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PATH COEFFICIENT ANALYSIS OF SOME YIELD COMPONENTS IN DURUM WHEAT (*TRITICUM DURUM* DESF.)

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Abstract

The results revealed that the direct and indirect effects on yield exhibited variation from year to year, eg., plant density had a direct effect towards reducing the yield with a path coefficient of -0.314 in the year 1999, while this trait had a positive direct effect towards increasing the yield, in the other three years with path coefficients between 0.045 and 0.494. The trait seed weight per spike had positive effect on yield during 4 years of the trial. This trait generally had a positive effect on yield indirectly through other traits as well. Seed number per spike and plant height had direct negative effects. Plant density, seed weight per spike and thousand kernel weight increased the yield with the direct effect values of 0.312. 0.295 and 0.286, respectively, based on the average of four years. However, plant height and seed number per spike had negative effects with the values of -0.078 and -0.064, respectively.

Introduction

Seed yield is the primary factor affecting the economical value in wheat. For this reason, agronomical and breeding studies on increasing seed yield are being conducted intensively. For effective selection, information on nature and magnitude of variation in population, association of character with yield and among themselves and the extent of environmental influence on the expression of these characters are necessary. In such situations, correlation and path coefficient analysis could be used as an important tool to bring information about appropriate cause and effects relationship between yield and some yield componenets (Khan *et al*., 2003). Path Analysis was conducted following the procedure developed by Wright (1921) and applied by Dewey & Lu (1959). This analysis is used to partition the relative contribution of yield components *via* standardized partial regression coefficients. The correlation coefficient can be seperated into the direct and indirect influences that one variable has on another. Path analysis was used in numerous researches with the aim of determining the effects of important yield components (Pandey & Torrie 1973; Maria *et al.*, 1984; Stafford & Seiler 1986; Turan 1989; Ball *et al*., 1993; Costa & Krostand 1994; Akanda & Mundt 1996; Dogney *et al.*, 1998; Mehetre *et al.*, 1997; Yağdı 2001; Naazar *et al*.,2003, Ahmed *et al*., 2003).

In this study, the effect of plant height, plant density, seed weight per spike, seed number per spike and thousand kernel weight on seed yield were investigated and interpreted through path analysis.

Material and Methods

The study was carried out in Faculty of Agriculture Uludağ University, Bursa/Turkey. Nineteen different durum wheat genotypes were used as plant material in the study. The trial was established according to randomized block design with 3 replicates and the plot was 6 m^2 . Plots consisted of eight rows, each 5.0 m long, with a row spacing of 0.15 m. Seeding rate was 500 seeds/m^2. Total rainfall values during the growth period (November-July) in the years 1998, 1999, 2000 and 2001 were recorded as 601.3 mm, 662.1 mm, 563.2 mm and 294.5 mm, respectively (Anon., 2002). The soil

of experimental area is clayey (47.76%), with neutral pH (7.97) and its salinity is at harmless level (0.233 mmhoscm^{-1}). Organic matter content of the soil is 1.53% whereas its phosphorus and potassium levels were 23.21 ppm, 1.12 me100^{-1}g respectively (Ozgüven & Katkat 1997).

Path analyses were carried out on the traits considered as the yield components, according to Dewey & Lu (1959). Seed yield was taken as dependent variable in the method. Plant height, plant density, seed weight per spike, seed number per spike and thousand kernel weight which were thought to be effective on seed yield were considered as independent variables. Correlation coefficients were found initially in order to determine the simple linear relations between the traits.

Thereafter correlation coefficients were calculated according to path equations below:

$r_{16} = a + br_{12} + cr_{13} + dr_{14} + er_{15}$
$r_{26} = ar_{12} + b + cr_{23} + dr_{24} + er_{25}$
$r_{36} = a\, r_{13} + br_{23} + c + dr_{34} + er_{35}$
$r_{46} = a\, r_{14} + br_{24} + cr_{34} + d + er_{45}$
$r_{56} = a\, r_{15} + br_{25} + cr_{35} + dr_{45} + e$

In the equation, a, b,c, d and e represents the direct effects of plant height (1), plant density (2), seed weight per spike (3), seed number per spike (4) and thousand kernel weight (5) ,whereas r is the correlation coefficient between two traits. For instance, r_{16} shows the correlation between plant height and seed yield (6).

Results

Path coefficients which show the direct and indirect effects on the dependent variable (seed yield), of the other traits for each year and as the mean of four years (Table1) and the diagramatic presantation of the effects of variables on yield is given in Fig. 1.

The correlation coefficient established towards the determination of the relations between traits were reported in the method. For example, the correlation coefficient is -0.075 in average between plant height and yield. This was divided by path analysis as shown below:

$r_{16} = a + br_{12} + cr_{13} + dr_{14} + er_{15}$

The direct effect of plant height…….: a	= -0.078
The indirect effect of plant height through plant density..…..: br_{12}	= -0.010
The indirect effect of plant height through seed weight per spike… : cr_{13}	= 0.029
The indirect effect of plant height through seed number per spike..: dr_{14}	= -0.017
The indirect effect of plant height through thousand kernel weight..: er_{15}	= 0.0 01
Total……: r_{16}	= -0.075

The results (1998) indicated that seed weight per spike had the greatest positive effect (1.057) on seed yield. This was fallowed by plant density with 0.396. The effects of other traits were negative direction towards reducing the yield. Especially seed number per spike had a prominent effect on yield in negative direction with – 0.800. The indirect effect of seed number per spike through seed weight per spike is negative (-0.670) and quite high. This effect was also in negative direction for plant height (-0.026), plant density (-0.016) and thousand seed weight (-0.033). The indirect effect of seed weight per spike through plant height, seed number per spike and thousand seed weight were towards increasing yield with 0.538, 0.879 and 0.584, respectively (Table 1).

Table 1. Direct and indirect effects of traits on seed yield.

Direct Effect	Indirect Effect	PC [1] (1998)	CC [2] (1998)	PC (1999)	CC (1999)	PC (2000)	CC (2000)	PC (2001)	CC (2001)	PC (Four Year)	CC (Four Year)
PH [3]		**-0.051**	**0.209**	**-0.237**	**0.048**	**-0.030**	**0.101**	**-0.009**	**-0.067**	**-0.078**	**-0.075**
	PD	0.007		0.065		0.130		0.001		-0.010	
	SWPS	0.538		0.192		-0.070		0.039		0.029	
	SNPS	-0.276		0.039		0.040		-0.053		-0.017	
	TKW	-0.009		-0.011		0.030		-0.043		0.001	
PD [4]		**0.396**	**0.290**	**-0.314**	**-0.217**	**0.494**	**0.345**	**0.045**	**0.015**	**0.312**	**0.128**
	PH	-0.001		0.049		-0.008		0.000		0.003	
	SWSP	-0.042		0.064		0.088		-0.204		-0.082	
	SNSP	-0.085		-0.004		-0.219		-0.004		-0.015	
	TKW	0.022		-0.012		-0.011		-0.005		-0.090	
SWPS [5]		**1.057**	**0.317**	**0.392**	**0.272**	**0.596**	**0.274**	**0.138**	**0.082**	**0.295**	**0.392**
	PH	-0.026		-0.116		0.004		-0.003		-0.008	
	PD	-0.016		-0.052		0.073		-0.007		-0.086	
	SNPS	-0.670		0.050		-0.385		0.009		-0.019	
	TKW	-0.033		-0.003		-0.014		-0.056		0.210	
SNPS [6]		**-0.800**	**0.090**	**0.062**	**0.248**	**-0.670**	**-0.152**	**-0.192**	**-0.175**	**-0.064**	**0.071**
	PH	-0.018		-0.152		0.002		-0.003		-0.021	
	PD	0.042		0.021		0.160		0.001		0.072	
	SWPS	0.879		0.318		0.341		-0.007		0.087	
	TKW	-0.014		-0.001		0.019		0.025		-0.003	
TKW [7]		**-0.059**	**0.185**	**0.048**	**0.154**	**-0.149**	**0.376**	**-0.172**	**-0.100**	**0.286**	**0.405**
	PH	-0.008		0.052		0.006		-0.002		-0.001	
	PD	-0.147		0.078		0.036		0.001		-0.098	
	SWPS	0.584		-0.001		0.055		0.045		0.216	
	SNSP	-0.185		-0.024		0.084		0.028		0.001	

[1]Path coefficient, [2]Correlation coefficient, [3]Plant height, [4]Plant density, [5]Seed weight per spike, [6]Seed number per spike, [7]Thousand kernel weight.

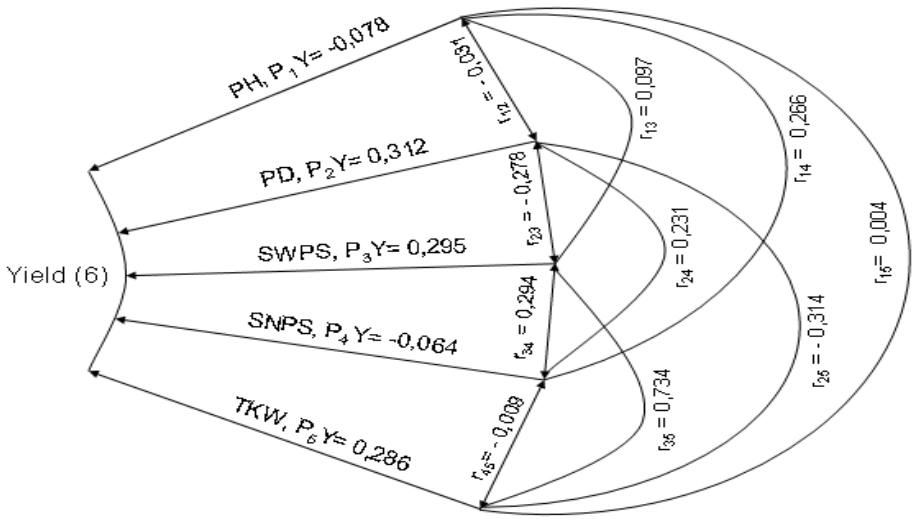

Fig. 1. Diagramatic representation of direct and indirect effects of variables on seed yield. (P_nY :path coefficient for each trait with yield, r: correlation coefficient, PH(1): plant height, PD (2): plant density, SWPS (3): seed weight per spike, SNPS (4): seed number per spike, TKW (5): thousand kernel weight).

The direct effect of seed weight per spike on yield was observed to be high and in positive direction (0.392), according to the path coefficients determined in the year 1999. The values of seed number per spike and thousand kernel weight had positive effect on yield with 0.062 and 0.048, respectively, though these linear effects were smaller. In this year, plant height and plant density had reducing effect on yield with quite high negative values (-0.237 and – 0.314). The indirect effect of seed weight per spike (0.318) was thought to be an important factor on the positive value determined for the trait of seed number per spike.

High direct effects of seed weight per spike (0.596) and plant density (0.494) were determined on yield in 2000, the third year of the trail. The seed number per spike showed its high adverse effect on yield with -0.670. Similarly, negative direct effect values on yield were determined in traits of thousand kernel weight (-0.149) and plant height (-0.030). Negative and high indirect effect of seed number per spike was notable among the traits having positive direct effect on yield. The negative direct effect of this trait (-0.670) is interesting, since the indirect effects of all other traits through this trait were positive (between 0.002 and 0.341).

Seed weight per spike and plant density had an improving effect on yield with positive values of 0.138 and 0.045, respectively in the year 2001. Nevertheless, seed number per spike and thousand kernel weight affected the yield in negative direction with the values of -0.192 and -0.172, respectively. The direct effect of plant height which was -0.009 was negligible compared with the effects of the other traits. In this experimental year, the indirect effects of all traits were weaker as compared to the effects of traits in other years.

For each trait in the study, when the means of 4 years, plant density (0.312), seed weight per spike (0.295) and thousand kernel weight (0.286) were observed to have positive effect on yield, whereas the traits of plant height (-0.078) and seed number per spike (-0.064) had direct effect on yield towards reducing it (Table 1 and Fig. 1). Plant density and seed number per spike had negative indirect effect on yield through plant height. However, plant height had positive indirect effect through plant density with 0.003, whereas the other traits had negative indirect effects between -0.015 and -0.090. Thousand kernel weight through seed weight per spike was determined to have positive indirect effect at the highest level on yield with 0.210, while other three traits had negative indirect effects. The indirect effects of plant height and thousand kernel weight on yield through seed number per spike were found negative, whereas plant density and seed weight per spike had positive effects towards improving the yield. In the trait thousand kernel weight, especially the indirect effect of seed weight per spike (0.216) had an effect towards improving the yield. The indirect effects of the other three traits on this trait remained at lower values between -0.001 and 0.001.

Discussion

Poehlman (1979) reported that grain yield is affected by all of the environmental conditions influencing the growth of the wheat plant and the interaction of these with the plant's genetic makeup and it is affected by the number of heads per unit area, the number of grains per head, the average weight per grain. De Pauw & Shabeski (1973), Akanda & Mundth (1996), ShouFu *et al*.,(1997), Dencic *et al*., (2000) and Yağdı (2001) determined positive direct relation of seed weight per spike with yield in their researches. Direct positive effect of plant density is known to be effective on yield was reported by

Peterman *et al*., (1985) and Akanda & Mundt (1996). In present study seed weight per spike and plant density were observed to have positive effect on yield when the means of four years. Therefore our results shows in parallelism with these studies. In addition, 1000 kernel weight was found positive direct effect on the yield in the study. Similar results have been determined by Peterson *et al*., (1992), Knezevic *et al*., (2001), Pochaba & Wegrzyn (2001), Dhaliwal & Suchchain (2003) and Kashif & Khaliq (2004).

Kraljevic- Balalic *et al.*, (1982) reported that the number of grain and their spike mass are yield components that are independent from other components in the early stages of onthogenesis. The success of pollination and fertilization also have a big influence on expression of this trait (Knezevic *et al*., 2001). The direct positive effect of grain number per spike on yield had been shown by De Pauw & Shabeski (1973), Moreira & Osoria (1978) and Pochaba & Wegrzyn, (1999). Similar results have been reported for this trait by Akanda & Mundt (1996), Dencic *et al*., (2000), Subhani & Chowdry (2000), Kashif & Khaliq (2004). The finding of negative direct effect between seed number per spike with yield determined in the present study is contradictory to the results of these studies.

Plant height has direct effect on 'genotype x environment' interaction and influence on yield (Knezevic *et al*., 2001). However, the direct effect of plant height was negative on each years and the means of four years in our research. Zecevic (1996), Pochaba & Wegrzyn (2001), Ashraf *et al*., (2002), Khan *et al*., (2003) and Kashif & Khaliq (2004) reported that this trait showed positive correlation with yield . The research finding of negative relation between plant height and yield indicated in our study is contradictory to the results of these studies, but it shows in agreement with other study by Ahmed *et al*.,(2002).

In this study, the most effective trait towards increasing yield was determined to be seed weight per spike, when the years were considered individually. However, the mean correlation coefficient of thousand kernel weight (0.405) was found higher than the correlation coefficient of seed weight per spike which was 0.396. This may indicate means that negative indirect effects of plant height, seed number per spike and plant density have smaller masking effect on thousand kernel weight than seed weight per spike. Moreover, it can be thought that the indirect effect of seed weight per spike through thousand kernel weight could be an important factor. It should be taken into consideration that all the traits investigated are quantitative characters and affected by environmental conditions to a greater extent, as well. As a matter of that, the results changing from year to year support this suggestion.

References

Ahmed, H.M., B.M. Khan, S. Khan, N. Kissana and S. Laghari. 2003. Path coefficient analysis in bread wheat. *Asian J. of Plant Sci*., 2(6): 491-494.

Akanda, S.I. and C.C. Mundt. 1996. Path coefficient analysis of the effects of stripe rust and cultivar mixtures on yield and yield components of winter wheat, *Theorical and Applied Genetics*, 92 (6): 666-672.

Anonymous. 2002 . Turkish State Meteoroligical Service.

Ashraf, M.A., A. Ghafoor, N.A. Khan and M. Yousaf. 2002. Path coefficient in wheat under rain fed conditions. *Pakistan J. Agric. Res*., 17:1-6.

Ball, A.R., R.W. McNew, E.D. Vories, T.C. Keisling and L.C. Purcell. 1993. Path analysis of population density effects on short-season soybean yield. *Agron. J*., 1: 187.

Costa, J.M. and W.E. Krostand. 1994. Association of grain protein concentration and selected traits in hard red winter wheat populations in the pacific northwest. *Crop Sci*., 34: 1234-1239.

De, Pauw and I.H. Shebeski. 1973. An evaluation of early generation yield testing procedure in *T.aestivum*., *Canadian Journal of Plant Science*, 53: 465-470.

Dencic, S., R. Kastori, B. Kobiljski and B. Duggan. 2000. Evaluation of grain and ıts components in wheat cultivars and landraces under near optimal and drought conditions. *Euphytica*, 113: 43-52.

Dhaliwal, L. and S. Sukhchain. 2003. Correlation and path-coefficient of yield and various other traits in wheat (*T. aestivum* L.) under flooding. *Crop İmp*., 30(1) : 99-101.

Dewey, D.R.and K.H. Lu. 1959. A Correlation and path-coefficient analysis of components of crested wheatgrass seed production. *Agron. J*., 51: 515-518.

Dogney, M.L. V.K. Gour and A.K. Mehta. 1998. Path coefficient analysis of yield attributing characters in backcross. *Crop Research Hisar*.,16 (3): 352-357.

Kashif, M. and I. Khalıq. 2004. Heritability, correlation and path coefficient analysis for some metric traits in wheat., *Int. J. Agri. & Biol*., 1: 138-142.

Khan, A.S., M. Ashfaq and M.A. Asad. 2003. A correlation and path coefficient analysis for some yield components in bread wheat. *Asian J. of Plant Sci*., 2(8): 582-584.

Knezevic, D., V. Zecevic, N. Djukic, D.Urosevic, M. Pavlovic, D. Micanovic, V. Urosevic, M. Kuburovic and S. Jordacijevic. 2001. Harvest index and yield components in 12 Yugoslav winter wheat cultivars. *Annual Wheat Newsletter*, 47: 312-315.

Kraljevic-Balalic, M., I. Mihaljev and M.A. Leghari. 1982. Ecological and genetic variability of number and weight of grain pers pike. *J. Agric. Sci*., 43: 495-504.

Maria, J.O. Z., A.A. Rosielle, J.G. Waines and K.W. Foster. 1984. A heritability and correlation study of grain yield, yield components and harvest index of common bean in sole crop and intercrop., *Field Crops Research*, 9: 109-118.

Mehetre, S.S., R.B. Shinde, U.M. Borle and P. Suraa. 1997. Correlation and path analysis studies of partioning in root growth and yield characters in soybean *(Glycine max* (L.) *Merill*). *Crop Research Hisar*, 13 (2): 415-422.

Moreira, J. and A. Osoria. 1978. Association of morphological characters of the wheat plant with grain yield. *Naciional de Pesquisa de Trigo: Passe Funde*, 706-707.

Naazar, A., F. Javidfar, J.Y. Elmira and M.Y. Mirza. 2003. Relationship among yield components and selection criteria for yield improvement in winter rapeseed (*Brassica napus* L.). *Pakistan J. Bot*., 35(2): 167-174.

Ozgüven, N.Ç. and A.V. Katkat. 1997. Determination of the fertility levels of the soils in the experimental farm of agricultural faculty, *Journal of Uludağ University Agricultural Faculty* (In Turkish, with English Abstract), 13: 43-54.

Peterman, C.J., R.G. Sears and E.T. Kanemasu. 1985. Rate and duration of spikelet ınitation in 10 winter wheat cultivars, *Crop. Sci.*, 221-225.

Peterson, C.J. , R.A. Graybosch., P.S. Baenziger and A.W. Grombacher. 1992. Genotype and environment effects on quality characteristics of hard red winter wheat. *Crop. Sci*., 32: 98-103.

Pochaba, L.& S.Wegrzyn. 2001. Variability of some characters in winter wheat and their relations.,Ogolnopolskie Symposium. Genetyka İlosciowa Roslin Uprawnych. *Biuletyn-Instytutu-Hodowli-i- Aklimatyzacji-Roslin*, 216(2): 261-266.

Poehlman, J.M. 1979. *Breeding field crops. The AVI Pubs. Co. Inc*. Westport, Connecticut.

ShouFu, X., W. FengJun and J. Runsheng. 1997. Correlation analysis of several quantitative characters of barley. *Barley Genetics Newsletter*: 27 (in: http://wheat. Pw.usda. gov/ ggpages/ bgn/27/xfltxt.html).

Stafford., R.E. and G.J. Seiler. 1986. Path coefficient analysis of yield components in guar. *Field Crops Research*, 14: 171-179.

Subhani, G.M. and M.A. Chowdhry. 2000. Correlation and path coefficient analysis in bread wheat under drought stres and normal conditions. *Pakistan J. Biol. Sci*., 3: 72-77.

Turan, Z.M. 1989. Some agronomical and technological characters of certain rapeseed cultivars under bursa conditions, their inheritance and path analysis.,*Uludağ University.* (In Turkish, with English Abstract), 12-24.

Wright, S. 1921. Correlation and causation. *J. Agric. Res.*, 1(20): 557-585.

Yağdı, K. 2001. The correlation and path coefficient analysis for yield and some yield components of common wheat (*Triticum aestivum l.*) in bursa ecological conditions. *Journal of Uludağ University Agricultural Faculty* (In Turkish, with English Abstract) 15: 11-18.

Zecevic, V. 1996. *Genetic identification of different winter wheat* (*Triticum aestivum L.*). *Ph. D. Thesis*. Univ of Novi Sad. In: Knezevic, D., V. Zecevic, N. Djukic, D.Urosevic, M. Pavlovic, D. Micanovic, V.Urosevic, M. Kuburovic & S. Jordacijevic, 2001., Harvest index and yield components in 12 Yugoslav winter wheat cultivars. *Annual Wheat Newsletter*. 47: 312-315.

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