GENETIC ANALYSIS OF F_2 DIALLEL CROSSES IN DURUM WHEAT

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ABSTRACT

Inheritance of yield, combining ability and inbreeding depression were investigated in durum wheat of F_2 half diallel crossing among the 7 varieties Vis: Leeds, Waha, Azeghar1, Um-Rabie3, Brashua, Cyprus1 and Korfila. Genotypes, general and specific combining ability mean square were highly significant. The durum wheat yield was under the dominance gene effect. The parents Leeds and Um-Rabie3 were considered suitable according to their yield capacities and general combining ability effects. The two hybrids (Leeds x Brashua) and (Waha x Brashua) had significantly higher yield (2.943 and 2.955 ton per hectare respectively) as compared with others, and also possessed significant positive specific combining ability effects, highly significant positive inbreeding depression values and deviation from local variety Um-Rabei5, therefore they were considered to be promising hybrids.

INTRODUCTION

Durum or macaroni wheat, *Triticum durum*, (2n=4x=28, genomes AABB), is grown on about 30 million hectares and accounts for almost 8 percent of total world wheat production. Recently,Fawzi(2001), durum wheat has received proper attention of geneticists and breeders resulting in gathering of information on the nature and magnitude of gene effects governing the inheritance of yield and other quantitative traits.

Several breeding methods have been established to increase the yields of durum wheat varieties and their hybrids. In order to choose the best hybrid combinations a large number of subjectively chosen varieties are crossed. It would be a considerable advantage to be able to estimate the combining ability of parents, gene effects and heterotic effects of crosses before making crosses among varieties. Diallel crossing programs have been applied to achieve this goal by providing a systematic approach for the detection of suitable parents and crosses for the investigated characters. In addition, diallel analysis gives plant breeders the opportunity to choose the most efficient selection method by allowing them to estimate several genetic parameters ,Singh and Ghaudhary(1979).

Combining ability describes the breeding values of parental lines to produce hybrids. Sprague and Tatum (1942) used the term general combining ability (gca) to designate the average performance of a variety in hybrid combinations, and used the term specific combining ability (sca) to define those cases in which certain combinations do relatively better or worse than would be expected on the basis of the average performance of the varieties involved. In many studies, gca effects for parents and sca effects for crosses were estimated in wheat (Saad, 1999; Hamada *et al*., 2002; Iqbal and Khan 2006; Kamaluddin *et al*., 2007). Non additive gene effects for yield were found to be significant in wheat (Dere and Yildirim, 2006; Amein, 2007 ;Abd-El-Haleem *et al*., 2009). In addition, heritability degrees varied from low to moderate for yield (Aycicek and Yildirim, 2006; Yagdi and Sozen, 2009; Maniee *et al*., 2009).

Inbreeding depression is defined as the deviation of F_1 mean from F_2 one of the same hybrid, and generally high positive values are desirable for yield in durum

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wheat. Abd-El-Haleem *et al*.,(2009) found negative inbreeding depression values for the most of hybrids from their study on durum wheat, indicating yield depression in F_2 generation. The objectives of this study were to estimate the genetic parameters and inbreeding depression and to determine suitable parents and promising crosses for yield in F_2 half diallel among seven durum wheat varieties.

MATERIALS AND METHODS

Seven varieties,Vic; Leeds, Waha, Azeghar1, Um-Rabie3, Brashua, Cyprus1 and Korfila obtained from IPA center for Agricultural Research and Field Crops Depts., College of Agric., and Forestry, Mosul Univ., were crossed in using half diallel mating scheme in the 2003-2004 growing season. F_2 were obtained from selfing of $F_{1's.}$ The parents, their 21 F_2 populations and a commercial variety that registered in Iraq (Um-Rabie5), 29 entries in total, were grown at Field Crops Dept. farm, center of Mosul University in the 2007-2008 growing season. The plots were represented by three rows, 3 m long and spaced 20cm apart with sowing rates of 140kg per hectare. The experimental design was a randomized complete block design with 3 replications. Cultural practices were consistent with the production of wheat according to the recommendations of Iraqi Ministry of Agriculture, and yield of each genotype (variety or hybrid) was obtained from each plot and transformed to ton per hectare. Data obtained from the 21 F_2 progeny and 7 parents were analyzed by Jinks-Hayman type diallel analysis for genetic parameters as outlined by Singh and Chaudhary (2007) and the following parameters and rations were estimated:

E = The expected environmental component of variation =[(Error SS + Reps. SS) /d.f]/r

D = Variation due to additive effect of the gene.

H_1 = Component of variation due to the dominance effect of the gene.

H_2 = Corrected dominance variance.

h^2=Dominance effect (as the algebric sum over all loci in heterozygous phase in all crosses

F=The mean of Fr (cov. of additive & dominance effects in a single array) over the arrays.

$(H_1 / D)^{1/2}$ = Mean degree of dominance.

KD / KR = Proportion of dominant and recessive genes in the parents.

$H_2/4H_1$ = Proportion of genes with positive and negative effects in the parents.

$K(h^2 / H_2)$=Number of groups of genes which control the character and exhibit dominance. Griffing's Method 2 Model 1 was used to analyze combining abilities (Griffing, 1956). The analysis were performed using (SAS program), Inbreeding depression (I) values were calculated as deviation of expected F_1 means (EF_1) for each hybrid from F_2 means (Gomma and Shaheen, 1995 and Hassan, 1997). The expected F_1 means estimated from the equation suggested by Mather and Jinks (1982) [$EF_1 = 2F_2 - 1/2P_1 - 1/2P_2$], and the significance of inbreeding depression was investigated by t-test [$t = (I - 0) / SEI$], where SEI mean standard error of inbreeding depression and estimated from the difference between variance of F_1 mean (VF_1) and variance of F_2 mean (VF_2). Narrow sense heritability degree was calculated according to the methods of Crumpacker and Allard (1962) as reviewed by (Singh and Chaudhary, 2007).

RESULTS AND DISCUSSION

The analysis of variance for genotypes, and later for combining ability in durum wheat are presented in table 1. It was shown that genotypes mean square was highly significant for yield per hectare, which suggested the importance of studying the gene action for this character. General and specific combining ability mean square were also highly significant, indicated the importance of additive and non additive gene effects in the inheritance of this characters

Table (1): Mean square obtained from primary analysis and combining abilities in diallel durum wheat crosses among 7 varieties.

Source of variation	d. f.	Mean Squares
Replication	2	0.00019
Genotype	27	0.11814**
Error (Preliminary)	54	0.00135
General Combining Ability	6	0.06255**
Specific Combining Ability	21	0.13402**
Error (for combining ability)	54	0.00045
gca/sca		0.467

(**) indicate significant at 1% level.

The genetic parameters for the yield per hectare estimated from F_2 half diallel cross population among the seven varieties included in this study are given in Table (2).

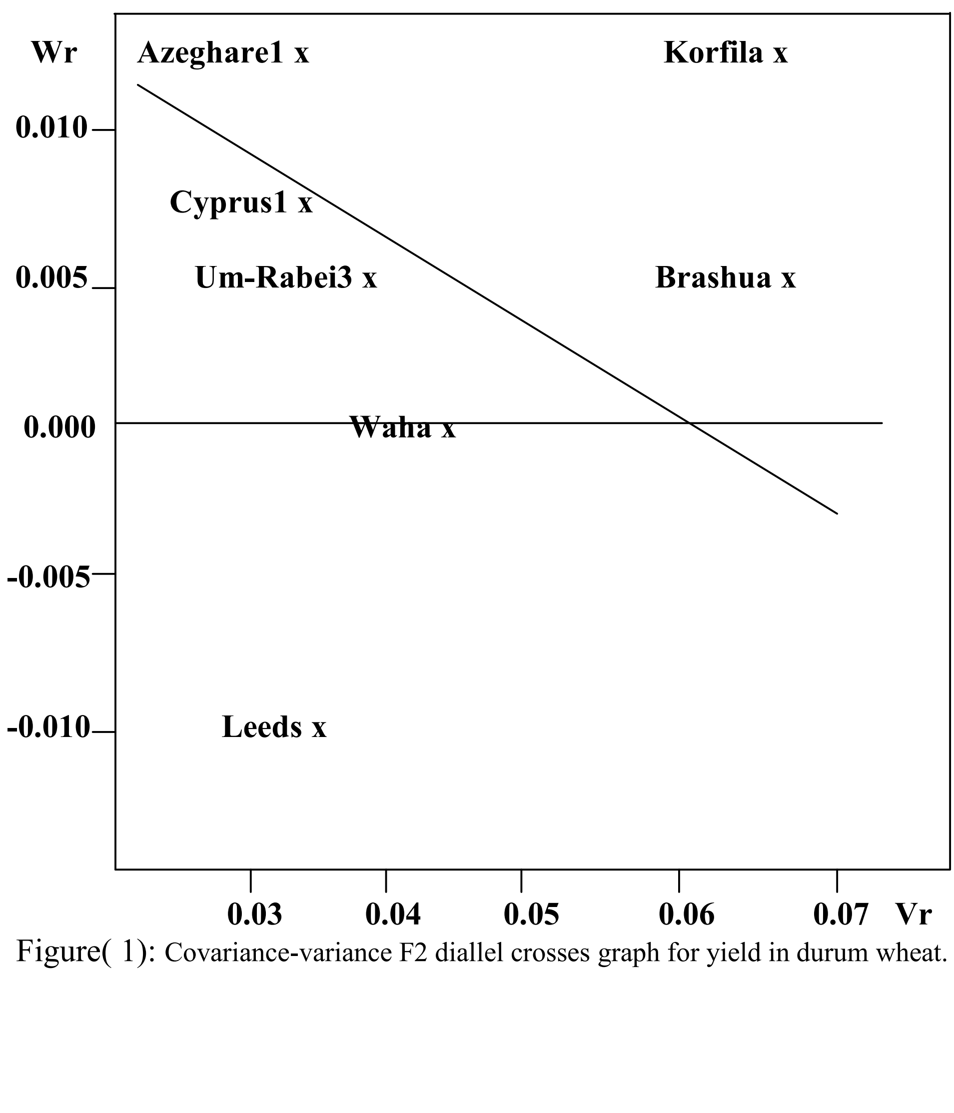
Table(2): Genetic parameters and ratios estimated from 7 x 7 diallel cross in durum wheat.

Genetic parameters and ratios	Grain yield (ton/hectare)
F	0.05494 ± 0.04209
h^2	0.18700 ± 0.01244
E	0.00044 ± 0.00296
D	0.03979 ± 0.02092
H_1	0.17771 ± 0.02623
H_2	0.06900 ± 0.01775
$(H_1 / D)^{1/2}$	2.003
$KD / KR = [(4DH_1)^{1/2} + F] / [(4DH_1)^{1/2} - F]$	1.970
$K(h^2 / H_2)$	2.71
Heritability Degree (Narrow Sense)	0.0643
$\acute{r}$ (Yr, Wr + Vr)	-0.614^{ns}
	$\acute{r}_{(5, 0.01)} = 0.874$ $\acute{r}_{(5, 0.05)} = 0.754$

(ns) indicate non significant.

While a negative F value indicates an excess of recessive alleles in the parents, a positive value shows more dominant alleles than recessive in the parents. Crampacker and Allard (1962) reported that, if the dominant and recessive alleles of each gene are distributed equally among the parents, the F value will be equal to zero. In the present study and as an indicator of the relative frequency of dominant and recessive alleles, the F value was found to be positive and significant from zero (= 0.05494) which means either that no alleles exhibit dominance or else that the dominant and recessive alleles are distributed equally among the parents (Verhalen and Murray, 1967). From the other results of the study, the latter alternative may apply since the variances for H_1 and H_2 are significantly different from zero. It may thus be concluded that the dominant and recessive alleles of the related genes are distributed equally among the parents. Since the mean dominance effect of the heterozygote locus (h^2) was significant, high heterotic effect values in F_2 (or positive significant inbreeding depression values) would be expected for durum wheat yield among crosses. The parameters (E), an estimate of environmental variation was not different from zero, and (D), the estimate of additive genetic variance was different from zero (Table 2). The parameter (D), which may also include a portion of the additive x additive epistatic variances as well as additive genetic variance itself, was significant for yield. Dominance variance (H_1) and corrected dominance variance (H_2) were also significantly different from zero (= 0.17771 and 0.069 respectively), but its values are higher than additive one. It may thus be concluded that dominante gene effects more important in the inheritance of this characters. This result was also supported by the ratio (less than unity) of gca/sca mean square (0.467). Dere and Yildirim (2006), Amein (2007) and Abd-El-Haleem *et al*. (2009) obtained similar results in wheat. As the ratio h^2 / H_2 (k value) equal 2.71, approximately three genes will control durum grain yield. The estimate of narrow sense heritability was low (0.0358), and consistent with other researchers results, like Aycicek and Yildirim (2006) and Yagdi and Sozen (2009). The negative (but non significant) correlation value between (Yr and Wr + Vr = - 0.614) indicates that the parents with high grain yield may carry dominant genes.

The inheritance of yield is shown in a Wr-Vr graph in Figure 1. Partial dominance may be inferred from this graph since the regression line cut the Wr axis over the origin.



Figure(1): Covariance-variance F2 diallel crosses graph for yield in durum wheat.

With regards to yield, the varaieties Leeds, Waha and Um - Rabei3 had more dominant genes whereas Korfila and Brashua carried more recessive genes. Means of durum wheat yield and gca effects of parents are given in Table 3. Duncan's multiple range test showed significant differences for yield among parents.

Table (3): Mean of Parents and general combining ability (gca) effects for grain yield.

Parents	Yield (t/h)	gca effect
Leeds	2.800 a	0.069503*
Waha	2.440 cd	- 0.02398*
Azeghar1	2.640 b	0.011429*
Um-Rabie3	2.840 a	0.046243*
Brashua	2.320 e	- 0.06502*
Cyprus1	2.400 de	- 0.04428*
Korfila	2.520 c	0.006095
Um-Rabie5 (Commercial)	2.738 a	-----
S. E. (gca effect)		0.010002

(*) indicate significant from zero.

- yield means followed by the same letter have non significant difference among them.

While varieties Leeds, Um-Rabie3 and commercial one Um-Rabie5 can be considered significantly high yielding as compared with others (2.800, 2.840 and 2.738 ton / hectare respectively), The two parents Leeds and Um-Rabie3 had higher yield and statistically significant and desirable gca effects.Means of specific combining ability effects, inbreeding depression and deviation from commercial variety (Um-Rabie5) values for crosses are given in Table 4. The two crosses, (Leeds x Brashua) and (Waha x Brashua) had significantly higher yield capacities as compared with others (2.943 and 2.995 ton per hectare respectively). These two F_2 crosses also had significantly higher and desirable specific combining ability effects and desirable deviation from expected F_1 and commercial variety Um-Rabie5. Seven crosses had significant non desirable specific combining ability effects for this character. Most of the best performing crosses usually had at least one parent with high gca effects Chaudhary *et al*.,(2000). It was shown that sixteen of the crosses had significant positive deviation of F_2 from expected F_1, but depression in F_2 occurred significantly in crosses (Leeds x Um-Rabie3), (Leeds x Cyprus1) and (Waha x Azeghar1) only, and non significantly in the cross (Um-Rabie3 x Brashua). This results are supported with findings ofAbd-EL- Haleem *et al*., (2009) whom reported the occurrence of depression (as a result of inbreeding) in durum wheat yield in F_2 generation. While eleven F_2 hybrids significantly surpassed the commercial variety Um-Rabie5, seven varieties significantly and negatively deviated from them.

Table (4): Mean yield, specific combining ability (sca) effects & inbreeding depression values of crosses.

Crosses	Yield(t/h)	sca Effects	Inbreeding depression	Deviation from Um-Rabei Variety
Leeds x Waha	2.835 de	0.103*	0.215**	0.097**
Leeds x Azeghar1	2.868 bcd	0.101*	0.148**	0.130**
Leeds x Um-Rabie3	2.507 ij	- 0.295*	- 0.313**	- 0.231**
Leeds x Brashua	2.943 a	0.252*	0.383**	0.205**
Leeds x Cyprus1	2.477 jk	- 0.234*	- 0.123**	- 0.261**
Leeds x Korfila	2.885 bc	0.124*	0.225**	0.147**
Waha x Azeghar1	2.437 k	- 0.236*	- 0.103**	- 0.301**
Waha x Um-Rabie3	2.788 f	0.079*	0.148**	0.050
Waha x Brashua	2.955 a	0.358*	0.575**	0.217**
Waha x Cyprus1	2.793 f	0.175*	0.373**	0.055*
Waha x Korfila	2.585 h	- 0.083*	0.105**	- 0.153**
Azeghar1 x Um-Rabie3	2.801 ef	0.058*	0.061*	0.063*
Azeghar1 x Brashua	2.487 jk	- 0.146*	0.007	- 0.251**
Azeghar1 x Cyprus1	2.845 cd	0.192*	0.325**	0.107**
Azeghar1 x Korfila	2.873 bcd	0.169*	0.293**	0.135**
Um-Rabie3 x Brashua	2.373 l	- 0.294*	- 0.207	- 0.365**
Um-Rabie3 xCyprus1	2.900 b	0.212*	0.280**	0.162**
Um-Rabie3 x Korfila	2.856 cd	0.118*	0.176**	0.118**
Brashua x Cyprus1	2.739 g	0.162*	0.379**	0.001
Brashua x Cyprus1	2.768 fg	0.141*	0.348**	0.030
Cyprus1 x Korfila	2.536 i	- 0.112*	0.076**	- 0.202**
S.E. (sca effect)		0.028		

(*) and (**) for heterosis indicate significant at 5% and 1% levels, respectively.
(*) for sca effects indicate significant from zero.
yield means followed by the same letter have non significant difference among them.

التحليل الوراثي للتهجينات التبادلية للجيل الثاني في الحنطة الخشنة

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الخلاصة

تضمنت الدراسة اختبار وراثة الحاصل والقدرة على الاتحاد والتدهورالوراثي نتيجة التربية الداخلية في عشائر من الحنطة الخشنة التي تم الحصول عليها من تهجين تبادلي في الجيل الثاني لسبعة اصناف هي :ليدز و الواحة وازيكار١ وام ربيع٣ وبراشوا وسبيرس١ وكورفيلا . اظهرت النتائج ان متوسط مربعات التراكيب الوراثية و القدرتين العامة والخاصة على الاتحاد كان معنويا عاليا.وكان حاصل الحبوب تحت سيطرة الفعل الجيني السيادي . يمكن اعتبار الصنفين ليدز وام ربيع٣ مناسبين لكفاءتهما الانتاجية العالية و قدرتهما العامة على الاتحاد المعنوية والمرغوبة. تميز الهجينان (ليدز× براشوا) و(واحة× براشوا) باعلى حاصل حبوب معنوي (٢.٩٤٣ و٢.٩٥٥طن بالهكتار على التوالي) ، وكذلك كانت قدرتهما الخاصة على الاتحاد معنويا بالاتجاه المرغوب، فضلا عن انحراف معنوي مرغوب للجيل الثاني عن كل من الجيل الاول والصنف التجاري ام ربيع٥ ،وبهذا يمكن اعتبارهما هجينين واعدين .

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