Kirkuk University Journal for Agricultural Sciences
ISSN:2958-6585
https://kujas.uokirkuk.edu.iq

RESEARCH ARTICLE https://doi.org. 10.58928/ku26.17305

Genetic Analysis of Germination and Early Seedling Stage Traits in Bread Wheat (*Triticum aestivum L.)* Using Half Diallel Mating Desing

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Received:16/10/2025 **Revised: 23/03/2026** **Accepted: 20/08/2026** **Published: 01/09/2026**

ABSTRACT

A half-diallel mating design was employed, crossing six diverse wheat varieties to generate 15 F1s hybrids. Both the hybrids and parents were assessed under laboratory conditions for traits including root length, shoot length, root and shoot weight, germination rate, germination speed, mean germination time, and seedling weight. Griffing's Method II, Model I, was employed to analysis the data and estimation the data in order to estimate general combining ability (GCA), specific combining ability (SCA), heritability, and the average degree of dominance. This approach provides a fixed-effect analysis of genetic components. Significant genetic diversity was indicated by the analysis of variance, which showed highly significant genotypic differences for every trait. For the majority of features, the GCA impacts were very significant, demonstrating the significance of additive gene action. Parent Jihan was shown to be a good general combiner for root length 15.818mm, while Parent AR89 showed positive GCA for germination rate and germination speed 3.264 and 2.455 days, respectively. Significant SCA effects were also observed, showing the role of non-additive gene action. Crosses Sulaimani2 × Dink and Monaliza × AR89 exhibited desirable SCA for root length and germination rate (20.620mm and 3.113) and (10.174mm and 3.988), respectively. All traits had high estimates of broad-sense heritability, but estimations of narrow-sense heritability ranging from moderate to low indicated that both additive and non-additive gene effects govern these traits. The results demonstrate that selective breeding based on early seedling traits is feasible. The identification of parents with strong GCA provides a source of favorable additive genes, while specific cross combinations with high SCA offer potential for developing hybrid varieties. This genetic information is valuable for accelerating wheat breeding programs aimed at improving seedling vigor and establishment under abiotic stress conditions.

Keywords**:** Wheat genotypes, Germination rate, Seedling treats, GCA, SCA and Heritability.

INTRODUCTION

Irregular rainfall patterns and salinity-induced water stress can severely hinder plant growth and reduce productivity. These pressures seriously jeopardize global agriculture by interfering with plant development, metabolism, and physiology [1,2]. Due to population growth, there is an increasing need to cultivate more land and improve agricultural performance in order to meet the world's expanding food demand. To meet these demands, food production is expected to need to expand by over 50% by 2050 [3,4]. Because of its excellent nutritional content and wide range of adaptation, bread wheat (*Triticum aestivum L.*) is the world's most extensively produced cereal crop [5]. Crop performance depends on the early growth stages, especially germination and seedling establishment, since stress during these times can drastically lower eventual yields. Therefore, strong early growth is crucial for cultivation in limited environments [6]. In saline soils, germination plays a role in establishing the crop [7,8,9]. Additionally, germination and seedling growth can be significantly impacted by salinity stress. Since roots and shoots are directly in charge of absorbing water and nutrients and subsequently transmitting these resources to the rest of the plant, they are among the main defenses against salt [10]. Additionally, root and shoot characteristics are useful markers for determining genotypes that can withstand drought or salinity [11,12]. According to research, early seedling traits including root length, shoot length, and coleoptile length can serve as trustworthy selection criteria for creating wheat types that can withstand drought [13,14,15]. The ratio of a seedling trait's mean value under stress and under normal circumstances is commonly used to compute the drought tolerance index [16]. Therefore, genotypes with strong early development and high germination rates are more suited for establishment under adverse environmental conditions. [6,17]. Breeding progress could be accelerated by incorporating seedling features into selection procedures, even though breeders frequently prioritize yield selection, which reflects favorable environmental conditions. Early screening for water stress tolerance can be done using characteristics including shoot height, root length, and coleoptile length. Diallel analysis is a popular biometric technique for comprehending the genetic foundation of such features [18]. Diallel crosses are an effective mating design in plant breeding, providing insight into the genetic makeup of parental lines and enabling evaluating the general combining ability (GCA) and specific combining ability (SCA). This information helps breeders identify superior parents and plan effective breeding strategies [19,20,21]. This study's objective is to analyses early germination-stage traits in bread wheat genetically, using a half diallel cross among six parental lines, to better understand the inheritance patterns and combining abilities of the studied traits.

Materials and methods

In a diallel cross, six variety of bread wheat were crossed, excluding the reciprocals during the winter season of 2023-2024. Viz (Suleimani 2, Jihan, Monaliza, dink, Sham 6, and AR89) During February 2nd 2025. The experiments were carried out in the laboratory of college of agriculture engineering sciences, University of Suleimani. Six parents and their 15 F1s crosses were put in 10 cm sterilized petri dishes with filter paper and sterile water seeds were considered to have germination when the radical measured more than 2 mm. Each petri-dish consisted of 25 seeds and replicated 3 times. The experiment was completed by recording observation of seedlings after 7 days and measuring it should take into account field characteristics, as these are more important than laboratory characteristics. The Diallel analysis was carried in conformity with the Griffing (1956) Method 2 model 1 (parents and one set of F1s). Multiple comparisons of genotypes mean were performed using Duncan multiple test. The following genetic parameters were done (General Combining Ability (GCA), Specific Combining Ability (SCA), Heritability in Broad Sense, Heritability in Narrow Sense, Degree of dominance(ā)) [22].

Combining Ability Analysis

Combining ability analysis was carried out utilizing method II model I, as developed by Singh and Chaudhary (1985), in accordance with Griffing's (1956) technique. The GCA and SCA were calculated using the generic linear model for the analysis, which is displayed as follows [22,23].

formula:

$Y_{ijk} = \mu + g_i + g_j + s_{ij} + r_k + \varepsilon_{ijk}$.

Heritability

According to Singh and Chaudhary (1985), heritability in both the broad and narrow sense was estimated based on the variance of general and specialized combining abilities as well as the variance of experimental error [22].

as follows:

$$h^2_{b.s} = \frac{\sigma^2 G}{\sigma^2 P} = \frac{\sigma^2 A + \sigma^2 D}{\sigma^2 A + \sigma^2 D + \sigma^2 e} = \frac{2\sigma^2 GCA + \sigma^2 SCA}{2\sigma^2 GCA + \sigma^2 SCA + \sigma^2 e}$$

$$h^2_{n.s} = \frac{\sigma^2 A}{\sigma^2 P} = \frac{\sigma^2 A}{\sigma^2 A + \sigma^2 D + \sigma^2 e} = \frac{2\sigma^2 GCA}{2\sigma^2 GCA + \sigma^2 SCA + \sigma^2 e}$$

The Average Degree of Dominance (ā)

For the traits under study, the degree of dominance was estimated as follows:

$$\bar{a} = \sqrt{\frac{2\sigma^2 D}{\sigma^2 A}} = \sqrt{\frac{2\sigma^2 SCA}{2\sigma^2 GCA}} = \sqrt{\frac{\sigma^2 SCA}{\sigma^2 GCA}}$$

Results

Data in Table 1 explains the analysis of variances for the attributes under study. With the exception of the traits root weight and root shoot ratio, which were significant, the mean squares for genotypes were highly significant for every trait. therefore, genetic analysis should be performed for all traits. With the exception of the trait Root shoot ratio, which was not important, the mean squares for GCA were very significant for every traits regarding to the mean square of SCA, which, was highly significant for all traits except the traits mean germination time which was significant and root weight which was not significant.

Data in Table 2 The performance of genotypes (parents + crosses) for all studied traits is shown. With regard to the crosses, the Cross 1×4 provided the highest values for root and shoot length, while the Cross 1×6 displayed the highest values for root weight and root shoot ratio. The highest values for shoot weight and seedling weight were produced by the cross 2×3. The highest values for germination rate and speed were exhibited by the cross 3×6. The maximum value for mean germination time and the lowest values for most traits were shown by the cross 4×5. Regarding to the parents it was noticed that parent 1 exhibited the highest values for the traits shoot length, root weight and seedling weight, while parent 2 gave the maximum values for root length and root weight, but parent 3 showed the highest values for root shoot ratio and germination speed. parents 5 and 6 recorded the maximum value for mean germination time and germination rate respectively but parent 4 gave the lowest values for some traits.

Table 3 displays the parents' estimated general combining ability. parent 1 gave maximum positive gca effects for the traits shoot length, root weight, shoot weight and seedling weight, while parent 2 showed maximum gca effects for root length and maximum negative gca effect for root shoot ratio. For both root weight and seedling weight, parent 4 had the most negative gca effect. parent 5 recorded the highest negative gca effect for most traits such as root length, germination rate, germination speed, and mean germination time. Parent 6 recorded the highest positive gca effect for root shoot ratio, germination rate, germination speed and mean germination time and also recorded maximum negative gca effect for shoot length and shoot weight.

Table 4 illustrates the specific combining ability effect $\hat{S}ij$ of F1 crosses for the studied traits. The Cross 1×2 gave the highest negative $\hat{S}ij$ effect for the trait shoot length, while the cross 1×3 recorded the highest negative effect of sca for the traits Root weight, Shoot weight, and Seedling weight. The cross 1×4 gave the maximum positive effect of sca for the trait root length, and the cross 1×5 showed the highest positive effect of gemination rate, but the cross 1×6 recorded maximum positive impact for the trait root shoot ratio. The cross 2×3 recorded the highest positive gca and sca effect for shoot weight and Seedling weight, and also recorded maximum negative effect for root length and root shoot ratio. the cross 3×6 exhibited the highest positive sca effect for germination speed and mean germination time. The highest negative sca effect of the traits germination rate, germination speed and mean germination time was recorded by the Cross 4×5 but the highest positive effect of sca for root weight was recorded by the cross 5×6.

Data in Table 5 explain some genetic parameters of the studied traits. Most traits such as root/ shoot ratio, germination rate and seedling weight show **σ^2gca/ σ^2sca** ratio significantly less than one, this indicates non additive gene action (dominance, epistasis) plays a larger role than additive effects for these traits. Only mean germination time (MGT) shows **σ^2gca/ σ^2sca** more than one 1.704 indicating additive gene actions dominates. **σ^2gca/ σ^2sca** for root weight 0.637g also shows relatively higher additive influence compared to others. High broad sense heritability for shoot length 0.991mm, root length 0.968mm and seedling weight 0.980g exhibit means a large proportion in the total phenotypic variation is due to total genetic variation (additive + non additive). The low narrow sense heritability for root/shoot ratio and shoot length indicates non additive effects dominate this genetic component. Root / shoot ratio, shoot length, seedling weight and germination rate shows strong dominance effect, in which they recorded 5.491, 6.661, 2.828 and 2.552 for dominance effect(**$\hat{a}$**) respectively.

Table 1: Mean squares of variance for studied traits.

SOV	DF	Root length (mm)	Shoot length (mm)	Root weight (g)	shoot weight (g)	Root shoot ratio	Germination rate%	Germination speed (days)	Mean germination time (days)	Seedling weight (g)
Replication	2	33.427	31.897	-0.0005	0.000	0.013	7.4445	5.413	2.6285	0.0005
Treatment	20	2700.041**	2534.204**	0.00005*	0.00035**	0.143*	126.716**	35.716**	36.962**	0.001**
GCA	5	2009.110**	598.577**	0.0001014**	0.0004**	0.089 N.S	141.378**	87.188**	91.828**	0.001**

SCA	15	2930.349**	3179.411**	0.00004	0.0003**	0.161**	121.829**	18.559**	18.674**	0.001**
Error	40	109.263	30.871	0.000025	0.000025	0.063	34.411	6.937	9.002	0.000025

Table 2: The performance of genotypes for studied traits.

Genotypes	Root length (mm)	Shoot length (mm)	Root weight (g)	shoot weight (g)	Root shoot ratio	Germination rate%	Germination speed (days)	Mean germination time (days)	Seedling weight (g)
1×2	20.7^{fgh}	29.888^{gh}	0.0137^{b}	0.0157^{c}	0.882^{abcde}	80.00^{cde}	11.100^{def}	2.290^{a}	0.0295^{def}
1×3	28.3^{fgh}	36.998^{fgh}	0.0151^{b}	0.0138^{c}	1.097^{abc}	84.00^{bcde}	15.958^{bcd}	1.627^{a}	0.0289^{def}
1×4	64.5^{cd}	47.777^{e}	0.0167^{b}	0.0145^{c}	1.175^{ab}	90.00^{abc}	14.688^{bcd}	2.355^{a}	0.0312^{cdef}
1×5	30.0^{fgh}	34.773^{fgh}	0.0153^{b}	0.0156^{c}	0.984^{abcd}	89.33^{abc}	14.462^{bcd}	2.187^{a}	0.0309^{cdef}
1×6	18.7^{gh}	31.777^{fgh}	0.0171^{b}	0.0137^{c}	1.269^{a}	86.00^{bcd}	16.041^{bcd}	1.479^{a}	0.0308^{cdef}
2×3	25.0^{fgh}	39.221^{efgh}	0.0158^{b}	0.0310^{b}	0.537^{de}	94.66^{ab}	14.599^{bcd}	2.167^{a}	0.0468^{b}
2×4	63.4^{cd}	35.222^{fgh}	0.0155^{b}	0.0158^{c}	0.986^{abcd}	92.33^{ab}	13.971^{cde}	2.486^{a}	0.0313^{cdef}
2×5	39.8^{ef}	40.221^{efg}	0.0150^{b}	0.0168^{c}	0.895^{abcde}	78.00^{de}	13.741^{cdef}	2.126^{a}	0.0318^{cdef}
2×6	37.0^{efg}	34.221^{fgh}	0.0157^{b}	0.0151^{c}	1.039^{abc}	92.66^{ab}	19.458^{ab}	1.471^{a}	0.0308^{cdef}
3×4	35.0^{efgh}	38.222^{efgh}	0.0154^{b}	0.0149^{c}	1.030^{abcd}	88.66^{abcd}	14.624^{bcd}	1.999^{a}	0.0303^{cdef}
3×5	24.0^{fgh}	28.555^{h}	0.0140^{b}	0.0154^{c}	0.913^{abcde}	88.66^{abcd}	11.871^{def}	2.965^{a}	0.0294^{def}
3×6	53.9^{de}	41.222^{ef}	0.0157^{b}	0.0168^{c}	0.962^{abcd}	98.66^{a}	22.750^{a}	1.143^{a}	0.0325^{cdef}
4×5	26.9^{fgh}	29.999^{gh}	0.0121^{b}	0.0132^{c}	0.920^{abcde}	74.00^{e}	8.554^{f}	3.205^{a}	0.0253^{f}
4×6	25.8^{fgh}	33.664^{fgh}	0.0118^{b}	0.0147^{c}	0.807^{abcde}	92.00^{ab}	15.158^{bcd}	1.803^{a}	0.0265^{ef}
5×6	14.2^{h}	29.889^{gh}	0.0142^{b}	0.0143^{c}	1.235^{a}	83.33^{bcde}	14.765^{bcd}	1.686^{a}	0.0313^{cdef}
1	76.2^{c}	116.887^{a}	0.0170^{b}	0.0636^{a}	0.457^{e}	89.66^{abc}	14.450^{bcd}	2.234^{a}	0.0921^{a}
2	135.9^{a}	111.887^{a}	0.0285^{a}	0.0229^{bc}	0.667^{cde}	94.66^{ab}	14.271^{cd}	2.312^{a}	0.0381^{cd}
3	100.3^{b}	99.665^{b}	0.0152^{b}	0.0189^{c}	1.140^{abc}	93.66^{ab}	19.583^{ab}	1.639^{a}	0.0399^{bc}
4	52.2^{de}	74.109^{d}	0.0210^{ab}	0.0195^{c}	0.721^{bcde}	92.66^{ab}	19.433^{ab}	1.539^{a}	0.0335^{cdef}
5	62.9^{cd}	88.775^{c}	0.0140^{b}	0.0218^{c}	0.653^{cde}	93.33^{ab}	9.338^{ef}	3.047^{a}	0.0361^{cde}

6	58.6^{cd}	73.999^{d}	0.0157^{b}	0.0181^{c}	0.881^{abcde}	99.33^{a}	18.641^{abc}	1.800^{a}	0.0338^{cdef}

Table 3: Estimation of general combining ability effect ĝii of parents for studies traits.

parents	Root length (mm)	Shoot length (mm)	Root weight (g)	shoot weight (g)	Root shoot ratio	Germination rate%	Germination speed (days)	Mean germination time (days)	Seedling weight (g)
1	-2.069	6.166	0.003	0.008	-0.012	-2.069	-0.585	-1.072	0.011
2	15.818	4.611	-0.001	0.001	-0.093	0.222	-0.553	-0.455	-0.000
3	4.476	2.236	0.001	-0.001	0.050	2.097	1.642	1.739	0.000
4	-1.382	-4.069	-0.002	-0.003	-0.007	-0.361	0.006	0.104	-0.004
5	-8.794	-3.084	-0.001	-0.002	-0.020	-3.153	-2.965	-2.868	-0.003
6	-8.049	-5.861	-0.000	-0.003	0.082	3.264	2.455	2.552	-0.003
S.E	3.735	2.039	0.001	0.002	0.0248	0.991	0.778	0.799	0.002

Table 4: Estimation of specific combining ability effect Ŝij of parents for studies traits.

Genotypes	Root length (mm)	Shoot length (mm)	Root weight (g)	shoot weight (g)	Root shoot ratio	Germination rate%	Germination speed (days)	Mean germination time (days)	Seedling weight (g)
1×2	-40.380	-33.126	-0.004	-0.012	0.070	-7.470	-2.881	-2.381	-0.017
1×3	-21.372	-23.642	-0.005	-0.013	0.142	-5.345	-0.218	0.282	-0.018
1×4	20.620	-6.557	-0.001	-0.010	0.278	3.113	0.148	0.648	-0.011
1×5	-6.435	-20.546	-0.002	-0.010	0.100	5.238	2.894	3.394	-0.012
1×6	-18.514	-20.765	-0.001	-0.011	0.282	-4.512	-0.947	-0.447	-0.012
2×3	-42.593	-19.864	-0.000	0.012	-0.337	3.030	-1.609	-1.692	0.011
2×4	1.699	-17.556	0.002	-0.001	0.169	3.155	-0.602	-0.685	0.001
2×5	-14.522	-13.544	0.001	-0.001	0.091	-8.387	2.140	2.057	-0.000
2×6	-18.068	-16.766	0.001	-0.002	0.133	-0.137	2.437	2.353	-0.001
3×4	-15.393	-12.182	0.000	-0.001	0.070	-2.387	-2.143	-2.227	-0.001

3×5	-18.980	-22.834	-0.002	-0.001	-0.034	0.405	-1.924	-2.008	-0.003
3×6	10.174	-7.390	-0.001	0.001	-0.087	3.988	3.534	3.451	0.001
4×5	-10.222	-15.084	-0.001	-0.001	0.031	-11.804	-3.583	-3.667	-0.002
4×6	-12.101	-8.642	-0.002	0.001	-0.185	-0.220	-2.422	-2.506	-0.001
5×6	-16.222	-13.404	0.003	0.000	0.257	-6.095	0.174	0.091	0.003
S.E	4.219	1.820	0.001	0.002	0.044	1.344	0.573	0.581	0.002

Table 5: Estimation of some genetic parameters for studied traits

Parameters	Root length (mm)	Shoot length (mm)	Root weight (g)	shoot weight (g)	Root shoot ratio	Germination rate%	Germination speed (days)	Mean germination time (days)	Seedling weight (g)
σ^2e	109.263	30.871	0.000025	0.000025	0.063	34.411	6.937	9.002	0.000025
σ^2gca	237.481	70.963	0.0000096	0.000047	0.0033	13.371	10.031	10.353	0.00012
$\sigma^2sca= \sigma^2D$	2821.086	3148.54	0.000015	0.00028	0.098	87.418	11.622	9.672	0.00098
σ^2gca/ σ^2sca	0.084	0.0225	0.637	0.170	0.033	0.153	0.863	1.704	0.122
σ^2A	474.964	141.926	0.000019	0.000094	0.0065	26.742	20.063	20.707	0.000244
â	3.447	6.661	1.253	2.440	5.491	2.557	1.076	0.967	2.828
$h^2b.s$	0.968	0.991	0.577	0.937	0.624	0.768	0.820	0.773	0.980
$h^2n.s$	0.1394	0.0427	0.323	0.236	0.039	0.180	0.519	0.526	0.196

discussion

There are very strong genetic differences between the genotypes for the almost all traits studied. Both additive and non-additive gene action are important, but each trait has a different proportion contribution. These results are with a good agreement with some the searches that reported significant effect of the majority of germination characteristics: the Sham-3 variety produced the highest values of radicle length and germination percentage, whereas the Crezo variety produced the highest coleoptile length, coefficient of velocity of germination%, and least number of days needed for germination [24]. For every trait, there was substantial genotypic variance. Additive dominance model revealed full fitness of the data for RL, DSW, FRW, DRW, but was partially fit for SL, FSW, R/S [25].

The results of the performance of genotypes provide clear guidance for plant breeders to make informed decisions on parent selection and cross combinations to improve early seedling traits. For every trait among the cultivars in study, all found to differ statistically significantly at the 1% probability level, radicle length, shoot length, seedling length, fresh weight, dry weight, radicle to shoot length ratio, germination index, germination rate, germination energy, germination percentage, seedling vigor, mean germination time, and mean germination rate [26].

The GCA analysis provides a genetic roadmap for plant breeders. It moves beyond simply identifying which parents genetically equipped to produce good offsprings increasing the efficiency of breeding program. The results provide key insights into the proportionate significance of additive and non-additive gene action, heritability, and the potential for genetic gain through selection for the studied traits in the plant material. Kızılgeçi 2021 reported that the optimal cross combinations for shoot length and root length, respectively, are determined by the SCA effects of crossings, would be 1x4 and 3x1. Plant breeders may find these results beneficial, and diallel analysis may be a helpful technique for early drought stress resistance testing of current or future cultivars [27].

The outcome demonstrate that while general combining ability identifies good parents, specific combining ability reveals optimal parent combinations, both types of information being essential for an efficient breeding program aimed at developing superior hybrid varieties. El-Rawy and Hassan showed that seedling characteristics were influenced by both additive and non-additive effects. According to reports, dry weight of the root and shoot/root ratio show epistasis, while root length and dry weight of the shoot explain the additive dominance model with overdominance for both features. Additionally, it was noted that there was a mainly additive gene effect for root length, shoot dry weight, root dry weight, and root-shoot ratio was additionally reported by [28]. Under all circumstances, high additive effects have existed observed in root length [29]. The high broad-sense heritability values found in every traits in under investigation supported the idea that these qualities are less affected by the environment. The differences between estimates of heritability in the broad and narrow sense in the regulation of these traits showed the presence of non-additive genetic effects [13]. Under osmotic stress, the genetic components of variation and heritability were generally smaller than beneath normal circumstances. With the exception of germination percentage, shoot length, and coleoptile length, every feature displayed significant genetic diversity. A Heritability in the broad sense was also moderate to high for every character in every setting [30,31,32,33]. Additive genes with moderate to high narrow sense heritability inherited all of the traits, suggesting a wider range of selecting in the early generations [25].

Conclusion

The hybrid seeds of wheat was smaller in size compared to their parents which directly responsible for the poorer germination and early seedling characteristics values shown in comparison to its parents. A reduced endosperm was probably the result of this seed size reduction.

The hybrid wheat seeds assessed in this study showed lower values for important germination and early seedling features than their parental lines, according to the data observed. In particular, the hybrid exhibited a lower fresh and dry weight of seedlings, a slower germination rate, and worse seedling vigor as evidenced by shorter shoot and root length.

Therefore, this specific hybrid combination might not be beneficial for breeding programs where consistent and quick stand establishment is essential for crop production. The results highlight how crucial it is to specifically screen hybrid offspring for critical early vigor features in addition to choosing parents with high yield potential in order to guarantee overall agronomic superiority.

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لتحليل الوراثي للانبات و بعض صفات المبكرة للبادرة حنطة الخبز باستخدام التضريب التبادلي النصفي (*Triticum aestivum* L.)

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الخلاصة

تم أستخدام تصميم تزاوج ثنائي الأليل النصفي، حيث تم تزاوج ستة أصناف متنوعة من حنطة الخبز لتوليد 15 هجيناً من الجيل الأول ***F1*** . تم تقييم الأباء و الهجن و ذلك من خلال عدة صفات البادرة المبكر مثل طول الجذير، طول الرويشة، وزن الجذير، وزن الرويشة، معدل الأنبات، سرعة الأنبات، معدل وقت الأنبات و وزن البادرة. تم تحليل البيانات باستخدام طريقة (***Griffing's Method II, Model I)*** النموذج الأول لتقدير القدرة العامة على الأئتلاف (***GCA)*** و القدرة الخاصة على الأئتلاف (***SCA)*** و معدل درجة السيادة و درجة التوريث في معناها العام الخاص. أوضح تحليل التباين عن أختلافات كبيرة لجميع الصفات المروسة، مما يشير الى التباين الوراثي الكبير. كانت تاثير القدرة العامة على الأئتلاف كبيرة للغاية بالنسبة لمعظم الصفات و التي تسلط الضوء على أهمية عمل الجينات المضافة. يعتبر الأب (***Jihan)*** ذات القدرة العامة الجيدة على الأئتلاف لطول الجذير بينما أظهر الأب (***AR89)*** قدرة عامة موجبة لمعدل الأنبات و سرعة الأنبات. تم ملاحظة تاثير معنوي ل (***SCA)*** و الذي يشير الى دور الفعل الجيني الغير اضافي. الهجين (***Sulaimani2 × Dink)*** و (***Monaliza × AR89)*** لهما تاثير مرغوب لقدرة الخاصة على الأئتلاف لطول الجذير و صفات الأنبات. تم الحصول على تقديرات عالية لدرجة التوريث في معناها العام لجميع الصفات. في حين المعدلات المنخفضة لدرجة التوريث في معناها الخاص تشير الى ان التاثيرات الجينية المضافة و غير المضافة تتحكم في هذه الصفات. تظهر النتائج ان التربية الداخلية القائمة على صفات المبكرة للبادرات ممكنة و تحديد الآباء مع (***GCA)*** قوية يوفر مصدر الجينات المضافة مواتية، في حين أن الهجين مع (***SCA)*** عالية توفر أمكانية تطوير أصناف هجينة. هذه المعلومات الوراثية ذات قيمة كبيرة لتسريع برامج تربية الحنطة التي تهدف الى تحسين قوة البادرات في ظل ظروف نقص الرطوبة.

الكلمات المفتاحية: الأنماط الوراثية للقمح، معدل الإنبات، معالجة الشتلات، القدرة العامة على التأقلم، القدرة الخاصة على التأقلم، وقابلية التوريث.