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Repeatability and correlations among peach physical traits

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ABSTRACT - *Selection fields of fruit crops are commonly installed without statistical design. This impairs the acquisition of trustworthy information and genetic parameters such as heritability. The coefficient of repeatability can be used to guide the selection since it defines the superior limit of heritability and can be estimated without much experimental sophistication. The coefficient of repeatability of fruit characters of peaches was estimated. It was verified that the selection based on samples of nine fruits leads to the accuracy of 0.90 in the evaluations of the permanent phenotypic values, indicating the efficiency of mass selection for length, diameter, and weight of the fruit, weight of the pit, firmness of the pulp and the pulp/pit and length/diameter ratios of the fruit. The coefficients of correlation indicate that the fruit physical traits can be improved by selecting for fruit diameter (highly correlated with fruit weight), low ratio L/D, and high ratio pulp/pit.*

Key words: *Prunus persica*, repeatability, genetic improvement, fruit quality.

INTRODUCTION

Peach, including the nectarine, belongs to the species *Prunus persica* L. Batsch, natural of China. It is a hardy deciduous temperate fruit crop species. The selection of genotypes with low chilling requirement for budbreak made commercial growing possible in mild winter areas at low latitudes. In Brazil, peach is grown from Rio Grande do Sul (32º lat S) to Minas Gerais (20º lat S). The genetic improvement was able to develop cultivars adapted to mild winter climates (Raseira and Nakasu 2002). Despite the development of well adapted cultivars the fruit quality needs to be improved.

The long juvenile period and the area required for each plant to grow restrict the adoption of selection fields with adequate statistical designs for the estimation of genetic parameters such as heritability, indispensable to guide genetic improvement programs. The coefficient of repeatability defines the superior limit of heritability (Falconer 1975) and it can be estimated without much experimental sophistication. The estimation of the adequate number of fruits to be sampled for genetic evaluations is very important to obtain good accuracy of the genetic value of the trait requiring least labor, contributing to more efficiency and lower costs.

The statistical concept of repeatability can be expressed as the correlation among the measures assessed in the same individual, repeated in time or in space. Therefore, it expresses

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the proportion of the total variation provided by the genotype and by the permanent environmental conditions (Cruz and Regazzi 1997). The practical importance of such estimates is to check if the performance of the individual reflects the real value of the phenotype. However, the increase of the number of evaluations in the same individual cannot increase the accuracy of the prediction of the phenotypic value when the trait is unstable, while regulated by different groups of genes expressed in different phases (Cruz and Regazzi 1997).

The objective of this work was to estimate the coefficient of repeatability of fruit physical traits of peach, in order to determine the number of measures necessary for an accurate prediction of the real genotype value and the correlation coefficients among the fruit traits.

MATERIAL AND METHODS

The experiment was conducted at the Federal University of Viçosa, in Minas Gerais State, Brazil. Fruits of the following cultivars were evaluated: Peaches - Alô Doçura (Rigitano 1964), Aurora 1 (Ojima et al. 1989), Aurora 2 (Ojima et al. 1989), Biuti (Rigitano and Ojima 1971), Bolão (Rigitano and Ojima 1971), Campinas 1 (O Agronômico 1980), Centenário (Campo-Dall'Orto et al. 1987), Colibri (Rigitano 1964), Cristal (Rigitano and Ojima 1971), FlordaSun (Sharpe 1964), Lake City, Maravilha (O Agronômico 1980), Marli (Nakasu et al. 1979), Okinawa (Rigitano et al. 1975), Ouro Mel (Rigitano and Ojima 1971), Pérola de Itaquera, Premier (Nakasu et al. 1971), Real (Rigitano and Ojima 1971), Régis (Ojima et al. 1987), Rei da Conserva, Relíquia (Rigitano 1964), Setembrino (O Agronômico 1980), Talismã (Rigitano 1964), Tropical (Barbosa et al. 1989), UFV 186 (Bruckner 1988) and UFV 286 (Bruckner 1988); Nectarines - Centenária (Ojima et al. 1988), Josefina (Ojima et al. 1986), and Sunred (Sharpe 1964).

The fruits were sampled in 1994 and 1995. Three to 20 fruits per plot were sampled at the stadium of maximum physiological development, when the ground color of the epidermis changed to green-yellowish or white-cream, according to the cultivar (Cantillano and Sachs 1984). The evaluated traits were: length (mm), diameter (mm), and weight of the fruit (g), weight of the pit (g), firmness of the pulp (kPa) and the length/diameter and pulp/pit ratios.

The software Genes (Cruz 2001) was used for the genetic-statistic analysis. The simple coefficients of correlations among the traits were obtained and their coefficients of repeatability were estimated through the variance analysis method with one variation factor by the model:

$$Y_{ij} = \mu + g_i + \varepsilon_{ij}$$

where

Y_{ij} = value of the trait in the i^{th} cultivar (i = 1, 2, ..., p) and in the j^{th} fruit (j = 1, 2, ..., n_i);

μ = general average;

g_i = random effect of the i^{th} cultivar under influence of the permanent environment;

ε_{ij} = effect of the temporary environment associated to the j^{th} measurement in the i^{th} cultivar.

The coefficient of repeatability was given by:

$$r = \hat{\rho} = \frac{\hat{Cov}(Y_{ij}, Y_{ij,})}{\sqrt{\hat{V}(Y_{ij})\,\hat{V}(Y_{ij,})}} = \frac{\hat{\sigma}_g^2}{\hat{\sigma}_y^2} = \frac{\hat{\sigma}_g^2}{\hat{\sigma}^2 + \hat{\sigma}_g^2}$$

The coefficient of determination was given by:

$$R^2 = \frac{nr}{1 + r\,(n-1)}$$

RESULTS AND DISCUSSION

The cultivars had significant differences in the length, diameter, and weight of the fruit, in the weight of the pit, firmness of the pulp and in the pulp/pit and length/diameter ratios at 1% probability in the two years of analysis (Tables 1), indicating the existence of genetic variability in all traits.

The elevated magnitudes of the coefficients of repeatability in two years (Tables 2 and 3) reflect the accuracy of the evaluation of the phenotypic values, the stability of the cultivars, and the strong genetic control (Cruz and Regazzi 1997) for the length, diameter, and weight of the fruit, the weight of the pit, the firmness of the pulp, and the pulp/pit and length/diameter ratios. Thus, the genotypic variance among the cultivars was relatively high, compared with the environmental variance, and considerable genetic gains could be expected with simple methods of improvement such as the mass selection (Oliveira and Costa Fernandes 2001).

The variation in fruit traits within the cultivars is caused by environmental effects due to the location of the fruits in the branches, competition among the fruits, differences in budbreak time and the occurrence of pests. The prediction of the real value (R^2) of the cultivars was less precise for length/diameter and pulp/pit ratios (Tables 2 and 3), indicating that these traits were more influenced by environmental effects than the other ones (Cruz and Regazzi 1997). While big and round fruits are preferable for marketing purposes, the selection should be done directly for high fruit diameter (highly correlated with fruit weight), low ratio L/D and high ratio pulp/pit. The selection for high fruit weight could lead to an indirect selection for longer fruits with higher L/D ratio (Table 4), which would no be desirable.

The estimates of the coefficients of repeatability expressed a greater stability for length, diameter, and weight of

the fruit, weight of the pit and firmness of the pulp than for length/diameter and pulp/pit ratios. The evaluation of nine fruits is enough to predict the real value of all characters with an accuracy (R^2) of 90% (Tables 2 and 3). A greater accuracy would increase the costs and the time of the evaluations while requiring too large samples (Oliveira and Costa Fernandes 2001). The high coefficient of repeatability indicates that mass selection would be effective to improve these traits.

Table 1. Summary of the variance analysis of peach physical traits

Sources of variation	1994		1995	
	df	MS	df	MS
		Fruit length		
Among cultivars	28	541.3506**	28	331.2216**
Within cultivars	544	14.2814	294	17.8897
		Fruit diameter		
Among cultivars	28	393.0655**	28	234.6959**
Within cultivars	544	12.9754	294	14.9907
		Fruit weight		
Among cultivars	28	4151.2710**	28	2756.5570**
Within cultivars	544	121.9285	294	170.2524
		Pit weight		
Among cultivars	28	22.1869**	28	9.0792**
Within cultivars	544	0.5437	294	0.5537
		Pulp firmness		
Among cultivars	28	176044.3500**	28	87338.8080**
Within cultivars	544	4739.6007	294	4947.8097
		Length/diameter ratio		
Among cultivars	28	0.7552×10^{-1}**	28	0.6165×10^{-1}**
Within cultivars	544	0.3645×10^{-2}	294	0.4381×10^{-2}
		Pulp/pit ratio		
Among cultivars	28	101.4351**	28	84.7108**
Within cultivars	544	4.6559	294	6.4427

**P < 0.01

Table 2. Coefficients of repeatability (r) and of determination (R^2) obtained for samples of 16 and 20 fruits (n) and number of fruits to be sampled to obtain R^2 of 0.90, 0.95 and 0.99 in 1994

Traits	r	R^2		n		
		n = 16	n = 20	R^2 = 0.90	R^2 = 0.95	R^2 = 0.99
Fruit length (L)	0.6513	0.9676	0.9739	4.82	10.17	53.00
Fruit diameter (D)	0.5972	0.9596	0.9674	6.07	12.81	66.77
Fruit weight	0.6258	0.9640	0.9710	5.38	11.36	59.19
Pit weight	0.6683	0.9699	0.9758	5.38	11.36	59.19
Pulp firmness	0.6466	0.9670	0.9734	4.47	9.43	49.13
L/D ratio	0.4995	0.9411	0.9523	9.02	19.04	99.20
Pulp/pit ratio	0.5127	0.9439	0.9546	8.55	18.06	94.10

Table 3. Coefficients of repeatability (r) and of determination (R^2) obtained for samples of 16 and 20 fruits (n) and number of fruits to be sampled to obtain R^2 of 0.90, 0.95 and 0.99 in 1995

Traits	r	R^2		n		
		n = 3	n = 12	R^2 = 0.90	R^2 = 0.95	R^2 = 0.99
Fruit length (L)	0.6116	0.8253	0.9497	5.72	12.07	62.87
Fruit diameter (D)	0.5686	0.7981	0.9405	6.83	14.42	75.12
Fruit weight	0.5773	0.8038	0.9425	8.15	13.91	72.47
Pit weight	0.5806	0.8060	0.9432	6.50	13.72	70.50
Pulp firmness	0.5996	0.8179	0.9473	6.01	12.69	66.11
L/D ratio	0.5403	0.7790	0.9338	7.66	16.17	84.23
Pulp/pit ratio	0.5221	0.7662	0.9291	8.24	17.39	90.63

Table 4. Estimates of the phenotypic correlations among seven fruit traits of peach in 1994 (above diagonal) and 1995 (below diagonal)

Traits	L	D	FW	PW	PF	L/D	Pulp/Pit
Fruit length (L)	-	0.8446**	0.8707**	0.6398**	-0.0371	0.4733**	0.4170*
Fruit diameter (D)	0.8349**	-	0.9554**	0.8140**	0.0042	-0.0659	0.2205
Fruit weight	0.8654**	0.9733**	-	0.8521**	0.0647	0.0548	0.2417
Pit weight	0.6006**	0.7321**	0.7573**	-	0.2428	-0.1507	-0.2840
Pulp firmness	0.1182	0.1984	0.2037	0.4245*	-	-0.0854	-0.2498
L/D ratio	0.4506*	-0.1098	-0.0055	-0.1012	-0.1072	-	0.4334
Pulp/pit ratio	0.5455**	0.5740**	0.5441**	-0.1107	-0.2382	0.0629	-

*, **P < 0.05 and P < 0.01, respectively

CONCLUSIONS

It was verified that the selection based on samples of nine fruits leads to an accuracy of 0.90 in evaluations of the permanent phenotypic values of peach quality traits. Selection based on fruit diameter, low length/diameter, and high pulp/pit ratios are adequate to select peach genotypes with big, round fruits that are rich in pulp.

Repetibilidade e correlações entre características físicas do pessegueiro

RESUMO - *Campos de seleção de fruteiras são comumente instalados sem delineamento estatístico. Isso dificulta a obtenção de informações e parâmetros genéticos como a herdabilidade. O coeficiente de repetibilidade pode ser usado para orientar a seleção, por definir o limite superior da herdabilidade e ser calculado sem muita sofisticação experimental. O coeficiente de repetibilidade de caracteres do fruto do pessegueiro foi estimado. Foi verificado que a seleção baseada em amostras de nove frutos proporciona acurácia de 0,90 nas avaliações dos valores fenotípicos permanentes, indicando a eficiência da seleção massal para comprimento, diâmetro e peso do fruto, peso da semente, firmeza da polpa e relações polpa/semente e comprimento/diâmetro do fruto. Os coeficientes de correlação indicam que o melhoramento para as características físicas do fruto pode ser feito com base na seleção para diâmetro do fruto (altamente correlacionado com peso do fruto), baixa relação comprimento/diâmetro e alta relação polpa/semente.*

Palavras-chave: *Prunus persica*, repetibilidade, melhoramento genético, qualidade de fruto.

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