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Determination of Interrelationships Among Important Nut Quality Characteristics on Palaz and Sivri Hazelnut Cultivars by Path Analysis

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Abstract: This study was carried out on Palaz and Sivri hazelnut cultivars grown in central Ordu and the surrounding area. The interrelationships among husk length, nut length, nut width, nut height nut weight, shell thickness, kernel length, kernel width, kernel height, , kernel weight and percent kernel were determined using path analysis. From the path analysis, it was found that percent kernel in Palaz cultivar was affected by shell thickness (r=-0.419**) and husk length (r=-0.350**) according to nut weight; in Sivri cultivar, it was affected by nut length according to nut weight (r=-0.351**) and by kernel width according to kernel weight (r=0.324**). There were also negative effects on percent kernel from the other characteristics according to nut weight. The correlations of percent kernel-nut length, percent kernel-kernel width, percent kernel-kernel height and percent kernel-kernel weight in Palaz cultivar, and percent kernel-nut weight, percent kernel-kernel length and percent kernel-kernel height in Sivri cultivar were not significant.

Palaz ve Sivri Fındık Çeşitlerinde Önemli Meyve Kalite Özellikleri Arasındaki Karşılıklı İlişkilerin Path Analizi ile Belirlenmesi

Özet: Bu çalışma, Ordu Merkez ilçe ve köylerinde yetiştirilen Palaz ve Sivri fındık çeşitlerinde yürütülmüştür. Çeşitlerde, zuruf uzunluğu, meyve uzunluğu, meyve genişliği, meyve yüksekliği, meyve ağırlığı, kabuk kalınlığı, iç uzunluğu, iç genişliği, iç yüksekliği, iç ağırlığı ve iç oranı özellikleri arasındaki karşılıklı ilişkiler path analizi ile belirlenmiştir. Çalışma sonucunda, Palaz çeşidinde; iç oranına, kabuk kalınlığının meyve ağırlığından dolayı olan negatif etkisi (r=-0.419**) ve zuruf uzunluğunun meyve ağırlığı dolayısıyla negatif etkisi (r=-0.350**); Sivri çeşidinde, iç oranına meyve boyunun meyve ağırlığından dolayı olan negatif etkisi (r=0.351**) ve iç genişliğinin iç ağırlığı dolayısıyla pozitif etkisi (r=-0.324**) çok önemli bulunmuştur. Ayrıca, her iki çeşitte de, iç oranına diğer bazı özelliklerin de meyve ağırlığı dolayısıyla genel olarak negatif yönde etki ettiği belirlenmiştir. Palaz çeşidinde, iç oranı-meyve boyu, iç oranı-iç genişliği, iç oranı-iç kalınlığı ve iç oranı-iç ağırlığı; Sivri çeşidinde, iç oranı-meyve ağırlığı, iç oranı-iç uzunluğu ve iç oranı-iç kalınlığı ilişkileri önemsiz çıkmıştır.

Introduction

The center of origin of the most important wild and cultivated species of hazelnut is Turkey, where cultivation and trade first took place. In Turkey, conventional production practices arising from a variety of factors have long been used and adaptation of improved production technologies is quite limited (1). In hazelnut growing, a variety of cultivars and forms have been used in Turkey (2).

Suckers are used for hazelnut propagation in Turkey. In hazelnut plantations containing a variety of cultivars and forms, the harvested product is mostly a mixture of nuts heterogeneous in shape, size and quality (3).

In hazelnut breeding, greater priority has been given to improving round and thin-shelled nuts with a high percent kernel (4).

The coefficient of correlation is not informative in all cases in explaining cause and effect relationships in the variables, since the association between two variables may depend on a third variable. The use of path analysis provides a plausible explanation of observed correlations by modeling the cause- and effect relations between the variables. Thus, it is possible to analyze the correlation coefficient of variables in the form of variance and covariance using path analysis (5).

The aim of this study is to determine interrelationships among important nut quality characteristics in hazelnut and to ease the difficulties encountered in breeding studies.

Materials and Methods

This study was carried out on the nuts of Palaz picked from 38 hazelnut plantations and of Sivri picked from 41 hazelnut plantations in Ordu region in 1995. A total of about 8000 samples (100 random samples from each plantation) were collected in central Ordu and the surrounding area. Of 8000 nuts, 1000 randomly selected samples (500 randomly selected samples from each

cultivar) were evaluated for important characteristics: husk length (HL), nut length (NL), nut width (NW), nut height (NH), nut weight (NWE), shell thickness (ST), kernel length (KL), kernel width (KW), kernel height (KH), kernel weight (KWE) and percent kernel (KP).

The maximum values between tip and base were used to determine nut and kernel length, between the sutures for nut width, between the cheeks for nut thickness, between sutures of cotyledons for kernel width and between the cheeks of cotyledons for kernel thickness (1). In determining weight and other measurements, a weighing machine (0.01 g) and compass (0.05 mm) were used, respectively. The nuts were weighed at a moisture level of 8%.

The formula used in determining the shape index is given below (1):

$$\text{Shape Index (SI):} \frac{\text{length}}{(\text{width}+\text{height})/2}$$

The coefficients of correlation between characteristics were calculated, and direct and indirect effects were studied using path analysis (6).

Results and Discussion

The mean values of the characteristics studied in Palaz and Sivri cvs. are presented in Table 1, and the coefficients of correlation between these characteristics are presented Table 2.

Table 1. Average values of characteristics examined in Plaz and Slvri Hazelnut cultivars

Traits	Palaz	Sivri
Husk length (cm)	3.835	3.810
Nut length (cm)	1.689	2.096
Nut width (cm)	1.899	1.630
Nut height (cm)	1.686	1.490
Nut weight (g)	2.021	1.925
Shell thickness (mm)	0.088	0.086
Kernel length (cm)	1.260	1.624
Kernel width (cm)	1.434	1.208
Kernel height (cm)	1.327	1.111
Kernel weight (g)	1.087	0.994
Percent kernel (%)	53.92	51.71
Nut shape index	0.945	1.344
Kernel shape index	0.913	1.401

Table 2. Correlation coefficients (r) between characteristics of Palaz (P) and Sivri (S) hazelnut cultivars (PK: percent kernel, KWE: kernel weight, KH: kernel height, KW: kernel width, KL: kernel length, ST: shell thickness, NWE: nut weight, NH: nut heigth, NW: nut width, NL: nut length, HL: husk length)

		KP	KWE	KH	KW	KL	ST	NWE	NH	NW	NL
HL	P	-0.350**	0.336**	0.269*	0.271*	0.006	0.195	0.454**	0.443**	0.499**	0.101
	S	-0.245*	0.409**	0.293**	0.209	0.259*	0.114	0.510**	0.393**	0.463**	0.359**
NL	P	-0.043	0.071	-0.046	-0.048	0.554**	0.070	0.069	0.020	-0.079	---
	S	-0.351**	0.497**	0.386**	0.124	0.795**	0.348**	0.630**	0.555**	0.426**	---
NW	P	-0.312**	0.729**	0.696**	0.720**	-0.293**	0.196	0.828**	0.820**	---	
	S	-0.277*	0.662**	0.551**	0.462**	0.388**	0.329**	0.785**	0.757**	---	
NH	P	-0.276*	0.738**	0.809**	0.607**	-0.150	0.121	0.815**	---		
	S	-0.282**	0.661**	0.853**	0.222*	0.410**	0.295**	0.787**	---		
NWE	P	-0.296**	0.919**	0.818**	0.803**	-0.148	0.362**	---			
	S	-0.166	0.915**	0.731**	0.546**	0.622**	0.304**	---			
ST	P	-0.419**	0.208	0.092	0.258*	-0.142	---				
	S	-0.287**	0.194	0.233*	0.055	0.179	---				
KL	P	0.236*	-0.040	-0.111	-0.286**	---					
	S	-0.130	0.566*	0.314**	0.216	---					
KW	P	0.017	0.841**	0.707**	---						
	S	0.324**	0.658**	0.246*	---						
KH	P	0.084	0.885**	---							
	S	0.092	0.749**	---							
KWE	P	0.096	---								
	S	0.235*	---								

*, **: significant at 0.05 and 0.01 probability, respectively. n=500

The shape index of Sivri cv. was higher than that of Palaz cv. The husk length of both cultivars were very similar (Table 1).

The percent kernel exhibited the highest correlation with shell thickness (r=-0.419**) in Palaz cultivar, whereas the greatest association of the percent kernel was with nut hength (r=-0.351**) and kernel width (r=0.324**) in Sivri cultivar (Table 2). The correlations of percent kernel-nut length, percent kernel-kernel width, percent kernel-kernel height and percent kernel-kernel weight in Palaz cultivar, and percent kernel-nut weight, percent kernel-kernel length and percent kernel-kernel height in Sivri cultivar were not significant (Table 2).

With the except of the correlation between kernel weight and kernel length, all the correlations of kernel weight with kernel length, kernel width and kernel height were positive in Palaz cultivar. In previous studies of hazelnut (7) and almond (8), similar results were obtained. The results revealed that the association of kernel width with kernel height was positive but it was negative with kernel length, at a level of probabilty of 0.01 in Palaz. In Sivri cultivar, positive and significant correlation coefficients were found between kernel height and kernel length (at a level of 0.01), and between kernel height and kernel width (at 0.05).

All the correlations of kernel weight with nut length, nut width and nut height were found to be positive and significant, in general at a level of 0.01, except for kernel weight-nut length, which was not significant in Palaz cultivar. The correlation between kernel weight and percent kernel was not significant in Palaz, but significant in Sivri cultivar. In similar studies of hazelnut (7), almond (8) and walnut (9, 10), positive and significant correlations were noticed between the characteristics mentioned above at a level of 0.01.

The correlation between kernel weight and shell thickness was positive and nonsignificant in the cultivars. In other similar studies of hazelnut, almond and walnut, it was determined that the correlations between kernel weight and shell thickness were positive and significant at a level of 0.01 in hazelnut (7) and walnut (10, 11), but nonsignificant in almond (8).

In both cultivars, percent kernel exhibited negative and significant correlations with nut width and nut height. In Sivri the association between percent kernel and nut length was negative and significant at a level of 0.01. These correlations in walnut (9, 12) were not significant, whereas in hazelnut, as in this study, some differences were obtained (7).

There was a negative and significant (at 0.01) correlation between percent kernel and shell thickness in both cultivars. In addition, the association between percent kernel and nut weight was negative and significant (at 0.01) in Palaz, but it was not significant in Sivri. These results showed that there were some similarities between our results and those from hazelnut (7) and walnut (10).

It has been accepted that husk properties are defining factors of the cultivars (4). The correlation of husk length-percent kernel was negative and significant at 0.01 in Palaz cultivar, while it was negative and significant in Sivri cultivar. It was observed that the correlations between husk length and kernel length, kernel width kernel height were all positive. The correlation coefficients of husk length with nut weight, nut height, nut width were significant at a level of 0.01 in both cultivars. Furthermore, a significant correlation was found between husk length and nut length in Sivri. A nonsignificant correlation was found between hust length and shell thickness was observed in both cultivars. The correlations above were similar to those of Bostan (7).

The path coefficient analysis of direct and indirect effects of important characteristics on percent kernel, effect percentages and correlation coefficients in Palaz and Sivri hazelnut cvs. are presented in Table 3 and 4.

In Palaz cultivar, the indirect effects of shell thickness, husk length, nut width and nut height according to nut weight on percent kernel were negative. The effect of kernel length on percent kernel according to nut weight was positive.

In Sivri cultivar, nut length, nut height, nut width, shell thickness and husk length had a negative effect on percent kernel according to nut weight. The direct effect of kernel weight and indirect effect of kernel width according to kernel weight on percent kernel were positive. The results of this study are in agreement with those of Bostan's study of hazelnut (7).

In conclusion, the percent kernel, which is an important nut characteristic, was affected by some other nut properties. In both cultivars, it was determined that nut weight and kernel weight had negative and positive effects, respectively on the other properties. Correlation coefficients between husk length and nut weight and between husk length and kernel weight were positive and significant at a level of 0.01, while between husk length

Table 3. Path coefficient analysis of direct effects (DE) and indirect effects of important characteristics on percent kernel and correlation coefficients (CC) in Palaz hazelnut cultivar (HL: husk length, NL: nut length, NW: nut width, NH: nut height, NWE: nut weight, ST: shell thickness, KL: kernel length, KW: kernel width, KH: kernel height, KWE: kernel weight)

	PALAZ		INDIRECT EFFECTS									
	CC	DE	HL	NL	NW	NH	NWE	ST	KL	KW	KH	KWE
HL	-0.350**	-0.022	---	-0.002	0.018	-0.039	-1.086	-0.005	0.000	0.003	0.020	0.763
NL	-0.043	-0.021	-0.002	---	-0.003	-0.002	-0.165	-0.002	-0.006	-0.001	-0.003	0.161
NW	-0.312**	0.037	-0.011	0.002	---	-0.072	-1.981	-0.005	0.003	0.008	0.052	1.656
NH	-0.276*	-0.088	-0.010	0.000	0.030	---	-1.950	-0.003	0.002	0.007	0.061	1.676
NWE	-0.296**	-2.393	-0.010	-0.002	0.031	-0.072	---	-0.010	0.002	0.009	0.061	2.088
ST	-0.419**	-0.027	-0.004	-0.001	0.007	-0.011	-0.856	---	0.002	0.003	0.007	0.472
KL	0.236*	-0.011	0.000	-0.002	-0.011	-0.013	0.354	0.004	---	-0.003	-0.008	-0.091
KW	0.017	0.011	-0.006	0.001	0.027	-0.053	-1.922	-0.007	0.003	---	0.053	1.911
KH	0.084	0.075	-0.006	0.001	0.026	-0.071	-1.957	-0.002	0.001	0.008	---	2.011
KWE	0.096	2.272	-0.007	-0.002	0.027	-0.065	-2.199	-0.006	0.000	0.010	0.066	---

Table 4. Path coefficient analysis of direct effects (DE) and indirect effects of important characteristics on percent kernel and correlation coefficients (CC) in Sivri hazelnut cultivar (HL: husk length, NL: nut length, NW: nut width, NH: nut height, NWE: nut weight, ST: shell thickness, KL: kernel length, KW: kernel width, KH: kernel height, KWE: kernel weight)

	SİVRİ		INDIRECT EFFECTS									
	CC	DE	HL	NL	NW	NH	NWE	ST	KL	KW	KH	KWE
HL	-0.245*	-0.010	---	-0.039	-0.002	-0.072	-1.061	-0.004	0.027	0.028	0.084	0.804
NL	-0.351**	-0.108	-0.004	---	-0.002	-0.102	-1.310	-0.012	0.083	0.016	0.111	0.977
NW	-0.272*	-0.005	-0.005	-0.046	---	-0.139	-1.633	-0.011	0.040	0.061	0.158	1.301
NH	-0.282**	-0.183	-0.004	-0.060	-0.004	---	-1.637	-0.010	0.043	0.030	0.245	1.300
NWE	-0.166	-2.080	-0.005	-0.068	-0.004	-0.144	---	-0.010	0.065	0.073	0.210	1.799
ST	-0.287**	-0.034	-0.001	-0.038	-0.002	-0.054	-0.632	---	0.019	0.007	0.067	0.381
KL	-0.130	0.104	-0.003	-0.086	-0.002	-0.075	-1.294	-0.006	---	0.029	0.090	1.113
KW	0.324**	0.133	-0.002	-0.013	-0.002	-0.041	-1.136	-0.002	0.022	---	0.071	1.294
KH	0.092	0.287	-0.003	-0.042	-0.003	-0.156	-1.520	-0.008	0.033	0.033	---	1.473
KWE	0.235*	1.966	-0.004	-0.054	-0.003	-0.121	-1.903	-0.007	0.059	0.088	0.215	---

and percent kernel it was negative and significant at a level of 0.01. In both cultivars, shell thickness had a negative effect on percent kernel, significant at a level of 0.01. There were some negative correlations between percent kernel and nut length, nut width and nut height, but positive correlations with kernel length, kernel width and kernel height.

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