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A RESEARCH ON RELATIONSHIPS AMONG THE CHARACTERS AND PATH COEFFICIENT ANALYSIS IN BARLEY *(Hordeum vulgare* L.)

M. Sait ADAK[1] **Muhip ÖZKAN[2]** **Mustafa GÜLER[1]**

1. Ankara University, Faculty of Agriculture, Department of Field Crops, Ankara-TURKEY
2. Ankara University, Faculty of Agriculture, Discipline of Biometry-Genetics of Animal Science. Ankara-TURKEY

SUMMARY: This research was conducted under Ankara conditions during 1996-1997 years with Tokak 157/37, Cumhuriyet 50, Ankara 93, Obruk 86 and Kavak two-rowed barley cultivars, to determine the relations among yield components which were mainly effective on grain yield per spike and grain yield per area by using correlation and path analysis technique. Moreover, the effectiveness ratios of these components on grain yield were determined. According to the results of the research; it could be concluded that upper internode length had high positive effects on both grain yield and grain yield per spike. The direct effects of flag leaf sheath length, upper internode length without sheath, the number of grains per spike, spike length, time to heading and number of days of heading-maturity on grain yield and grain yield per spike were statistically significant. The effects of upper internode length without sheath and flag leaf sheath length were negatively. Therefore, those characteristics have major importance as selection criteria in barley breeding.

ARPA *(Hordeum vulgare* L.)'DA ÖZELLİKLER ARASI İLİŞKİLER VE PATH KATSAYISI ANALİZİ ÜZERİNE BİR ARAŞTIRMA

ÖZET: *Bu araştırma, 1996-1997 yıllarında Ankara koşullarında yürütülmüştür. Araştırmada deneme materyali olarak Tokak 157/37, Cumhuriyet 50, Ankara 93, Obruk 86 ve Kavak iki sıralı arpa çeşitleri kullanılmıştır. Arpada başakta tane verimi ve birim alan tane verimi üzerine birinci derecede etkili verim öğeleri arasındaki ilişkilerin korelasyon ve path analizi ile saptanması amaçlanmıştır. Bununla birlikte, bu öğelerin verimi etkileme oranları da belirlenmiştir. Araştırmadan elde edilen sonuçlara göre; gerek tane verimi, gerekse başakta tane verimi üzerinde üst boğumarası uzunluğunun yüksek oranda olumlu etkisinin bulunduğu saptanmıştır. Bayrak yaprağı kını uzunluğu, kınsız üst boğumarası uzunluğu, başakta tane sayısı, başak uzunluğu, başaklanmaya kadar geçen gün sayısı ve başaklanma-hasat olum süresinin tane verimi ve başakta tane verimi üzerindeki doğrudan etkileri istatistiki yönden önemli bulunmuştur. Kınsız üst boğumarası uzunluğu ve bayrak yaprağı kını uzunluğunun etkileri olumsuz yönde olmuştur. Böylelikle arpada yapılacak olan ıslah çalışmalarında bu özelliklerin seleksiyon kriterleri olarak ele alınması önem taşımaktadır.*

INTRODUCTION

Barley used as a raw material in industry as well as human and animal nutrition is widely cultivated following wheat, rice and corn. Wide cultivation of barley is due to high adaptation capacity, cheap and easy production and large number of cultivars of this crop. Despite these positive aspects, sufficient increases in barley production could not be achieved due to ineffective breeding to increase and improve barley's yield and quality.

The main aim of a barley breeding is to increase and improve the yield and quality. But environmental factors as well as genotype affect yield and quality. Therefore, the effects of genotypic factors in the breeding programs should be clearly understood. It must be also known which factor or factors affect yield and quality and the degree of it. The correlation coefficient has been used for determining the relationship between the traits (Korkut et al., 1993). Since the correlation coefficients generally show relationships among independent characteristics and the degree of linear relations among the characteristics, they could not sufficiently describe the relationship when a clear cause-result relationship has been found between the characteristics. Therefore, the direct and indirect effects between yield and yield components should be known in breeding programs. For this purpose, the path analysis technique is used to determine the amounts of direct and indirect effects of the interrelated traits on a resulting trait such as yield. Dewey and Lu (1959) indicated the importance of certain important yield components in seed production using the path analysis technique in Crested wheatgrass. Gebeyehou et all. (1982) and Garcia del Moral et all. (1991) determined direct and indirect effects of various plant characteristics on yield and yield components using the path analysis technique in durum wheat and barley. Likewise, Hondelmann and Strauss (1990) determined the relationships among characteristics which are effective on yield components using the path analysis technique in *Euphorbia lathyrs* L.. In addition to them, Bhatt (1973) and Shamsuddin (1987) reported that the direct effects of number of heads per unit area, number of grains per spike and 1000 grain weight on grain yield were statistically significant.

MATERIALS AND METHODS

This research was carried out at the Experimental Field of the Department of Field Crops, Faculty of Agriculture, University of Ankara during 1996-1997 growing season. Tokak 157/37, Cumhuriyet 50, Ankara 93, Obruk 86 and Kavak, two-rowed barley cultivars, were used in the research. Field experiment was arranged in a Randomized Complete Blok Design with four replications. Each plot consisted of four rows of 2 m long and 1 m wide. Twelve kg/da Diammonium Phosphat (DAP) fertilizer was applied to each plot at sowing. Two rows were removed as border effect from each plot at harvest and observations and calculations of the characters were taken on five plants chosen randomly in the middle two rows. Simple correlation coefficients (Sokal and Rohlf, 1969) were calculated among grain yield (kg/ha), grain yield per spike (g), days of heading-maturity (days), plant height (cm), spike length (cm), upper internode length (cm), flag leaf sheath length (cm), upper internode length without sheath (cm), time to heading (days), 1000 grain weight (g), number of spikelets per spike, number of grains per spike and number of heads per unit area.

RESULTS AND DISCUSSION

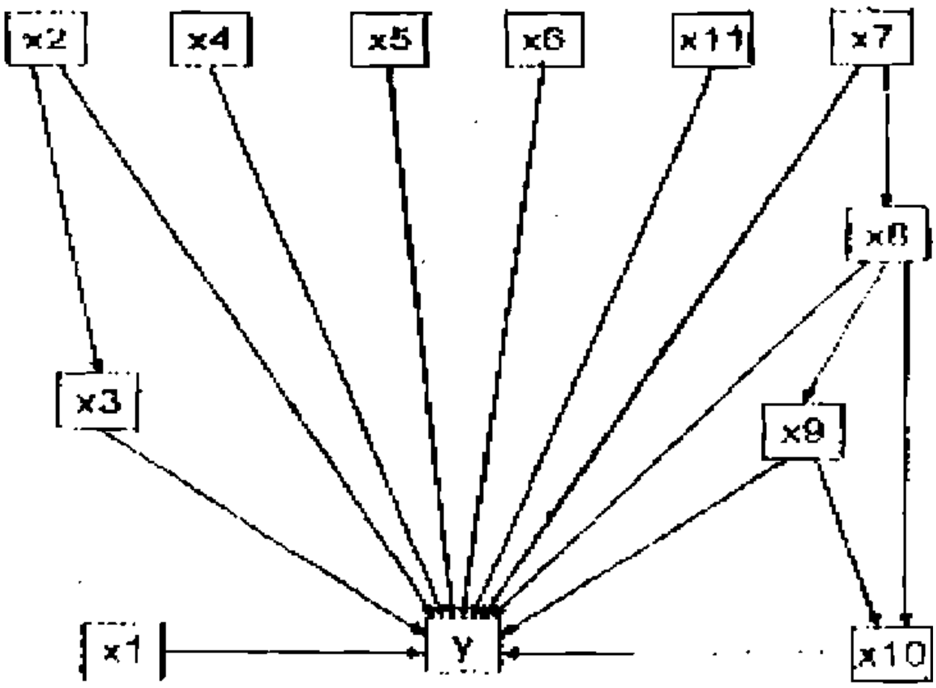
The direct and compound path coefficients between examined characters and grain yield (kg/ha) were given in Table 2.

Table 2. The direct and compound path coefficients between existent independent variables and grain yield (Y) variables path coefficient (P.C.)

X_8 - X_7	1000 grain weight-Time to heading)	0.071
X_9 - X_8	(The num. of spikelets per spike-1000 grain weight)	-0.396
X_3 - X_2	(Spike length-Plant height)	-0.043
X_{10} - X_8	(The num. of grains per spike-1000 grain weight)	-0.038
X_{10} - X_9	(The num. of grains per spike-The num. of spikelets per spike)	0.956*
Y-X_2	(Grain yield-Plant height)	0.147*
Y-X_4	(Grain yield-Upper internode length)	0.752*
Y-X_5	(Grain yield-Flag leaf sheath length)	-0.354*
Y-X_6	Grain yield-Upper internode length without sheath)	-0.413*
Y-X_{11}	(Grain yield-The num. of heads per unit area)	0.015
Y-X_9	Grain yield-The num. of spikelets per spike)	-0.380*
Y – X_{10}	(Grain yield-The num. of grains per spike)	0.531*
Y-X_8	(Grain yield-1000 grain weight)	0.069
Y-X_3	(Grain yield-Spike length)	-0.106*
Y-X_1	(Grain yield-Days of heading-maturity)	0.135*
Y-X_7	(Grain yield-Time to heading)	0.182*

R^2= 0.98

As seen in Table 2; the direct effect of upper internode length (X_4) on grain yield (as a dependent variable) was the highest (P_{YX4}=0.752). in the same way, the direct effects of plant height (X_2), flag leaf sheath length (X_5), upper internode length without sheath (X_6), the number of spikelets per spike(X_9), the number of grains per spike (X_{10}), spike length (X_3), days of heading-maturity (X_1) and time to heading *(X_7)* on grain yield have been found to be significant at the 0.05 level of significance. On the other hand, the direct effects of flag leaf sheath length, the number of spikelets per spike and spike length on grain yield were found to be negative. The effect of upper internode length without sheath on gram yield was also negative. In other words; while upper internode length without sheath increases one standard deviation, grain yield decreases 0.413 standart deviation. As regards in order to increase grain yield, it could be recommended that plants with shorter upper internode length without sheath must be selected. The path relationships between grain yield and the other characteristics were shown in Figure 1.



Figüre 1. Grain yield and the effective characteristics on grain yield

The correlation coefficients among Y (grain yield) dependent variable, all independent variables and defined intermediate variables are given in Table 3.

Table 3. Correlation coefficients among Y (Grain Yield) dependent variable, all independent variables and defined intermediate variables

	X_7	X_{11}	X_6	X_5	X_4	X_2	X_8	X_9	X_1	X_{10}	X_3
Y	0.182	0.015	-0.413	-0.354	0.752*	0.151	0.012	0.103	0.135	0.127	-0.112
X_8	0.071	-	-	-	-	-	-	-	-	-	-
X_9	-0.028	-	-	-	-	-	-0.369	-	-	-	-
X_{10}	-0.030	-	-	-	-	-	-0.417	0.972*	-	-	-
X_3	-	-	-	-	-	-0.043	-	-	-	-	-

As seen in Table 3; only the correlation coefficient between grain yield and upper internode length (X_4) was found to be statistically significant among all independent variables. On the other hand, the correlation coefficient between the number of spikelets per spike and the number of grains per spike has been found to be significant at 0.05 level (r_{x9x10}=0.972). The spike length (X_3), 1000 grain weight (X_8), the number of spikelets per spike (X_9) and the number of grains per spike (X_{10}) are defined as intermediate variables. The direct effects of the number of heads per unit area (X_{11}), 1000 grain weight (X_8) and plant height (X_2) on grain yield were statistically non-significant (P_{YX11}=0.015, P_{YX8}=0.069). The compound path coefficient of 1000 grain weight by the number of spikelets per spike on grain yield (-0.396 x -0.38 =0.15) is rather high in comparison with 0.069. Therefore, using the number of spikelets per spike (X_9) could be suitable as an intermediate variable from the point of view of showing up 1000 grain weight's effect on grain yield. Though the compound path coefficient of 1000 grain weight (X_8) by the number of grains per spike on grain yield (Y) is negative (-0.038 x 0.531), its efficiency was also very low (-0.02). Consequently, it could be concluded that 1000 grain weight by the number of grains per spike has not affected the grain yield. Also the compound path coefficient of plant height (X_2) by spike length (X_3) on grain yield (Y) is found rather low (-0.043 x -0.106 =0.0045). Therefore, it could be concluded that plant height (X_2) by spike length (X_3) has not affected grain yield.

The compound path coefficient of time to heading (X_7) by 1000 grain weight (X_8) and the number of spikelets per spike (X_9) on grain yield was low. Also the compound path coefficient of time to heading (X_7) through the number of grains per spike (X_{10}) on grain yield (Y) was small. Consequently, it could be concluded that time to heading (X_7) through 1000 grain weight (X_8), the number of spikelets per spike (X_9) and the number of grains per spike (X_{10}) have not affected the grain yield (Y). The compound path coefficient of 1000 grain weight (X_8) through the number of grains per spike (X_{10}) on grain yield is negative and too low (-0.038 x 0.531=-0.02). Therefore, 1000 grain weight through the number of grains per spike did not affect grain yield.

The direct and compound path coefficients between examined characters and grain yield per spike (Y_1) are given in Table 4.

Table 4. The direct and compound path coefficients between existent independent variables and grain yield per spike (Y,) variables path coefficient (P.C.)

X_8 - X_7 (1000 grain weight-Time to heading)	0.071
X_9 - X_8 (The num. of spikelets per spike-1000 grain weight)	-0.396
X_3 - X_2 (Spike length-Plant height)	-0.043
X_{10} - X_8 (The num. of grains per spike-1000 grain weight)	-0.038
X_{10} – X_9 (The num. of grains per spike-The num. of spikelets per spike)	0.956*
Y_1 – X_2 (Grain yield per spike-Plant height)	0.024
Y_1 - X_4 (Grain yield per spike-Upper internode length)	0.619*
Y_1 - X_5 (Grain yield per spike-Flag leaf sheath length)	-0.192*
Y_1 – X_6 (Grain yield per spike-Upper internode length without sheath)	-0.561 *
Y_1 – X_{11} (Grain yield per spike-The num. of heads per unit area)	-0.092 *
Y_1 – X_9 (Grain yield per spike-The num. of spikelets per spike)	-0.007
Y_1 - X_{10} (Grain yield per spike-The num. of grains per spike)	0.388*
Y_1 - X_8 (Grain yield per spike-1000 grain weight)	-0.048
Y_1 – X_3 (Grain yield per spike-Spike length)	0.064*
Y_1 – X_1 (Grain yield per spike-Days of heading-maturity)	0.202*
Y_1 - X_7 (Grain yield per spike-Time to heading)	0.211 *

R^2 =0.990

According to Table 4; the direct effect of upper internode length (X_4) on grain yield per spike (as a dependent variable) was found to be the highest (P_{Y1X4}=0-619). In the same way, the direct effects of flag leaf sheath length (X_5), upper internode length without sheath (X_6), time to heading (X_7), spike length (X_3), days of heading-maturity (X_1), the number of grains per spike (X_{10}) and the number of heads per unit area (X_{11}) on grain yield per spike (Y_1) were all found to be significant at the 0.05 level. These direct effects of flag leaf sheath length (X_5), upper internode length without sheath (X_6) and the number of heads per unit area (X_{11}) on grain yield per spike were negative.

The path relationships between grain yield per spike and the other characteristics were shown in Figure 2.

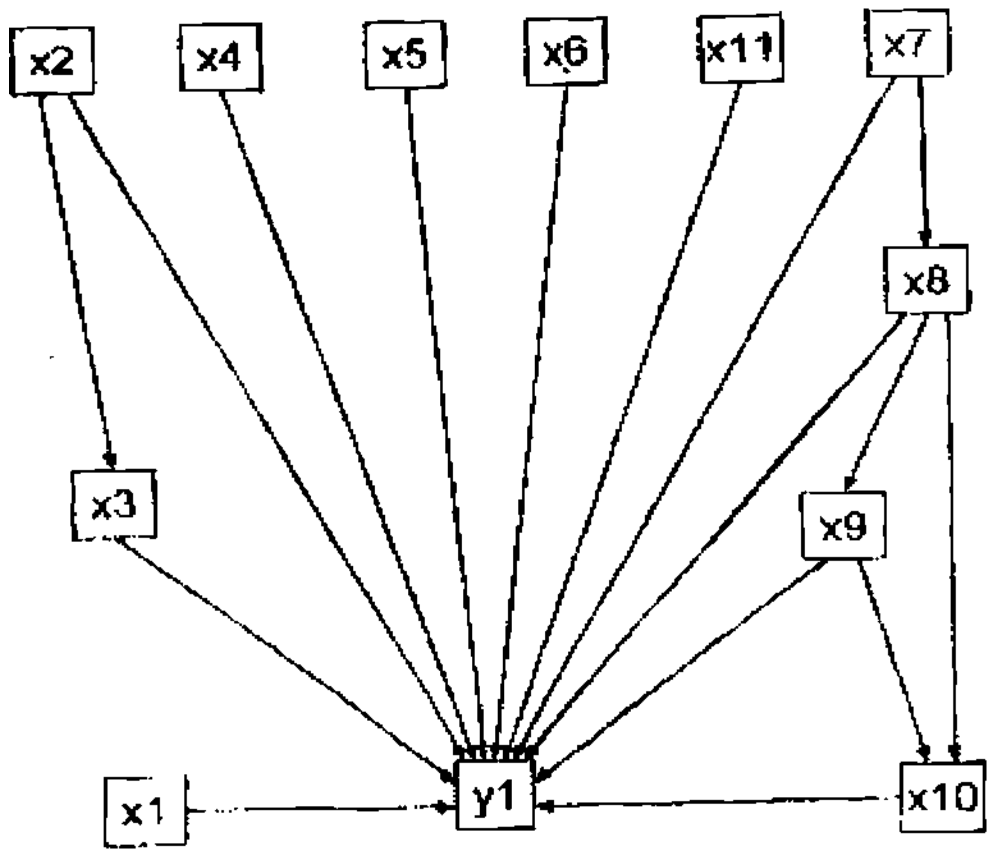


Figure 2. Grain yield per spike and the effective characteristics on grain yield per spike

Correlation coefficients among Y_1 dependent variable, all independent variables and defined intermediate variables were given in Table 5.

Table 5. Correlation coefficients among Y_1 (grain yield per spike) dependent variable, all independent variables and defined intermediate variables

	X_7	X_{11}	X_6	X_5	X_4	X_2	X_8	X_9	X_1	X_{10}	X_3
Y_1	0.197	-0.092	-0.561*	- 0.192	0.619*	0.021	- 0.190	0.382	0.202	0.388	0.064
X_8	0.071	-	-	-	-	-	-	-	-	-	-
X_9	-0.028	-	-	-	-	-	-0.396	-	-	-	-
X_{10}	-0.030	-	-	-	-	-	-0.417	0.972*	-	-	-
X_3	-	-	-	-	-	-0.043	-	-	-	-	-

As seen in Table 5; only, the correlation coefficients between the grain yield per spike and upper internode length (X_4); the grain yield per spike and upper internode length without sheath (X_6) were found to be significant at the 0.05 level. Also the correlation coefficient between the number of spikelets per spike and the number of grains per spike was significant at the 0.05 level (r_{x9xl0}=0.972). The spike length (X_3), 1000 gram weight (X_8), the number of spikelets per spike (X_9) and the number of grains per spike (X_{10}) could be defined as intermediate variables.

The direct effects of 1000 grain weight (X_8), the number of spikelets per spike (X_9) and plant height (X_2) on grain yield per spike were non-significant (P_{Y1X8}=-0.048, P_{Y1X9}=-0.007, P_{Y1X2}=0.024). The compound path coefficient of 1000 grain weight (X_8) by the number of spikelets per spike (X_9) on grain yield per spike (Y_1) was found as low as expected (-0.396 x -0.007 =0.0027). The compound path coefficient of 1000 grain weight (X_8) by the number of grains per spike (X_{10}) on grain yield per spike (Y_1) was -0.038 x 0.388; this value was too low in spite of negative (-0.0147). Therefore, it could be concluded that 1000 grain weight by the number of spikelets per spike (X_9) and the number of grains per spike (X_{10}) intermediate values would not affect grain yield per spike.

On the other hand, the compound path coefficient (-0.043 x 0.064) of plant height (X_2) through spike length (X_3) on grain yield per spike (Y_1) was negative but too low (-0.0027). Consequently, it could be said that plant height through spike length would not affect grain yield per spike too. The compound path coefficient of time to heading (X_7) through 1000 grain weight (X_8) and the number of spikelets per spike (X_9) on grain yield per spike (Y_1); and also the number of grains per spike (X_{10}) on grain yield per spike (Y_1) were found rather low. According to these results; it could be concluded that time to heading (X_7) by 1000 grain weight (X_8), the number of spikelets per spike (X_9) and the number of grains per spike (X_{10}) would not affect gram yield per spike (Y_1).

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