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Estimate Combining Ability and Gene Action of Yield, and Some Qualitative Traits of Bread Wheat Genotypes. (*Triticum aestivum* L.) of Half-Diallel Crosses

Tariq Raad Thaer Al-Mafarji[1], Jasim Mohammed Aziz Al-Jubouri[2], and Adnan Kanbar[3]

[1]*College of Agriculture – Al-Hawijah, University of Kirkuk, Iraq.*
[2]*College of Agriculture, University of Tikrit, Iraq.*
[3]*Botanical Institute, Karlsruhe Institute of Technology, Karlsruhe, Germany.*

[*]*Corresponding author: E-mail*: Jasim2017@tu.edu.iq

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ABSTRACT

In order to study the combining ability and gene action for the yield and specific traits related to the grain quality of the genotypes of seven bread wheat (SK94, SK 95, Side 12, Side14, Giemiza 7, Giemiza 9, and Al-Fayyad), Half diallel crosses was performed between them to obtain (21) single crosses. Individually the hybrids were planted along with the parental lines in three replicates in randomized complete block design. Data for plant yield, protein ratio, wet gluten ratio, and dry gluten ratio were measured. Analysis of variance showed significant differences among genotypes for all the evaluated traits. Parent Side 12 was distinguished by its general combining ability the traits of a plant yield, protein ratio, and wet gluten ratio, while the hybrid SK 95 x Side 12 was distinguished by a special combining ability all traits. The ratio between the components of the variance of general combining ability to the variance of specific combining ability was less than one for all traits, and this is evidence of the effect of dominance variances on traits. Genetic variance was greater than environmental variance for all traits. Also, the dominance variance was greater than additive variance for all traits. The broad sense heritability rate was high for all traits, while the narrow sense heritability rate was medium for the plant yield trait and low for the other traits. The expected genetic advance was low in all traits. Therefore, selection is not useful, and it is possible to benefit from heterosis breeding method and selection in subsequent generations.

تقدير الجمع بين القدرة والعمل الجيني من الغلة ، وبعض الصفات النوعية من الأنماط الجينية القمح الخبز (*Triticum aestivum* L.) من الصلبان نصف ديليل

طريق طارق ثاير المفرجي [1] ، جاسم محمد عزيز الجبوري[2] ، عدنان قنبر[3]
[1] كلية الزراعة-الحويجة ، جامعة كركوك ، العراق، كلية الزراعة ، جامعة تكريت ، العراق.
[2]المعهد النباتي ، معهد كارلسروه للتكنولوجيا ، كارلسروه ، ألمانيا.

الخلاصة

من أجل دراسة القدرة على الجمع والعمل الجيني للمحصول والصفات المحددة المتعلقة بجودة الحبوب للأنماط الجينية لقمح الخبز السبعة (SK94, SK 95, Side 12, Side14, Giemiza 7, Giemiza 9, and Al-Fayyad)، تم إجراء نصف صلبان ديليل بينهما للحصول على (21) صلبان مفردة. تم زرع الهجينة بشكل فردي جنبا إلى جنب مع الخطوط الأبوية في ثلاث نسخ متماثلة في تصميم كتلة كاملة عشوائية. تم قياس بيانات إنتاجية النبات ونسبة البروتين ونسبة الغلوتين الرطب ونسبة الغلوتين الجاف. أظهر تحليل التباين اختلافات كبيرة بين الأنماط الجينية لجميع السمات التي تم تقييمها. تميز الجانب الأم 12 بقدرته العامة على الجمع بين سمات محصول النبات, نسبة البروتين, ونسبة الغلوتين الرطب, بينما الهجين كورونا 95 س جانب 12 تميزت بقدرة الجمع الخاصة بكل الصفات. كانت النسبة بين مكونات تباين قدرة الجمع العامة إلى تباين قدرة الجمع المحددة أقل من واحد لجميع السمات ، و هذا دليل على تأثير تباينات الهيمنة على السمات. كان التباين الجيني أكبر من التباين البيئي لجميع السمات. أيضا ، كان تباين الهيمنة أكبر من التباين الإضافي لجميع السمات. كان معدل التوريث بالمعنى الواسع مرتفعا لجميع السمات ، بينما كان معدل التوريث بالمعنى الضيق متوسطا لسمة غلة النبات ومنخفضا للسمات الأخرى. كان التقدم الجيني المتوقع منخفضا في جميع السمات. لذلك ، فإن الاختيار ليس مفيدا ، ومن الممكن الاستفادة من طريقة تربية التغاير والاختيار في الأجيال اللاحقة.

الكلمات المفتاحية: الجمع بين القدرة ، قمح الخبز ، عمل الجينات ، التوريث ، تباين المكونات المظهرية

INTRODUCTION

Cereal crops are the mainstay of human nutrition, providing 50% of their energy needs and more than 25% of their protein needs (Tadesse *et al.,* 2019). Wheat is considered a major source of food for more than 35% of the world's population because it contains many nutrients such as carbohydrates (60-80%), proteins (8-15%), fats (1.5-2%), fiber (2.2%), vitamins B and E, and amino acids in addition to the gluten present in it (Shewry and Hay, 2015). Therefore, it plays a role in producing the finest types of bread. The percentage of gluten ranges between 30-35% of the wet weight in wheat and is useful for bread (Tadesse *et al.,* 2019). It consists of protein substances such as glutenin and gliadin, which the bread loaf depends on to increase its elasticity and size, (Baye *et al.,* 2020). Qualitative traits are of great importance in the breeding program to increase grain productivity. With the increasing challenges facing the agricultural sector, there is a need to improve the quality and efficiency of wheat production. Hence the importance of hybridization, which aims to exploit genetic diversity to improve the wheat crop, leading to an increase in its productivity and grain quality (Khalid *et al*., 2023). The use of half diallel cross is ideal because it gives the largest number of crosses with the least number of parents used in the cross, in addition to the possibility of estimating the combining ability of parents through the effects of general combining ability and evaluating crosses through the effects of specific combining ability (Hassan and Hadi, 2022)

The inheritance of dominant genetic action reinforces the idea of inheritance of the different traits studied either by selection or by heterosis (Al-Mafarji and AL-Jubouri, 2023a). Abas *et al.* (2018) indicated in their results that the effect of the variation in general combining ability on the variation in specific combining ability was smaller than the correct one in the individual plant yield trait. Zydan and AlJaboory (2020) stated that the Florca variety showed a significant and positive general combining ability in traits of plant yield, protein and gluten ratios, superior to the other parents, while the crosses (Hedab X Sham 6), (Kawz X Abu Ghraib 3), (Florca X Abu Ghraib 3) and (SiteMall X Abaa99) showed a significant and positive special combining ability in protein and gluten percentage traits, while the crosses (Hedab X Abaa99), (Milan X Auces) and (SiteMall X Aucis) showed a significant and positive special ability to combine in the individual plant yield. Choudhary *et al.* (2023) indicated that the effect of additive genetic variation was higher than the effect of dominant genetic variation in the individual plant yield trait, while the dominant genetic variation was higher than the effect of additive genetic variation in the protein ratio trait.

The study aims to determine the performance of seven bread wheat genotypes and their half-diallel crosses, by estimating variations of general and specific abilities and the dominant gene action for the quality traits of wheat grains and determining the best breeding method.

MATERIALS AND METHODS

Seven genotypes of bread wheat (*Triticum aestivum* L.) were used in our study as shown in Table (1). Field experiments for the present study were conducted in the agricultural research experimental station of the faculty of Agriculture, University of Kirkuk-Iraq. The experimental land was prepared, plowed with a disc plow, and then leveled. Before sowing, DAP fertilizer (P_2O_5 46%+N18%). Added by amount was 200 kg.h^{-1} urea fertilizer, and the concentration was (N46%+$P_2O_5$18%) is divided into two batches, the first batch is in the early stage of branching, and the second batch is in the elongation stage (Ministry of Agriculture, 2015).

Table 1. The names and pedigree of seven bread wheat genotypes

No.	Genotypes	Pedigree	Origin
1	SK 95	PASTOR//SITE//MO/3/CHEN/AEGILOPSSQUARROSA(TAUS)//BCN /4/ WBLL1 * CMA01Y00158S-040POY-040M-030ZTM-040SY-26M-0Y-0SY-0S	Egypt
2	Giemiza 9	Ald "S" / Huac "S" // CMH77A . 630/Sx *CGM4583 – 5GM – 1GM – 0GM	Egypt
3	Side 14	SW8488*2/KUKUNA	Egypt
4	Side 12	BUC//7C/ALD/5/MAYA74/ON//1160.147/3/BB/GLL/4/CHAT"S"/6/ MAYA/VUL// CMH74A.630/4*SX. SD7096-4SD-1SD-1SD-0SD	Egypt
5	SK 94	OPATA/RAYON//KAUZ.*CMBW90Y3180-0TOM-3Y-010M-010Y-10M-015Y-0Y-0AP-0S.	Egypt
6	Giemiza 7	CMH74A.630/SX//SERI82 /Agent* CGM4611- 2GM- 3GM- 1GM-0GM	Egypt
7	Al-Fayyad	ACSAD 875 // URES *2 / PRIS	Iraq

These genotypes are sown in two sowing periods. The first batch is on 15th November, 2021. The second time after15 days planting on first December, 2021. To ensure that enough first-generation crosses are obtained, the hybridization process between genotypes was carried out according to the half-diallel crosses to obtain the crosses and harvest on first June, 2022. Agricultural operations were similar to those in the first season, and the experiment was conducted using a randomized complete block design (RCBD) with three replications. Each iteration contains 28 rows. Genotypes were randomly assigned on November 15, 2022, and genotypes were harvested on May 25, 2023. After excluding the final plants, 10 plants were randomly harvested from each experimental unit. Grain yield per plant (g), protein ratio, wet and dry gluten ratio were measured. Protein content was estimated using an Inframatic device from the American company Perten Instruments, which is based on infrared analysis (Gomez-Becerra et al., 2010). 10g of flour sample was used in the test, and it was placed in a small cube-shaped container located inside the device. After turning on the device, the results were read within a few minutes. The wet gluten ratio in wheat flour was estimated using a (Berten 2200) device from the American company Perten Instruments. The wet gluten sample was dried in the oven at 105°C for 4 minutes using a GlutorK2020 device from the American company Perten Instruments, to estimate the dry gluten ratio. (Al-Abdullah and Al-Sarraj, 2016).

The statistical analysis of genotype data was based on the SAS 9.0 program for SAS Studio Company. General combining ability (GCA) and specific combining ability (SCA) analyses were performed according to the second method and the fixed model (Griffing,1956). Phenotypic variance components representing genetic variance (additive and dominance variance), environmental variance, in addition to broad and narrow heritability ratios, and degree of dominance were estimated using the expected mean variance (EMS) in a fixed model of variance analysis when parents are pure lines, based on a template in Excel. The means were tested using Duncan's multiple range test to compare the means of genotypes at 5% significance level. (Al-Mohammadi, 2009).

RESULTS AND DISCUSSION

The ANOVA table 2 shows that the parental genotypes differ significantly at the probability level 1% for all examined traits plant yield (g), protein %, dry gluten %, and wet gluten %. From the ANOVA table 3, it was found that the first-generation crosses were significant at the probability level 1% in all tested traits. This is evidence of genetically distinct parental genotypes and crosses differences resulting from half-diallel crosses. This result agreed with Schmitz and Ransom (2021) regarding trait of plant yield (g), protein %, traits, with Schwarzwälder *et al.* (2022) regarding trait of plant yield (g), protein %, and dry gluten, with Al-Mafarji and Al-Jubouri (2023a) regarding plant yield trait.

Table 2. Analysis of variance of parental for Plant Yield (g), Protein %, wet gluten %, and Dry gluten %.

S.O.V	D.F	Plant yield (g)	Protein %	Wet gluten %	Dry gluten %
Replicate	2	3.769	16.878	16.283	16.292
Parents	6	173.612**	2.525**	44.067**	4.703**
Error	12	1.956	0.076	0.100	0.071

****: Significant at 1% levels.**

Table 3. Analysis of variance of half-diallel cross for plant yield, protein %, wet gluten %, and dry gluten %

S.O.V	D.F	Plant yield (g)	Protein %	Wet gluten %	Dry gluten %
Replicate	2	4.862	48.845	745.45	49.899
Crosses	20	479.614**	2.332**	63.962**	6.835**
Error	40	3.284	0.101	0.090	0.082

**: Significant at 1% levels

It is noted from Table 4 that regarding the productivity of plant yield trait, the parent 2 (Giemiza 9) outperformed all the parents and gave the highest rate of (67.862 g). As for the protein content trait, parents 1 (SK 95) and 7 (Al-Fayyad) excelled significantly, obtaining the highest average (13.00 and 13.40), respectively. In the traits of wet and dry gluten, parent 1

(SK 95) was significantly superior to the rest of the parents and gave the highest average of (39.16 and 13.05), respectively. This result agreed with Askander *et al.* (2021), Mousa *et al.* (2023), Khoury *et al.* (2023). Al-Mafarji and Al-Jubouri (2023b), who found similar results for means of the studied traits

Table 4. Averages of parents for plant yield (g), protein %, wet gluten %, and dry gluten %.

Genotype	Plant yield (g)	Protein %	Wet gluten %	Dry gluten %
SK 95	45.177 e	13.00 a	39.16 a	13.05 a
Giemiza 9	67.862 a	11.90 b	37.19 c	12.33 b
Side 14	62.916 b	11.00 c	37..79 b	12.53 b
Side 12	63.484 b	12.10 b	34.02 d	11.34 c
SK 94	58.146 c	12.40 b	33.81 d	11.27 c
Giemiza 7	58.096 c	11.00 c	29.18 f	9.69 d
Al-Fayyad	52.355 d	13.40 a	30.10 e	10.12 d

Similar letters do not differ in terms of statistical significance.

It is noted from Table 5 that the productivity of the plant yield trait was significantly high for the crosses (Giemiza 9 x Giemiza 7) and gave the highest rate of (91.60 g). As for the protein content trait, the crosses (SK 95 × Side 12) showed significant success and gave the highest average of (13.50%). The wet gluten trait outperformed the crosses (Side 14 x Al-Fayyad) and (Side 12 × Al-Fayyad) gave the highest average of (39.29, and 39.66%), respectively. As for the dry gluten trait, the crosses (SK 95 x Side 12), (Giemiza 9 x Giemiza 7), (Side 14 x Al-Fayyad), (Side 12 x SK 94), (Side 12 x Al-Fayyad) showed the highest rate of (13.01, 13.00, 13.09, 12.72, and 13.22%), respectively. This result agreed with Aziz and hamadia (2019) Zydan and AlJaboory (2020), Al-Mafarji and Al-Jubouri (2023a), who found similar results for means of the studied traits.

It is noted from the analysis of the variance (Table 6) that the genotypes significantly differed in the studied traits at a 1% probability level. These differences between genotypes indicate variations in the genetic factors controlling the inheritance of these traits, as well as their interaction with external growth factors such as climate and soil, and internal growth factors specific to the genotype. This Emphasizes the need for continuous study to understand the genetic actions governing the inheritance of these traits. This result is crucial for analyzing combining ability according to the second method of Griffin (1956), which involves dividing the means of the squares of the genotypes into the averages of the squares of general and specific combining ability. Both GCA and SCA were highly significant at a 1% probability level for the studied traits.

Table 5. Means of half diallel crosses of seven bread wheat for plant yield (g), protein %, wet gluten %, and dry gluten %.

Crosses	plant yield (g)	Protein %	Wet gluten %	Dry gluten %
SK 95 x Giemiza 9	52.77 ijk	12.30 bcd	30.84 k	10.27 f
SK 95 x Side 14	67.68 e	11.90 de	30.45 k	10.16 fg
SK 95 x Side 12	72.13 d	13.50 a	38.92 bc	13.01 a
SK 95 x SK 94	53.78 hij	12.80 bc	32.30 i	10.81 de
SK 95 x Giemiza 7	72.28 d	11.10 fg	32.86 h	11.00 de
SK 95 x Al-Fayyad	74.43 d	9.60 h	35.27 e	11.75 c
Giemiza 9 x Side 14	51.13 jk	11.40 ef	29.58 l	9.73 gh
Giemiza 9 x Side 12	84.56 b	12.40 bcd	31.52 j	10.52 ef
Giemiza 9 x SK 94	72.24 d	10.60 g	29.44 l	9.77 gh
Giemiza 9 x Giemiza 7	91.60 a	12.40 bcd	39.02 bc	13.00 a
Giemiza 9 x Al-Fayyad	84.15 b	11.90 de	26.18 n	9.02 i
Side 14 x Side 12	85.45 b	12.70 bc	28.12 m	9.37 hi
Side 14 x SK 94	56.75 gh	12.70 bc	36.88 d	12.28 b
Side 14 x Giemiza 7	66.67 e	11.90 de	23.87 o	8.02 j
Side 14 x Al-Fayyad	58.12 g	12.20 cd	39.29 ab	13.09 a
Side 12 x SK 94	64.84 ef	12.90 b	38.67 c	12.72 ab
Side 12 x Giemiza 7	77.54 c	12.20 cd	28.14 m	9.39 hi
Side 12 x Al-Fayyad	54.95 hi	12.00 de	39.66 a	13.22 a
SK 94 x Giemiza 7	54.77 hi	11.80 de	33.77 g	11.27 cd
SK 94 x Al-Fayyad	50.37 k	11.80 de	32.63 hi	10.87 de
Giemiza 7 x Al-Fayyad	63.49 f	10.80 g	34.62 f	11.55 c

Similar letters do not differ in terms of statistical significance.

When comparing the ratio of the components of the variance of the GCA to the components of the variance of the SCA, it is noted that it was less than the correct one for all the traits. This is the result of an increase in the proportion of the components of the variance of the SCA, confirming that it is under the control of the action of the dominance genes. Thus, it can be improved through heterosis breeding. This result is consistent with findings from with Roy *et al.* (2021), Chaudhary *et al.* (2022), and Kaury *et al.* (2023), who found significant differences between general and specific combining ability genotypes in traits plant yield, protein and gluten content.

In order to evaluate the genotypes, the effects of the general combining ability (gi) and its variation V(gi), as well as the variations in the effect of the specific combining ability V(si), were estimated for the studied traits (Table 7). For single plant yield, the highest effects on the general combining ability were seen in parent 2 (Giemiza 9) with values of 5.87, parent 4 (Side 12) with 5.23, and parent 6 (Giemiza 7) with 2.58. Similarly, the variation in the specific combining ability was highest in parent 2 with 1278.72, followed by parent 4 with 534.25, and parent 6 with 482.47, respectively. This suggests that parent 2 (Giemiza 9) passed on his genes for some of his crosses, while parents 4 (Side 12) and 6 (Giemiza 7) passed on their genetic traits to many of their crosses.

Table 6. Analysis of variance of genotypes and mean square of general (GCA) and specific combining ability (SCA) for plant yield (g), protein %, wet gluten %, and dry gluten %.

S.O.V	D.F	Plant Yield (g)	Protein %	Wet gluten %	Dry gluten %
Replicate	2	7.420	65.719	61.725	66.191
Genotypes	27	439.417**	2.305**	58.503**	6.245**
GCA	6	570.862**	2.038**	28.494**	3.187**
SCA	21	401.861**	2.381**	67.077**	7.119**
Error	54	2.912	0.092	0.090	0.077
σ^2GCA/σ^2SCA		0.158	0.094	0.047	0.049

**: Significant at 1% levels.

For the protein ratio trait, parent 4 (Side 12) showed a significant effect on the general combining ability in the desired direction, with a value of 0.443, indicating genes that increase the protein value. Meanwhile, the variance of the effect of the specific combining ability for parent 4 reached 1.204, suggesting that this parent passed on most of its genes to his crosses. In terms of wet gluten ratio, parents 1 (SK 95), 4 (Side 12), and 5 (SK 94) demonstrated effects on the general combining ability with values of 1.37, 0.71, and 0.53, respectively. The variance in the specific combining ability was lower for parent 1 (SK 95) at 46.80 compared to parent 4 (Side 12) at 111.19 and parent 5 (SK 94) at 55.54, indicating that they transferred their genetic traits to their crosses. For dry gluten ratio, parent 1 (SK 95) was noted for its positive effect on the general combining ability with a value of 0.47, reflecting genes that enhance dry gluten. The specific combining ability for this parent was 5.12, indicating a significant involvement in passing down genetic traits. These results were similar to arya *et al*. (2018), Homadia and aziz (2019), Al-Mafarji and Al-Jubouri (2023 b) in the traits of plant yield, protein and gluten content.

For the purpose of evaluating representative crosses and determining the best ones in terms of their special combining ability, which must be taken into account for breeding and improvement, Table 12 shows the results. For the single plant yield trait, the crosses SK 95 x Side 14, SK 95 x Side 12, SK 95 x Giemiza 7, SK 95 x Al-Fayyad, Giemiza 9 x Side 12, Giemiza 9 x SK 94, Giemiza 9 x Giemiza 7, Giemiza 9 x Al-Fayyad, Side 14 x Side 12, and Side 12 x Giemiza 7 showed positive and desirable significance at the 1% probability level, with values ranging from 4.82 to 18.23.

Table 7. Effects of the general combining ability (gi) and its variance (**$\sigma^2 g_i$**) and the variance of the effect of the special combining ability (**$\sigma^2 s_i$**) for Plant yield (g), protein %, wet gluten %, and dry gluten %.

Parents	Effects and variance	Plant yield (g)	Protein %	Wet gluten %	Dry gluten %
SK 95	g_i	-3.99**	0.143	1.37**	0.47**
	Vg_i	15.66	0.012	1.86	0.21
	Vs_i	648.30	7.497	46.80	5.12
Giemiza 9	g_i	5.87**	-0.124	-0.63**	-0.21
	Vg_i	34.17	0.007	0.39	0.04
	Vs_i	1278.72	3.116	145.90	15.35
Side 14	g_i	-0.86	-0.124	-0.32*	-0.13
	Vg_i	0.46	0.007	0.09	0.01
	Vs_i	680.94	1.057	157.83	17.06
Side 12	g_i	5.23**	0.443**	0.71**	0.22
	Vg_i	27.09	0.187	0.50	0.04
	Vs_i	534.25	1.204	111.19	11.71
SK 94	g_i	-5.59**	0.165	0.52**	0.15
	Vg_i	30.97	0.018	0.26	0.02
	Vs_i	137.08	2.858	55.54	5.87
Giemiza 7	g_i	2.58**	-0.413**	-1.78**	-0.59**
	Vg_i	6.36	0.162	3.16	0.34
	Vs_i	482.47	1.934	148.28	15.88
Al-Fayyad	g_i	-3.24**	-0.090	0.13	0.09
	Vg_i	10.20	-0.001	0.01	0.01
	Vs_i	737.80	6.761	122.65	12.23
S.E(g_i)		0.80	0.143	0.14	0.13

*, **: Significant at 5% and 1% levels, respectively.

For the protein ratio trait, the crosses SK 95 x Side 12, SK 95 x SK 94, Giemiza 9 x Giemiza 7, and Side 14 x Giemiza 7 showed significant effects of 0.93, 0.50, 0.95, and 0.67, respectively, at the 1% probability level. The crosses Side 14 x Side 12, Side 14 x Giemiza 7, and Side 14 x Al-Fayyad showed a significant effect of 0.39, 0.45, and 0.42, respectively, at the 5% probability level. For the wet gluten trait, the crosses SK 95 x Side 12, Giemiza 9 x Giemiza 7, Side 14 x SK 94, Side 14 x Al-Fayyad, Side 12 x SK 94, Side 12 x Al-Fayyad, SK 94 x Giemiza 7, and Giemiza 7 x Al-Fayyad showed a significant effect ranging from 1.70 to 8.10 at the 1% probability level. For the dry gluten trait, the crosses SK 95 x Side 12, Giemiza 9 x Giemiza 7, Side 14 x SK 94, Side 14 x Al-Fayyad, Side 12 x SK 94, Side 12 x Al-Fayyad, SK 94 x Giemiza 7, and Giemiza 7 x Al-Fayyad showed a significant effect ranging from 0.59 to 2.69 at the 1% probability level. Crosses that have shown significant heterosis and have a parent with significant general combining ability can be used in a breeding program for heterosis. These results were similar to Ahmed *et al*. (2017), patel *et al*. (2020), Mohammad and Al-Taweel (2020). in the traits of plant yield, protein content and gluten content.

Table 8. Estimation the effects of the special combining ability (Sij) for plant yield (g), protein %, wet gluten %, and dry gluten % in a half-diallel cross between seven bread wheat genotypes.

Crosses	Plant yield (g)	Protein %	Wet gluten %	Dry gluten %
SK 95 x Giemiza 9	-14.02**	0.29	-3.23**	-1.09**
SK 95 x Side 14	7.61**	-0.11	-3.93**	-1.29**
SK 95 x Side 12	5.97**	0.93**	3.51**	1.21**
SK 95 x SK 94	-1.56	0.50**	-2.92**	-0.92**
SK 95 x Giemiza 7	8.78**	-0.62**	-0.06	0.01
SK 95 x Al-Fayyad	16.74**	-2.44**	0.44*	0.08
Giemiza 9 x Side 14	-18.80**	-0.34*	-2.80**	-1.04**
Giemiza 9 x Side 12	8.54**	0.09	-1.89**	-0.60**
Giemiza 9 x SK 94	7.05**	-1.43**	-3.78**	-1.28**
Giemiza 9 x Giemiza 7	18.23**	0.95**	8.10**	2.69**
Giemiza 9 x Al-Fayyad	16.60**	0.13	-6.65**	-1.97**
Side 14 x Side 12	16.16**	0.39*	-5.60**	-1.83**
Side 14 x SK 94	-1.72	0.67**	3.35**	1.15**
Side 14 x Giemiza 7	0.03	0.45*	-7.36**	-2.37**
Side 14 x Al-Fayyad	-2.71**	0.42*	6.15**	2.02**
Side 12 x SK 94	0.28	0.30	4.11**	1.23**
Side 12 x Giemiza 7	4.82**	0.18	-4.13**	-1.36**
Side 12 x Al-Fayyad	-11.96**	-0.34*	5.48**	1.79**
SK 94 x Giemiza 7	-7.14**	0.06	1.70**	0.59**
SK 94 x Al-Fayyad	-5.72**	-0.26	-1.35**	-0.49**
Giemiza 7 x Al-Fayyad	-0.77	-0.69**	2.93**	0.93**
$S.E_{(Sij)}$	1.13	0.20	0.20	0.18

*, **: Significant at 5% and 1% levels, respectively

Table 9 shows the components of phenotypic variation and genetic parameters for various traits. It is evident from the table that genetic variation outweighed environmental variation for the traits under study. Dominance variance was found to be higher than additive variance, highlighting the significance of dominance in the inheritance of these traits and therefore the reliance on breeding methods that prioritize heterosis. These results agreed with Schwarzwalder *et al.* (2022) of the studied traits. The broad-sense heritability ratio was notably high, ranging from 96.7% for protein ratio to 99.9% for wet gluten ratio, attributed to the higher genetic variation in comparison to environmental variation. These results agreed with Tomar *et al*. (2019). Regarding traits of plant yield, protein content, and gluten content. In contrast, the narrow-sense heritability ratio appeared average for single plant yield trait at 23.9%. The average degree of dominance exceeded the correct one for the studied traits, indicating the prevalence of superior dominance and a greater number of dominant alleles relative to recessive alleles.

The expected genetic advance ratio, calculated as a proportion of the general rate of the trait, was relatively low, ranging from 5.58 for plant yield to 0.251 for dry gluten ratio, providing further evidence of the influence of dominance genetic action on these traits. These findings align with previous studies by Al-Najjar and Al-Zubaidy (2019). Bayar and Askander (2023), and El-Rashidy and El-Abedeen (2023). of the studied traits

Table 9. Estimation of genetic parameters for single plant yield (g), protein %, wet gluten %, and dry gluten %.

Genotype	Plant yield (g)	Protein %	Wet gluten %	Dry gluten %
V_E	0.971 ± 0.55	0.031 ± 0.02	0.030 ± 0.02	0.026 ± 0.02
V_G	175.053 ± 95.14	0.907 ± 0.34	24.433 ± 4.75	2.578 ± 0.53
V_P	176.024 ± 27.66	0.938 ± 0.15	24.463 ± 3.84	2.603 ± 0.41
V_A	42.070 ± 21.14	0.144 ± 0.08	2.104 ± 1.06	0.230 ± 0.12
V_D	132.983 ± 39.50	0.763 ± 0.23	22.329 ± 6.59	2.347 ± 0.70
$h^2_{b.s}$%	99.4	96.7	99.9	99.0
$h^2_{n.s}$%	23.9	15.4	8.6	8.8
$\bar{a}$	2.514	3.254	4.607	4.514
ΔG%	5.58	0.262	0.749	0.251

CONCLUSION

We note from the above that the hybrid (SK95xSide12) showed a special combining ability in all the studied traits, and the parent (Side 12) showed a general combining ability in traits of plant yield, protein ratio, and wet gluten, while the parent (SK 95) showed a general combining ability in traits of wet and dry gluten. Thus, it is possible to continue breeding for heterosis and obtain superior genetic compositions through severe isolation, tracking and selecting them in the late isolation generations. This is confirmed by the percentage of heritability in the narrow sense, which was medium in the trait of plant yield and low in the traits of protein percentage and wet and dry gluten, as well as the large number of dominant alleles compared to alleles with additional genetic action, which was shown by the degree of superior dominance, which was greater than one in all traits, in addition to the low ratio of expected genetic advance in all traits as well.

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