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THE USE OF ESTIMATES OF HERITABILITY AND GENETIC VARIANCES IN SELECTION FOR CHIP COLOUR BETWEEN POTATO POPULATIONS

ABSTRACT

The objective of this research was to examine the expected responses to selection for colour of chips (= crisps) produced directly from tubers stored at 4-6°C for three months in three potato populations. Population 1 was obtained from crossing cv. Lady Claire with parental line M-62774, Population 2 was derived from crossing cv. Snowden with parental line M-62724. Both populations originated from crosses between cold chipping parents. Population 3 was produced by intermating cold chipping parent (cv. Snowden) with good chipping parent (M-62805) that requires the reconditioning treatment. Fifty-eight to sixty random clones for each population plus four parents and four control cultivars were planted in 2003 and 2004 at Młochów Research Center of Plant Breeding and Acclimatization Institute. A considerable genotypic variation in chip colour after cold storage has been found within three hybrid populations. Heritability estimates were moderate, ranging from 0.42 to 0.53, and each of these populations exhibited good potential advance by selection for chip colour after cold storage.

Key words: breeding, chip colour, heritability, potato, selection response

INTRODUCTION

The development of processing cultivars and improvement of parental lines, which are characterized by low level of reducing sugars and ability to give light coloured fried product after cold storage (4-6°C) is receiving high priority in potato breeding programmes in North America and Europe (Thill and Peloquin, 1995; Mackay *et al.*, 1997; Hayes and Thill, 2002). The choise of breeding populations for improving fry colour has been based on tuber progeny test (Mackay *et al.*, 1997; Esplin and Thill, 2004). The use of parental forms with positive general combining ability effects for chip colour obtained after cold storage or parental combinations with specific combining ability effects increases the frequency of progeny individuals characterized by light chip colour (Ehlenfeldt *et al.*, 1990; Pereira *et al.*, 1995; Domański *et al.*, 2004d). The use of estimates of heritability and genetic variances gives further chances of improvement of potato populations by selection. For potatoes, a clonally propagated crop,

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heritability in the broad sense should be used to predict the response to selection within breeding population because all genetic variability is utilizable between asexual generations of selection (Tai and Young, 1984; Nyquist, 1991).

The purpose of this study was to examine the expected responses to selection for chip (crisp) colour after storage at 4-6°C in three potato populations originated from crosses between parents with good chipping quality.

MATERIAL AND METHODS

Hybrid populations derived from crosses among five parents were used in this study. The chosen parents represented good chipping ability. Clones M-62724 and M-62774 and cultivars Lady Claire and Snowden were cold chipping parents. Clone M-62805 was parent with good chipping ability after cold storage with reconditioning. Population 1 consisting of 58 randomly chosen clones was derived from the cross cv. Lady Claire x M-62774; Population 2 (n=59) was obtained from the cross cv. Snowden × M-62724; Population 3 (n=60) was derived from the cross cv. Snowden × M-62805. The four parents, plus four cultivars (Bila, Danusia, Saturna, Triada) ranging broadly in chipping ability were also included in experiments. Potatoes were grown in field trials over two years (2003-2004) at Młochów Research Center of the Plant Breeding and Acclimatization Institute.

Clones of the three hybrid populations were nonreplicated and randomly distributed in each of the trials. Each trial was planted as an augmented block design (Federer and Raghavarao, 1975). Control cultivars were replicated three times in a randomized complete block design. The experimental unit consisted of single three-hill plots spaced 38 cm apart with 67.5 cm between drills. The soil was a loamy sand and was fertilized with nutrients of the following doses ($kg \times ha^{-1}$): 110 N, 75 P_2O_5, 165 K_2O, 75 S, 19 MgO. Pest control and other cultural practices were similar to the commercial plantings in the area. The harvest of tubers was performed at full maturity of plants and at air temperatures above 10°C. The 8-tuber samples of marketable size (55-75 mm in diameter), free from disease and damage symptoms were selected from each plot for assessment of chip colour. The assessment was done after three months of storage at 4-6°C without reconditioning. Chips were produced directly after cold storage. Three 1.6 mm thick slices were cut transversally from mid-section of each tuber. Slices were fried in hydrogenated vegetable oil at 180°C in a thermostatically controlled chip fryer until bubbling ceased. Chip colour was visually assessed on 1-9 scale using the IBVL cards (9 = light). Each of the clone/control cultivar means which were used as input data for ANOVA, was based on 24 scores of individual slices.

A random effects model was assumed for statistical analyses. The combined analyses of variance over years were performed for each of the three hybrid populations and the control cultivars. The results of ANOVA for control cultivars provided the estimates of experimental error for testing clone × year mean squares. Components of genetic variance and heritability in the broad sense (plot basis) were estimated by equating mean squares to their expectations

according to the form of ANOVA as described by Pereira *et al.* (1994). Expected responses to selection (R) were computed using formula given by (Falconer, 1989):

$$R = i \times h^2 \times \sigma_p^2 = i \times h^2 \times \sigma_g^2$$

where i, h^2, σ_p^2 and σ_g^2

are standardized selection differential, heritability, phenotypic variance, and genotypic variance, respectively.

All these statistical analyses were performed using MSTAT-C software (Michigan Univ., 1991) and STATGRAPHICS *Plus* v.4.1.

RESULTS AND DISCUSSION

Combined analysis of variance for chip colour after storage at 4-6°C for the eight control cultivars showed significant differentiation between cultivars and years of the frying test (Table 1). The significant effect of interaction cultivar × environment (year) indicated that at least some cultivars responded differently in each year of testing. The analysis of variance for clones in each of the three hybrid populations indicated that the variability of the means for clones and years were all highly significant (Table 2). Mean squares for interaction of clone x year (C × E) were significant in Populations 1 and 3 and not significant in Population2 when tested by the error mean square of the control cultivars.

Table 1

Combined analysis of variance for chip colour scores after cold storage (4-6°) for three months for 8 cultivars

Source of variation	Degrees of freedom	Mean square
Year (E)	1	4.03**
Cultivars (C)	7	7.18**
C × E	7	0.50*
Replications/E	4	0.16
Error	28	0.15

*, ** - significant at $\alpha = 0.05$ and $\alpha = 0.01$ respectively

Mean chip colour scores were on similar level for all populations, however, the frequency of cold chipping clones e.g. (with light chip colour after cold storage at 4-6°C – scores ? 6.8, equal of cv. Snowden) was significantly lower in Population 3 as compared to Populations 1 and 2 (Table 3). Looking at frequency distributions of clones for chip colour we can see that distributions of Populations 1 and 2 were skewed towards high scores, while in Population 3 approximated to normality, what was proved by chi-square analysis of contingency tables.

Populations 1 and 2 originated from crosses between cold chipping parents (Domański *et al.*, 2004a, b). Population 3 was produced by intermating cold chipping parent (cv. Snowden) with good chipping parental line (M-62805) that requires the reconditioning treatment.

Table 2

Combined analysis of variance for chip colour scores after cold storage (4-6°C) for three months for clones of three potato populations grown at Młochów, 2003 and 2004

Population	Source of variation	Degrees of freedom	Mean square
1. Lady Claire × M-62774	Year (E)	1	1.84*
	Clones (C)	57	0.71**
	C x E	57	0.29*
2. Snowden × M-62724	Year (E)	1	6.04**
	Clones (C)	58	0.72**
	C x E	58	0.22
3. Snowden × M-62805	Year (E)	1	14.46**
	Clones (C)	59	0.84**
	C × E	59	0.33*
	Errora		0.15

[a] Mean squares from the analysis of variance of the control cultivars
*, ** - significant at $\alpha = 0.05$ and $\alpha = 0.01$ respectively

The significant mean squares among clones in each of the three populations (Table 2) and the fact that genetic variance components exceeded all other variance components (Table 4), indicate that genetic variation for chip colour after cold storage (4-6°C) existed in all three populations. It was high enough to indicate that genetic improvement for the above mentioned trait could be made through selection. Heritability values for chip colour were moderate, ranging from 0.42 to 0.53 and were similar to the estimates reported by Pereira *et al.* (1995). Population 2 had slightly higher heritability estimates than the other two populations. The expected response to selection were similar in all populations under study. These results indicate that all three populations possess good potential advance by selection for chip colour after cold storage. Out of five parents which were used to develop these populations cv, Snowden and parental lines M-62724 and M-62774 were identified as good general combiners for chip colour in earlier progeny test (Domański *et al.*, 2004c). The valuable features of parental lines M-62774 and M-62805 are high resistance to common and necrotic strains of PVY, medium to high yielding ability, increased starch content and satisfactory tuber appearance (Domański *et al.*, 2004b).

Table 3

Frequency distributions of clones of the three hybrid populations for chip colour

Population	N	Class intervals of chip colour a							Mean ± SE	Percentage of cold chipping clones with chip score ≥ 6,8 [b]
		4.6 - 5.0	5.1 - 5.5	5.6 - 6.0	6.1 - 6.5	6.6 - 7.0	7.1 - 7.5	7.6 - 8.0		
1. Lady Claire × M-62774	58		5	6	21	13	12	1	6.5 ± 0.38	38.0 [a]
2. Snowden × M-62724	59		3	9	16	15	15	1	6.6 ± 0.33	40.7 [a]
3. Snowden × M-62805	60	5	7	18	15	11	4		6.1 ± 0.41	17.5 [b]
Control cultivars			Danusia	Triada M-62805	Saturna	Snowden M-62774	L. Claire			

[a] Chip colour scores: 1 = dark, 9 = light
[b] Comparable frequencies followed by the same letter are not significantly different (á = 0.05) according to Tuckey's Honestly Significant Difference Test

Table 4

Variance components: genetic (σ_g^2); genotype x environment (σ_{ge}^2); error (σ_e^2) and estimates of heritability (h^2), and expected response (R) for chip colour scores for three populations grown at Młochów in the years 2003-2004

Population	Variance components			h^2	R
	σ_g^2	σ_{ge}^2	σ_e^2		
1. Lady Claire × M-62774	0.21	0.14	0.15	0.42	0.52
2. Snowden × M-62724	0.25	0.07	0.15	0.53	0.59
3. Snowden × M-62805	0.25	0.18	0.15	0.43	0.58

CONCLUSIONS

A considerable genotypic variation in chip colour after cold storage has been found within three potato hybrid populations. All these populations possess good potential advance by selection for chip colour. The additional criterion differentiated hybrid populations was the frequency of clones which transgressed the target value for chip colour.

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