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Study Of Path Coefficient And Some Indicators Of Vegetation And Genotype Components Of Wheat (Triticum Aestivum L.)

Mohammed H. N. AL-jana and Fouad R. Al-Burki

Dep. Field crops -Coll. Agric. Al-Muthanna University
Email: Mohammad.noor@mu.edu.iq

Abstract

Four genotypes of bread wheat were used to study the quantitative traits (grain yield per plant, No. of spikes per plant, No. of grains per spike, weight of 1000 grains, harvest index and biology yield) and growth traits (plant height, flag leaf area, and No. of tillers per plant).The study included estimation of genetic and phenotypic correlation coefficients between grain yield and its components and some growth traits. The results gave a positive and high genetic correlation for grain yield with harvest index, No. of grains per spike, weight of No. 1000 grains, No. of tillers and plant height, while analysis of the phenotypic correlation coefficient gave a high and positive significant correlation between grain yield and the harvest index and the weight of 1000 grains and the No. of tillers. Path coefficient analysis showed that there are direct, high and positive effects of harvest index and biological yield on grain yield. The estimates of heritability showed that the traits, No. of grains per spike, grain yield, No. of tillers, flag leaf area, weight of 1000 grains, and plant height, were highly heritability. Through these results, it became clear that the trait of harvest index can be used as an selection index in bread wheat improvement programs.

Key words: Bread wheat, path coefficient, correlations, genotypes, heritability.

Introduction The wheat crop (Triticum aestivum L.), is unique among all cereal crops of great economic and nutritional importance, as it is grown and consumed as a basic food in many countries of the world, and provides the equivalent of 22% of energy and 19% of protein to build the human body in developing countries (Braun, 2007) and about 40-60% of the daily energy in the countries of West Asia and North Africa (CIMMYT, 2009), and ranks first in the world in terms of cultivated area and is mainly relied upon to bridge the food gap with the increase in the population, which is expected to reach 9 billion people in the year 2050 (Tilman et al., 2020). The trait of grain yield is one of the most important traits in any program to improve grain crops, and it is a quantitative trait that is controlled by a large No. of genes, so many researchers partitioned it into its main and secondary components and suggested choosing one of the components instead of the yield, Also, the study of the correlation between the yield and its components and between the components is necessary to select high varieties for grain production, (EL-Hamadany and El-Gibury, 2015). Relying on the phenotypic form in diagnosing plants is very difficult, therefore, another trait that is easy to diagnose, such as the No. of spikes or the length of the spike or the height of the plant, for example, and this program was called by indirect selection, (Falconar, 1981), which requires studying the phenotypic and genetic correlations between the grain yield and its components to identify the nature of the effect of the traits associated with its genes, quantitative traits are affected by a large number of genes, which may cooperate by affecting both synergistically on the two correlated traits, or act antagonistically. Many studies results indicated a positive correlation between grain yield and yield component traits in wheat such as plant height (Ahmad et al., 2018), biological yield and harvest index (Ghaderi et al., 2009), grains/spike (Khan et al., 2010), number of spikelets spike^{-1}and spike length (Ahmad et al., 2018), but the selections based on simple correlation coefficients without considering the interactions between yield and its components may mislead breeders to reach the main breeding purposes (Majumder et al., 2008).

To overcome this, it is suggested to analyze the path coefficient by dividing the coefficients of the apparent and hereditary correlation between the yield and each of its components into direct and indirect effects, according to (Wright, 1921).Path coefficient analysis showed that biological yield and harvest index had the highest positive phenotypic and genotypic direct effect on grain yield (Bayeet al., 2020). Thisresearch aims to study the genetic and phenotypic correlations between the grain yield and its components, and analyze the genetic pathway coefficient by dividing the genetic correlations with the grain yield and its components into direct and indirect effects. The information obtained from this can be used to develop further breeding strategies and selection procedures to develop new varieties of wheat with high production capacity.

Materials and methods

Three genotypes of bread wheat were used in the study, namely (N2, N8 and N12) introduced from (ICARDA) with the Iraqi variety (Aba 99), and the seeds were planted in the winter season (2019-2020) in the second agricultural research station Experiments / College of Agriculture - University of Al-Muthanna, using the RCBD design and with three replications, the genotypes seeds were planted in each replicate at a rate of 2 m2 for each experimental unit, the plants in the tillers stage were sprayed with nano potassium fertilizer (4 g/L).

The data were recorded for the traits of grain yield per plant (gm), weight of 1000 grains (gm), No. of grains per spike, No. of tillers per plant, spike length, flag leaf area, plant height, biological yield and harvest index.

The genetic and phenotypic correlation coefficient was estimated between the studied traits with all possibilities, and the common genetic and phenotypic variances were used to estimate the genetic and phenotypic correlation coefficients between the yield and all the studied traits using the equations presented by (Walter, 1975).An estimate of the genetic correlation between the two traits is as follows

$$rG = \frac{\sigma(G\times Y)}{\sqrt{Msg(1)\ \times Msg(2)}}$$

Whereas, σ"(G×Y)" is the common genetic variance between the two traits and it was estimated as follows:$\sigma(G\times Y) = \frac{Msg(cov)\ -\ Mse(cov)}{r}$

An estimate of the phenotypic correlation between the two traits is as follows: $rP = \frac{Msp(cov.)}{\sqrt{Msp(1) \times Msp(2)}}$

$$Msp(cov.) = Msg(cov.) + Mse(cov.)$$

The genetic correlations were used in the pathway coefficient analysis to segment the correlations of the grain yield, its components and some other growth traits into direct (Piy) and indirect (Wright, 1921) effects in the manner explained by (Al-Rawi and Khalaf Allah, 2000): [P] = [R]-1 [r]

Where: [Piy] = Direction of Direct Effects,

$[R]^{-1}$ = the inverse of the matrix of correlation coefficients between all possible pairs of independent variables, [r] = the direction of the genetic correlation coefficients between the outcome and the studied traits.

Lenka and Mishra (1973) have proposed a measure of the significance of the values of direct and indirect effects as given below:

Values of direct and indirect effects	Rate of scale
0.00 – 0.09	Negligible
0.10 -0.19	Low
0.20 – 0.29	Moderate
0.30 – 0.99	High
More than	Very high

Minitab was used to find the inverse of the correlation coefficients matrix. As for the indirect effects, they were estimated according to the following equation:

Indirect effect = PY (R)

Phenotypic and Genotypic coefficient of variation (PCV and GCV)

The phenotypic and genotypic coefficient of variation was computed as per Burton and Dewane (1953) for low moisture stress.

$$\text{PCV}\ (\%) = \frac{\sigma_P}{\overline{X}} \times 100$$

$$\text{GCV}\ (\%) = \frac{\sigma_g}{\overline{X}} \times 100$$

Where:

σ_P= Phenotypic standard deviation, σ_g= Genotypic standard deviation

X = Grand mean of character, PCV = Phenotypic coefficient of variation

GCV = Genotypic coefficient of variation, PCV and GCV were classified according to Robinson et al., (1949). 0-10% was considered as low, 10-20% as moderate and 20% and above as high.

Heritability (%)

Broad sense Heritability estimate as per cent mean was calculated using the formula (Hanson et al., 1956):$h^2(\%) = \frac{V_g}{V_p} \times 100$

Where:

h^2% = Heritability percentage, V_g = Genotypic variance, V_p = Phenotypic variance

Heritability percentage was categorized as follows (Robinson et al., 1949), 0 to 30 per cent was considered as low.

Results and discussion

The results of table (1) showed the results of the analysis of variance of the genotypes of the studied traits for the four genotypes, where it is noted that there are significant differences between the averages of the genotypes at the 5% probability level for all the studied traits except for the length of the spike and the biological yield, which did not show any significant effect.

Table 1: Analysis of variance for genotypes by experimental design method for the studied traits in bread wheat

So.v	df	Ms								
		Plant height (cm)	Flag leave area (cm^2)	no. of tiller per plant	spike length (cm)	1000 grain weight (g)	no. of grain per spike	Biological yield ton/h^{-1}	Harvest index (%)	Total yield ton/h^{-1}
Replication	**2**	57.46	5.22	0.10	0.09	2.20	31.32	0.04	2.63	0.17
Genotype	**3**	48.02*	47.94*	5.88*	0.81	79.60*	54.11*	15.06	92.29*	1.20*
Erorr	**6**	5.70	3.81	0.38	0.24	2.87	4.46	6.27	4.54	0.34
Total	**11**									

Genetic, phenotypic and environmental correlation coefficients using nano potassium fertilizer

In Table (2), the genetic correlation coefficient was positive and highly significant at a significant level of 1% for a No. of traits, including grain yield with harvest index traits, weight of 1000 grains, No. of grains per spike, No. of ribs per plant, and plant height, which had a value of (0.956, 0.930, 0.849, 0.833 and 0.787) respectively.

The results also showed a significant and positive correlation at the 1% level also between the trait of the No. of grains in the spike and a No. of traits, the No.of tillers per plant, plant height and the area of the flag leaf, whose values reached (0.995, 0.950 and 0.924) sequentially, and there was a significant positive correlation at the 1% level. Also, there was a positive genetic correlation between the weight of 1000 grains and the No. of tillers per plant, which reached a value of (0.994), and between the vital yield and the height of the plant, which reached (0.720), in When the results showed a significant and positive correlation at the 5% level for the traits, the No. of ribs and the area of the flag leaf, with a value of (0.668), and between the weight of 1000 grains and the height of the plant, which amounted to (0.688) and between the harvest index and the No. of grains per spike which amounted to (0.652), this indicates that multiple genes share synergistically in affecting each of the two correlated traits, and that the selection of any of them will affect the other in the same direction. This result is consistent with the findings of (Nukasani et al., 2013; Ojha et al., 2018) of a relationship between grain yield and the No. of tillers in wheat, and of a relationship between the flag leaf area and the height of the plant.

With regard to the phenotypic correlation coefficient, it showed a positive and high significant correlation at the level of 1% between (grain yield x weight of 1000 grains), (No. of tillers × plant height) and (No. of grains/spike ×No. of straws/plant), which values of the correlation coefficient reached (0.846 and 0.807

and 0.784), and the results showed a significant and positive correlation between a No. of traits at the level of 5% between the grain cultivar, the two characteristics of the harvest index and the No. of straws, which amounted to (0.688 and 0.621) respectively, and between the No. of grains, the two traits of the flag leaf area and the height of the plant, as their values reached (0.705 and 0.634) sequentially, and between the weight of 1000 grains and the No. of tillers amounted to (0.603), and this result is consistent with the findings of (Nukasani, 2013) that there is a significant positive correlation between the yield of grains and the No. of tillers in wheat.

The results of table No. (1) showed that the genetic correlation coefficient was negative and significant at the level of 1% between the length of the spike and the flag leaf area, and between the No. of grains in the spike and the spike length, and between the grain yield and the biological yield, as well as the presence of the genetic and phenotypic correlation coefficient that is negative and moral between the index Harvest and biological yield, and the negative significant correlation indicates that whenever there is an increase in the first trait, there is a corresponding decrease in the second trait and vice versa. This means that the selection of one of the two traits affects the other trait in the opposite direction, and this may be attributed to the fact that the multiple genes that help the studied pairs of traits work in opposition Antagonistically.

Table (2): Correlation coefficient between total yield and other traits

	Correlation	Plant height (cm)	Flag leave area (cm^2)	No. of tiller per plant	Spike length (cm)	1000 grain weight (g)	No. of grain per spike	Biological yield ton/h^{-1}	Harvest index (%)	Total yield ton/h^{-1}
Plant height (cm)	G	1								
	P	1								
Flag leave area (cm^2)	G	0.470	1							
	P	0.529	1							
No. of tiller per plant	G	0.994**	0.668*	1						
	P	0.807**	0.451	1						
spike length (cm)	G	-0.415	-0.994**	-0.338	1					
	P	-0.292	-0.576	-0.297	1					
1000 grain weight (g)	G	0.688*	-0.064	0.728**	0.525	1				
	P	0.475	-0.105	0.603*	0.431	1				
no. of grain	G	0.950**	0.924**	0.995**	-0.765*	0.490	1			

per spike					*					
	P	0.634*	0.705*	0.784**	-0.253	0.423	1			
Biological yield ton/h^{-1}	G	0.720**	-0.411	0.212	-0.079	-0.024	-0.212	1		
	P	0.118	-0.294	0.113	0.017	0.172	-0.121	1		
Harvest index (%)	G	0.197	0.501	0.446	0.110	0.551	0.652*	-0.939**	1	
	P	0.159	0.353	0.407	0.095	0.492	0.511	-0.663*	1	
Total yield ton/h^{-1}	G	0.787**	0.415	0.833**	0.258	0.930**	0.849**	-0.804**	0.956**	1
	P	0.301	0.123	0.621*	0.204	0.846**	0.505	0.083	0.688*	1

*, ** significant at P (0.05, 0.01) respectively

Path factor analysis

The path coefficient analysis was conducted at the level of simple genetic correlation for all the studied traits, with the aim of partition the correlation coefficient between each of these traits studied and the grain yield into its components of direct and indirect effects, to determine the traits that have the most influence on the grain yield as selection indicators to improve the yield.

Table (3) shows the values of direct and indirect genetic effects for the traits mentioned in the grain yield, and it is noted that the values of the direct effects were positive for the studied traits on the yield of grain, except for the two traits of plant height and No. of grains in the spike, whose values were negative despite the fact that their genetic correlation was high positive (Table 2), and the harvest index trait was characterized by giving it a direct genetic effect that was very high, as its value reached (1.403), wth a high and positive genetic correlation with grain yield, it is noted that the weight of 1000 grains made an average contribution to the indirect effects of the harvest index in increasing the grain yield by (0.138), whereas, the indirect effects by the flag leaf area, the No. of tillers and the length of the spike were low, and this is consistent with what was found (Ayer et al. 2017).

With regard to the biological yield, its direct effect on the yield was positive and very high (0.612) compared to the genetic correlation coefficient in Table (2), which was negative and significantly high. As for the indirect effects of the traits, the No. of grains per spike and the No. of skeletons were very low (0.039 and 0.031). The traits had a negative indirect effect. As for the important trait, the weight of 1000 grains, it showed a high direct effect on the grain yield, but it showed an increase in the indirect effects with the traits evidence of harvest, No. of tillers and spike length (0.774, 0.107 and 0.011), while the rest of the indirect effects were negative. The trait of plant height showed a direct negative effect on grain yield, while the indirect effects were positive from medium to very high with the traits of vital yield, harvest index, weight of 1000 grains and No. of tillers, whose values were (0.441, 0.277, 0.172, 0.157, 0.065) sequentially , and it was few with the flag leaf area, which amounted to (0.065),While most of the indirect effects of the trait of the area of the flag leaf were negative, except for the characteristics of the harvest index, the area of the flag leaf and the No. of tillers, which amounted to (0.703, 0.138, and 0.098) in sequence. The indirect effects of the No. of ribs in the plant on increasing the grain yield were (0.625, 0.182 and 0.130) respectively, while the indirect effect value was shown to decrease by the area of the flag leaf as it reached (0.093), while the rest of the traits showed negative and unimportant effects. The length of the spike has contributed to a low direct effect on the grain yield by (0.020), and this is the result of the absence of any significant correlation with the other traits. 0.154, 0.139 and 0.132) respectively, while it showed a decrease in the value of the indirect effect through the height of the plant by (0.060).Based on that, it is noted that the trait of spike length when partitioning with other traits to determine its effect on grain yield was found to have an indirect influence with the above traits, and these traits have an important role as selective evidence in inheriting traits to increase grain yield. It is also noted from the data that the value of the direct effect of the No. of grains in the spike was negative, although the genetic correlation was positive and high, as the indirect effects were very high for the No. of grains in the spike by means of harvesting index (0.915), followed by the No. of tillers, the flag leaf area and the weight of 1000 A grain of (0.148, 0.128, and 0.123) respectively, while the rest of the effects were negative. We conclude from this results that the trait of the No. of grains per spike shares the traits of the vegetative covering, the No. of tillers and the flag leaf area in increasing the grain yield of the plant.

Table (3): Estimation of path coefficient analysis for some studied traits on the total yield

Traits	**Path coefficient value**	**Traits**	**Path coefficient value**
1- Effect of plant height on yield:		5- Effect of 1000 grain weight on yield:	
Direct effect	**-0.144**	Direct effect	**0.251**
Indirect effect through Flag leave area	0.065	Indirect effect through plant height	-0.099
Indirect effect through no. tiller per plant	0.157	Indirect effect through flag leave area	-0.009
Indirect effect through spike length	-0.008	Indirect effect through no. tiller per plant	0.107
Indirect effect through1000 grain weight	0.172	Indirect effect through spike length	0.011
Indirect effect through no. of grain per spike	-0.173	Indirect effect through no. of grain per spike	-0.089
Indirect effect through biological yield	0.441	Indirect effect through biological yield	-0.015
Indirect effect through Harvest index	0.277	Indirect effect through Harvest index	0.774
Sum of total effect	0.787	Sum of total effect	0.931
2- Effect of Flag leave area on yield:		6- Effect of no. of grain per spike on yield:	
Direct effect	**0.138**	Direct effect	**-0.182**
Indirect effect through plant height	-0.068	Indirect effect through plant height	-0.137
Indirect effect through no. tiller per plant	0.098	Indirect effect through flag leave area	0.128

Indirect effect through spike length	-0.022	Indirect effect through no. tiller per plant	0.148
Indirect effect through1000 grain weight	-0.016	Indirect effect through spike length	-0.015
Indirect effect through no. of grain per spike	-0.168	Indirect effect through 1000 grain weight	0.123
Indirect effect through biological yield	-0.252	Indirect effect through biological yield	-0.130
Indirect effect through Harvest index	0.703	Indirect effect through Harvest index	0.915
Sum of total effect	0.413	Sum of total effect	0.850
3- Effect of no. tiller per plant on yield:		7- Effect of biological yield on yield:	
Direct effect	**0.147**	Direct effect	**0.612**
Indirect effect through plant height	-0.154	Indirect effect through plant height	-0.104
Indirect effect through flag leave area	0.093	Indirect effect through flag leave area	-0.057
Indirect effect through spike length	-0.007	Indirect effect through no. tiller per plant	0.031
Indirect effect through1000 grain weight	0.182	Indirect effect through spike length	-0.002
Indirect effect through no. of grain per spike	-0.183	Indirect effect through 1000 grain weight	-0.006
Indirect effect through biological yield	0.130	Indirect effect through no. of grain per spike	0.039
Indirect effect through Harvest index	0.625	Indirect effect through Harvest index	-1.318
Sum of total effect	0.833	Sum of total effect	-0.805
4- Effect of spike length on yield:		8- Effect of Harvest index on yield:	
Direct effect	**0.020**	Direct effect	**1.403**
Indirect effect through plant height	0.060	Indirect effect through plant height	-0.028
Indirect effect through flag leave area	-0.150	Indirect effect through flag leave area	0.069
Indirect effect through no. tiller per plant	-0.050	Indirect effect through no. tiller per plant	0.066
Indirect effect through1000 grain weight	0.132	Indirect effect through spike length	0.002
Indirect effect through no. of grain per spike	0.139	Indirect effect through 1000 grain weight	0.138
Indirect effect through biological yield	-0.048	Indirect effect through no. of grain per spike	-0.119
Indirect effect through Harvest index	0.154	Indirect effect through biological yield	-0.575
Sum of total effect	0.257	Sum of total effect	0.956

Genetic variability parameters

With regard to the coefficient of phenotypic variance (PCV and GCV) in Table (4), it showed the traits, harvest index (22.498 and 20.933), grain yield (18,843 and 14,256), No. of tillers of (16,664 and 15.183), No. of grains per spike of (12,983 and 12.312) and the flag leaf area of (12.516 and 11.155) respectively, the values of phenotypic and genetic variance were medium, while the weight of 1000 grains (9.179 and 8.147), spike length (5.789 and 3.864) and plant height (5.105 and 4.308), respectively, recorded a decrease in the values of PCV and GCV. As for the biological yield, it recorded a medium value of PCV phenotypic variance of 16.275 and a low value of GCV genetic variance of 9.190. Moreover, it was observed that for almost all traits, a narrow difference was observed between PCV and GCV indicating that the influence of environment on all these traits was minimal.

The heritability estimates also showed that most traits recorded a high inheritance (Table No. 4), which is the No. of grains per spike, grain yield, No. of tillers, area of the flag leaf, weight of 1000 grains and plant height, which amounted to (89.920, 89,569, 83.015, 79.437, 78.786 and 71.226). Sequentially, while the rest of the traits recorded a decrease in the percentage of heritability, which indicates that although the traits are less affected by environmental influences, the selection and improvement of these traits may not be useful, because heritability in the broad sense depends on the total genetic variance which includes both additive and non-additive differences (dominant variance and superiority variance).

Table 3 : Estimates of genetic parameters for yield and related traits in 4 wheat genotype under condition of AL-muthana -Iraq

Sl. No.	Traits	PCV (%)	GCV (%)	h^2 (%)
1	Plant height (cm)	5.105	4.308	71.226
2	Flag leave area	12.516	11.155	79.437
3	no. tiller per plant	16.664	15.183	83.015
4	spike length(cm)	5.789	3.864	44.555
5	no. of grain per spike	12.983	12.312	89.928
6	Weight of 1000 grain (g)	9.179	8.147	78.786
7	Biological yield ton.h^{-1}	16.275	9.190	31.882
8	Harvest index	22.498	20.933	86.569
9	Total grain yield ton.h^{-1}	18.843	14.256	57.235

Conclusions

The results of the genetic correlation analysis showed that the correlation of grain yield with harvest index followed by 1000 grain weight, No. of grains per spike, No. of tillers and plant height was positive and highly significant, indicating that these traits were decisive. Besides, the path analysis showed that harvest index followed by biological yield had the highest direct positive effect on grain yield, while the indirect positive effect of high No. of grains per spike by harvest index, followed by indirect positive effects on the No. of tillers per plant by harvest index as well, which agrees with what was found by (Bayeet al., 2018; Ahmad et al., 2018). The strong correlation and the positive direct effect of harvest evidence with grain yield on the one hand and the direct negative effect and the strong correlation between plant height and grain yield showed that the selection of these genotypes with high harvest evidence and moderate plant height should be the emphasis during selection to improve grain yield.

Therefore, selection of genotypes of wheat with high biological yield and high yield index along with consideration at the same time of moderate plant height and 1000-grain weight is a prerequisite for achieving improvement in wheat grain yield, which agrees with what was found by (Ayer et al. 2017; Ojha et al., 2018) and confirmed by (Abdulhusseinet al., 2018).

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