Potential of selection among and within potato clonal families

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ABSTRACT - *Objective of this work was to estimate genetic parameters among and within potato clonal families for tuber yield, average tuber weight, tuber appearance and chip color. Twenty families were evaluated in spring 2003 and fall 2004 on the experimental field of Embrapa Clima Temperado, Pelotas, state of Rio Grande do Sul, Brazil. A randomized complete block design with three replications was used. The experimental unit consisted of ten clones represented in five plants each. ANOVA revealed significant differences among and within families for all traits, except for the genotype x growing season interaction. Two families had a superior mean and only one superior variance. The heritability and selection gain estimates among families were higher than within families for tuber appearance, average tuber weight and tuber yield. Only for chip color, heritability and selection gain the estimates among families were similar to the population estimates.*

Key words: *Solanum tuberosum* L., selection gain, heritability, genetic variability.

INTRODUCTION

Any breeding program depends on the availability of a superior population that contains the necessary genetic variability for the selection of new cultivars (Tai 1975).

Potato breeding programs normally begin by obtaining hybrid families, produced in a greenhouse or on the field (Rodrigues and Pereira 2003). The generation of true potato seeds (TPS) used for the production of segregating families is laborious and difficult due to high flower bud dropping and low fruit setting. However, the resulting TPS have a potential for selection of improved clones since they combine parents with complementary traits, allowing the breeder to capitalize on heterosis (Pinto 1999). Eventually, among the hundreds of new clones obtained from these crosses there will be some that combine the parental traits and will be selected, offering advantages over the grown cultivars (Pereira 2003). In order to have success in the identification of superior genotypes, a large number of clones has to be evaluated over two or three years, with a small chance of being selected. In this case, a selection of elite parents becomes necessary to increase the frequency of superior progenies and broaden the segregation at family level, which provides more information on the traits of interest (Swiezynski 1965, 1978).

The choice of a population and a breeding strategy based on families depends on the mean performance and

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the magnitude of variability, which in turn depend on the replication number and the environments in which each family was tested (Eckebil et al. 1977). An alternative method of maximizing the probability of success of a breeding program is to evaluate a few genotypes of a family and to infer on their means. The families showing the highest potential for selection of the desired individuals are selected (Macedo et al. 1998).

Objective of this work was to estimate genetic parameters among and within potato clonal families for tuber yield, average tuber weight, tuber appearance and chip color.

MATERIAL AND METHODS

Twenty potato clonal families from the Embrapa Clima Temperado breeding program, Pelotas, RS, Brasil, were used. They were derived from crosses between adapted and introduced genotypes aiming at cultivar development, in fall 2001: 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.

The first tubers were produced in a greenhouse in spring 2001 and stored for eight months in a cold chamber at 4 ºC. The hybrid families, composed of 60 genotypes, were cloned in the field in spring 2002. After harvest, the tubers were also cold-stored to break the dormancy.

The evaluations were carried out in spring 2003 and fall 2004, using 30 randomly selected clones from each family. The two experiments were conducted in the field, using a randomized complete block design, with three replications. The experimental unit consisted of ten clones per family where each clone was represented by five plants. The cultural practices were those recommend regionally for the crop.

Data were obtained for the following traits: tuber yield, average tuber weight, tuber appearance and chip color.

The evaluation methodology of Love et al. (1997) was adapted to raise the feasibility and precision. The tuber yield of each clone was counted and weighed. The average tuber weight was obtained by dividing the yield by the number of tubers.

The tuber appearance was evaluated in a five-point scale: 1 = excellent appearance (appealing appearance; smooth, white or intense red skin; long oval shape; shallow eyes; medium to large size) and 5 = poor appearance (rough skin; deep eyes; shape defects such as irregular shape, pointed, curved, cracked).

Three medium-size tuber samples of each clone were evaluated for chip color. The tubers were peeled and cut in slices. Nine slices of each clone were dried in paper towel and fried in hydrogenated vegetable fat at an initial temperature of 180 °C. After drying, the chips were placed on paper towel to eliminate any spare fat and evaluated for color by a five-point color chart (1 = light; 5 = dark) of the Potato Chip & Snack Food Association, USA.

The data were analyzed statistically to estimate the genetic parameters according to Paiva et al. (2002). The heritability of the population (H), among (Hf) and within (Hw) families were estimated using the following expression:

$$H = s^2_G / s^2_P$$
$$Hf = s^2_{Gf} / s^2_{Pf}$$
$$Hw = s^2_{Gw} / s^2_{Pw}$$

Selection gains of the population (GS), among (GSf) and within (GSw) families were calculated considering a selection index (i) of 0.10 as follows:

$$GS = H*SG*i$$
$$GSf = Hf*SGf*i$$
$$GSw = Hw*SGw*i$$

The procedures PROC GLM of the software SAS (2002) were used to evaluate the estimates. The general ranking index proposed by Mulamba and Mock (Cruz and Regazzi 1997) was used simply to identify the best families in relation to the set of studied traits. The indexes generated from the variances were also included, which were considered variables for choosing the best genetic constitutions, instead of calculating the genetic gain obtained from this selection, as proposed by the authors.

The confidence intervals for heritability and selection gain were calculated according to Tai (1983) at a probability of 5%. Means and variances were compared with confidence intervals at 5% probability, as proposed by Ramalho et al. (2000).

RESULTS

Analysis of variance revealed significant (P = 0.05) differences among and within families for all traits, except

for the genotype x growing season interaction.

Means of yield, average tuber yield, tuber appearance and chip color are shown in Figure 1. Families derived from C-1485-6-87/Felsina and Divina/C-1226-35-80 crosses showed superior tuber yield means, but only the first one presented a higher variance than the other families.

In relation to the average tuber weight, families from C-1485-6-87/Felsina and C-1750-15-95/Felsina crosses had superior means. The majority of the families had high and similar variance, except for the families from C-1750-15-95/Canoinhas, C-1750-15-95/Exquiza and Shepody/Eliza crosses.

The tuber appearance means of the families derived from C-1485-6-87/Felsina, Shepody/Eliza, C-1750-15-95/Divina, C-1750-15-95/Felsina, C-1714-7-94/Imola, Divina/C-1226-35-80, and Asterix/2CRI-1149-1-78 crosses were superior. Small variances were estimated only for Agria/C-1226-35-80 and Agria/2CRI-1149-1-78 families, indicating the low variability for this trait in these crosses.

The industrial quality component, the chip color, was superior to all others in the family of the Asterix/C-1311-11-82 cross. This family constituted the group with the widest variance.

Table 1. Means and variances for tuber yield, average tuber weight, tuber appearance, and chip color of 20 families of experiments conducted in spring 2003 and fall 2004

Family	Tuber yield		Average tuber weight		Chip color		Tuber appearance		Ranking
	Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance	Total
C-1485-6-87/Felsina	1[1]	19[2]	1[1]	4[2]	14[1]	11[2]	3[1]	4[2]	57[3]
Divina/C-1226-35-80	2	6	6	2	9	14	6	12	57
Asterix/2CRI-1149-1-78	3	13	10	14	2	7	7	15	71
Shepody/Eliza	4	14	3	20	18	6	1	7	73
C-1750-15-95/Asterix	5	4	4	8	13	19	9	10	72
Asterix/C-1226-35-80	6	5	12	12	4	3	20	16	78
Agria/C-1226-35-80	7	10	9	9	5	16	13	20	89
Agria/2CRI-1149-1-78	8	7	8	13	6	4	19	19	84
Imola/C-1226-35-80	9	1	13	6	20	15	17	14	95
White Lady/2CRI-1149-1-78	10	2	11	1	16	1	12	17	70
C-1750-15-95/Felsina	11	20	2	3	11	2	4	9	62
Columbus/Eliza	12	3	15	7	15	12	16	3	83
C-1714-7-94/Imola	13	12	5	5	17	17	5	2	76
C-1750-15-95/Divina	14	15	7	15	10	10	2	6	79
Asterix/C-1311-11-82	15	16	16	10	1	8	18	8	92
C-1750-15-95/Canoinhas	16	18	14	17	19	5	10	11	110
C-1485-6-87/Asterix	17	8	20	16	8	20	14	1	104
C-1750-15-95/Panda	18	9	17	19	7	13	11	5	99
White Lady/C-1311-11-82	19	11	19	11	3	9	8	13	93
C-1750-15-95/Exquiza	20	17	18	18	12	18	15	18	136

[1]Values in the column represent the ranking of means of each family
[2]Values in the column represent the ranking of means of each family
[3]Values in the column represent the sum of all rankings in the line
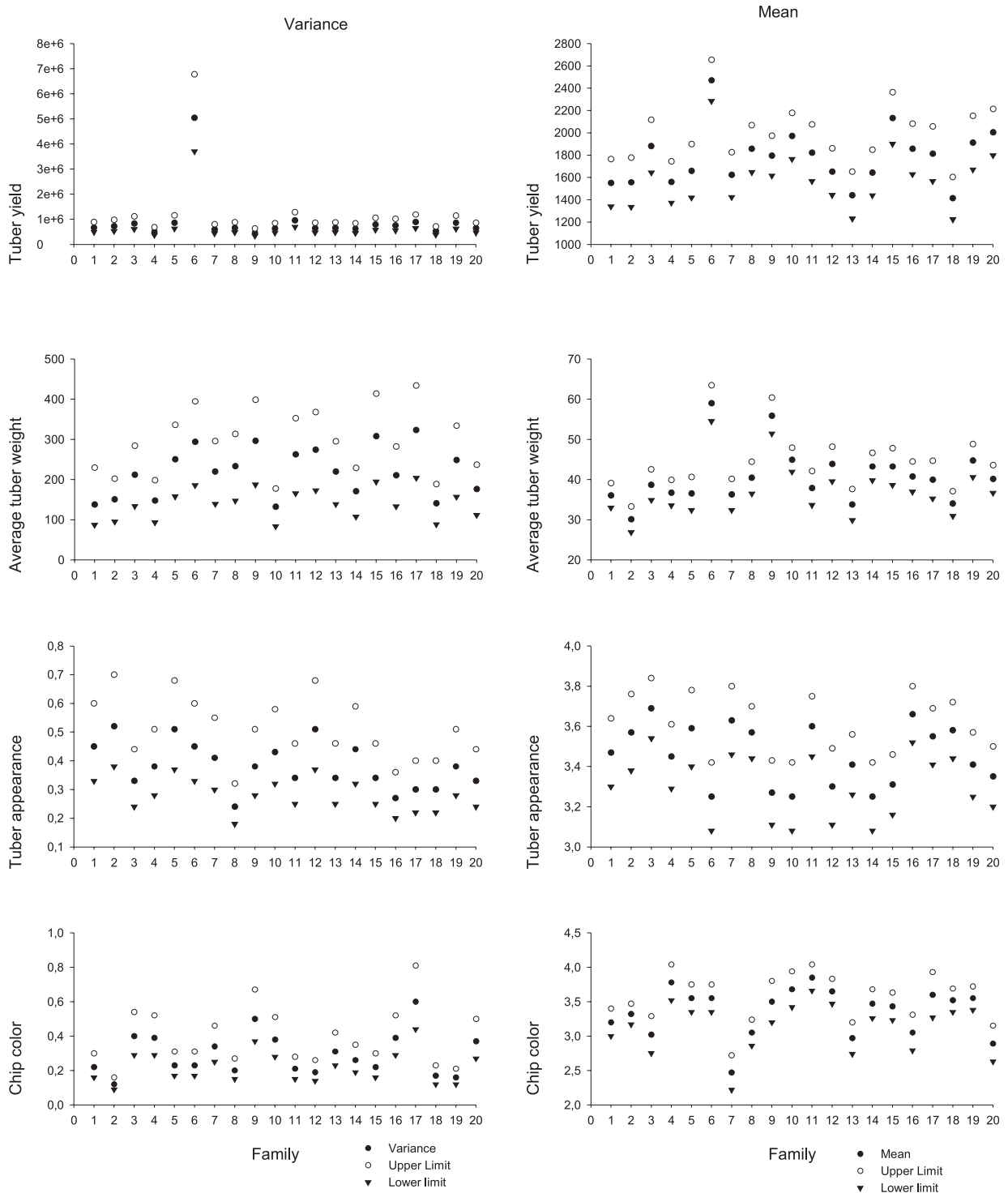
Figure 1. Point and confidence interval estimates of mean and variance for tuber yield, average tuber weight, tuber appearance and chip color of 20 potato clonal families (1 = C-1750-15-95/Panda; 2 = C-1485-6-87/Asterix; 3 = Asterix/C-1226-35-80; 4 = C-1750-15-95/Canoinhas; 5 = Columbus/Eliza; 6 = C-1485-6-87/Felsina; 7 = Asterix/C-1311-11-82; 8 = Agria/C-1226-35-80; 9 = C-1750-15-95/Felsina; 10 = Shepody/Eliza; 11 = Imola/C-1226-35-80; 12 = C-1714-7-94/Imola; 13 = White Lady/C-1311-11-82; 14 = C-1750-15-95/Divina; 15 = Divina/C-1226-35-80; 16 = Agria/2CRI-1149-1-78; 17 = White Lady/2CRI-1149-1-78; 18 = C-1750-15-95/Exquiza; 19 = C-1750-15-95/Asterix; 20 = Asterix/2CRI-1149-1-78) of experiments conducted in spring 2003 and fall 2004

The ranking index for the set of traits showed that families derived from C-1485-6-87/Felsina and Divina/C-1226-35-80 crosses were the best-classified ones, matching those with the best means and variances for the yield components (Table 1).

Estimates of heritability revealed higher genetic differences among than within families. The heritability among families was superior for tuber yield, average tuber weight and tuber appearance (Table 2). Only for chip color, the heritability estimate for among families was similar to the population, i.e., the set of all families.

The selection gain among families was greater than within families for tuber yield, average tuber weight and tuber appearance (Table 2). The selection response for chip color among families was similar to the population.

Observed and expected means are shown in Tables 3 and 4. The expected mean among families was higher than within families for tuber yield, average tuber weight and tuber appearance.

DISCUSSION

Any plant breeding program aims at producing superior segregating populations with a high potential of bringing forth selectable individuals during the selection cycles (Simmonds 1996). The parents are selected according to the objectives proposed; this choice constitutes the most important phase in the process of exploiting the maximum of genetic variability possible within families (Macedo et al. 1998).

Results of this study showed that the highest means and variances were observed in families derived from C-1485-6-87/Felsina and Divina/C-1226-35-80 crosses, which can be explained by transgressive segregations observed mainly for tuber yield in the family C-1485-6-87/Felsina

(Figure 1). This hypothesis can be proved by the results of means and variances of tuber yield as well by the general ranking index. The rankings followed the classifying order of the families for the set of traits. It therefore shows these two families ranking close to the best ones for the majority of the studied traits, since they had the same weight.

The selection of two superior families, C-1485-6-87/ Felsina and Divina/C-1226-35-80, corresponds to 10% of the total number of families, indicating that the selection intensity used to calculate the selection gain is according to the number of tested families. The parents used in the crosses of all families were superior for the studied traits, showing that the differences among families were due to segregation deviations.

The general ranking index allows one to identify superior progenies for a set of traits, considering that the sum of individual rankings in an increasing order allows the identification of top-score populations, which could be considered for recalculating the genetic gains if only the means are considered instead of including the variances as variables. According to Eckebil et al. (1977), the choice and strategy of selection based on families depend on the mean performance and the existing variation magnitude, besides other sources of variation that can influence them.

The low number of superior families observed in this work agrees with Gopal (1997), which compared the progeny means and identified moderate efficiency at selecting families that had progenies with superior means for the studied traits. This author reported that even if the efficiency was low, the gains were high, as it reduced the number of evaluated crosses.

Compared to the within-families heritability estimate, the among-families estimate presented a higher selection efficiency for tuber yield, average tuber weight and tuber appearance, since the percentage of genetic variance

Table 2. Point and confidence interval estimates of heritability among (Hf), within (Hw) families and the population (H), selection gain among (GSf), within (GSw) families and the clonal population (GS) for tuber yield, average tuber weight, chip color, and tuber appearance of potato

Estimate	Tuber yield	(0.95<IC<0.05)	Av. tuber wt.	(0.95<IC<0.05)	Chip color	(0.95<IC<0.05)	Tuber appear.	(0.95<IC<0.05)
H f	0.686	(0.505, 0.794)	0.704	(0.534, 0.806)	0.625	(0.574, 0.959)	0.742	(0.594, 0.832)
H w	0.114	(0.061, 0.180)	0.117	(0.062, 0.167)	0.312	(0.234, 0.565)	0.124	(0.060, 0.238)
H	0.287	(0.197, 0.346)	0.328	(0.227, 0.336)	0.685	(0.597, 0.844)	0.195	(0.088, 0.247)
GSf	38.234	(29.15, 51.13)	1.240	(0.880, 2.282)	0.052	(0.055, 0.090)	0.030	(0.020, 0.076)
GSw	3.811	(2.106, 6.815)	0.105	(0.060, 0.261)	0.010	(0.009, 0.012)	0.003	(0.002, 0.005)
GS	16.005	(9.79, 19.62)	0.577	(0.255, 0.797)	0.057	(0.056, 0.085)	0.008	(0.006, 0.010)

Table 3. Observed (X) and estimated means from selection gain among families (Mf), within families (Mw) and the population (M) for tuber yield and average tuber weight of 20 potato families

Family	Tuber yield kg plot[-1]				Average tuber weight g			
	X	Mf	Mw	M	X	Mf	Mw	M
C-1485-6-87/Felsina	2269.97	2308.20	2273.78	2285.97	41.06	42.30	41.17	41.64
Divina/C-1226-35-80	2132.12	2170.35	2135.93	2148.12	50.06	51.30	50.17	50.64
Asterix/2CRI-1149-1-78	2005.78	2044.01	2009.59	2021.78	55.06	56.30	55.17	55.64
Shepody/Eliza	1971.32	2009.55	1975.13	1987.32	45.06	46.30	45.17	45.64
C-1750-15-95/Asterix	1911.29	1949.52	1915.10	1927.29	54.06	55.30	54.17	54.64
Asterix/C-1226-35-80	1880.42	1918.65	1884.23	1896.42	38.06	39.30	38.17	38.64
Agria/C-1226-35-80	1857.81	1896.04	1861.62	1873.81	43.06	44.30	43.17	43.64
Agria/2CRI-1149-1-78	1855.67	1893.90	1859.48	1871.67	51.06	52.30	51.17	51.64
Imola/C-1226-35-80	1821.33	1859.56	1825.14	1837.33	46.06	47.30	46.17	46.64
White Lady/2CRI-1149-1-78	1811.82	1850.05	1815.63	1827.82	52.06	53.30	52.17	52.64
C-1750-15-95/Felsina	1794.50	1832.73	1798.31	1810.50	44.06	45.30	44.17	44.64
Columbus/Eliza	1658.95	1697.18	1662.76	1674.95	40.06	41.30	40.17	40.64
C-1714-7-94/ Imola	1651.05	1689.28	1654.86	1667.05	47.06	48.30	47.17	47.64
C-1750-15-95/Divina	1643.15	1681.38	1646.96	1659.15	49.06	50.30	49.17	49.64
Asterix/C-1311-11-82	1623.67	1661.90	1627.48	1639.67	42.06	43.30	42.17	42.64
C-1750-15-95/Canoinhas	1558.68	1596.91	1562.49	1574.68	39.06	40.30	39.17	39.64
C-1485-6-87/Asterix	1555.72	1593.95	1559.53	1571.72	37.06	38.30	37.17	37.64
C-1750-15-95/Panda	1550.69	1588.92	1554.50	1566.69	36.06	37.30	36.17	36.64
White Lady/C-1311-11-82	1440.80	1479.03	1444.61	1456.80	48.06	49.30	48.17	48.64
C-1750-15-95/Exquiza	1413.25	1451.48	1417.06	1429.25	53.06	54.30	53.17	53.64

attributed to the differences among families was higher than within families. This was possibly due to the lower influence of the environment on among-families than among individuals of a family. According to Simmonds (1996), the discrimination of the magnitudes of variation among families is much more efficient than the discrimination of variation among individuals of the same family.

The selection gains verified that the best selection response was among families, which depends on the heritability and the selection pressure used. According to Zobel and Talbert (1984), the best selection strategy is the one that reduces the variability within families and

increases it among families, i.e. combines selection among and within populations in order to achieve a higher gain and selection efficiency.

The observed and expected means indicate the performance of families by selection gain. According to Falconer and Mackay (1996), the expected response can only be extrapolated to the following generation, as the selection response depends on the heritability of the trait in the generation it was measured. Furthermore, the selection gain modifies the heritability in each generation since it changes the genotypic frequency of the population.

Table 4. Observed (X) and estimated means from selection gain among families (Mf), within families (Mw) and the population (M) for chip color and tuber appearance of 20 potato families

Family	Chip color				Tuber appearance			
	X	Mf	Mw	M	X	Mf	Mw	M
Agria/C-1226-35-80	2.47	2.42	2.46	2.41	3.63	3.60	3.63	3.62
C-1750-15-95/Exquiza	2.89	2.84	2.88	2.83	3.35	3.32	3.35	3.34
C-1714-7-94/ Imola	2.97	2.92	2.96	2.91	3.41	3.38	3.41	3.40
Asterix/2CRI-1149-1-78	3.02	2.97	3.01	2.96	3.69	3.66	3.69	3.68
Agria/2CRI-1149-1-78	3.05	3.00	3.04	2.99	3.57	3.54	3.57	3.56
C-1750-15-95/Canoinhas	3.05	3.00	3.04	2.99	3.66	3.63	3.66	3.65
C-1485-6-87/Felsina	3.20	3.15	3.19	3.14	3.47	3.44	3.47	3.46
Divina/C-1226-35-80	3.32	3.27	3.31	3.26	3.57	3.54	3.57	3.56
Asterix/C-1311-11-82	3.43	3.38	3.42	3.37	3.31	3.28	3.31	3.30
C-1750-15-95/Divina	3.47	3.42	3.46	3.41	3.25	3.22	3.25	3.24
Imola/C-1226-35-80	3.50	3.45	3.49	3.44	3.27	3.24	3.27	3.26
C-1750-15-95/Panda	3.52	3.47	3.51	3.46	3.58	3.55	3.58	3.57
White Lady/C-1311-11-82	3.55	3.50	3.54	3.49	3.41	3.38	3.41	3.40
C-1750-15-95/Asterix	3.55	3.50	3.54	3.49	3.59	3.56	3.59	3.58
Asterix/C-1226-35-80	3.55	3.50	3.54	3.49	3.25	3.22	3.25	3.24
C-1485-6-87/Asterix	3.60	3.55	3.59	3.54	3.55	3.52	3.55	3.54
Columbus/Eliza	3.65	3.60	3.64	3.59	3.30	3.27	3.30	3.29
White Lady/2CRI-1149-1-78	3.68	3.63	3.67	3.62	3.25	3.22	3.25	3.24
Shepody/Eliza	3.78	3.73	3.77	3.72	3.45	3.42	3.45	3.44
C-1750-15-95/Felsina	3.85	3.80	3.84	3.79	3.60	3.57	3.60	3.59

Potencial de seleção entre e dentro de famílias clonais de batata

RESUMO - *O objetivo deste trabalho foi estimar parâmetros genéticos entre e dentro de famílias clonais de batata para rendimento, peso médio e aparência de tubérculo, e cor chips. Vinte famílias foram avaliadas na primavera de 2003 e outono de 2004, no campo experimental da Embrapa Clima Temperado, Pelotas-RS, Brasil. O delineamento experimental foi blocos casualizados, com três repetições. A unidade experimental foi constituída por dez clones com cinco plantas cada. A ANAVA revelou significância entre e dentro de famílias, para todas as variáveis analisadas, exceto para a interação genótipo x período de cultivo. Duas famílias foram superiores em relação à média, sendo que apenas uma apresentou variância superior. As estimativas de herdabilidade e de ganho de seleção entre famílias foram maiores do que dentro de famílias em relação à aparência, rendimento e peso médio de tubérculo. Somente as estimativas de herdabilidade e ganho de seleção de cor de chips entre famílias foram semelhantes às estimativas da população.*

Palavras-chave: *Solanum tuberosum* L., ganho de seleção, herdabilidade, variabilidade genética.

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