ISSN 1110-0419

Annals Of Agric. Sc., Moshtohor,
Vol. 43(4):1677-1687, (2005).

CORRELATION AND PATH COEFFICIENT ANALYSIS OF YIELD CHARACTERS IN BREAD WHEAT (*Triticum aestivum L*)

BY

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ABSTRACT

The major goal of this investigation is studying the correlation for yield and yield components. Ten bread wheat genotypes (Gemmiza 7, Sakha 61, Sakha 69, Sakha 93, Sakha 8, Sids 6, Line 1, Line 2, Line 6 and Line 8) represent a wide local and exotic germplasm were evaluated under recommended conditions at Nubaria in 1999/2000 and 2000/2001. Grain yield and its components; number of spikes per m^2, number of kernels per spike and 1000- kernel weight were recorded during the genotypes evaluation to study the possibility of using these parameters as indices in selection breeding program.

The phenotypic correlation was highly significant positive between grain yield and number of spikes per plant, while it was significant positive with number of kernels per spike and 1000-kernel weight. The results indicated that the most important sources of variation in grain yield are the direct effect of number of spikes per plant followed by 1000-kernel weight and number of kernels per spike. Indirect effects of yield components in grain yield revealed that the interaction between number of kernels per spike and number of spikes per plant was the first indirect effect followed by interaction between number of spikes per plant and 1000-kernel weight.

INTRODUCTION

Correlation coefficient is important in plant breeding because it measures the degree of association (genetic or non-genetic) between two or more characters. If association was exists, selection for one trait will cause changes in other traits, this is called correlation response. Environmental conditions also exists because measurements of several traits are taken from some individuals or from the some families. Sornprach (1988) reported that yield components showed positive correlation to grain yield and number of kernels /spike was the most important direct effect on grain yield. Bhowmik *et al.* (1989) studied correlations and path coefficient in 56 F_1 and 8 parents populations for six characters in wheat. They found that in most of the cases genotypic correlations were higher than the phenotypic correlations. Number of spikes/plant and spike length showed highly significant positive correlation with grain yield both at genotypic and phenotypic levels. Sairam and Singh (1989) found that grain yield was positively correlated with tiller number, grain number/spike, 1000 grain weight, biomass, harvest index, N-use efficiency, and N uptake. Biomass and harvest index had the maximum effect on grain yield. Amin *et al.*, (1990) reported that grain yield was positively and significantly correlated with plant height and number of spikes/m2. number of spikes m^2 and 1000-grain weight registered maximum positive and direct effect on yield. Barma *et al.*, (1990) concluded that grain yield/plant correlated positively with number of spikes /plant, grains/spike and 1000-grain weight but number of spikes /plant correlated positively with days to maturity and ear length but negatively with number of grains/spike. Trethowan *et al.*, (1991) found that under moisture stress height was positively correlated with grain yield, 1000-grain weight, number of kernels/spike, test weight and rate of grain filling. Tillers/m^2 was negatively associated with 1000-grain weight and rate of grain filling in stressed conditions. Similar foundations were conducted by El-Marakaby *et al.*, (1992), Budak and Yildirim (1995), Sayre *et al.*, (1997) Larbi *et al.*, (2000), Esmail (2001), Semeena and Singh (2001), Garc *et al.*, (2003) and Solomon *et al.*, (2004).

Path coefficient analysis revealed that number of spikes/plant, spike length and kernel weight were related with grain yield through direct effect Bhowmik *et al.*, (1989), Amin *et al* (1990), Akanda and Mundt, (1996), Dencic *et al* (2000), Semeena and Singh (2001) and Solomon *et al.*, (2004) found that number of kernels per spike and 1000-kernel weight had the greatest direct effects on grain yield under stress and non-stress conditions.

MATERIALS AND METHODS

The studied wheat (*Triticum aestivum* L.) genotypes were selected from germplasm bank of Wheat Research Program, Agricultural Research Center, Egypt which represented a wide genetic background. The studied genotypes included four lines represent leaf rust resistant materials from CIMMYT (Table 1). The present investigation was carried out at Nubaria Agriculture Research Station, Agriculture Research Center.

In both seasons 1999/2000 and 2000/2001, the ten genotypes were evaluated in each season, the experiment was designed in a randomized complete block design with three replications. Each plot consisted of 6 rows, 2.5m long with 20 cm between rows. Seeds were drill in the row by hand on 19^{th} and 28^{th} of November in the first and second seasons, respectively. The dry method of planting was used in this concern. Weed control had done as hand weeding. After evaluation of ten genotypes, six genotypes were selected for wide range of leaf rust resistant and other characteristics. These genotypes were Gemmiza 7, Sakha 8, Sakha 69, Sakha 93, Line 1 and Line 2.

In 2001/2002 growing season, grains from each of the six parental varieties and/or lines were sown at a various planting dates ((19th and 28th of November in the first and second seasons, respectively). During this season, all possible parental combinations without reciprocals were made between the previous six parents giving a total of 15 F_1 crosses (Table 2).

Table (1): Name and pedigree of the studied breed wheat genotypes.

No.	Variety	Pedigree	
1	**Gemmiza 7**	CMH 74A. 630/5x//Seri 82/3/Agent CGM 4611-2GM-3GM-1GM-0GM	**Egypt**
2	**Sakha 8**	Indus 66/Norteno "S" PK 3418-6S-1SW-0S	**Egypt**
3	**Sakha 61**	Inia/RL 4220//17c/Y_{50} CM 15430-2S-6S-0S	**Egypt**
4	**Sakha 69**	Inia/RL 4220//17c/Y "s" CM 15430-2S-6S-0S	**Egypt**
5	**Sakha 93**	Sakha 92/TR 810328 S 8871-1S-2S-1S-0S	**Egypt**
6	**Sids 6**	Maya "S"/Mon"S"//CMH 74A..592/3/Giza 157* SD 10002-4SD-3SD-1SD-0SD	**Egypt**
7	**Line 1**	KAUZ"S"/Kauz"S" ICW91-0493-0TS-5AP-0TS-1AP-0AP-O…	**CIMMYT**
8	**Line 2**	KAVZ"S"//Kea "S"/Tan "S" ICW90-0335-0AP-1AP-0TS-2AP-0L-O…	**CIMMYT**
9	**Line 6**	Opata/Bow//Bau/3/Opata/Bow CMPW89Y00819-0TOPM-0AP-0TS-2AP-0TS-3AP-O…	**CIMMYT**
10	**Line 8**	Tzpp*2/Anc//Inia/3/Cno/Jar//Kvz/4/ Mn 72252/5/ RmnF 12-1/Jup"S" ICW92-0012-0AP-4AP-0L-0AP-O…	**CIMMYT**

In 2002/2003 growing season, all of 15 F_1 crosses were sown to get F_2 seeds. Two adjacent experiments were sown in 2003/2004 growing season, the first was parents and F_1 and the second was F_2 crosses in a randomized complete block design (RCBD) with three replications. Each replicate consisted of two rows for each parent, one row for each F_1 cross in the first experiment and ten rows for each F_2 crosses in the second experiment. Each row was two meter long with 30 cm between rows and plants within row were 20 cm apart allowing a total of 10 plants per row.

Data were recorded on an individual plant in each row excluding the border plants, the following characters i.e grain yield per plant of F_1's and F_2's in half diallel cross in the second part and grain yield per plot (kg/Feddan) for evaluated parents in the first part, number of spikes per plant for F_1's and F_2's in half diallel cross in the second part and the same data per m^2 for evaluated parents in the first part, number of kernels per main spike and 1000-kernel weight (gm).

Statistical Analysis:

The correlation coefficient (Snedcore and Cochran, 1967), Path coefficient and coefficient of determination were calculated through MSTAT-C, 1991 and SAS, 1985. The simple phenotypic correlations were made between yield and yield components in parent and F_2 generations.

RESULTS AND DISCUSSION

Concerning correlation coefficient for parental genotypes, the phenotypic correlation was highly significant positive between grain yield and each one of biological yield, number of spikes per m^2, number of kernels per spike and 1000-kernel weight, Table (2). The phenotypic correlation between biological yield and each one of grain yield, number of spikes per m^2, number of kerneks per spike and 1000-kernel weight was highly significant positive. Highly significant positive correlation was noticed between number of spikes per m^2 and grain yield, biological yield and number of kernels per spike, while insignificant positive phenotypic correlation was detected between number of spikes/plant and 1000-kernel weight. The results indicated that the phenotypic correlation between number of kernels per spike and each one of grain yield i.e biological yield, number of spikes per m^2 and 1000-kernel weight was highly significant positive.

Regarding to 1000-kernel weight, the phenotypic correlation was highly significant positive between this trait and each of biological yield and number of kernels per spike, while the correlation was insignificant positive with number of spikes per m^2, Table (2).

In case of path coefficient analysis and coefficient of determination, partitioning of simple correlation coefficient between grain yield and its components i.e. number of spikes per m^2, number of kernels per spike, and 1000-kernel weight are presented in Table (3), number of kernels per spike had the largest direct effect (0.38) followed by number of spikes per m^2 (0.34) and 1000-kernel weight (0.29), respectively.

Table (2): Phenotypic correlation between yield and its components for parental genotypes.

Trait	Grain Yield	Biological Yield	No. of spikes/ plant	No. of kernels /plant	1000-kernel weight
Grain Yield	1.000	0.91**	0.53**	0.63**	0.46**
Biological Yield		1.000	0.52**	0.58**	0.46**
Number of spikes/plant			1.000	0.35**	0.17
Number of kernels/plant				1.000	0.39**
1000-kernel weight					1.000

*, ** significant and highly significant at $P < 0.05$ and 0.01, respectively.

The coefficient of determination were calculated for the direct and indirect effects of the three yield studied factors and transformed into percentage in order to evaluate these factors for their importance as sources of variation in grain yield. The components for grain yield variation are presented in Table (4). The results indicated that the most important sources of variation in grain yield are the direct effect of number of kernels per spike followed by direct effect of number of spikes per m^2 and the direct effect of 1000-kernel weight. These three sources account for approximately 34.46 of grain yield variation. Indirect effects of yield components in grain yield revealed that the interaction between number of kernels per spike and number of spikes per m^2 was the first indirect effect followed by interaction between number of kernels per spike and 1000-kernel weight, while the interaction between number of spikes per m^2 and 1000-kernel weight was the last indirect effect in grain yield. These three previous sources account of indirect effects for approximately 21.03 of grain yield variation.

Table (3): Path coefficient analysis for yield and its components in parents.

Traits	No. of spikes/m^2	No. of kernels/spike	1000-kernel weight	Correla-tion
No. of spikes/m^2	0.340	0.133	0.058	0.530
No. of kernels/spike	0.133	0.380	0.115	0.630
1000-kernel weight	0.058	0.115	0.290	0.460

Table (4): Coefficient of determination for yield component and its contribution to grain yield in parents.

Trait	Coefficient of Determination	Contribu-tion
No. of spikes/plant	0.116	11.60
No. of kernels /spike	0.144	14.40
1000-kernel weight	0.084	08.46
No. of spikes/plant X No. of kernels/spike	0.090	09.04
No. of spikes/plant X 1000-kernel weight	0.033	03.35
No. of Kernels/spike X 1000-kernel weight	0.086	08.64
Residual	0.446	44.60
Total	1.000	100.00

In selecting high yielding genotypes, the breeders needs to identify those characters having strong association with grain yield as well as quantifying their relative contribution to grain yield. Numerous studies used simple correlation to study associations among grain yield-related traits.

Highly significant and positive association were obtained between grain yield and each of number of spikes per m2, number of kernels per spike and 1000-kernel weight. Therefore, under recommended conditions selection for higher number of spikes, or number of kernels per spike, and /or heavy seed weight and biological yield is more effective for obtained new higher yielding varieties. Agrama and Moussa (1996) explained that the correlation among the trait refer to (i) pleiotropy of the same gene or (ii) effects of two or more tightly linked genes.

Partitioning of simple correlation coefficient between grain yield and its components as number of kernels per spike had the largest direct effect followed by number of spikes per m^2, respectively. Sornprach (1988), Sayre *et al* (1997) Dencic *et al* (2000) and Garc *et al* (2003) concluded that number of kernels per spike is the one of the main yield components which might improve directly the yielding ability in new varieties.

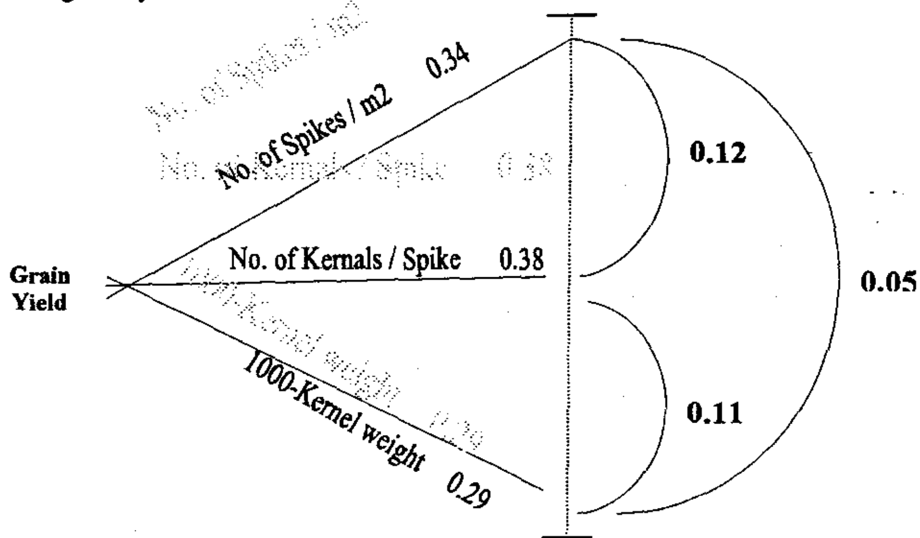

Figure (1): Sequential path analysis for grain yield and its components in parents.

The coefficient of determination were calculated for the direct and indirect effects of the three yield factors, it could be concluded that the most important sources of variation in plant yield are the direct effect of number of kernels per spike followed by direct effect of number of spikes per m^2 and 1000-kernel weight. Consequently, the indirect effect for number of kernels per spike with number of spikes followed by indirect effect for number of kernels per spike with 1000-kernel weight had the largest values for indirect selection for grain yield, the same finding was obtained by Garc *et al.* (2003), Solomon *et al.*, (2004), Semeena and Singh (2001) and Esmail *et al.*, (2001).

In case of correlation coefficient in F_2 populations, it was noticed that the phenotypic correlation was highly significant positive between grain yield and number of spikes per plant, while the correlation was significant positive with number of kernels per spike and 1000-kernel weight. The phenotypic correlation between number of spikes per plant and number of kerneks per spike, was highly significant positive, while these two traits were insignificant positive with 1000-kernel weight, Table (5).

Table (5): Phenotypic Correlation between yield and its components in F_2 populations

Traits	Grain Yield	No. of spikes/plant	No. of kernels /plant	1000-kernel weight
Grain Yield	1.000	0.367**	0.259*	0.298*
No. of spikes/plant		1.000	0.388**	0.132
No. of kernels /plant			1.000	0.148
1000-kernel weight				1.000

*, ** significant and highly significant at P< 0.05 and 0.01 respectively.

With respect to the path coefficient analysis and coefficient of determination, partitioning of simple correlation coefficient between grain yield and its components i.e. number of spikes per plant, number of kernels per spike, and 1000-kernel weight in F_2 are found in Table (6). Number of spikes per plant had the largest direct effect (0.27) followed by 1000-kernel weight (0.23) and number of kernels per spike (0.16), respectively.

The coefficient of determination were calculated for the direct and indirect effects of the three yield studied factors and were transformed into percentage in order to evaluate these factors for their importance as sources of variation in grain yield. The components in percent for grain yield variation are presented in Table (7). The results indicated that the most important sources of variation in grain yield are the direct effect of number of spikes per plant followed by direct effect of 1000-kernel weight and the direct effect of number of kernels per spike. These three previous sources account for approximately 15 % of grain yield variation. Indirect effects of yield components in grain yield revealed that the interaction between number of kernels per spike and number of spikes per plant was the first indirect effect followed by interaction between number of spikes per plant and 1000-kernel weight, while the interaction between number of kernels per spike and 1000-kernel weight had the last indirect effect on grain yield. These three previous sources account of indirect effects for approximately 6 % of grain yield variation.

Table (6): Path coefficient analysis for yield and its components in F_2 generations

Traits	No. of spikes/ plant	No. of kernels/ spike	1000-kernel weight	Correlation
No. of spikes/plant	<u>0.270</u>	0.062	0.043	0.370
No. of kernels /spike	0.066	<u>0.160</u>	0.033	0.260
1000-kernel weight	0.043	0.033	<u>0.230</u>	0.300

Table (7): Coefficient of determination for yield component and its contribution to grain yield in F_2 generation.

Trait	Coefficient of Determination	Contrib-ution
Number of spikes per plant	0.07	07.0
Number of kernels per spike	0.03	03.0
1000-kernel weight	0.05	05.0
Number of spikes/plant X Number of kernels /spike	0.03	03.0
Number of spikes/plant X 1000-kernel weight	0.02	02.0
Number of Kernels/spike X 1000-kernel weight	0.01	01.0
Residual	0.79	79.0
Total	1.00	100.0

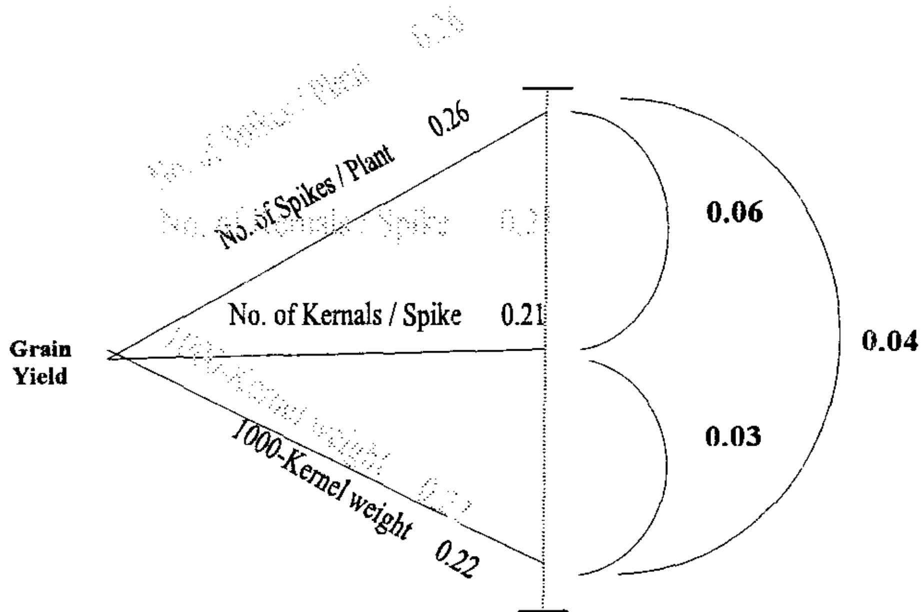

Figure (2): Sequential Path analysis for grain yield and its components in F_2 generation

Significant and positive association were obtained between grain yield and each of number of spikes per m2, number of kernels per spike and 1000-kernel weight. Therefore, under recommended conditions selection for higher number of spikes, or number of kernels per spike, and /or heavy seed weight and biological yield is more effective for obtained new higher yielding varieties.

Partitioning of simple correlation coefficient between grain yield and its components, number of spikes per plant had the largest direct effect followed by 1000-kernel weight and number of kernels per spike, respectively. Comparing with parental genotypes, number of spikes per plant in F_2 generation plays an important role for grain yield and might improve directly the yielding ability in new varieties.

The coefficient of determination were calculated for the direct and indirect effects of the three yield studied factors, the indirect effect for number of kernels per spike with number of spikes followed by indirect effect for number of spikes per plant with 1000-kernel weight had the largest values for indirect selection for grain yield. Low estimated values for direct and indirect effect in F_2 generation referred to that environmental effects had a highly contribution in the expression of these traits. In general, the lack of direct and indirect effects for yield components in F_2 generation comparing with the higher values in parent generation, lead the researcher to study the path-coefficient in parent generation. The same finding was obtained by Garc *et al.*; (2003), Solomon *et al.*, (2004), Semeena and Singh (2001) and Esmail *et al.*, (2001).

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تحليل التلازم و معامل المرور لصفات المحصول في قمح الخبز

قسم المحاصيل – كلية الزراعة بمشتهر– جامعة بنها.
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إن الهدف الرئيسى لهذا البحث هو دراسة التلازم بين المحصول و مكوناته. تم تقييم عشرة تراكيب وراثية محلية و أجنبية تمثل مدى واسع من التباين فى منطقة النوبارية خلال مواسم ١٩٩٩/٢٠٠٠ و ٢٠٠٠/٢٠٠١. تم دراسة صفات محصول الحبوب، عدد السنابل/م٢ ، عدد الحبوب فى السنبلة و وزن ال١٠٠٠ حبة و كذلك المحصول البيولوجى و ذلك خلال تقييم الآباء لدراسة إمكانية استخدام هذه الصفات كدلائل فى برنامج التربية بالانتخاب.

بالنسبة للتراكيب الوراثية الأبوية، وجد أن درجة التلازم كانت عالية المعنوية بين صفة المحصول ومكوناته (عدد السنابل للنبات الفردى ، عدد الحبوب فى السنبلة و وزن الألف حبة). أظهرت صفة عدد الحبوب فى السنبلة التأثير المباشر الرئيسى فى المحصول تلتها صفة عدد السنابل ثم وزن الألف حبة و التفاعل بين عدد الحبوب فى السنبلة و عدد السنابل للنبات أظهرت التأثير الغير المباشر الرئيسى بالنسبة للمحصول ثم تلتها بقية التفاعلات.

أجرى تهجين دائرى متضمنا ستّة تراكيب وراثية من القمح تم انتخابها من خلال التقييم السابق و ذلك لدراسة التلازم ، معامل المرور و معامل التحديد فى المحصول و مكوناته. أظهرت النتائج إلى وجود تلازم معنوى بين صفة المحصول وكل من عدد السنابل للنبات الفردى و عدد الحبوب فى السنبلة وصفة وزن الألف حبة. بالنسبة إلى التأثير المباشر والغير المباشر لمكونات المحصول، أظهرت النتائج فى الجيل الثانى إلى أن صفة عدد السنابل للنبات الفردى كانت ذات التأثير المباشر الأول فى المحصول ثم تلتها صفة وزن الألف حبة ثم صفة عدد الحبوب فى السنبلة.

أظهرت النتائج إلى أن التفاعل بين عدد السنابل للنبات الفردى وعدد الحبوب فى السنبلة كانت ذات التأثير الغير نباشر الرئيسى للمحصول ثم تلتها التفاعل بين عدد السنابل للنبات الفردى و وزن الألف حبة ثم التفاعل بين عدد الحبوب فى السنبلة و وزن الألف حبة.