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EARLY GENERATION SELECTION FOR TUBER APPEARANCE AND ITS INFLUENCE ON POTATO YIELD TRAITS

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Abstract
The objective of this study was to verify the influence of selection for tuber appearance on potato yield traits. A potato hybrid population composed of 20 clones from the Embrapa Temperate Climate breeding program was evaluated. The selection for tuber appearance had a positive effect on genetic gains for yield.

Key words: *Solanum tuberosum* L.; correlation; heritability.

Introduction

Potato breeding programs constantly need new strategies to improve efficiency by increasing the frequency of selected genotypes and reducing time and costs. The possibility of predicting genetic gains that can be achieved by a certain selection strategy is one of the most important contributions of quantitative genetics to plant breeding.

Breeders often select for several traits at each selection stage. However, it is important to know the selection effect of one specific trait on the others (Pereira et al. 1994).

The existence of genetic associations between traits indicates that selection practiced for one trait may lead to changes in another. Depending on the direction, the association between traits may be of interest for breeding. Knowledge on the relationships between traits is therefore very important to choose a suitable selection strategy for a target trait. The strategy may be based on other very closely correlated traits, with higher heritabilities that are easier to measure or to identify (Cruz and Regazzi 2001). In potato, tuber appearance is normally selected in the early and yield in subsequent generations.

The objective of this study was to verify the influence of selection for tuber appearance on yield traits of potato.

Material and Methods

In this study it was used a hybrid population composed of 20 families, randomly sorted from the potato breeding program of Embrapa Temparate Climate, Pelotas, RS, Brazil. The families were derived from crosses targeting cultivar development: C-1750-15-95/Panda, C-1485-6-87/Asterix, Asterix/C-1226-35-80, C-1750-15-95/Canoinhas, Columbus/Eliza, C-1485-6-87/Felsina, Asterix/C-1311-11-82, Agria/C-1226-35-80, C-1750-15-95/Felsina, Shepody/Eliza, Imola/C-1226-35-80, C-1714-7-94/Imola, White Lady/C-1311-11-82, C-1750-15-95/Divina, Divina/C-1226-35-80, Agria/2CRI-1149-1-78, White Lady/2CRI-1149-1-78, C-1750-15-95/Exquiza, C-1750-15-95/Asterix, and Asterix/2CRI-1149-1-78.

A population of 600 clones (30 of each family) was evaluated on the experimental field of the Embrapa Temperate Climate (31°S, 52°W), using second generation clones in spring of 2003, and using third generation clones in autumn 2004. The experiment had a randomized block design, with five plants per clone (plot) in three replications of 200 clones (10 clones of each family/block). The recommended agricultural practices were applied. The following traits were evaluated: yield (g/plot), number of tubers/plot, average tuber weight (yield/number of tubers), tuber appearance (1= excellent: clones with smooth skin, shallow eyes, less long shape, uniform shape, and size), skin smoothness (1= smooth, 5= rough), eye depth (1= shallow, 5= deep), tuber shape (1= long, 5= round), tuber size, and shape uniformity (1= uniform, 5 = non-uniform).

The data were subjected to analysis of variance to estimate genetic parameters. The estimates of variance components were calculated according to Cruz (2001). The environment was treated as fixed effect and the genotype as random effect. The phenotypic (r_p) and genotypic (r_g) correlations between traits were calculated according to the statistical model described by Cruz (2001). The expected correlated response (CR) was estimated according to Falconer (1989). The gain from selection for traits was estimated according to Simmonds (1979).

Results and Discussion

The analysis of variance presented statistical differences ($p \leq 0.05$) for all traits, except for uniformity of tuber size. This indicates the efficiency of the traits to differentiate the genotypes. The genotype x environment interaction was significant for tuber appearance, number of tubers, skin smoothness, and average tuber weight, indicating that the environments caused differential responses of at least one genotype, i.e., the best genotype in one environment may not have been the best in another. The coefficient of genetic variation, which indicates the relative genetic variation, showed similar values among the traits, varying from 3.08% for uniformity of tuber shape to 14.09% for average tuber weight (data not shown).

The selection efficiency depends on the heritability, which indicates the phenotypic superiority of genetic origin that can be transmitted to descents, can be used to estimate response to selection. In the present study, heritability coefficients varied from moderate (0.52) to high (0.73). Only the value for uniformity of tuber size was very low (0.06). The results indicate that this population has genetic variability for most of the evaluated traits. So, tuber appearance and yield traits can be inherited by the descents and estimates of selection gain could be effective at predicting genetic gains (Tai and Young 1984). For uniformity of tuber size, the heritability estimate indicated that a selection strategy based directly on this trait would not provide considerable genetic gain. So, selection for other traits could promote higher gains in uniformity of tuber size than direct selection for this trait (Goldenberg 1968) (Table 1).

Environmental conditions can cause correlations of environmental nature only. Therefore, the phenotypic correlation can be partitioned into their components, environmental and genotypic correlations, which is the most important for breeding. The phenotypic and genotypic correlation coefficients are presented in Table 1. The highest number of significant associations are among the coefficients of genetic correlations, indicating that the environmental effect could be masking the effect of the genetic expression of correlation between traits.

Table 1. Genetic (r_g) and phenotypic (r_p) correlation between tuber appearance traits and yield traits in potato, direct response to selection in percentage of the mean of yield traits, and heritability (h^2).

Traits	Yield		Number of tubers		Average tuber weight		h^2
	r_g	R_p	R_g	r_p	r_g	R_p	
Tuber appearance	-0.49*	-0.38	0.83*	0.49*	-0.99*	-0.68*	60.5
Tuber shape	-0.17	-0.08	-0.12	-0.06	-0.05	-0.01	70.19
Uniformity of tuber shape	0.28	0.14	0.56*	0.29	-0.22	-0.11	51.63
Eye depth	0.22	0.20	0.16	0.09	0.08	0.14	53.44
Skin smoothness	-0.39	-0.23	0.68*	0.47*	-0.85*	-0.56*	72.22
Uniformity of tuber size	0.24	0.14	1.00*	-0.35	-0.21	-0.15	6.48
Direct effect	81.55		92.93		120.3		-
h^2	65.77		70.94		72.90		-

*Significant at a level of 5% probability of the error.

Tuber appearance showed significant genetic correlations with yield and its components (number of tubers and average tuber weight). It indicates that more appealing tubers were produced in plants with small number of tubers (0.83), higher average tuber weight (-0.99) and yield (-0.49). On the other hand, the magnitudes for phenotypic correlations were smaller and only significant for tuber appearance with number of tubers (0.65) and average tuber weight (-0.68). Besides the association with tuber appearance, the only significant genetic correlation of yield was with average tuber weight (0.71), indicating that as the yield increases so does the average tuber weight (Table 1).

Except for the relationship described with tuber appearance, the trait number of tubers had significant genetic correlation with uniformity of tuber shape (0.56), uniformity of tuber size (1.00) and skin smoothness (0.68). These results allow the conclusion that the increase in number of tubers is associated with a reduction in tuber shape and uniformity of tuber size, resulting in tuber roughness. The phenotypic correlations had smaller magnitudes and were not significant. Thompson et al. (1983) also reported significant genetic correlations for these traits, indicating that the higher the number of tubers the less uniform they are. Besides the previously described correlations, skin smoothness had a significant and negative genetic correlation with average tuber weight (-0.85), indicating that the selection for skin smoothness would result in an increase of the mean tuber weight.

The expected correlated response estimates for yield traits by selecting for tuber appearance traits are shown in Table 2. Considering the traits with significant genetic correlation, the yield would be affected only when selecting for tuber appearance. This effect, however, would result in less than 50% of the estimated direct genetic gain in yield. In a similar study that focused only on indirect gain in yield, Barbosa and Pinto (1997) did not found superior responses than with direct selection for this trait either.

Table 2. Correlated and direct response to selection in percentage of the mean of yield traits[1] by selecting for tuber appearance traits[2] in potato.

Traits	Tuber appearance[2]	Tuber shape	Uniformity of tuber shape
Yield[1]	-38.98	-14.33	20.22
Number of tubers	71.53	-11.14	44.39
Average tuber weight	-109.65	-5.91	-22.27
	Eye depth	Skin smoothness	Uniformity of tuber size
Yield	16.17	-33.34	6.13
Number of tubers	12.93	63.87	28.06
Average tuber weight	8.24	-101.88	-7.52

The selection for tuber appearance, uniformity of tuber shape, skin smoothness, and uniformity of tuber size would result in changes in the number of tubers (Table 2). However, it would take a toll on the traits tuber appearance, skin smoothness, uniformity of tuber size and uniformity of tuber shape (Table 1). Besides, gains with indirect selection for these traits would be lower than by direct selection (92.93%) (Table 1).

Average tuber weight would result in higher gain if tuber appearance and skin smoothness were selected. The selection for these two traits would result in gains of 109.65 and 101.88%, respectively (Table 2). Nevertheless, these values do not exceed the gain expected by a direct selection for average tuber weight, which would be 120.33% (Table 1).

The expected correlated gains expressed that the selection for less complex traits, which are easier to measure and have higher heritabilities and high correlations, could favor selection for yield and tuber appearance. These two traits are complex and influenced by several individual traits and are therefore controlled by various genes and often under strong environmental influence.

Conclusions

Selection for tuber appearance modifies the genetic gains for yield positively, while yield components do not have any influence on yield due to the absence of significant genetic correlations. The expected response for yield by selecting for tuber appearance does however not surpass the direct response.

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АНАЛИЗ РОДОСЛОВНЫХ СОРТОВ КАРТОФЕЛЯ СИБНИИСХ

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Селекция картофеля в Омске началась в 1919 г. на Западно-Сибирской селекционной станции (ныне – Сибирский НИИ сельского хозяйства), где под руководством В.В. Таланова начал работать Л.И. Венени. В качестве метода селекции Л.И. Венени использовал клоновый отбор из местного материала, в котором преобладал сорт Ранняя роза. В 1937 г. селекционные работы в СибНИИСХ были продолжены Л.В. Катиным-Ярцевым и Л.И. Ивановой. В 1939 г. по решению Экономического совета при Совнаркоме СССР, Сибирскому НИИ