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A Diallel Cross Analysis of Some Quantitative Traits in Bread Wheat (*Triticum aestivum* L.)

M.O. Ghandorah, I.I.S. El-Shawaf, and Kh. A. Moustafa
Department of Plant Production, College of Agriculture
King Saud University, Riyadh, Saudi Arabia

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Abstract. Three cultivars and one line of bread wheat with diverse genetic background namely, Yecora Rojo, Mexipak, Barouk, and F10-4 were crossed to obtain a half set of a diallel cross. The four parents and the six driven F2 populations were evaluated for four quantitative traits, i.e., plant height, number of spikes per plant, grain yield per plant, and spike weight. The half set of the diallel cross (6 - driven F2) was used to estimate the type, and relative amount of genetic variance components as well as the nature of gene actions that conditioning the aforementioned traits of bread wheat grown in the semiarid condition.

Genetic differences were detected among the four parents as well as among and within the six F2 populations for the studied traits.

Genetic analysis indicated that both additive and dominance gene effects were important in conditioning plant height. Meanwhile, additive, dominance, and interactions were involved in controlling number of spikes / plant, grain yield / plant, and spike weight. However, dominance gene effects was more important than the additive gene effects in all traits. Nature and degree of dominance were studied and revealed the presence of over-dominance for all traits. However, dominance with asymmetry gene distribution in the four parents were estimated for plant height and grain yield. Parents F10-4 and Mexipak possessed excess of dominant genes for plant height and grain yield per plant, while Yecora Rojo and Barouk possessed predponderance of recessive genes. The parents Mexipak, F10-4, and Yecora Rojo possessed dominant genes for number of spikes / plant. Conversely, Barouk possessed preponderance of recessive genes for all traits.

Heritability in narrow sense was low for grain yield / plant which suggested selection breeding program based on pedigree method and progeny test. Meanwhile, it was moderate for the other traits.

Introduction

Diallel analysis can be used as a tool to provide ample of genetic informations on an array of pure lines and/or cultivars, [1-3]. Moreover, the method of diallel analysis provides estimations on variance, covariance, relative genetic components, and useful genetic ratios. In addition, nature of gene effects, distributions among the parents, and heritability ratio of a quantitative character can be also estimated, [4, p.

255-287]. Griffing [5] stated that the parents and the data of the F1 have distant advantage over data from segregating generations in studying quantitative genetic system due to unaffected by segregation and linkage. However, similar genetic information can be obtained in segregating generations by adapting the diallel method to the F2 generation, [4, p. 255-287 and 6].

The objective of this study were:

1. To provide genetic informations on the genetic system that conditioning plant height, spikes/plant, grain yield/plant, and spike weight of bread wheat grown in semiarid condition.
2. To express the nature of gene action in conditioning these traits.
3. To estimate hertability ratios of the studied traits.
4. To evaluate the genetic constituent of the four parents.

Materials and Methods

The materials used in this study included four parents of bread wheat with diverse genetic origin namely, Yecora Rojo, Barouk, Mexipak, and F10-4. These parental materials were maintained for more than eight years at Dirab Agriculture Research Station of the College of Agriculture, King Saud University. All possible crosses were made among the four parents excluding reciprocal in 1989, and one set of a four parents diallel cross was obtained. Due to the small quantities of F1 seeds that obtained by hand pollination, the F2 generation was obtained for each cross in 1990 season. The four parents and their six F2 segregating generation were sown in 1991 season at Dirab Agriculture Research farm. The plant materials were arranged in a randomized complete block design experiment with seven replicates. Each block consisted of 10 plots. Each plot comprised of three rows, 2 m long and spaced 30 cm apart. Standard cultural practices were used as recommended for wheat production in the region. At maturity, data were collectd on a single plant basis of the middle row for the following characters: 1- Plant height 2- Number of spike per plant 3- Grain yield per plant, and 4- Spike weight.

The data were subjected to the standard method of analysis of variance, [7, p. 195-221]. Then, data were subjected to the method of diallel analysis as described by Hayman [1] and Jinks [2 and 6]. Moreover, gene action and dominance were interpreted from Wr, Vr regression, [4, p. 255 - 287].

Results and Discussion

The analysis of variance of the experimental design showed highly significant differences among genotypes (Four parents and six driven F2) for plant height and grain yield/plant. Significant differences were also estimated for spike numbr/plant and

spike weight, (Table 1). Moreover, parents and all F2 generations exhibited significant differences amongst themselves for all the studied characters.

The parent Yecora Rojo exhibited a shorter plant height (81.06 cm) and the line F10-4 was a tall parent (103.14 cm). These two parents produced high number of

Table 1. The analysis of variance for plant height, spike No. per plant, grain yield per plant and spike weight in the 4 × 4 diallel cross in wheat.

S.O.V.	d.f	Plant height	Spike No. per plant	Grain yield per plant	Spike weight
Blocks	6	56.50	3.30	1.30	0.14
TRT.	9	583.83**	5.50*	16.95**	0.17*
Error	54	24.75	1.48	1.44	0.04

*, ** indicate significant and highly significant at 0.05 and 0.01 levels respectively.

spike/plant 8.19 and 8.24 spikes for Yecora Rojo and F10-4, respectively, (Table 2). Higher grain yield/plant was produced by Maxipak (11.37 g) followed by Yecora Rojo (11.20 g), and F10-4 (10.84 g). Barouk was lower in grain yield/plant (9.62 g). The Maxipak parent produced heavy spike weight (1.54g) followed by Barouk (1.46 g), and Yecora Rojo (1.39 g). F10-4 line produced a light spike weight (1.31 g).

Table 2. Mean performance of cultivars and their F2 for plant height, spike No. per plant, grain yield per plant and spike weight in the 4 × 4 diallel crosses in wheat

Genotypes	Plant height	Spike No. per plant	Grain yield per plant	Spike weight
Yecora Rojo	81.06	8.19	11.20	1.39
F10-4	103.14	8.24	10.84	1.33
Barouk	98.57	6.83	9.82	1.46
Mexipak	98.10	7.42	11.37	1.54
Yecora × F10-4	105.23	9.49	14.10	1.51
Yecora × Barouk	76.24	8.71	10.66	1.23
Yecora × Mexipak	95.05	8.31	13.21	1.59
F10-4 × Barouk	97.00	9.44	13.28	1.47
F10-4 × Mexipak	96.87	7.21	11.31	1.61
Barouk × Mexipak	98.39	7.77	13.86	1.79
LSD 0.05	5.32	1.30	1.28	0.21
LSD 0.01	7.07	1.73	1.71	0.28

The average plant height in centimeters of the F2 generations is given in Table 2. Higher plants were obtained in the F2 from the cross involved Yecora Rojo X F10-4 (105.23 cm), and shorter plants from the cross of Yevora Rojo X Barouk (76.34 cm). The range among the 6 F2 generations was 28.89 cm. The F2 of the cross Yecora Rojo X F10-4 produced high number of spikes/plant (9.49 spikes). Meanwhile, low number of spikes/plant was produced in the F2 from cross involved F10-4 X Mexipak (7.21 spikes). The range of spike number/plant among F2 generations wa s (2.28 spikes). Average grain yield/plant ranged from (14.10 g) in F2 of Yecora Rojo X F10-4, and (10.66 g) in the F2 of Yecora Rojo X Barouk, (Table 2). The average spike weight ranged from (1.79 g) in the F2 driven from the crossing Barouk by Mexipak to (1.2 g) in F2 of Yecora Rojo X Barouk.

The obtained results indicated that there were considerable genetic differences among the four parents. Moreover, high genetic variations among and within the six F2 generations would be expected since segregation occurred in the F2 generation.

The diallel cross analysis as proposed by Hayman [1], Jinks [2] and adapted for F2 generation by Jinks [6] provided valuable information about the nature of genetic system affecting plant height, spike number/plant, grain yield and spike weight of bread wheat grown under the semiarid weather condition in the central region of the Kingdom.

Mean estimation of genetic variance components were calculated for all the studied traits, (Table 3). Plant height was the only trait that exhibited significant value of the additive genetic variance (D). This suggested that additive gene effect was important in the inheritance of plant height. This was confirmed by the regression of the parent-offspring covariance (Wr) on the array variances (Vr), Fig. 1 which indicated that the regression coefficient of (Wr, Vr) was significantly deviated from zero, but not significantly different from unity for plant height ($b=0.55 + 0.13$). Similar finding was reported by Tandon *et al.*, [8]. However, dominance gene effects (H1) was more important in controlling plant height, the value of H1 was significant and greater than the additive gene effects ($H1 > D$). This was in accordance with Hanna [9].

The additive gene effects obtained for spike number/plant, grain yield/plant and spike weight showed insignificant value. The dominance gene effects were also insignificant except for grain yield/plant which showed significant value. However the values of H1 were greater than the values of D which indicated that dominance gene effects was more important in controlling these traits. However, non allelic gene interactions were involved since the regression coefficients were insignificantly different from zero, but significantly different from unity ($b=0.31 + 0.33$, $b=0.60 + 0.35$, and $b=0.33 + 1.22$) for spikes/plant, grain yield/plant, and spike weight, respectively), (Fig. 2-4). Similar findings were reported by Tandon *et al.* [8] for grain

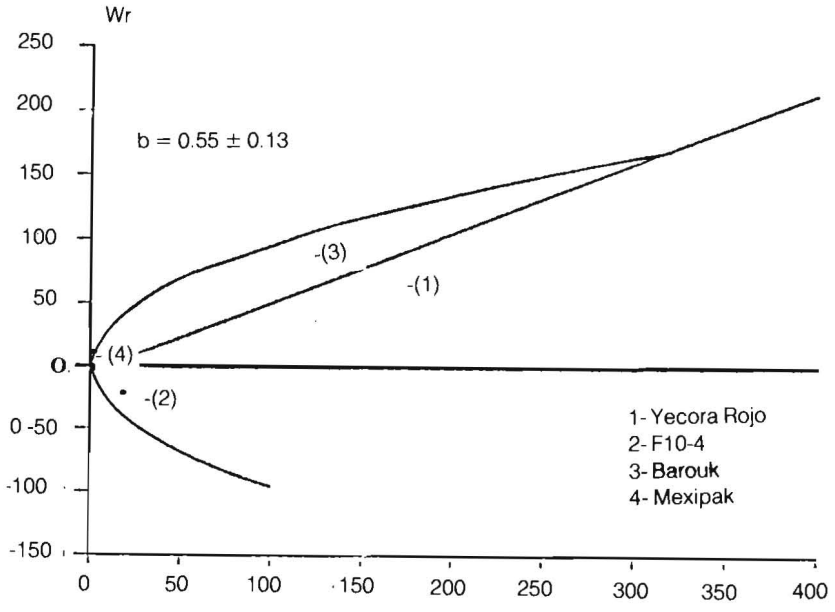

Fig. 1. Wr, Vr regression analysis for plant height.

Table 3. Estimates of genetic variance components of a 4 × 4 diallel crosses in bread wheat

Parameters	Plant height	Spike No. per plant	Grain yield per plant	Spike weight
	*			
D	87.539±37.69	0.215±0.406	0.284±0.38	0.003±0.011
F	47.896±190.7	-0.03±2.06	0.288±2.76	-0.024±0.06
	*		**	
H1	939.10±437.6	7.808±4.72	38.64±4.41	0.260±0.13
	*		**	
H2	825.89±400.7	6.332±4.36	39.17±4.07	0.216±0.12
		**	**	**
h2	26.91±273.99	71.988±2.96	407.2±2.76	1.116±0.08
E	3.5±16.83	0.237±0.18	0.200±0.170	0.006±0.005

D = Additive effects of genes.
H1 = Dominance effects of genes.
H2 = Dominance indicated asymmetry of positive and negative effects of genes.
F = Covariance of dominance and additive effects.
E = Error.
h2 = The ovarall dominance effects of heterozygous loci
* ** indicate significant and highly significant at 0.05 and 0.01 levels respectively.

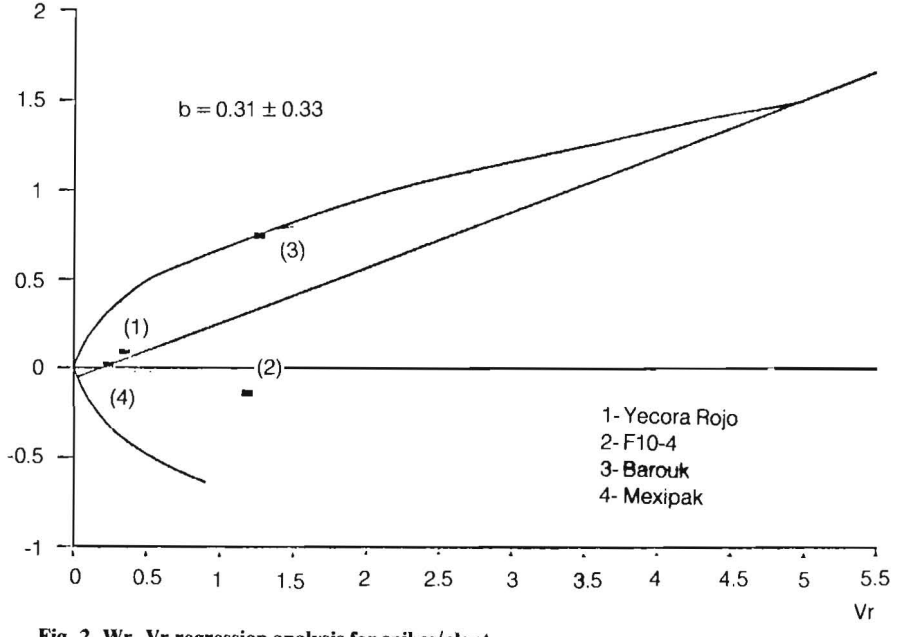

Fig. 2. Wr, Vr regression analysis for spikes/plant.

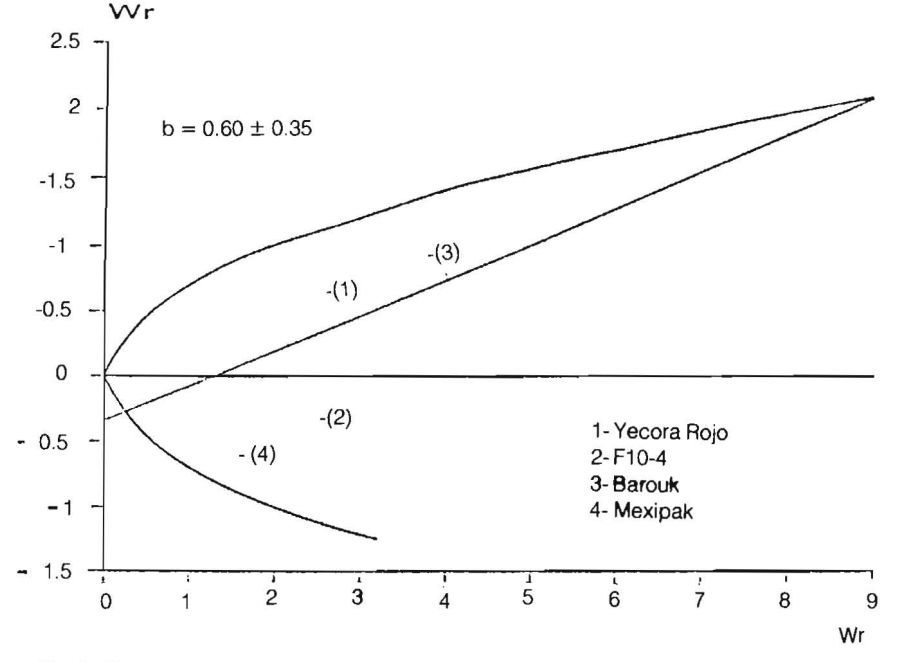

Fig. 3. Wr, Vr regression analysis for grain yield/plant.

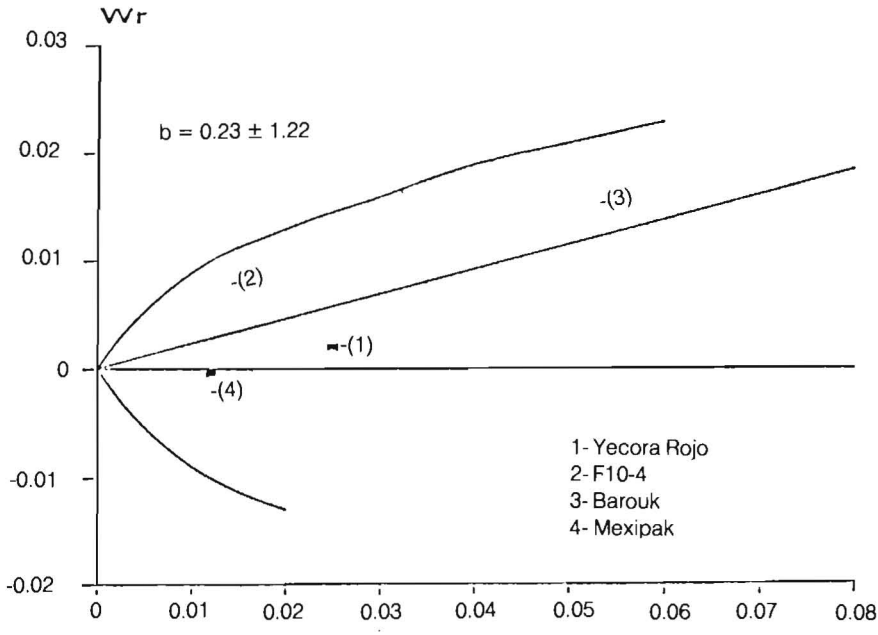

Fig. 4. Wr, Vr regression analysis for spikes/weight.

yield and ear number/plant in the F2 generation. Moreover, additive, dominance, and epistatic gene effects were found to be important in the inheritance of spike production, Merrit, [10].

The significant estimated values of H2 for plant height and grain yield/plant, (Table 3), showed dominance with asymmetrical gene distribution in the four parents for these two traits. However, the estimates of overall dominance effects (h2) of the heterozygous loci were highly significant and positive for spikes/plant, grain yield/plant, and spike weight, (Table 3). These could indicate the prevalence of positive genes that control these traits.

Average degree of dominance $[1/4\ (H1/D)^{1/2}]$ was greater than unity (1.6) for plant height. High ratios were obtained for spikes/plant (3.01), grain yield/plant (5.83), and spike weight (4.66), (Table 4). These high estimated values are likely in flated by non allelic gene interaction which are confirmed by Wr, Vr regression as mentioned above. Hayman [1] indicated that the estimation of the degree of dominance could be in flated by genic interaction.

The crude estimate of the frequency of negative versus positive alleles (H2/4H1), at loci which exhibit dominance in the parents was 0.25 for grain yield/plant, (Table 4). Meanwhile, plant height, spikes/plant and spike weight exhibited ratios of 0.22, 0.20, and 0.21, respectively. Therefore, plant height was the only trait that exhi-

Table 4. Estimates of various ratios derived from a 4 × 4 diallel crosses for plant height, spike no./pant, grain yield/plant and spike weight of bread wheat

	Plant height	Spike No. per plant	Grain yield per plant	Spike weight
$[1/4(H1/D)]^{1/2}$	1.60	3.01	5.83	4.66
H2/4H1	0.22	0.20	0.25	0.21
K=h2/H2	0.03	11.37	10.40	5.17
H (n.s)	0.28	0.35	0.04	0.38

[1/4(H1/D)] = Average degree of dominance
H2/4H1 = Average frequency of negative vs. positive alleles
K = h2/H2 = Estimated number of groups of genes exhibiting dominance
H (n.s) = Narrow sense heritability.

bited symmetric distributions of positive and negative alleles at the "non - additive" loci in the parents as suggested by Crumpaker and Allard [11]. The estimates of gene groups (ratio of h2/H2) showed that spikes/plant, grain yield, and spike weight were under the control of large number of dominant gene groups.

The inspection of Wr, Vr graphs (Figs. 1-4) revealed that the line of the unit slope intercepts the Wr - axis below the origin in all traits suggesting overdominance and this was in harmony with that obtained in Table 4. Moreover, the parents F10-4 and Mexipak expressed high frequencies of dominant genes for plant height, and grain yield/plant (Figs. 1 and 3), while parents Yecora Rojo and Barouk possessed preponderance of recessive genes. Parents Mexipak. F10-4, and Yecora Rojo were responsible for the excess of dominant genes of spikes/plant, (Fig. 2). The array point for parent Barouk indicated a preponderance of recessive gene for spike weight, (Fig. 4) as well as the other traits, (Figs. 1-3).

The narrow sense heritability ratio was low for grain yield/plant (4%). However, moderate estimates were obtained for spike weight (38%), spikdes/plant (35%), and plant height (28%). Similar results were reported by Hanna [9] for plant height and by Hucl and Baker [12] for spikes/plant in the F2 generation. However, Hanna [9] found moderate narrow sense heritability for grain yield/plant under both stress and non stressed for drought in bread wheat.

The low value of narrow sense heritability for grain yield/plant in this study could implicate breeding program based on pedigree method of breeding, while moderate heritability estimate for the other traits suggested that the selection would be appropriate using the mean of each plot.

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التحليل الوراثي للهجن المقفلة لبعض الصفات الكمية في قمح الخبز

محمد عمر غندورة، إبراهيم إبراهيم الشواف، وخالد أحمد مصطفى
قسم الإنتاج النباتي، كلية الزراعة، جامعة الملك سعود،
الرياض المملكة العربية السعودية
(قدم للنشر في ١٤١٣/١٠/٢٩هـ؛ وقُبل للنشر في ١٤١٤/٧/٢٩هـ)

ملخص البحث. أوضحت الدراسة وجود اختلافات وراثية بين الآباء المستخدمة وكذلك بين وداخل عشائر الجيل الثاني بالنسبة لصفات طول النبات وعدد السنابل للنبات ووزن محصول النبات ومتوسط وزن السنبلة.

وأظهر التحليل الوراثي أهمية التباين الراجع للفعل المضيف والسيادي للجينات في وراثة صفة الطول للنبات. بينما كان التباين المضيف والتباين للسيادة وكذلك التباين التفاعلي بينهما ذات أهمية في وراثة كل من عدد السنابل ومحصول النبات ومتوسط وزن السنبلة. كما أوضحت الدراسة أن الفعل للجينات بالسيادة أكبر من الفعل المضيف في وراثة الصفات المدروسة. وكانت السيادة فائقة لجميع الصفات المدروسة وكان توزيع الجينات السائدة والمتنحية متساو بين الآباء بالنسبة لصفة طول النبات بينما كان ذلك غير متساوٍ لبقية الصفات. حيث أوضحت الدراسة بأن الآباء F10-4 ومكسيباك يحتويان على نسبة كبيرة من العوامل الوراثية السائدة لصفتي طول النبات والمحصول بينما كان يوكورا روجو وباروك يحتويان على نسبة كبيرة من العوامل المتنحية. وأظهرت الأصناف مكسيباك، ويوكورا روجو والسلالة F10-4 وفرة من العوامل السائدة لصفة عدد السنابل للنبات. بينما أظهر الصنف باروك وفرة من الجينات المتنحية لكل الصفات.

كما أوضحت الدراسة أن معامل التوريث في المدى الضيق لصفة المحصول منخفضة وعليه يكون برنامج التربية أكثر فاعلية باستخدام طريقة سجلات النسب. بينما كان معامل التوريث معتدلاً لبقية الصفات.