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Estimate of Genetic Parameters of Grain Yield and Some Agronomic Traits in Durum Wheat Using Diallel Crosses

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Abstract: Five varieties of durum wheat were crossed in full diallel fashion through 2010/2011 growing season. The five parents and their 20 F1 progenies were grown in 2011/2012 at the farm of faculty of agricultural and forestry, Duhok university, Iraq, using randomize complete block design with three replications to estimate heterosis, heritability and some genetic parameters for yield and its components. The results showed highly significant difference among genotypes for all studied traits. The parent Um Raby-5 had a positive general combining ability effect for most traits including grain yield. The crosses (Kokorete71 × LD – 357E), (Crezo × Um Raby-5), (Cimeto × Um Raby-5), (Cimeto × crezo) and (Cimeto × Kokorete 71) exhibited significant desirable specific combining ability effect for most traits. The dominance was greater than additive almost traits. Heritability inbroad sense was high but heritability in narrow sense was low. The expected genetic advance as percent of traits mean was low for all traits. Most crosses showed significant positive heterosis for most traits and two crosses, (Crezo Cimeto) and (Cimeto Um Raby-5) had the highest positive heterosis for the most studied traits including grain yield.

Key words: Duhok, faculty, full diallel, heterosis, heritability.

1. Introduction

Durum wheat (*Triticum durum* Desf.) covers approximately 20 million hectares wordwide, which represents less than 10% of total wheat areas [1] in Iraq during 2003, the planted area by wheat about 1.85 million hectares that produced 2.553 million tons, but in Kurdistan region the planted area by wheat was about 670.989 thousand and production was 504.078 thousand tons. The percentage of durum wheat from this production was more than 50%.

Successful breeding program mainly depends on the variability of genetic variation [2]. However, utilization of genetic recourses as a source of variability requires their proper systematic evaluation [3]. Wheat breeder tends to use new strategies and techniques to predict the expected gain in the cultivar development program. Diallel cross analysis a helps breeders to realize basis of genetic, the nature of gene action and planning appropriate breeding strategies. In this way, diallel analysis is frequently used by plant breeders to assess general combining ability (GCA) of the parents, specific combining ability (SCA) of crosses progeny, heritability, heterosis patterns for investigated traits [4-6]. Specific combining ability is defined as deviation in performance of across combination from that predicted on the basis of the general combining abilities of parents involved in the cross. In a dialed design, GCA is associated with genes which are additive in effects and describes the breeding value of parental lines to produce hybrids. Specific combining ability is attributed primarily to deviation from the additive scheme caused by dominance and epistasis [6].

In wheat, many researchers have applied the diallel mating design to work out the genetic control of grain yield and related components, and to identify good

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general combining parents. Some of studies reported significant additive gene effects, or GCA variances, and non additive gene effects, or SCA variances, Chowdhary [6] and Oettler [7] for most of economic traits in wheat, diallel mating design has been provided information regarding genetic mechanisms controlling grain yield and other traits [8].

However, studies have shown that the parents had highly general ability effects for traits (plant height, number of tiller/plant, number of grain/spike, grain yield/plant) [9-12].

Significant reciprocal effects in the expression of grain yield and other economically important traits have been reported by Chowdhary [6] in bread wheat and [13-15] in durum wheat. This indicates maternal influence in determining the phenotypes of F_1 and thus importance of selecting parents while making crosses. Also, there is evidence for expression of heterosis in grain yield and almost of agronomic traits in wheat [5].

The objective of this study was to estimate GCA and SCA effect for grain yield, and some agronomic traits among five genotypes complete diallel cross of durum wheat to appropriate parents and crosses for the investigated.

2. Materials and Methods

The experiment was carried out at the field of faculty of agriculture and forestry, university of Duhok. Five durum wheats comprised: Kokorete 71, LD-357E, Crezo, Cimeto and Um Raby-5 were used as parents in this study. These genotypes were planted 15/12/2010 in rows (3 m length and 1 m) wide, and full diallel cross among them was done and reciprocal F_1 to obtain F_1 seeds. The parents, F_1 and reciprocal crosses (25 genotypes) were evaluated using randomize complete block design with three replications. Each genotype (15 seeds) was grown in rows of 3 m length with 30 cm width and 20 cm plant to plant distance in each replication. The study was conducted on the same field during 2011-2012. The following traits were studied days to 50% flowering, plant height (cm), flag leaf area (cm^2), No. of spikes/plant, No. of grains/spike, 1,000-grain weight (g) and grain yield/plant (g).

The data were subjected to analysis of variance according to experimental design used and the differences between genotypes tested using DMRT [16]. The mean square of genotypes partitioned to GCA, SCA and reciprocal according to method of one [4], to estimate the effect of GCA for parents and SCA for F_1 crosses and reciprocals F_I. Using expected mean square of GCA, SCA, reciprocal error, the components of variance additive, dominance total genetic and environmental were estimated, and then broad and narrow sense heritability were determined. Heterosis as departure of F_1 and reciprocal F_1's from mid parents were estimated and its significant tested using *t*-test.

3. Results and Discussion

The analysis of variance results are given in Table 1 that revealed highly significant mean square of genotypes for all traits. The mean performance of parent, F_1 crosses and reciprocal F_1 crosses for different traits were presented in Table 2. Less number of days to 50% flowering observed in parent LD357E, Which took 137.25 days while parent Cimeto was the latest which had taken 155.87 days, the difference between parents reflected significantly on their crosses. The cross Crezo × cimetowas the earliest, with 138.91 days, while the cross Kokerete 71 × cimeto which took the longest period (156.68 days) to flowering. The maximum plant height of 66.0 cm was found in the parent UmRaby 5, while the minimum height of 48.66 cm was recorded by parent Crezo. Among the crosses, maximum (70.30 cm) plant height was observed in the cross Crezo × Cimeto, while the minimum (48.60 cm) height was exhibited by cross Kokerete71 × UmRaby5. The highest mean of flag leaf area was observed in parent UmRaby5 with a value of 36.97 cm^2, while the lowest mean was 20.11

Table 1 Analysis of variance (mean square values) for different traits of genotypes and hybrids according to Griffing method 1956.

Characters s.o.v	d.f	Days to 50% flowering	Plant height (cm)	Flag leaf area (cm^2)	No. of spikes/plant	No. of grain/spike	1,000 grain weight (g)	Grain yield/plant (g)
Rep.	2	3.27	18.28	0.56	0.43	9.78	0.75	3.10
Hybrid	24	130.81**	119.88**	330.53**	9.96**	415.57**	155.18**	119.96**
Error	48	0.265	1.34	10.23	0.09	1.017	1.01	0.23

*significant at $P = 0.05$; **significant at $P = 0.01$.

Table 2 Means performance for studied traits in parents, hybrids and reciprocal.

Parents and hybrids	Days to 50% flowering	Plant height (cm)	Flag leaf area (cm^2)	No. of spikes/plant	No. of grains/spike	1,000 grain weight (g)	Grain yield/plant (g)
Parents							
Kokerete71	145.83 ij	60.0 de	20.11 g	11.38 de	58.36 g	40.28 k	26.11 n
LD 357E	137.25 n	55.66 gh	36.95 g	10.51 f	66.50 e	49.43 ef	26.91 m
Crezo	155.87 ba	48.66 j	36.17 hg	9.95 g	52.47 i	49.56 ef	27.97 L
Cimeto	155.16 bc	61.3 d	32.09 k	8.92 h	41.83 m	44.75 ij	25.85 n
UmRaby5	149.75 g	66.0 c	36.97 g	11.03 ef	56.99 g	46.49 hi	28.72 L
Hybrids							
Kokerete71×LD357E	153.85 e	61.6 d	22.56 p	11.39 de	49.92 j	46.15 hij	35.43 gf
Kokerete71×Crezo	155.16 ab	50.6 j	31.46 k	11.01 ef	38.72 n	38.46 L	32.57 j
Kokerete71×Cimeto	156.68 a	50.0 j	40.64 f	14.93 a	50.01 j	52.21 d	34.00 i
Kokerete71×UmRaby	153.66 e	48.6 j	34.85 i	13.32 b	57.42 g	49.62 ef	43.13 c
LD357E×Crezo	156.66 a	55.3 gh	28.70 m	11.43 de	54.39 h	47.67 gh	33.02 j
LD357E×Cimeto	154.00d e	67.3 bc	36.06 h	11.34 de	43.86 L	44.58 j	33.92 i
LD357E×UmRaby5	154.81 cd	50.6 j	29.77 L	12.80 c	62.30 f	52.87 d	39.14 e
Crezo×Cimeto	138.91 m	70.3 a	46.21 e	14.62 a	72.80 bc	62.71 a	46.16 a
Crezo× UmRaby5	145.25 j	57.3 gf	54.55 bc	15.01 a	70.13 d	59.91 c	44.28 b
Cimeto×UmRaby5	140.18 Lk	68.6 ab	55.15 b	15.07 a	70.75 d	62.85 a	44.86 b
Recp. hybrids							
UmRaby5×Cimeto	151.83 f	61.6 d	30.15 L	11.32 de	50.34 j	48.85 gf	34.24 hi
UmRaby5×Crezo	156.00 ab	61.6 d	57.01 a	11.02 ef	71.20 cd	46.53 hi	36.07 f
UmRaby5×LD357E	153.75 e	53.0 i	26.96 n	11.39 de	73.93 b	49.91 ef	35.72 gf
UmRaby5× Kokerete71	149.05 g	55.0 h	25.33 o	11.41 de	46.56 k	46.12 hij	34.89 gh
Cimeto×Crezo	147. glh	59.0 ef	33.44 j	10.61 f	41.78 m	52.83 d	28.59 L
Cimeto×LD357E	146.25 i	62.0 d	32.25 k	11.43 de	52.78 hi	39.74 Lk	31.04 k
Cimeto×Kokerete71	152.33 f	57.0 gfh	35.58 hi	11.70 d	44.27 L	51.08 de	34.36 hi
Crezo×LD357E	140.81 k	56.3 gh	54.06 c	13.32 b	69.99 d	60.29 bc	44.66 b
Crezo× Kokerete71	139.25 m	56.3 gh	27.43 n	15.01 a	70.09 d	61.85 ab	42.51 c
LD357E×Kokerete71	139.30 Lm	66.6 bc	48.78 d	15.00 a	75.70 a	60.28 bc	40.84 d

Values for each having the same letters are not significantly different.

cm^2 in parent Kokerete71. The differences between the parents reflected significantly in their crosses. Means for crosses ranged from 22.56 to 57.01 cm^2 in the crosses Kokerete71 × LD357E and UmRaby5 × Crezo, respectively. The hybrid with greater flag leaf area is desirable because they provide more photo synthetic activity for the growth of plant. The highest number of spikes/plant was 11.38 in parent Kokerete71, while the lowest number was recorded by parent Cimeto (8.92). The crosses Crezo × UmRaby5 and Crezo × Kokerete71 gave maximum number of spikes of 15.01 and the minimum number was observed for the cross LD357E × Kokerete71, whereas the cross Kokerete71 × Crezo has the lowest mean of 38.72. Among the parents variety LD357E showed maximum (66.50) grains/spike, while variety Cimeto had least value of 41.83. Abroad grange of variation was observed between the parents and their F_1 progenies. The individual comparison of means of all genotypes given in Table 2 revealed that the parent

Crezo had maximum 1,000-grain weight of 49.569, while parent Kokerete71 had minimum mean of 40.289. Among F1, the cross Crezo × Cimeto had maximum 1,000-grain weight with a mean value of 62.27 g; whereas, cross Kokerete71 × Crezo showed the lowest mean value of 38.46 g for this trait. For grain yield/plant, parent UmRaby5 produced the highest mean (28.729), while parent Cimeto produced the lowest plant yield (25.859). In the case of crosses, the maximum grain yield/plant (46.469) was obtained by cross Crezo × Cimeto, while the cross Cimeto × LD357E had least value of 31.049, from pervious results it was shown that the parent UmRaby5 was surpassed others for most traits (plant height, flag/leaf area, and grain yield/plant), while the parent LD357E was surpassed for days to 50% flowering and number of grains/spike and also the parent Crezo was surpassed for 1,000-grain weight then these parents could be used inbreeding program with other varieties to improve these traits.

The cross Crezo × Cimeto was surpassed other from most traits (days to 50% flowering, plant height, 1,000-grain weight and grain yield/plant, while the cross UmRaby5 × Crezo gave high flag leaf area, and the cross Cimeto × UmRaby5 recorded the maximum number of spikes/plant, whereas the cross LD357E × Kokerete71 recorded the highest value of grains/spike, then these crosses could be used in selection program to improved varieties. The same results have been reported by other researchers like Tawfiq [17], Ali [18] and Rashidi [19].

Analysis of variance for general, specific combining ability and reciprocal is presented in Table 3. Mean square of GCA and SCA were highly significant for all traits indicating additive and non additive type of gene action involved in the manifestation of traits under study. Also, the mean square of reciprocal was highly significant for all studied traits indicating the maternal effect on the behavior of cross produced by reciprocal. The ration of GCA to SCA components was less than 1 for all studied traits, which revealed the more importance of dominance gene action in controlling these traits which could be improved through hybridization. These results are consistent with other researchers' results like Nazir [20], Hassan [21], Ammen [22], Mahpara [23] and Akram [24].

Table 4 showed, estimates of general, specific and reciprocal effect of parents, crosses for all studied traits. The parent Kokerete71 and LD357E gave negative effects of GCA for number of day to 50% flowering (-0.034, -1.802), respectively, which indicate the ability of these parents to reduce the number of days to 50% flowering, while the parents Crezo, Cimeto and UmRaby 5 have a positive GCA values (0.021, 0627 and 1.187) sequence, which delayed the days of flowering. For plant height, the maximum positive value of GCA was 3.426 in parent Cimeto indicating the high contributing of this parent in the inheritance of plant height to its crosses. For flag leaf area trait, parent Crezo gave the maximum positive value (3.983) for GCA, indicating thecontribution of this parent in increasing the flag leaf area in its crosses. For number of spikes/plant parent Kokerete71 gave the highest value of GCA (0.470) ratifying the contribution of this parent in possible improving of this traits, while three parents (LD357E,

Table 3 Analysis of variance for general and specific combining ability according to Griffing method 1956.

s.o.v	d.f	M.S						
		Days to 50% flowering	Plant height (cm)	Flag leaf area (cm^2)	No. of spikes/plant	No. of grains/spike	1,000 grain weight (g)	Grain yield/plant (g)
GCA	4	15.05**	57.46**	171.41**	1.28**	257.11**	29.018**	18.84**
SCA	10	1,236.48**	1,717.56**	2,801.54**	81.42**	1,930.84**	1,283.96**	1,426.95**
Reciprocal	10	1,746.16**	552.51**	3,411.67**	142.61**	5,447.37**	2,126.03**	1,258.13**
MSE	48	0.265	1.34	0.230	0.09	1.01	1.01	0.23
Vg.c.a Vs.c.a		0.01	0.03	0.06	0.01	0.13	0.02	0.01

**significant at $P = 0.01$.

Crezo, Cimeto) gave negative value of gca for number of grains/spike and the parent UmRaby5 and LD357E gave maximum positive values of GCA (3.936 and 3.863, respectively), which indicates the contribution of this parents in increasing this trait is high, while the parents Kokerete71 and Cimeto gave negative value. For 1,000-grain weight, the parent Crezo gave the highest positive effects (2.336) confirming the increase in the value of this trait in its crosses, while parent Kokerete71 gave the highest negative effect (-1.967). The results in Table 4 indicate that the parent UmRaby5 gave the highest positive effect of GCA (1.577) for grain yield/plant, this parent contributes the inheritance of this trait to the crosses. The maximum negative value was -1.512 shown by parent Cimeto, which expresses the contribution of this parent in the reduction of the value of this trait in the some of its crosses.

From pervious results, it was shown that parent Cimeto had desirable general combining ability for plant height, flag leaf area, number of spikes/plant, number of grains/spike, 1,000-grain weight and grain yield and followed by parent Crezo for flag leaf area, number of grains/spike, 1,000-grain weight and grain yield/plant, then these two genotypes could be used inbreeding program. In other words, the crosses Kokerete71 × LD357E, Kokerete71 × Crezo, Crezo × Cimeto, Cimeto × UmRaby5 recorded negative SCA for days to 50% flowering while the crosses (Kokerete71 × Cimeto, Kokerete71 × UmRaby5, LD357E × UmRaby5, LD357E × Cimeto, LD357E × UmRaby5) scored (non desirable) SCA effect for this trait. For plant height, the crosses (Kokerete71 × Crezo, Kokerete71 × Cimeto, Kokerete71 × UmRaby5, LD357E × Crezo, LD357E × UmRaby5) recorded negative effect for SCA, while positive effects were recorded by crosses (Kokerete71 × LD357E, LD357E × Cimeto, Crezo × Cimeto, Crezo × UmRaby5, Cimeto × UmRaby5). For flag leaf area, the crosses (Kokerete71 × LD357E, Kokerete71 × Cimeto, LD357E × Crezo, Crezo × UmRaby5 and Cimeto × UmRaby5) scored positive SCA effect. For trait number of grains/spike, the value of SCA effect ranged between highest positive Crezo × UmRaby5 7.323 and the highest negative in cross Kokerete71 × UmRaby5 (-6.888). For 1,000-grain weight, the positive SCA effect was recorded by cross Kokerete71 × LD357E (5.148), while the highest negative SCA effect was recorded by cross LD357E × Cimeto (-7.711). All crosses were scored positive sca effect for grain yield/plant, except cross LD357E × Cimeto, gave negative SCA effect for this trait.

For previous results, it was concluded that the crosses Kokerete71 × LD357E and Cimeto × UmRaby5 had significant desirable SCA for all studied traits, followed by Crezo × Cimeto which had significant desirable for all traits except number of days to 50% flowering and 1,000-grain weight. The results presented in Table 3 exhibited some crosses appeared high SCA from contrast parents from ability of GCA, for example, the parents Kokerete71 and LD357E appeared negative GCA for the most traits, but the cross produced from them, Kokerete71 × LD357E was recorded highest SCA for all traits and to the contrary, the cross Cimeto × UmRaby5, one of parent had high GCA for the most traits and other parent had negative SCA but cross produced highest SCA for all traits.

The data in Table 4 showed the estimation of reciprocal effect for crosses. The crosses UmRaby5 × Cimeto and Cimeto × Crezo showed positive reciprocal effect for all traits except, plant height and number of days to 50% flowering. The remaining of reciprocal crosses exploited positive or negative SCA for different traits. These results are in agreement with those reported by Farooq [25], Khan [8], Ameen [22] and Akram [24].

Table 5 presents variance components and some genetic parameters. It was shown that the dominance genetic variance was more than additive for all traits, indicating the preponderance of over dominance gene effect in the genetic control of these traits. The

Table 4 Estimates of general and specific combining ability for parents, hybrids and reciprocal.

Genotypes	Days to 50% flowering	Plant height (cm)	Flag leaf area (cm^2)	No. of spikes/plant	No. of grains/spike	1,000 grain weight (g)	Grain yield/plant (g)
Parents							
Kokerete71	-0.034	-1.840	-5.832	0.470	-2.782	-1.967	0.405
LD 357E	-1.802	-0.006	-1.232	-0.289	3.863	-0.566	-0.640
Crezo	0.021	-2.006	3.983	-0.009	1.697	2.336	0.980
Cimeto	0.627	3.426	0.828	0.332	-6.697	-0.163	-1.512
UmRaby5	1.187	0.426	2.253	0.160	3.936	0.363	1.577
S.E	0.084	0.189	0.078	0.049	0.164	0.164	0.079
Hybrids							
Kokerete71×LD357E	-0.705	7.673	6.197	0.792	4.005	5.148	3.780
Kokerete71×Crezo	-1.663	-1.093	-5.242	0.330	-2.215	-0.817	1.566
Kokerete71×Cimeto	4.697	-6.526	6.576	0.957	-1.100	3.177	0.696
Kokerete71×UmRaby	0.987	-5.193	-2.769	-0.302	-6.888	-1.122	2.437
LD357E×Crezo	1.305	-0.593	2.092	0.534	-1.078	1.609	3.100
LD357E×Cimeto	2.082	2.806	-1.974	-0.212	-6.568	-7.711	-0.766
LD357E×UmRaby5	5.680	-7.026	-9.189	0.009	2.589	0.992	1.091
Crezo×Cimeto	-6.449	4.806	-1.525	0.737	4.585	4.998	2.510
Crezo×UmRaby5	0.198	2.640	13.006	0.649	7.323	-0.081	2.218
Cimeto×UmRaby5	-5.024	2.873	3.027	1.150	5.582	5.051	4.088
S.E	0.174	0.391	0.161	0.101	0.339	0.339	0.162
Reciprocal hybrids							
UmRaby5×Cimeto	-5.825	3.500	12.50	1.876	10.201	7.003	5.310
UmRaby5×Crezo	-5.375	-2.166	-1.233	1.995	-0.533	6.683	4.103
UmRaby5×LD357E	0.533	-1.166	1.405	0.705	-5.816	1.480	1.711
UmRaby5× Kokerete71	2.308	-3.166	4.661	1.133	5.426	1.750	4.116
Cimeto×Crezo	-4.500	5.666	6.386	2.006	15.511	4.936	8.785
Cimeto×LD357E	3.870	2.666	1.905	-0.043	-4.461	2.418	1.440
Cimeto×Kokerete71	2.175	-3.500	2.530	1.616	2.870	0.568	-0.178
Crezo×LD357E	7.925	-0.500	-12.683	-0.866	-7.799	-6.310	-5.816
Crezo× Kokerete71	8.291	-2.833	2.011	-1.996	-15.688	-11.695	-4.971
LD357E×Kokerete71	7.175	-2.500	-13.106	-1.805	-12.893	-7.061	-2.708
S.E	0.210	0.391	0.193	0.123	0.411	0.411	0.197

value of environmental variance was low for all traits. The value of the average degree of dominance was more than one for all traits, indicating the presence of over dominance. Heritability in broad sense was high for all traits, while narrow sense heritability was low for all traits and ranged from 2.37% for number of days to 50% flowering and 21.02 for number of grains/spike. Expected genetic advance as percent of traits means was ranged from 0.01% for days to 50% flowering and 0.64% for number of grains/spike and it was low for all traits. These results are in agreement with some earlier findings [13, 17, 22, 26-28].

Heterosis for all traits as departure traits as departure of F1 from mid parents was presented in Table 6. Negative heterosis was observed in crosses (Crezo × Cimeto, Crezo × UmRaby5, Cimeto × UmRaby5, UmRaby5 × Cimeto, Cimeto × Crezo, Crezo × LD357E, Crezo × Kokerete71, LD357E × Kokerete71) for days to 50% flowering, while the remaining crosses gave positive heterosis (in non desirable direction) for this trait. For plant height, the crosses (Kokerete71 × LD357E, LD357E × Cimeto, Crezo × Cimeto, Cimeto × UmRaby5, UmRaby5 ×Crezo, Cimeto × Crezo, Cimeto × LD357E, Crezo ×

Table 5 Estimates of components of genetic variance (VA and VD) and environmental variance for studied traits.

Variance	Days to 50% flowering	Plant height (cm)	Flag leaf area (cm^2)	No. of spikes/plant	No. of grains/spike	1,000 grain weight (g)	Grain yield/plant (g)
VA	30.11	114.93	342.82	2.57	514.23	58.03	37.69
VD	1,236.48	1,717.56	2,801.54	81.42	1,930.84	1,283.96	1,426.95
VE	0.265	1.349	0.230	0.01	1.017	1.01	10.230
a	9.06	5.46	4.04	7.90	2.74	6.65	8.70
h^2b.s	99.97	99.92	99.99	99.89	99.95	99.92	99.98
h^2n.s	2.37	6.26	10.90	3.06	21.02	4.32	
G.A	2.15	12.79	9.20	1.61	37.28	7.66	2.57
G.A of mean	0.01	0.21	0.25	0.13	0.64	0.15	0.07
Means	149.21	58.44	36.54	12.22	57.72	50.60	35.40

VA = additive genetic variance; VD = dominance genetic variance; VE = environmental variance; a = average degree of dominance; h.b.s and h.n.s = heritability in broad and narrow sense; GA = genetic advance.

Table 6 Heterosis relative to the mid parent for studied characters.

Hybrids	Days to 50% flowering	Plant height (cm)	Flag leaf area (cm^2)	No. of spikes/plant	No. of grains/spike	1,000 grain weight (g)	Grain yield/plant (g)
Kokerete71×LD357E	12.308**	3.833**	-5.965**	0.440	-12.513**	1.298	8.915**
Kokerete71×Crezo	4.981**	-3.666**	3.315**	0.350	-16.695**	-6.405**	5.531**
Kokerete71×Cimeto	6.183**	-10.666**	14.54**	4.780**	-0.080	9.696**	8.021**
Kokerete71×UmRaby	5.875**	-14.333**	6.31**	2.475**	-0.256	6.240**	15.711**
LD357E×Crezo	10.106**	3.166*	-7.863**	1.356**	-5.095*	-1.826	5.583**
LD357E×Cimeto	7.791**	8.833**	1.545**	1.623**	-10.306	-2.515*	7.540**
LD357E×UmRaby5	11.316**	-10.166**	-7.185**	2.031**	0.550	4.911**	11.323**
Crezo×Cimeto	-16.601**	15.333**	12.078**	5.186**	25.655**	15.548**	19.256**
Crezo×UmRaby5	-7.560**	0.000	17.975**	4.525**	15.401**	11.881**	15.936**
Cimeto×UmRaby5	-12.275**	5.000**	20.616	5.098**	21.336**	17.233**	17.580**
UmRaby5×Cimeto	-0.625	-2.000	-4.383**	1.345**	0.933	3.226**	6.960**
UmRaby5×Crezo	3.190**	4.333**	20.441**	0.535	16.468**	-1.495	7.730**
UmRaby5×LD357E	10.250**	-7.833**	-9.995**	0.621	12.183**	1.951	7.900**
UmRaby5×Kokerete71	1.258*	-8.000**	-3.013**	0.208	-11.113**	2.740*	7.478**
Cimeto×Crezo	-7.601**	4.000**	-0.695	1.173**	-5.368*	5.675**	1.686**
Cimeto×LD357E	0.041	3.500**	2.265**	1.710**	-1.383	-7.351**	4.660**
Cimeto×Kokerete71	1.833	-3.666**	9.480**	1.546**	-5.820**	8.560**	8.378**
Crezo×LD357E	-5.743**	4.166**	17.503**	3.090**	10.501**	10.793**	17.216**
Crezo× Kokerete71	-11.601**	2.000	-0.708	4.343**	14.681**	16.925**	15.475**
LD357E×Kokerete71	-2.041**	8.833**	20.616**	4.050**	13.273**	15.421**	14.331**

*significant at *P* = 0.05; **significant at *P* = 0.01.

LD357E, LD357E × Kokerete71) gave positive heterosis and significant at 1% level and of 5% in cross LD357E × Crezo. For flag leaf area 12 crosses showed significant positive heterosis in desirable direction, flag leaf area contributes tremendously in the development of grain yield and appreciably adds to the grain yield, while six crosses appeared significant negative heterosis except the crosses Cimeto × Crezo and Crezo × Kokerete71 showed positive and non-significant effect. Desirable heterosis (positive) was found in 15 crosses for number of spikes/plant, while all other crosses showed non-significant effects. The value of heterosis effect in Table 6 indicated that 33% of crosses gave positive effect over their mid parents. The range of heterosis effect for grains/spike was from 0.93 UmRaby5 ×

Cimeto to 25.65% Crezo × Cimeto. Out of 20 crosses, eight had highly significant heterosis, seven had negative significant and five had non significant heterosis. The highest value of heterosis was 25.65% exhibited by cross Crezo × Cimeto, followed by cross Cimeto × UmRaby5 with value of 21.33%.

Positive heterosis for 1,000-grain weight was found in the 20 crosses. Highly significant results indicated by 13 crosses ranging from 2.740 g in the cross UmRaby5 × Kokerete71 to 17.233 g in the cross Cimeto × UmRaby5, while two crosses showed non-significant positive heterosis. For grain yield/plant all crosses showed significant increase with highest value 19.256 in cross Crezo × Cimeto and followed by cross Cimeto × UmRaby5 (17.580) while all other crosses showed positive significant effect and ranged from 4.660 to 15.475.

From the previous information, it was concluded that crosses Crezo × Cimeto, Crezo × UmRaby5, Cimeto × UmRaby5, Crezo × LD357E and LD357E × Kokerete71 had significant desirable heterosis over mid parent for all studied traits. We found that the two crosses Crezo × Cimeto and Cimeto × UmRaby5 had aremarkab significant positive heterosis with high value of heterosis for all studied traits specially grain yield/plant. When the crosses had significantly desirable deterosis (positive or negative) over mid parents which revealed the predominance of non additive gene action controlling these traits while the crosses not appeared significantly heterosis, this indicate the additive gene action controlling these traits. These finding are in accordance with Ansari [29] and the theory, which have been to explain the mechanism of heterosis. The present results are in agreement with the findings of researcher like Kundan [30], Khattab [31] and Akbar [32].

4. Conclusions

The data indicated that all the traits show significant genotypic differences.

Genetic Analysis shows that all traits studied are controlled by dominance type of gene action. Presence of dominance gene action in traits like days to 50% flowering, plant height, flag leaf area, No. of spikes/plant, No. of grains/spike, 1,000-grain weight and grain yield/plant suggested improvement by hybridization.

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