca. 480 kg per 4200 m^2), Samar El-Shakhess in her post-graduate studies seeked for heterobeltiosis in crosses among local cultivars and exotic genotypes via diallel crosses (Shabana *et al* 1984 and El-Ahmer *et al* 1984). Thus, both basic and applied studies are needed for achieving high yielding ability in sesame. Previous studies indicated that the non-additive gene action was predominant for number of branches pl.$^{-1}$, number of capsules pl. $^{-1}$ and seed weight pl.$^{-1}$ (Manivannan and Ganesan 2001, Sankar and Kumar 2003, Kumar *et al* 2004, Attia 2004, Gawade *et al* 2007, El-Shakhess and Khalifa 2007, El-Shakhess *et al* 2009, Abd-elaziz *et al* 2010) and Ranjith and Kumar (2011). However, (Kim *et al* 2006, Banerjee and Kole 2009 and Ramesh *et al* 2014) reported the importance of both additive and non-additive gene actions for such traits. Commercial exploitation of heterosis is best and simple traditional breeding approach to achieve higher yield in the crop plants. Heterosis is a complex phenomenon depending upon the dominance and their interacting components as well as distribution of genes in parental lines. For obtaining the highest production per unit area, heterosis breeding is the most important, that has been exploited in both self and cross-pollinated crops. The present study was undertaken to assess the magnitude of heterosis, combining ability and gene action for seed yield and its components in eighteen sesame crosses along with their nine parents.

MATERIALS AND METHODS

The present study was carried out at Ismailia Agricultural Research Station, during the summer of 2013 and 2014. The materials used were six genotypes, viz. Shandaweel-7 (L1), Line N.A.638 (L2), Line N.A.636 (L3), Line S/3 (L4) Shandaweel-3(L5) and Line 133-4 (L6) and three testers, viz. Line N.A.637 (T1), Shandaweel-8 (T2) and Line 141-1 (T3) (Table1).

Table 1. Pedigree of the sesame genotypes used in this study.

Genotype	Origin	Pedigree
Shandaweel-7	Egypt	A selected line from Giza32xN.A.130
Line N.A. 638	U.S.A (1987)	PI
Line N.A. 636	U.S.A (1987)	PI
Line S/3	Egypt	Landrace
Shandaweel-3	Egypt	A selected line from Giza32xN.A.130
Line 133-4	Egypt	A selected line from Giza32 x N.A372-7
Line N.A. 637	U.S.A (1987)	PI
Shandaweel-8	Egypt	A selected line from Giza32xN.A.130
Line 141-1	U.S.A (1983)	A selected line from N.A.372xN.A.130

The six genotypes and three testers were crossed in a line x tester mating scheme in 2013. The resulting 18 F_1 crosses and their parents were grown in a randomized complete block design with three replications in 2014. Each entry was grown in a plot consisting of three rows 4m long, 50 cm apart and plants were spaced at 20 cm within rows. The recommended cultural practices were applied at the proper time. At maturity, data recorded on ten randomly taken plants were plant height (cm), length of fruiting zone (cm), number of branches plant-1, number of capsules plant-1, seed yield plant-1 (g), 1000-seed weight(g), seed yield fed-1 (ardab) (where one fedan= 4200m2 and one ardab= 120kg) and oil percentage. The mean values were subjected to line x tester analysis as suggested by Kempthorne (1957). Heterobeltiosis percentage was estemated for individual F_1 cross as the percentage deviation from the better parent according to Sinha and Khanna (1975) and Shabana *et al* (1996).

RESULTS AND DISCUSSION

Analysis of variance

The analysis of variance with respect to the studied traits is presented in Table (2). Data showed significant variation among genotypes.

Table 2. Mean squares for ANOVA and combining ability of eight traits for parents and eighteen sesame crosses.

SOV	df	Plant height (cm)	Length of fruiting zone (cm)	Number of branches plant $^{-1}$	Number of capsules plant $^{-1}$	Seed weight plant $^{-1}$ (g)	1000-seed weight (g)	Seed yield fed $^{-1}$ (ardab)	Oil (%)
Replication	3	4.6	0.90	0.64	11.57	5.86	0.52	0.07	0.69
Genotypes	26	2528.5**	4307.2**	5.32**	966.91**	132.25**	1.87**	2.13**	10.51**
Parents(P)	8	560.9**	726.7**	2.75**	170.06**	11.35**	1.99**	1.25**	12.12**
Crosses ©	17	3209.7**	3659.9**	6.49**	992.38**	69.41**	2.64**	1.96**	9.63
P. *vs*. C.	1	6688.9**	43956.5**	6.02**	6908.83**	2167.69**	1.78**	12.07**	12.52**
Lines(L)	5	1270.3	1392.8	1.11	507.30	64.63	0.81	1.01	8.26
Testers (T)	2	5835.2	5978.7	47.13*	36.74	142.40	0.32	1.59	13.14
L x T	10	3654.4**	4329.7**	1.05**	1426.04**	57.21**	2.55**	2.50**	9.61**
Error	78	10.7	7.28	0.15	19.58	2.05	0.04	0.03	3.31
Variance due to GCA		104	188.34	3.95	69.03	21.23	0.31	0.43	1.76
Variance due to SCA		104.9	190.6	0.22	91.62	13.79	0.63	0.62	1.58
GCA/SCA Variance ratio		0.99	0.99	17.95	0.75	1.68	0.49	0.69	1.13

One ardab= 120 kg seeds.

Significant variances were also observed among crosses for all studied traits. The variance due to parents *vs* crosses revealed highly significant values for all traits, indicating the presence of heterosis for all studied traits. The variance due to males was greater than that due to females for all traits except number of capsules plant^{-1} and 1000-seed weight, indicating a greater diversity in males than in females. The variance due to interaction L x T was highly significant for all traits. The magnitude of SCA was greater than GCA for most studied traits except number of branches plant^{-1}, seed weight plant^{-1} and oil percentage, indicating the importance of non-additive gene effect. These results agreed with those of Vidhyahvathi *et al* (2005), El-Shakhess (2007), El-Shakhess (2010), Jawahar *et al* (2013), Paerimala *et al* (2013), Ramesh *et al* (2014) and Meenakaumari *et al* (2015).

Mean performance of parents and their crosses

Results in Table (3) revealed that crosses were superior to parents in seed yield and most yield components. However, they did not differ significantly from parents in oil percentage. The cross L5 x T3 had high values for plant height, length of fruiting zone, number of capsules plant^{-1}, seed weight plant^{-1}and seed yield fed.$^{-1}$

General combining ability effects (GCA)

Results in Table (4) show positive (favorable) and significant GCA effects for seed yield and most yield components. Among lines, L3 and L5 had positive (favorable) highly significant GCA effects for plant height.

Table 3. Mean performance of nine parents and eighteen crosses.

Genotype		Plant height (cm)	Length of fruiting zone (cm)	No. of branches plant $^{-1}$	No. of capsules plant $^{-1}$	Seed weight plant $^{-1}$ (g)	1000-seed weight (g)	Seed yield fed $^{-1}$ (ardab)	Oil (%)
Lines	Shandaweel-7	118.3	59.3	0.27	33.3	8.8	4.8	4.0	59.0
	Line N.A. 638	146.3	80.0	1.40	44.6	8.0	3.9	4.4	57.0
	Line N.A. 636	142.0	63.0	1.80	44.7	6.7	4.8	4.8	58.7
	Line S/3	152.6	85.3	1.00	45.3	11.2	5.6	5.4	58.3
	Shandaweel-3	135.3	76.0	1.00	52.9	6.9	5.0	3.8	58.0
	Line 133-4	157.0	65.3	1.07	49.5	10.8	5.2	4.8	55.3
Testers	Line N.A. 637	129.3	57.0	1.13	40.5	8.0	4.4	5.1	54.3
	Shandaweel-8	145.0	73.0	2.40	46.8	8.9	3.9	3.9	56.0
	Line 141A1	139.0	98.3	1.47	34.3	10.8	3.4	4.4	55.0
Crosses	L1 X T1	106.8	63.3	0.33	48.0	16.3	4.4	5.1	57.3
	L1 X T2	166.0	139.0	2.83	95.3	13.3	5.5	6.0	54.7
	L1 X T3	197.6	160.3	0.33	42.7	25.7	4.5	6.0	50.7
	L2X T1	165.3	125.0	0.63	75.0	21.0	4.5	5.1	57.0
	L2X T2	145.3	121.7	2.60	62.3	21.3	4.9	5.2	58.0
	L2X T3	151.6	119.3	1.07	78.0	20.0	5.4	5.3	56.0
	L3 X T1	131.3	74.0	0.30	56.0	15.7	5.2	6.2	57.0
	L3 X T2	174.6	131.0	2.67	57.7	20.7	5.6	4.5	56.7
	L3 X T3	180.3	129.0	1.90	63.7	17.0	4.3	4.9	55.7
	L4 X T1	145.0	114.7	0.50	58.3	11.7	5.8	5.3	55.7
	L4 X T2	165.0	118.7	3.50	43.0	17.3	3.6	5.2	58.3
	L4 X T3	117.0	63.7	1.00	79.0	19.7	5.6	4.1	54.7
	L5X T1	181.0	134.3	0.33	78.3	15.7	5.0	5.0	56.7
	L5X T2	140.3	94.7	3.07	37.7	20.3	5.5	4.6	56.0
	L5X T3	199.3	160.7	1.00	95.7	28.3	4.9	6.6	55.7
	L6 X T1	109.0	74.3	0.13	54.0	16.7	4.5	4.3	55.3
	L6 X T2	182.6	143.0	3.97	59.0	15.3	3.6	4.5	56.0
	L6 X T3	172.0	118.3	2.17	61.3	15.3	5.1	6.1	58.0
LSD 0.05		4.59	3.78	0.54	6.19	2.00	0.29	0.25	2.55

Table 4. General combining ability (GCA) of nine parents for studied traits.

Genotype		Plant height (cm)	Length of fruiting zone (cm)	No. of branches plant $^{-1}$	No. of capsules plant $^{-1}$	Seed weight plant^{-1} (g)	1000-seed weight (g)	Seed yield fed^{-1} (ardab)	Oil (%)
Line	Shandaweel7 (L1)	-0.42	5.06**	-0.39**	1.50	0.04	-0.08	0.46**	-1.57**
	Line N.A. 638 (L2)	-3.14**	6.17**	-0.13	11.28**	2.37**	0.06	-0.01	0.87
	Line N.A. 636 (L3)	4.86**	-4.50**	0.06	-1.39	-0.63	0.16**	-0.04	0.31
	Line S/3 (L4)	-14.92**	-16.83**	0.02	-0.39	-2.19**	0.12	-0.35**	0.09
	Shandaweel3 (L5)	16.31**	14.06**	-0.09	-8.61**	3.04**	0.23**	0.16**	-0.02
	Line 133-4 (L6)	-2.69**	-3.94**	0.53**	-2.39	-2.63**	-0.48**	-0.24**	0.31
S.E. (lines)		-0.39	0.78	0.11	1.28	0.41	0.06	0.05	0.52
(gl- gj) line		1.34	1.10	0.16	1.81	0.58	0.09	0.07	0.74
Tester	Line N.A. 637 (T1)	1.50	-18.22**	-1.19**	1.11	-2.24**	0.02	-0.06	0.37
	Shandaweel8 (T2)	11.28**	8.83**	1.55**	-1.33	-0.35	-0.12**	-0.22**	0.48
	Line 141A1 (T3)	-1.39	9.39**	-0.36**	0.22	2.59**	0.11**	0.28**	-0.85**
S.E.(testers)		-8.61	0.55	0.08	0.90	0.29	0.04	0.04	0.37
(gt- gj) tester		0.95	0.78	0.11	1.28	0.41	0.06	0.05	0.52

Regarding length of fruiting zone, L1, L2 and L5 exhibited desirable highly significant GCA effects, L6 exhibited highly significant positive GCA effect on number of branches plant^{-1}.Only one line (L2) had a highly desirable GCA for number of capsules plant^{-1}. Data showed that L2 and L5 had highly significant and positive (gi) effects for seed weight plant^{-1}. Highly significant positive (gi) effect with respect to 1000-seed weight was shown by L3 and L5. Regarding seed yield fed^{-1}, results in Table (4) showed that L1 and L5 had positive GCA effects. However, none of the lines had a significant (gi) effects for oil percentage.

Among testers, highly significant desirable (gi) effects were obtained from T2 for plant height, length of fruiting zone and number of branches plant^{-1} and T3 for length of fruiting zone. None of the testers exhibited significant desirable (gi) effect for plant capsule number. T3 exhibited highly significant positive (gi) for seed weight pl^{-1}, 1000-seed weight and seed yield fed^{-1}. Meanwhile, none of the lines had a significantly positive (gi) effect for oil percentage. From the previous results it could be concluded that L5 (Shadaweel-3) proved to be a good combiner for several attributes, i.e plant height, length of fruiting zone, seed weight plant^{-1},1000-seed weight and seed yield fed^{-1}. In addition T2 (Shandaweel-8) was a good combiner for plant height, length of fruiting zone and number of branches plant^{-1}. Meanwhile, T3 (line N.A.141-1) was a good combiner for seed weight plant^{-1}, 1000-seed weight and seed yield fed^{-1}. Thus, they could be considered promising sources to improve these traits in sesame.

Specific combining ability (SCA) effects

Specific combining ability of eighteen top crosses for all studied traits is presented in Table (5).

Table 5. Specific combining ability of eighteen line × tester scrosses for studied traits.

Top cross	Plant height (cm)	Length of fruiting zone (cm)	No. of branches pl^{-1}	No. of capsules pl^{-1}	Seed weight (g)	1000-seed weight (g)	Seed yield fed^{-1} (ardab)	Oil (%)
L1 X T1	-32.50**	-39.33**	0.35	-15.11**	0.13	-0.45**	-0.56**	2.41**
L1 X T2	4.08*	9.28**	0.12	34.67**	-4.76**	0.82**	0.54**	-0.37
L1 X T3	28.42**	30.06**	-0.48*	-19.56**	4.63**	-0.37**	0.03	-2.04*
L2X T1	28.72**	21.22**	0.39*	2.11	2.46**	-0.43**	-0.02	-0.37
L2X T2	-13.86**	-9.17**	-0.38	-8.11**	0.91	0.04	0.18*	0.52
L2X T3	-14.86**	-12.06**	-0.01	6.00**	-3.37**	0.38**	-0.16	-0.15
L3 X T1	-13.28**	-19.11**	-0.13	-4.22	0.13	0.14	1.04**	0.19
L3 X T2	7.47**	10.83**	-0.50**	-0.11	3.24**	0.68**	-0.43**	-0.26
L3 X T3	5.81**	8.28**	0.64**	4.33	-3.37**	-0.82**	-0.60**	0.07
L4 X T1	20.17**	33.89**	0.10	-2.89	-2.31**	0.78**	0.51**	-0.93
L4 X T2	17.58**	10.83**	0.37	-15.78**	1.46*	-1.31**	0.51**	1.63
L4 X T3	-37.75**	-44.72**	-0.48*	18.67**	0.85	0.53**	-1.03**	-0.70
L5X T1	24.94**	22.67**	0.05	25.33**	-3.54**	-0.13	-0.36**	0.19
L5X T2	-38.31**	-44.06**	0.05**	-12.89**	-0.76	0.48**	-0.53**	-0.59
L5X T3	13.36**	21.39**	-0.11	-12.44**	4.30**	-0.35**	0.90**	0.41
L6 X T1	-28.06**	-19.33**	-0.77**	-5.22*	3.13**	0.08	-0.60**	-1.48
L6 X T2	23.03**	22.28**	0.33	2.22	-0.09	-0.71**	-0.26**	-0.93
L6 X T3	5.03**	-2.94*	0.44*	3.00	-3.04**	0.63**	0.86**	2.41**
S.E (SCA)	1.64	1.35	0.19	2.21	0.72	0.10	0.09	0.91
Slj- Skl	2.32	1.91	0.27	3.13	1.01	0.15	0.13	1.29

The data revealed that the ten crosses (L1 x T2), (L1 x T3), (L2 x T1), (L3 x T2), (L3 x T3), (L4 x T1), (L4 x T2), (L5 x T1), (L5 x T3) and (L6 x T2) showed desirable significant (SCA) effect for plant height and length of fruiting zone. Also, the cross (L3 x T3) showed desirable SCA effects for number of branches plant^{-1}. Considering number of capsules plant^{-1}, the crosses (L1 x T2) and (L2 x T3) had desirable significant effects for SCA. The crosses (L1 x T3), (L2 x T1), (L3 x T2), (L5 x T3) and (L6 x T1) exhibited desirable significant (SCA) for seed weight plant^{-1}. The crosses (L1 x T2), (L2 x T3), (L3 x T2), (L4 x T3), (L4 x T1), (L5 x T2) and (L6 x T3) exhibited desirable significant SCA effects for 1000 seed weight. The six crosses (L1 x T2), (L3 x T1), (L4 x T1), (L4 x T2), (L5 x T3) and (L6 x T3) exhibited desirable and significant SCA effects for seed yield fed^{-1}. The cross (L1 x T1) showed significant SCA effects for oil percentage.

Heterotic effects

Heterobeltiosis Table (6) calculated as percent increase of F_1 over its better parent. With respect to plant height, nine crosses exhibited positive significant heterobeltiosis.

Table 6. Heterobeltiosis of eight studied traits for eighteen line × tester crosses.

Top cross	Plant height (cm)	Length of fruiting zone (cm)	No. of branches pl^{-1}	No. of capsules pl^{-1}	Seed yield pl^{-1} (g)	1000-seed weight (g)	Seed yield fed^{-1} (ardab)	Oil (%)
L1 x T1	-31.9**	-35.6**	-86.1	-9.2**	45.8**	-21.6**	-6.2**	-3.8**
L1 x T2	5.73*	41.4**	18.1	80.3**	19.0**	-1.2	11.1**	-9.8**
L1 x T3	25.9**	63.1**	-86.1	-19.3**	129.2**	-18.6**	11.1**	-16.7**
L2 x T1	5.3*	27.1**	-73.6	41.9**	87.5**	-18.6**	-4.9**	-4.5**
L2 x T2	-7.4**	23.7**	8.3	17.9**	90.5**	-12.6**	-4.3**	-2.3
L2 x T3	-3.4	21.4**	-55.6	47.5**	78.6**	-2.4	-1.2	-6.8**
L3 x T1	-16.3**	-24.7**	-87.5	5.9	39.9**	-6.6**	14.2**	-4.5**
L3 x T2	11.2**	33.2**	11.1	9.1**	84.5**	0.6	-16.0**	-5.3**
L3 x T3	14.8**	31.2**	-20.8	20.4**	51.8**	-22.2**	-9.9**	-7.6**
L4 x T1	-7.6**	16.6**	-79.2	10.3**	4.2	4.2	-1.2	-7.6**
L4 x T2	5.1*	20.7**	45.8	-18.7**	54.8**	-35.9**	-4.3**	-1.5
L4 x T3	-25.4**	-35.3**	-58.3	49.4**	75.6**	1.2	-23.5**	-9.8**
L5 x T1	15.2**	36.6**	-86.1	48.2**	39.9**	-10.2**	-8.0**	-5.3**
L5 x T2	-10.6**	-3.7	27.8	-28.8**	81.5**	-1.8	-14.2**	-6.8**
L5 x T3	26.9**	63.4**	-58.3	-25.0**	153.0**	-12.6**	21.6**	-7.6**
L6 x T1	-30.5**	-24.4**	-94.4	2.1	48.8**	-19.2**	-19.8**	-8.3**
L6 x T2	16.3**	45.4**	65.3	11.6**	36.9**	-35.9**	-16.7**	-6.8**
L6 x T3	9.5**	20.3**	-9.7	16.0**	36.9**	-7.8**	13.6**	-2.3

The crosses (L1 x T3) and (L5 x T3) showed the maximum desirable heterotic effects. Meanwhile, twelve crosses showed positive and significant heterobeltiosis for length of fruiting zone. The crosses (L1 x T3), (L5 x T3) and (L6 x T2) exhibited maximum desirable heterotic effects. None of the crosses exhibited positive and significant heterobeltiosis for number of branches plant^{-1}. The maximum, positive and significant heterobeltiosis was recorded at (L4 x T3) and (L5 x T1) for number of capsules plant^{-1}. With regard to seed weight plant^{-1}, all the line × tester crosses showed positive and significant heterobeltiosis. The cross (L5 x T3) exhibited the maximum desirable heterotic effect. For 1000-seed weight, none of the crosses exhibited significant heterobeltiosis. With respect to seed yield fed^{-1}, five crosses revealed highly significant and positive heterobeltiosis. The highest heterotic value in seed yield fed^{-1}, was obtained from cross (L5 x T3). None of the crosses showed a significantly positive heterobeltiosis for oil percentage. These results are in harmony with those of Mothilal and

Manoharan (2004), Sumathi and Muralidharan (2008), Torpore (2008), Abd elaziz (2010), Georgiev *et al* (2011). Padma and Kamala (2012),Vavdiya *et al* (2013), Jawahar *et al* (2013), Ramesh *et al* (2014) and Meenakumari *et al* (2015).

CONCLUSION

In light of the present findings it could be concluded that line x tester hybrids (Line N.A.638 x Shandaweel-8), (Line N.A.636x Line 141-1), (S/3 x Line N.A.637), (S/3 x Shandaweel-8), (Shandaweel-3 x Line 141-1) and (Line 133-4 x Shandaweel-8) were excellent harmonious combinations for SCA effects for most traits including seed yield plant^{-1}. It would yield transgressive segregants for seed weight plant^{-1} in F_2 and late segregating generations. The maximum heterosis for number of capsules plant^{-1} and seed weight plant^{-1} was observed in the cross (line133-4 x Shandaweel-8). This cross can be utilized for sesame yield improvement through heterosis breeding.

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تحليل السلالة x الكشاف في السمسم

رحاب حمدان عبدالكريم عبد الرحمن[1] ، وفاء وهبه محمد شافعي[2]

١. قسم المحاصيل الزيتية – معهد المحاصيل الحقلية – مركز البحوث الزراعية – مصر

٢. المعمل المركزي للتصميم والاحصاء– مركز البحوث الزراعية – مصر

أجري هذا البحث علي محصول السمسم بهدف دراسه القدرة علي الائتلاف وقوة الهجين للمحصول ومكوناته. وقد تم التهجين بين سته تراكيب وراثيه من السمسم كأمهات وهي (شندويل–٧ , مستورد ٦٣٨ , مستورد ٦٣٦و سلالة s/3, شندويل–٣ وسلالة ١٣٣–٤) وثلاث أباء اختباريه (كشافات) وهي (مستورد ٦٣٧, شندويل–٨ وسلالة ١٤١–١) بنظام تحليل السلالة x الكشاف. تم تقييم سلوك الأباء وهجنها القميه في الجيل الأول بمحطة بحوث الاسماعيلية. وقد أظهرت النتائج أن القدرة الخاصة علي الائتلاف لها دور أكبر من القدرة العامه علي الائتلاف موضحة أهميه الفعل الجيني غير المضيف في وراثة الصفات المدروسة. كما أظهرت النتائج أن السلاله (شندويل ٣) كانت الأفضل في قدرتها العامه علي الائتلاف لصفات طول النبات وطول المنطقة الثمريه ومحصول البذور للنبات ووزن الألف بذرة ومحصول البذور للفدان. وقد أظهر الأب الاختباري السلالة(شندويل–٨) قدرة عامة علي الائتلاف لصفات ارتفاع النبات وطول المنطقة الثمرية وعدد الأفرع علي النبات, بينما أظهر الأب الأختباري (سلالة ١٤١–١) قدرة عامة علي الائتلاف لصفات محصول البذور للنبات ووزن الألف بذرة ومحصول البذور للفدان. وقد أوضحت النتائج أن الهجينين (١x٢ , ٣x٥) أظهرا تفوقاً في صفات ارتفاع النبات وطول المنطقة الثمرية ومحصول البذور للنبات ووزن الألف بذرة ومحصول البذور للفدان.

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