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Combining Ability for some Quantitative Traits in Sorghum (*Sorghum Bicolor* l. Moench) Using 9x9 Half Diallel Cross Scheme

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Abstract

This study was carried out in co-operation between Fac. Agric. Benha Univ., and each of (ACSAD) in shandaweel and new valley Research Station (ARC) during 2018 and 2019 season. In the first season, a half diallel cross was made among the nine parents. The nine parents and their hybrids were evaluated in two location i.e. shandweel (L1) and El-Kharga oasis (L2) during 2019 season. The characters studied were plant height (cm), flag leaf area (cm^2), leaves dry weight (g), grain yield (g), grain yield (ton/fad) and protein%. Location mean square for all studied trait under study were significant except for grain yield / plant, with mean values in L1 higher than those in L2 for all traits. Mean squares for genotype, parents, F1 hybrid were significant for all traits at both and across locations. Appreciable parent *vs* crosses mean square were detected for all cases grain yield/plant at both locations as well as the combined analysis, protien % at the first location and grain yield / fed. at the L2. Mean square for parent x location and crosses x locations were significant for all traits. Significant parents *vs* crosses x location mean squares were obtained in flag leaf area. Regarding grain yield /plant or fed , the parental genotypes P1 and P4 expressed significantly highest mean values compare the other parents. Also, the two crosses P2xP6 and P3xP5 expressed significantly the highest mean values of this trait. The mean squares due to general and specific combining ability were highly significant for all studied traits.GCA/SCA ratio was used as measure reveal the nature of genetic variance involved for all studied traits, all trait exhibited high ratios which largely exceeded the unity were obtained, indicating that large part of the total genetic variability associated with these trait was additive and additive by additive gene effect.The mean squares of interaction between location and both types of combining ability were significant for all studied trait. The parental genotypes (p_5 and P7) expressed significant desirable gi effect for flag leaf area, leaves dry weight, grain yield/ plant and grain yield/ feddan. Meanwhile, it gave insignificant negative for other cases.The most desirable inter and intra allelic interactions were presented by P_1xP_3, P_2xP_3, P_2xP_5 andP_4xP_5 for grain yield / plant and grain yield/ feddan exhibited significant positive $\hat{S}_{ij}$ effects.

Keywords: Combining ability, sorghum, GxE, diallel, GCA, SCA

Introduction

Sorghum (*Sorghum bicolor* L. Moench) is the 5thmost important cereal grain crop originated from West Africa and staple food for millions of poor in semi-arid tropics of Africa and Asia (Haussmann et al., 2002). It has gained importance as a fodder (green/dry) and feed crop in the last decade. Besides being an important food, feed and forage crop, it provides raw material for the production of starch, fiber, dextrose syrup, biofuels, alcohol and other products. Sorghum has been classified under family Graminae, subfamily Poaceae, tribe Andropogonae and genus Sorghum. Breeding strategies based on selection of hybrids require expected level of heterosis as well as the specific combining ability (SCA). Sprague and Tatum (1942) were the first to develop the concept of combining ability. They defined "general combining ability" (GCA) as the average performance of the lines in hybrid combinations and "specific combining ability" (SCA) as the deviation of a cross from the average performance of the lines. Heterosis or hybrid vigor is the superiority or inferiority of the hybrids over its parents. The primary objective of any plant breeding program is to increase the yield and improve the quality of crop plants through gene recombination. In breeding high yielding varieties of crop plant, the breeders often face with the problem of selecting parents and crosses. Combining ability analysis is one of the powerful tools available to estimate the combining ability effects and aids in selecting the desirable parents and crosses for the exploitation of heterosis (Sarker et al., 2002 and Rashid et al., 2007). Presence of heterosis and SCA effects for yield and its related traits are reported by Nuruzzaman et al. (2002), Faiz et al. (2006), Saleem et al. (2008), El Hosary (2020),Marisol et al. (2020), Sedhom et al., (2021) and Turk et al. (2021). To exploit maximum heterosis using cytoplasmic male sterile (CMS) technique in the hybrid programme, we must know the combining ability of different male sterile and restorer lines. This study was carried out to achieve the following: - Formation of high yielding sorghum hybrids (Sorghum bicolor L. Moench) using diallel cross analysis. Estimation of general combining ability for parents and specific combining ability for hybrids.

Materials and Methods

The parental varieties or lines in this study were p1 (Var. Izraa7), p2 (Var. Izraa62), p3 (Var. Shalakh6), P4 (Var. Shalakh7) , p5 (line Acsad56), p6 (line Acsad60), p7 (line Acsad63), p8 (Var. Giza15), p9 (Var. Dwrado). A half diallel cross was made among the nine parents during 2018 giving a total of 36 crosses. The nine parents and their hybrids were evaluated in two location i.e. shandweel ResearchStation (L1) of the Agricultural Research Center, Sohag Governorate (26˚33 N 31˚41.67 E) and the second location is Agricultural experiment station, Desert Research center (DRC)(L2), El-Kharga oasis, New valley Governorate (27 ˚ 47.7 N , 30˚ 24.7 E) during 2019 season. The dry method of planting was on 1st, 2ndAgust, at L1 and L2, respectively. Each experiment was designed in randomized complete block design with three replications in both locations. Each plot consisted of two ridges of five meter length and 70 cm width. Each was spaced 20 cm with two kernels planted per hill and late thinneel to one plant/ hill. The other cultural practices of growing sorghum were practiced at each location. Ten guarded plants from parents and the F_1's were selected randomly from each plot for recording observations on different characters.The characters studied were plant height (cm), flag leaf area (cm^2), leaves dry weight (g), grain yield (g), grain yield (ton/fad) and protein%. Regular analysis of variance of RCBD design was allowed for each location then the combined across location was made after test of homogeneity of errors. The analysis of variance for combining ability for eachlocation andcombined analysis across them was carriedout to estimation of various effects (GCA and SCA) was done following the technique of griffing (1956) for method 2 ,model 1

Results and Discussion

Anova for all studied characters at each and across locations(Table 1).Location mean square for all studied trait under study were significant except for grain yield / plant , with mean values in L1 (Shandaweel) higher than those in L2 (El-kharga) for all traits, Table2.

The increase in the first location in these traits may be due to the prevailing of favorable temperature and high fertility of soil and dulcet water leading to greater vegetative growth, yield and its component of sorghum plant therefore, the first location seemed to be non-stress environment. These results are in harmony with those obtained by **Castro-Nava *et al*. (2012) and Jabereldar *et al* (2017)**.

Mean squares for genotype, parents, F1 hybrid were significant for all traits at both and across locations. Appreciable parent *vs* crosses mean square were detected for all cases grain yield/plant at both locations as well as the combined analysis, protien % at the first location and grain yield / fed. at the second location. This indicates the wide diversity between the parental materials used in the present study.

Mean square for parent x location and crosses x locations were significant for all traits. This may revealed that the performance at genotypes,parent,and crosses differed from location to another.

Significant parents *vs* crosses x location mean squares were obtained in flag leaf area, indicating that parental genotypes were less affected by location variation than their F1 hybrids. on the contrarily, insignificant overall heterotic effect was obtained for other trait, reflecting that both at the grand mean of the parental genotypes and their F1 hybrids increased in same direction and magnitude from location to location.

Combining ability analysis:

The analysis of variance for combining ability at the combined analysis for all the studied trait is presented in table 1.

The variance of general combining (GCA) includes the additive and additive by additive genetic portion. While, specific combining ability (SCA) represents the non-additive genetic portion of the total variance arising largely from dominance and epistatic deviations. The mean squares due to general and specific combining ability were highly significant for all studied traits.

If both general and specific combing ability mean squares are significant, one may ask which type and or types of gene action are important in determining the performance of single–cross progeny.To overcome such situation the size of mean squares can be used to assume the relative importance of both types of combining ability. For all traits general and specific combing ability mean squares were highly significant. Hence GCA/SCA ratio was used as measure reveal the nature of genetic variance involved for all studied traits, all trait exhibited high ratios which largely exceeded the unity were obtained, indicating that large part of the total genetic variability associated with these trait was additive and additive by additive gene effect.

The mean squares of interaction between location and both types of combining ability were significant for all studied trait. Such result showed that the magnitude of all types of gene action varied from location to another. If is fairly evident that the ratio for

Table 1. Observed mean squares from ordinary analysis and combining ability for the studied traits in each and across locations.

S.O.V.	d.f.		Plant height (cm)			Flag leaf area (cm2)			Leaves dry weight (g)		
	S	C	L1	L2	Comb	L1	L2	Comb	L1	L2	Comb
Location (L)		1			41777.97**			2276.5**			474.89**
Rep/L	2	4	487.48**	15709.41**	8098.45**	51.49	353.54**	202.51**	287.73**	699.74**	493.73**
Genotypes	44	44	4369.77**	2950.08**	4895.36**	14778.45**	15500.87**	27966.92**	126.36**	123.25**	209.41**
parents	8	8	3020.13**	4259.35**	6003.11**	15885.75**	13893.62**	28414.27**	157.71**	149.55**	300.28**
Crosses	36	36	4768.85**	2687.91**	4701.08**	14818.84**	16267.69**	28502.85**	121.16**	118.81**	191.04**
Par.vs.cr.	1	1	1199.15**	1652**	2833.05*	4506.67**	1520.07**	5630.7*	57.39**	68.31**	125.46*
G/L		44			2424.5**			2312.4**			40.2**
par./L		8			1276.37**			1365.1**			6.97
Cr./L		35			2755.68**			2583.68**			48.93**
Par.vs.cr.x.L		1			18.1			396.03*			0.24
Error	88	176	28.09	15.76	21.93	39.07	26.12	32.6	4.18	3.93	4.06
GCA	8	8	4619.41**	1992.36**	4845.94**	12553.86**	12198.13**	23901.26**	165.23**	140.88**	285.04**
SCA	36	36	753.74**	759.14**	917.53**	3231.1**	3604.47**	6082.54**	14.76**	18.91**	21.97**
GCA x L		8			1765.83**			850.73**			21.07**
SCA x L		36			595.35**			753.04**			11.7**
Error	88	176	9.36	5.25	7.31	13.02	8.71	10.87	1.39	1.31	1.35
GCA/SCA			6.13	2.62	5.28	3.89	3.38	3.93	11.19	7.45	12.97
GCA x L/GCA					0.36			0.04			0.07
SCA x L/SCA					0.65			0.12			0.53

S.O.V.	d.f.		Grain yield/ plant (g)			Grain yield/ feddan (ton)			Protin%		
	S	C	L1	L2	Comb	L1	L2	Comb	L1	L2	Comb
Location (L)		1			2.96			0.05*			5.76**
Rep/L	2	4	152.56**	52.23**	102.4**	0.31**	0.24**	0.27**	1.14	17.96**	9.55**
Genotypes	44	44	123.68**	134.35**	210.05**	0.19**	0.24**	0.3**	3**	7.41**	6.87**
Parents	8	8	129.83**	180.81**	216.18**	0.21**	0.32**	0.45**	1.5*	7.65**	5.75**
Crosses	36	36	125.58**	127.08**	214.62**	0.19**	0.23**	0.27**	3.42**	7.46**	7.25**
Par.vs.cr.	1	1	7.8	17.21	0.92	0.13**	0.03	0.14*	0.13	3.99**	2.78*
G/L		44			47.98**			0.13**			3.54**
par./L		8			94.46**			0.08**			3.39**
Cr./L		35			38.04**			0.15**			3.63**
Par.vs.cr.x.L		1			24.09			0.02			1.34
Error	88	176	10.07	7.32	8.7	0.02	0.01	0.01	0.72	0.42	0.57
GCA	8	8	120.37**	144.81**	225.99**	0.23**	0.21**	0.34**	1.78**	5.48**	5.03**
SCA	36	36	23.64**	22.56**	35.36**	0.03**	0.05**	0.05**	0.83**	1.8**	1.68**
GCA x L		8			39.19**			0.1**			2.22**
SCA x L		36			10.84**			0.03**			0.95**
Error	88	176	3.36	2.44	2.9	0.01	0	0	0.24	0.14	0.19
GCA/SCA			5.09	6.42	6.39	8.23	4.2	7.43	2.15	3.04	2.99
GCA x L/GCA					0.17			0.28			0.44
SCA x L/SCA					0.31			0.7			0.56

* and ** refers to significant p< 0.05 and p< 0.01, respectively.
L1,L2 and C refer to shandweel, El-Kharga and combined across locations, respectively.

Table 2. Estimates of general combining ability effects of nine inbred lines for all the studied traits across two locations.

parent	**Plant height (cm)**	**Flag leaf area (cm2)**	**Leaves dry weight (g)**	**Grain yield/ plant (g)**	**Grain yield/ feddan (ton)**	**Protin%**
g1	-7.26**	62.44**	-5.54**	1.6**	-0.04*	0.72**
g2	2.78**	0.38	-1.22**	-1.95**	-0.06**	0.05
g3	-5.29**	-24.73**	-2.08**	-0.97*	-0.07**	-0.28*
g4	2.55**	-1.17	2**	0.97*	0.02	-0.39**
g5	8.68**	3.3**	2.98**	3.67**	0.08**	-0.09
g6	27.1**	24.35**	5.42**	3.97**	0.23**	0.78**
g7	8.69**	10.86**	3.15**	1.61**	0.09**	0.13
g8	-11.96**	-20.2**	-0.96**	-3.31**	-0.07**	-0.46**
g9	-25.28**	-55.23**	-3.76**	-5.59**	-0.2**	-0.47**
L.S.D gi 0.05	1.51	1.84	0.65	0.95	0.04	0.24
L.S.D gi 0.0	1.98	2.41	0.85	1.24	0.05	0.32
L.S.D gi-gj 0.05	2.26	2.75	0.97	1.42	0.06	0.37
L.S.D gi-gj 0.01	2.96	3.61	1.27	1.87	0.07	0.48

* and ** refers to significant p< 0.05 and p< 0.01, respectively.

L1,L2 and C refer to shandweel, El-Kharga and combined across locations, respectively.
SCAxL /SCA was higher than ratio of GCAxL/GCA for all studied trait. The result indicated that non additive effect were more influenced by the environmental condition than additive effect Specific combining ability was stated by several investigators to be more sensitive to environmental change than GCA, (**Gilbert, 1958**, **Fernandez, 1992, Raman *et al.*, 2012, Menezes *et al.*, 2015, Mohammadi, 2016, Abebe *et al.*2020, El Hosary 2020,Marisol *et al.* 2020, Sedhom et al., 2021 and Turk *et al*. 2021.**

Estimates of GCA effect (g1) for individual parental genotypes at the combined are presented in table 2. General combining ability effect computed here in were found to differ significantly from zero in all traits. High positive values would be of interest under all trait in question except plant height where high negative over would be useful from the breeder point of view.

The parent No.1 exhibited significant desirable g_1 effect for plant height, flag leaf area, grain yield / pant or feddan and protein%. The parental genotype (p3) expressed significant negative gi effect for plant height. It had undesirable gi effect for other cases.

The parental genotype (p4) exhibited significant desirable gi for leaves dry weight and grain yield/ plant. Also, it had a boor combines for other traits.The parental genotypes (p_5 and P7) expressed significant desirable gi effect for flag leaf area, leaves dry weight, grain yield/ plant and grain yield/ feddan. Meanwhile,it gave insignificant negative for other cases.The parental genotype (p6) behaved as good combines for flag leaf area, leaves dry weight, grain yield/ plant and grain yield/ feddan and protin%. Therefore, the parental p_6 could be considered as an excellent parent in breeding programs towards releasing high yielding varieties. The parenta no 8 and 9 expressed significant negative, gi effect for plant height. Moreover, the both parental genotypes p8 and p9 gave undesirable gi effect for others traits.

Specific combining ability effect of the parental combinations at the combined analysis are presented in Table 3. The most desirable inter and intra allelic interactions were presented by P_1xP_4, P_1xP_5, P_1xP_6, P_1xP_7, P_2xP_7, P_2xP_8, P_2xP_9, P_3xP_4, P_3xP_8,P_3xP_9, P_4xP_7,

P_4xP_9, P_5xP_7, P_5xP_8, P_5xP_9, P_6xP_7, P_6xP_8 and P_6xP_9, for plant height, P_1xP_3, P_1xP_5, P_1xP_8, P_2xP_3, P_2xP_5, P_2xP_6, P_2xP_8, P_3xP_6, P_4xP_5, P_4xP_6, P_4xP_8, P_5xP_6, P_6xP_7, P_6xP_9, P_7xP_8 and P_7xP_9, for flag leaf area; P_1xP_3, P_2xP_3, P_2xP_5, P_2xP_8, P_3xP_5, P_4xP_5, P_4xP_6, P_4xP_8, P_7xP_8 and P_7xP_9, for leaves dry weight; P_1xP_3, P_2xP_3, P_2xP_5 and P_4xP_5 for grain yield / plant and grain yield/ feddan exhibited significant positive $\hat{S}_{ij}$ effects. These crosses may be prime importance in breeding programmers either towards hybrid sorghum production or traditional breeding for high yielding which involved the good combiners for the traits in view. In these crosses showing specific combining ability-involving only one good combiner such combinations would show desirable transgressive sigregates, providing that the additive genetic system present in the good combines as well as the complementary and epistatic effect present in the cross, act in the same direction to reduce undesirable plant characteristics and maximize the character in view. Therefore, The previous crosses might be of prime importance in breeding program for traditional breeding procedures. In most traits, the values of SCA effect were mostly different from location to another. This finding coincided with that reached above were significant SCA by locations mean squares were detected in Table (1).

Table 3. Estimates of specific combining ability effects of all parental combinations for all studied traits across two locations.

cross	Plant height (cm)	Flag leaf area (cm2)	Leaves dry weight (g)	Grain yield/ plant (g)	Grain yield/ feddan (ton)	Protin%
P1xP2	5.5 *	3.37	-10.21 **	-2.47	-35.53 **	0.2
P1xP3	20.75 **	54.14 **	3.90 *	11.12 **	49.57 **	0.57
P1xP4	-16.45 **	-15.42 **	-2.83	5.49 **	-207.94 **	-0.07
P1xP5	-14.68 **	18.28 **	-0.12	6.06 **	-118.43 **	0.22
P1xP6	-21.89 **	-7.27 *	-5.56 *	9.85 **	-53.55 **	-0.47
P1xP7	-28.72 **	-12.62 **	-11.68 **	-2.91	-227.93 **	-0.35
P1xP8	2.17	6.44 *	-0.92	-5.73 **	246.47 **	0.26
P1xP9	-0.44	-14.19 **	2.96	-5.06 **	260.13 **	0.23
P2xP3	45.4 **	103.87 **	30.59 **	17.82 **	513.6 **	1.94 **
P2xP4	-4.72	-1.19	-3.37	-1.96	12.75 **	-0.13
P2xP5	28.96 **	81.67 **	11.06 **	5.09 **	270.1 **	1.16 **
P2xP6	2.51	52.46 **	3.1	2.45	39.48 **	0.02
P2xP7	-25.54 **	-53.56 **	-9.24 **	-5.48 **	-187.9 **	-1.36 **
P2xP8	-7.6 **	11 **	8.16 *	-3.16 *	-22.67 **	0.51
P2xP9	-29.57 **	-75.8 **	-12.03 **	-5.37 **	-237.5 **	-0.86 *
P3xP4	-24.13 **	-48.59 **	-12.04 **	-8.52 **	-199.14 **	-0.69
P3xP5	-2.34	-86.72 **	9.02 **	2.31	91.88 **	-0.76
P3xP6	17.4 **	72.23 **	1.35	4.97 **	94.09 **	0
P3xP7	-0.06	-1.28	-6.12 *	-4.42 **	-11.79 **	0.33
P3xP8	-13.54 **	-32.56 **	-6.43 *	-3.75 *	-121.9 **	-1.48 **
P3xP9	-9.64 **	-17.36 **	-3.38	-3.74 *	-83.06 **	0.21
P4xP5	41.67 **	57.05 **	12.56 **	5.17 **	342.53 **	2.02 **
P4xP6	26.52 **	45.67 **	6.64 **	0.48	192.74 **	1.2 **
P4xP7	-13.34 **	-77.68 **	0.82	0.97	-115.47 **	-0.88 *
P4xP8	2.95	45.72 **	8.52 **	5.08 **	36.25 **	-0.43
P4xP9	-8.29 **	-2.25	-1.55	0.21	-57.41 **	-1.18 **
P5xP6	-0.36	30.53 **	-0.48	-3.26 *	-40.25 **	0.02
P5xP7	-30.83 **	-102.48 **	-9.14 **	-6.04 **	-280.12 **	-1.34 **

P5xP8	-20.84 **	-18.92 **	-12.91 **	-3.34 *	-215.73 **	-1.36 **
P5xP9	-12.64 **	-22.89 **	-6.86 *	-4.66 **	-104.4 **	-0.59
P6xP7	-5.61 *	38.81 **	-0.33	-1.88	-50.41 **	-0.27
P6xP8	-22.12 *	-3.8	-3.79 *	-3.79 *	-110.18 **	-0.57
P6xP9	-8.51 *	10.4 **	-2.11	-2.52	-73.85 **	-0.72
P7xP8	29.83 **	54.35 **	9.76 **	5.89 **	260.77 **	1.19 **
P7xP9	25.58 **	25.88 **	4.16 **	3.42 *	217.1 **	0.9 *
P8xp9	14.34 **	-35.06 *	-4.91 *	2.24	-164 **	0.72
LSD5%(sij)	6.35	5.88	3.14	3.04	0.12	0.78
LSD1%(sij)	4.82	7.75	4.14	4	0.16	1.03
LSD5%(sij-sik)	21.72	35.94	9.2	4.48	0.18	1.15
LSD1%(sij-kl)	28.62	47.36	12.12	5.9	0.23	1.52

* and ** refers to significant p< 0.05 and p< 0.01, respectively.

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القدرة على التالف لبعض الصفات الكمية فى الذرة الرفيعة الحبوب بأستخدام تحليل نظام التهجين النصف تبادلى 9x9

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1- قسم المحاصيل – كلية الزراعة – جامعة بنها

2- شعبة البيئة النباتية – مركز بحوث الصحراء

اجريت هذه الدراسة بالتعاون بين كلية الزراعه . جامعة بنها ، وكل من منظمه (أكساد) و (مركز البحوث الزراعيه) في موقعين هما محطة أبحاث شندويل وواحه الخارجه خلال موسم 2018 و 2019. في الموسم الأول ، تم عمل تهجين نصف تبادلي بين تسعه اباء في اتجاه واحد .ثم تم تقييم الهجن الناتجه (36 هجين) في موقعين هما شندويل (سوهاج)وواحة الخارجه (الوادي الجديد) تحت ظروف الاجهادات البيئيه خلال موسم 2019. كانت الصفات المدروسة هي ارتفاع النبات (سم) ، مساحة ورقة العلم (سم 2) ، الوزن الجاف للأوراق (جم) ، محصول الحبوب (جم) ، محصول الحبوب (طن / فدان) ونسبة البروتين.

كان موقع متوسط المربعات / بوبحلا لوصحم ءانثتساب ًايونعم ةساردلا تحت ةسوردملا تافصلا عيمجل نبات ، حيث كانت قيم متوسطات المربعات في موقع (شندويل) أعلى من تلك الموجودة في موقع (واحه الخارجه) لجميع الصفات تحت الدراسه . كانت متوسطات مربعات الطرز الجيني والآباء وهجن الجيل الا ول معنويه لجميع الصفات تحت الدراسه .وعبر المواقع تم الكشف عن الاب الافضل مقابل الهجن متوسطة المربعات لجميع االصفات محصول الحبوب / نبات في كلا الموقعين بالإضافة إلى التحليل المشترك ، نسبة البروتين في موقع (شندويل) ومحصول الحبوب / فدان في موقع(واحه الخارجه) كان متوسط المربعات للاباء x الهجن x المواقع معنويا لجميع الصفات تحت الدراسه . الآباء مقابل الهجن × الموقع يعني أنه تم الحصول على متوسط المربعات في منطقة أوراق العلم. فيما يتعلق بمحصول الحبوب / للنبات او للفدان، فقد عبرت الطرز الوراثية الأبوية P1 و P4 عن أعلى قيم متوسطات معنو ، أَضياً .نيرخلآا ءابلآاب ةنراقم ةي عبر الهجينان P2xP6 و P3xP5 بشكل ملحوظ عن أعلى قيم متوسطات لهذه الصفه .

كانت متوسطات المربعات بسبب القدره العامة والخاصة علي الائتلاف ذات معنويه عاليه لجميع الصفات المدروسه . تم استخدام القدره العامه والخاصه علي الا ئتلاف كمقياس للكشف عن طبيعة التباين الجيني المتضمن لجميع الصفات المدروسة ، تم الحصول علي جميع الصفات التي اظهرت نسب عاليه الي حد كبير نيابتلا نم أربيك أءزج نأ ىلإ ريشي امم ،الجيني الكلي المرتبط بهذه الصفه أفاضم ناكمن خلال التاثير الجيني المضاف. كانت متوسطات المربعات للتفاعل بين الموقع و بين نوعي القدره العامه والخاصه على الائتلاف معنوية لجميع الصفات المدروسة. أظهرت الطرز الوراثية للاباء (P7 , p_5) ًابوغرم ًايونعم اريثأت على مساحة ورقة العلم ، ووزن الأوراق الجاف ، وحاصل الحبوب / نبات ، وحاصل الحبوب / فدان. وفي الوقت نفسه ، أعطت نتائج سلبية طفيفة بالنسبة للصفات الأخرى. ثم تم عرض أكثر التفاعلات المرغوبة بين الأليلات وداخل الأليلات بواسطة P1xP3 و P2xP3 و P2xP5 و P4xP5 لمحصول الحبوب / نبات وأظهرت صفه محصول الحبوب / فدان تأثيرات إيجابية معنوية.