Correlation and Path Analysis of Grain Yield and Yield Components of some Turkish Oat Genotypes

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Abstract

This research was carried out in 2002-03 and 2005-06 crop years in Kahramanmaras province located in East-Mediterranean Region of Turkey. The experimental design was randomized complete block design with four replications. The aim of research was to determine correlation coefficients among grain yield (GY) and plant height (PH), grain number per panicle (GNP), grain weight per panicle (GWP), 1000 grain weight (1000-GW), grain filling period (GFP), days to maturity (DM), panicle number per m-2 (PN m-2) of 17 oat genotypes. It was also determined direct and indirect effects of yield components on GY through path analysis.

Based on the results of this study, correlation coefficients revealed that GY was significantly and negatively correlated with PH (r=-0.280*), while the other yield components were not significantly related with GY. Path coefficient analysis indicated that PN m-2 (0.23), 1000-GW (0.35) and GNP (0.22), GFP (0.16) and DM (0.09) had positive direct effects on GY while GWP (-0.40) and PH (-0.24) had negative direct effects on GY. However, when the positive direct and indirect effects were added to the negative direct and indirect effects for traits, the sum of direct and indirect effects of GFP, PN m-2 and DM on GY were positive and at the rate of 72.48, 57.34 and 35.05 %, respectively. The effects of these traits were higher than those of 1000-GW and GNP. The sum direct and indirect effects of PH was negative and at the rate of 58.92 %. Therefore, GFP, PN m-2, DM and PH could have priorities in breeding programs for the conditions of East Mediterranean region of Turkey.

Key words: oat, path analyses, correlation coefficients.

Introduction

Oat (*Avena* spp.) is a cereal crop that is used throughout the world for human food and animal feed. Compared to other cereal crops, oat is reputed to be better suited for production under marginal environments, including cool-wet climates and soils with low fertility (Hoffmann, 1995). However, oat yield can not compete with wheat and barley grain yields, in the other production areas. It needs improved grain yield for most of the production areas. Grain yield is the result of a number of complex morphological and physiological processes affecting each other and occurring in different growing stages (Dokuyucu and Akkaya, 1999). In general, oat breeders select varieties based on grain yield and desirable traits, observed from heading to maturity. Beside grain yield, these traits are panicle number per square meter, plant height, grain number per panicle, grain weight per panicle, 1000-grain weight, days to maturity and grain filling period.

The advantage of path analysis is that; it permits the partitioning of the correlation coefficient into its components (Dewey and Lu, 1959). In agriculture, path analyses have been used by plant breeders to assist in identifying traits that are useful as selection criteria to improve crop yield (Dewey and Lu, 1959; Milligan et al., 1990). This technique is useful in determining the direct influence of one variable on another, and also separates the correlation coefficient into its components (Rodriguez et al., 2001). Path analysis is a tool that is available to the breeder for better understanding the causes involved in the associations between traits and to partition the existing correlation into direct and indirect effects, through a main variable (Lorencetti et al., 2006). There is rather agreement among plant breeders that associations among oat (*Avena sativa* L.) agronomic traits are very important to increase the use of indirect selection to improve grain yield (Benin, et al., 2003).

The objectives of this study were i-) to estimate Pearson correlation coefficients between grain yield and yield components for oat genotypes, and ii-) to investigate direct and indirect effects of yield components on oat grain yield.

Material and Method

Seventeen oat (*Avena* spp.) genotypes used in this study were nine cultivars (Ankara-76, Ankara-84, Apak 2-3, Bozkır 1-5, Seydişehir, Faikbey, Yeşilköy-330, Yeşilköy-1179, and Checota) and eight landraces (Erzurum, Ordu, Amasya, Sivas, Antalya, Tokat, Çanakakale-Ovacık Köyü and Samsun Ladik-İbiköyü). Field experiments were carried out in rainfed conditions for two winter cropping years (2002-03 and 2005-06) in Kahramanmaras province located in between 37^0 53^1 N, 36^0 58^1 E in East-Mediterranean Region of Turkey. Some climatically data in the region were given in Table 1. Available rainfall in experiment years was higher than average rainfall of long-term years (Table 1). Some chemical and physical traits of two years experiment soils sampled from 0-30 cm topsoil are shown in Table 2.

Pearson correlations and path coefficients among yield and yield components were determined by statistical software of TARIST (Açıkgöz et al. 1994).

Table 1. Some average climatically data belong to experiment (2002-03 and 2005-06) and long term years (1930-2006) in Kahramanmaras province.

	Rainfall (mm)			Temperature (°C)		
Months	2002-03	2005-06	Long Term (1930-2006)	2002-03	2005-06	Long Term (1930-2006)
November	75.8	69.6	60.1	13.5	10.8	12.0
December	78.1	93.5	119.4	4.2	8,4	6.5
January	120.0	102.0	133.1	7.1	3.8	4.3
February	213.8	232.7	110.1	3.8	6.9	6.3
March	145.8	96.8	90.4	8.0	11.7	10.4
April	88.7	36.6	68.7	15.0	17.0	14.9
May	30.4	14.1	35.0	14.1	21.9	19.9
June	1.6	-	7.0	25.6	27.4	24.7
Total	754.2	645.3	623.8			
Mean				11.4	13.5	12.4

Table 2. Some chemical and physical traits of topsoil (0-30 cm), in the experiment field.

Years	Depth (cm)	Texture	pH	Lime ($CaCO_3$) (%)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Organic Matter (%)
2002-03	0-30	Loamy	7.51	24.48	95.4	911.7	1.077
2005-06	0-30	Loamy	7.54	23.74	55.2	1062.6	1.081

Results and Discussion

Correlation coefficients between all pairs of variables used in this experiment are shown in Table 3. According to the correlation coefficients, there was a negative and significant correlation between GY and PH (r= -0.280*), while there were positive and significant correlations between PH and GNP (r=0.281*), GWP and GNP (r=0.702**), 1000-GW and GWP (r=0.422**), 1000-GW and GFP (r=0.352**), DM and GFP (r=0.349**), PN m-2 and 1000-GW (r=0.234*).

Table 3. Correlation coefficients between grain yield and yield-related traits.

	1.	2.	3.	4.	5.	6.	7.	8.
1. Plant Height	1.000							
2. Grain Number per Panicle	0.281*	1.000						
3. Grain Weight per Panicle	0.227	0.702**	1.000					
4. 1000 Grain Weight	0.101	0.147	0.422**	1.000				
5. Grain Filling Period	0.201	0.027	0.207	0.352**	1.000			
6. Days to Maturity	0.018	0.113	0.195	0.050	0.349**	1.000		
7. Panicle Number per m^2	0.044	0.005	0.090	0.234*	0.071	0.109	1.000	
8. Grain Yield	-0.280*	0.170	0.195	0.007	0.213	0.105	0.222	1.000

According to these values, GY was significantly and negatively correlated with only PH. This situation may be due to lodging occurred in plots. In previous works, Buerstmayr et. al (2006) determined significant and negative correlations between plant height and grain yield in oat plants and reported that plant height and lodging severity were also positively correlated.

Rocquigny et. al. (2004) also reported that the semi dwarf character in cereals was associated with increased yield.

Negative indirect effects of GNP through GWP, PH and 1000-GW were higher than its positive direct effect. Yang, (1986) and Moradi et al. (2005) also determined that GNP showed the highest direct effect on GY of oat genotypes. Our findings are partly in agreement with these results mentioned above. Grain weight per panicle had negative direct effect on GY at the rate of 48.65 %; while it had positive indirect effect through GNP and 1000-GW (18.46 and 17.78 % respectively). Benin et al. (2003) reported that direct and indirect effect of GWP on GY. Although, 1000 grain weight had positive direct effect at the rate of 50.51 % on GY, it had negative indirect effects at the rate of 49.46 % through all the other traits. Therefore, contribution of 1000-GW to GY was less.

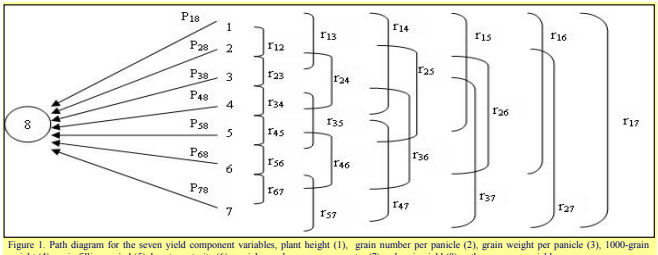

Figure 1. Path diagram for the seven yield component variables, plant height (1), grain number per panicle (2), grain weight per panicle (3), 1000-grain weight (4), grain filling period (5) days to maturity (6), panicle number per square meter (7) and grain yield (8) as the response variable.

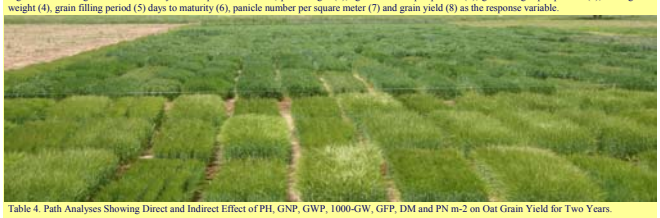

Table 4. Path Analyses Showing Direct and Indirect Effect of PH, GNP, GWP, 1000-GW, GFP, DM and PN m-2 on Oat Grain Yield for Two Years.

Traits	Effect Values	The Ratio in Total (%)	Traits	Effect Values	The Ratio in Total (%)
Plant Height			**Grain Filling Period**		
Direct Effect on GY, P_{18}	-0.240	50.60	Direct Effect on GY, P_{58}	0.162	34.22
Grain Number per Panicle, $r_{12}P_{28}$	0.062	13.05	Plant Height, $r_{12}P_{18}$	0.048	10.22
Grain Weight per Panicle, $r_{13}P_{38}$	-0.092	19.45	Grain Number per Panicle, $r_{23}P_{38}$	-0.006	1.26
1000 Grain Weight, $r_{14}P_{48}$	0.035	7.47	Grain Weight per Panicle, $r_{24}P_{48}$	0.084	17.86
Grain Filling Period, $r_{15}P_{58}$	-0.033	6.85	1000 Grain Weight, $r_{25}P_{58}$	-0.124	26.23
Days to Maturity, $r_{16}P_{68}$	-0.001	0.35	Days to Maturity, $r_{26}P_{68}$	0.032	6.68
PanicleNumber m^{-2}, $r_{17}P_{78}$	-0.010	2.19	Panicle Number m^{-2}, $r_{27}P_{78}$	0.017	3.50
Grain Number per Panicle			**Days to Maturity**		
Direct Effect on GY, P_{28}	0.220	34.30	Direct Effect on GY, P_{68}	0.090	30.29
Plant Height, $r_{12}P_{18}$	-0.067	10.52	Plant Height, $r_{12}P_{18}$	0.004	1.47
Grain Weight per Panicle, $r_{23}P_{38}$	-0.286	44.57	Grain Number per Panicle, $r_{23}P_{38}$	0.025	8.34
1000 Grain Weight, $r_{24}P_{48}$	-0.052	8.05	Grain Weight per Panicle, $r_{24}P_{48}$	-0.079	26.53
Grain Filling Period, $r_{25}P_{58}$	-0.004	0.68	1000 Grain Weight, $r_{25}P_{58}$	-0.018	5.93
Days to Maturity, $r_{26}P_{68}$	0.010	1.59	Grain Filling Period, $r_{26}P_{68}$	0.056	18.88
Panicle Number m^{-2}, $r_{27}P_{78}$	0.001	0.19	Panicle Number m^{-2}, $r_{27}P_{78}$	0.025	8.53
Grain Weight per Panicle			**Panicle Number per m^2**		
Direct Effect on GY, P_{38}	-0.407	48.65	Direct Effect on GY, P_{78}	0.234	60.64
Plant Height, $r_{13}P_{18}$	-0.054	6.49	Plant Height, $r_{13}P_{18}$	0.011	2.76
Grain Number per Panicle, $r_{23}P_{28}$	0.155	18.46	Grain Number per Panicle, $r_{23}P_{28}$	0.001	0.29
1000 Grain Weight, $r_{34}P_{48}$	0.149	17.78	Grain Weight per Panicle, $r_{24}P_{48}$	0.037	9.47
Grain Filling Period, $r_{35}P_{58}$	-0.033	4.00	1000 Grain Weight, $r_{35}P_{48}$	-0.082	21.31
Days to Maturity, $r_{36}P_{68}$	0.017	2.10	Grain Filling Period, $r_{36}P_{68}$	0.011	2.95
Panicle Number m^{-2}, $r_{37}P_{78}$	-0.021	2.51	Days to Maturity, $r_{37}P_{68}$	0.098	2.54
1000 Grain Weight					
Direct Effect on GY, P_{48}	0.352	50.51			
Plant Height, $r_{12}P_{18}$	-0.024	3.47			
Grain Number per Panicle, $r_{23}P_{28}$	-0.032	4.63			
Grain Weight per Panicle, $r_{24}P_{38}$	-0.172	24.68			
Grain Filling Period, $r_{25}P_{58}$	-0.057	8.16			
Days to Maturity, $r_{26}P_{68}$	-0.004	0.65			
Panicle Number m^{-2}, $r_{27}P_{78}$	-0.055	7.87			

According to this result, the effect of 1000-GW may be accepted as changeable. In previous works, Yang (1986), Ram (1992), Mehetre et al. (1994), Samonte et al. (1998), Sürek et al. (1998) reported that GY was influenced by 1000-GW. Bhutta et al. (2005) also reported negative indirect effect of 1000-GW on GY. Our results are in agreement with findings of previous researchers. Grain filling period had positive direct effect on GY (34.22 %) and it had positive indirect effects through GWP (17.86 %), PH (10.22 %), DM (6.68 %) and PNm-2 (3.50 %), while it had a negative indirect effects through 1000-GW (26.23 %) and GNP (1.26 %). When the positive direct and indirect effects of GFP on GY were added to the its negative indirect effects, the sum effect was positive and at the rate of 72.48 %. Therefore, GFP had the highest effect on GY of oat plants. This situation may be due to oat genotypes with higher GY, earliness heading and longer GFP. In previous works, Buerstmayr et al. (2005) pointed out that earliness was a breeding goal in many oat breeding programs.

Lorencetti et al. (2006) also reported that selection for plants with longer period between flowering and maturation. Our findings are in agreement with the results obtained from previous works. Days to maturity had positive direct effect on GY (30.29 %) and it had positive indirect effect on GY through GFP (18.88 %), PN m-2 (8.53 %), GNP (8.34 %), and PH (1.47 %) but it had negative indirect effect on GY through GWP (26.53 %) and 1000-GW (5.93 %). When the positive total effects was added to the negative effects, the sum effect of DM on GY was positive and at the rate of 35.05 %. These findings are in agreement with the result of previous work.

It was reported that selection for plants with fewer days from emergence to flowering and longer period between flowering and maturation would provide higher grain yielding genotypes (Lorencetti et al., 2006). Panicle numbers per m^2 had the highest direct effect on GY at the rate of 60.64 % and it had positive indirect effects through GWP (9.47 %), GFP (2.95 %), PH (2.76 %), DM (2.54 %) and GNP (0.29 %) but it had negative indirect effect on GY through 1000-GW (21.31 %). When the positive direct and indirect effects were added to the negative indirect effect of 1000-GW, the sum effect of PN m-2 on GY was positive and at the rate of 57.34 %. Our findings are in agreement with the results of previous works. Moradi et al. (2005) reported that PN m-2 and GNP had the largest direct effect on GY. Lorencetti at al. (2006) also reported higher direct effect of PN m-2 on GY and its great importance in determining GY of a genotype.

Conclusions

According to the correlation coefficients, GY negatively and significantly correlated with PH. Path analysis revealed that PN m-2, 1000-GW, GNP, GFP and DM were the most important traits that had positive direct effect (at the rate of 60.64, 50.51, 34.30, 34.22 and 30.29 % respectively) on oat grain yield. On the other hand, PH and GWP had negative direct effects on GY (50.60 and 48.65 % respectively). However, when the positive direct and indirect effects were added to the negative direct and indirect effects for traits, the sum of direct and indirect effects of GFP, PN m-2 and DM on GY were positive and at the rate of 72.48, 57.34 and 35.05 %, respectively. The effects of these traits were higher than those of 1000-GW and GNP. The sum of direct and indirect effects of PH was negative and at the rate of 58.92 %. Therefore, GFP, PN m-2, DM and PH could have priorities in breeding programs for the conditions of East Mediterranean region of Turkey.

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