# Agronomic performance of potato interspecific hybrids

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## ABSTRACT

Hybrids from crosses among potato cultivars (*Solanum tuberosum* L.) and *S. tuberosum ssp. andigena*, *S. chacoense* and *S. phureja* clones were assessed. Hybrid families with different proportions of exotic species genome (50, 25, and 12.5%) were compared with families derived from the cross only among *S. tuberosum* cultivars. Three experiments in two locations were carried out in southern Minas Gerais State, one in an augmented block design and the other two in lattice designs to assess the families and clones. The families with higher percentages of exotic species genome presented lower tuber yield, lower percentage of large tubers and lower average tuber weight. The main limitation of some hybrids was tuber appearance, and there was a high frequency of clones with undesirable tuber appearance. Clones derived from different genomic compositions could be selected with high yield, good percentage of large tubers, high tuber specific gravity and good tuber appearance.

**KEY WORDS:** *Solanum chacoense*, *Solanum phureja*, *Solanum tuberosum* ssp. *andigena*, *Solanum tuberosum*, potato breeding, exotic species.

## INTRODUCTION

In spite of efforts from many breeders to develop new potato cultivars, the genetic potential for yield in breeding programs for this crop made little increase during the twentieth century (Douches et al., 1996) and has been not very successful compared to other crops (Bradshaw and Mackay, 1994). Yield has increased much more due to perfecting crop management practices and changes in production areas than due to breeding (Furumoto, 1993). Several authors have considered the narrow genetic base of the crop as the primary cause of low yield gains (Plaisted and Hoopes, 1989; Furomoto et al., 1991).

The potato (*Solanum tuberosum* L.) genetic base can be widened fairly easily as the *Solanum* genus has an enormous quantity of species that can be easily crossed with the cultivated species. For example, the use of the ssp. *andigena* germplasm that has the same ploidy level (2n = 4x = 48) and crosses easily with the tetraploid cultivars. Cultivated or wild diploid species (2n = 2x = 24) are also used such as the *S. phureja* and *S. chacoense* species that have important traits such as high tuber dry matter content, pest and disease resistance and tolerance to abiotic stresses (Ortiz, 1998). In the latter case, the ploidy must be reduced from the tetraploid species to the diploid level to allow hybridization, transforming it into a dihaploid (2n = 2x = 24). Next, the dihaploid is crossed with the diploid species, also creating diploids hybrids that are backcrossed with *S. tuberosum,* re-establishing tetraploidy by the production of non-reduced gametes by the diploid parent.

For the potato crop, the 4x level is preferred to 2x because tetraploid families perform better compared to diploids (Maris, 1990). Theoretically, the tetraploid hybrids possess the advantage of exceeding their intralocus interaction level, as the different alleles are introduced via 2n gametes (preserving the heterozygosis and epistatic interactions present in the diploid material). Heterosis in polyploids is more complex than in diploids, and the intra and interloci interactions are important (Mendoza and Haynes, 1974).

Tuber production from hybrid tetraploid progeny from the 4x x 2x cross in most cases exceeds that found in families derived from intercrossing among tetraploid cultivars (Darmo and Peloquin, 1991; Ortiz et al., 19991; Peloquin and Ortiz, 1992). However, negative aspects are frequently found in 4x x 2x progeny such as late maturity (Buso et al., 1999a), dark colored chips (Darmo and Peloquin, 1991) and long shoots (Andrade et al., 1998). Several studies have also shown the presence of large heterosis in crosses among the *tuberosum* and *andigena* groups, with high progeny vigor and yield (Cubillos and Plaisted, 1976; Munoz and Plaisted, 1981; Tarn and Tai, 1977; Hoopes et al., 1980).

There are still few studies involving diploid species and 4x x 2x crosses in Brazil and most of the hybridizations are carried out among introduced cultivars poorly adapted to the environmental conditions of the country. The development of populations adapted to tropical conditions including high temperatures and high pathogen and pest populations requires the use of a wider genetic base. Furthermore, the demand for cultivars with high tuber quality requires the use of sources that have alleles which confer this trait in breeding programs.

The objective of this study was to assess the performance of hybrids resulting from the cross between *S. tuberosum* cultivars with *S. tuberosum* ssp. *andigena, S. chacoense* and *S. phureja* clones. Hybrids with different proportions in the genome of exotic species genome (50, 25 and 12.5%) were compared with clones of families derived from crossess only among *S. tuberosum* cultivars.

## MATERIAL AND METHODS

Clones were assessed from 43 families involving the *S. tuberosum, S. tuberosum* ssp *andigena, S. chacoense* and *S. phureja* species (Table 2). The crosses were carried out to obtain hybrids with different proportions of the genome of each species.

The genotypes used as parents, called OMM, are hybrids between dihaploids of *S. tuberosum* and *S. chacoense*, possessing 50% of the *S. tuberosum* genome; those coded as EOA are derived from crosses of *S. tuberosum* cultivars with *S. tuberosum* x *S. chacoense* hybrids presenting 25% of *S. chacoense* and 75% *S. tuberosum*; THP-71 is a tetraploid hybrid between *S. tuberosum* and *S. phureja*; the materials designated ESL are tetraploid hybrids between clones from the *andigena* group with *S. tuberosum*. The PI-229895 and PI-279291 clones are materials from the *andigena* group obtained from botanic seeds from the Potato Production Station, Sturgeon Bay, USA. The *S. tuberosum*, Aracy, Chiquita, Contenda, Itararé and Mantiqueira cultivars were used for adaptation to environmental conditions found in southern Minas Gerais state, and Atlantic, Panda and Premiére for the high tuber dry matter content. An amount of pollen from the EOA clones was used to pollinate the same EOA clones, maintaining a proportion of 75% of the *S. tuberosum* genome in the families derived from these crosses.

Three experiments were performed, the first of which was carried out in the wet season (November 1999 to February 2000) at the EPAMIG experimental station located in Maria da Fé, southern Minas Gerais. Nine hundred clones from 33 families were tested in this experiment. An augmented block design (Federer, 1956) was used with Achat and Monalisa cultivars as controls. The experimental plot consisted of a row of three plants, spaced at 0.30m x 0.80m. The other two experiments were conducted in the winter season (June to October 2000) in the experimental area of the Department of Biology – UFLA in Lavras, southern Minas Gerais. In one of the experiments, 574 clones from 33 families were assessed, using a 24 x 24 lattice with two replications. The Achat and Monalisa cultivars were used as controls and the plot consisted of a row of five plants, spaced at 0.30m x 0.80m. In the other experiment, 35 clonal families containing different percentages of the *S. tuberosum* genome were assessed. A 6 x 6 lattice design with three replications was used, including the Monalisa cultivar in the experiment as control. Each family was represented by a sample of 30 genotypes and the plot consisted of three rows of 10 plants, also in the 0.30m x 0.80m spacing.

The following traits were evaluated: tuber yield (g/plant), percentage of large tubers (tubers with cross diameter > 45mm), average weight of large tubers, tuber appearance score (1 = worst to 5 = best), plant vegetative cycle and tuber specific gravity [(weight in air)/(weight in air – weight in water)]. Tuber appearance was not assessed in the experiment at Maria da Fé. Analyses of variance were performed for all traits, according to the statistical model. The Scott and Knott (1974) test was used to compare the means of the treatments. In the clone experiments at Maria da Fé and Lavras, the adjusted means of clones from the same family were summed and the family means calculated. As these were represented by different numbers of clones per family, the intra-family comparison used the harmonic mean of the number of averaged plots as a divider of the mean for the test. In the Lavras family experiments, the partitioning of families' sum of the squares was carried out according to groups based on the percentage of the genome of exotic species. This was only performed in this experiment where a larger number of families of crosses only within *S. tuberosum* was included.

To help in the selection of superior clones, the index based on the sum of the ranks was used (Mulamba and Mock, 1978). This index consists of classifying the materials according to each trait, in an order to favor breeding. The ranks corresponding to each trait were summed to obtain a mean which is taken as index for clone selection (Cruz and Regazzi, 1997).

## RESULTS AND DISCUSSION

The analysis of variance of individual experiments will be considered in the discussion of the results. A joint analysis of the data was not performed because the experiments were carried out in different experimental designs and with different numbers of clones in the same family. Although there were differences in the performance of the families, which were expected due to the genotype x environment interaction, the conclusions about the family behavior based on their genomic composition were practically the same in the three experiments.

The Lavras experiment detected significant family differences in most traits, the exception was plant vegetative cycle, after the partitioning of the sum of the squares in groups according to the percentage of the genome of the exotic species. The families with greater percentage of the genome from exotic species presented lower tuber yield, lower percentage of large tubers, lower average weight of large tubers and worse tuber appearance (Table 1). This tendency was also observed in the other two experiments. This indicates that the use of exotic species would only bring advantages if the proportion of its genome were lower than 12.5%. The group with 12.5% of the exotic genome showed identical performance in tuber production and its components to the group of families derived from the cross within *S. tuberosum*. Further, this group outperformed those with greater proportion of exotic genome for most traits, except plant vegetative cycle. For tuber specific gravity, the families with 12.5% of exotic genome presented a greater average than all the others. However, this result was not necessarily due to the 12.5% of exotic genome but more likely to the greater specific gravity of the two parents used to obtain the families. The *S. tuberosum* Atlantic, Panda and Premiére have high specific gravity and were crossed with EOA clones whose values are also relatively high (Andrade et al., 1998).

The family means in the three experiments, coefficients of environmental variation and genetic parameters estimates are shown in Table 2. Generally, the broad sense heritability estimates and the coefficients of genetic variation for the families were high. The ratios between the coefficients of genetic variation (CVg) and the environmental variation (CVe) were greater or equal to 1 for the clones (data not shown), and this is a favorable situation for selection, according to Vencovsky and Barriga (1992).

Some coefficients of environmental variation were fairly high, mainly for individual tuber yield (40.24%) in Maria da Fé and for average weight of large tuber (33.02%) in the clone experiment, in Lavras. It is pointed out that the experimental plots in Maria da Fé consisted of a single row with only three plants and that there was a high incidence of nematodes. The damage caused by the pathogen was not assessed, but visually it was noted that most of the clones were susceptible unlike the controls Achat and Monalisa, which presented low incidence of infested tubers. It is reported that the cultivar Achat presents moderate resistance to *Meloidogyne incognita* (Charchar and Moita, 1996) and *M. javanica* (Charchar and Moita, 2001), which are the main species present in Brazil. The tuber yield general mean in Maria da Fé was fairly low (350 g/plant) and most of the clones presented few or even no large tubers. Thus, for this experiment the statistical analysis of tuber classification was done for percentage and average weight of marketable tubers (transversal diameter > 33mm). However, about 20% of the clone population presented mean above 500 g/plant, and some produced more than 1000 g/plant, while the control means were 542 and 364 g/plant for the Monalisa and Achat cultivars, respectively.

The Lavras experiments presented relatively high tuber yield means and percentage of large tubers. Families 5, 10, 20, 21 30 and 31 were outstanding for tuber yield. Families 6, 14 and 23 presented poor performances for tuber yield and percentage of large

**Table 1.** Mean of the family groups classified according to the percentage of exotic genome, large tuber percentage and average weight, appearance, tuber specific gravity and plant vegetative cycle. Lavras, 2000 [1/].

| Family Groups | % of exotic genome | Tuber yield (g/plant) | % of large tubers | Average weight of large tubers (g) | Tuber appearance | Tuber specific gravity (g) | Vegetative cycle (days) |
|---|---|---|---|---|---|---|---|
| Group 1 | 50 % | 604 b | 59.4 c | 116 c | 2.0 c | 1.0765 b | 88.8 a |
| Group 2 | 25 % | 680 b | 68.4 b | 126 b | 2.7 b | 1.0748 b | 88.9 a |
| Group 3 | 12.5 % | 723 a | 78.7 a | 133 a | 2.6 b | 1.0823 a | 88.6 a |
| Group 4 | 0 % | 802 a | 76.4 a | 139 a | 3.2 a | 1.0753 b | 88.3 a |

[1/] Means followed by the same letter did not differ by the Scott and Knott test (P<0.05).

tubers and average weight of large tubers. The parental clones of these latter families also presented low tuber yield and low percentage of large tuber in assessments by Nurmberg and Pinto (1998) and Andrade et al., (1998). In general, the non-adapted species presented small sized tubers and, when crossed with adapted cultivars, transmitted this trait to the hybrid (McHale and Lauer, 1981a, Ortiz et al., 1991). However, fairly productive clones were found in all types of families, close or higher than the mean of the Monalisa control in the two experiments (Tables 3 and 4).

Regarding tuber specific gravity, the means of the experiments in Lavras were quite high. Tuber specific gravity is an important trait because it is highly correlated with tuber dry matter content, and is used as a quality indicator for frying. According to Gould (1988), the desirable values for industrial processing should be greater than 1.0800. The higher temperatures observed in the wet season in association with the stress caused by nematodes may have caused the lower specific gravity values observed in Maria da Fe. Some families derived from crosses with the Atlantic, Panda,

**Table 2**. Means for the family and control cultivars' tuber yield, percentage of large tubers, average weight of large tubers, tuber specific gravity, and tuber appearance. Maria da Fé, 1999-2000 - experiment with clones; and Lavras, 2000 - experiments with families (Lav-F) and with clones (Lav-C).

| Family Number/ Genealogy | % of exotic species genome[1/] | Tuber Yield (g/plant) | | | Percentage of large tubers | | | Average weight of large tubers (g) | | | Tuber specific gravity | | | Tuber appearance | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M. Fé | Lav -F | Lav -C | M. Fé | Lav -F | Lav -C | M. Fé | Lav -F | Lav -C | M. Fé | Lav -F | Lav -C | Lav-F | Lav-C |
| 42- PI- 279291 x Chiquita | 50 adg | 228 d | 617 a | 767 c | 64 c | 65 b | 43 e | 34 e | 117 b | 98 c | 1.0650 d | 1.0780 a | 1.0741 c | 2.3 b | 2.1 c |
| 43- PI –229895 x Chiquita | 50 adg | - | 592 a | - | - | 54 b | - | - | 115 b | - | - | 1.0750 b | - | 1.7 b | - |
| 10- Aracy x ESL-114 | 25 adg | 450 a | 540 a | 875 b | 75 b | 67 b | 73 b | 33 e | 118 b | 124 c | 1.0644 d | 1.0680 c | 1.0697 d | 2.7 a | 2.4 a |
| 13- Atlantic x ESL-101 | 25 adg | 428 a | - | 848 c | 79 b | - | 74 b | 39 d | - | 127 c | 1.0722 b | - | 1.0791 c | - | 2.3 b |
| 12- Mantiqueira x ESL-52 | 25 adg | 382 b | 837 a | 893 b | 66 c | 73 a | 68 c | 35 d | 139 a | 120 c | 1.0553 e | 1.0670 c | 1.0681 d | 3.2 a | 2.5 a |
| 30- Aracy x ESL-101 | 25 adg | 488 a | 630 a | 983 a | 86 a | 67 b | 78 b | 48 c | 126 b | 136 b | 1.0718 c | 1.0750 b | 1.0771 c | 3.0 a | 2.4 a |
| 31- Aracy x ESL-58 | 25 adg | 449 a | 810 a | 956 a | 81 b | 64 b | 65 c | 40 d | 114 b | 126 c | 1.0660 d | 1.0750 b | 1.0697 d | 3.2 a | 2.4 a |
| 32- THP-71xAracy | 25 phu | 386 b | 675 a | 792 c | 69 c | 74 a | 68 c | 39 d | 146 a | 133 b | 1.0675 d | 1.0750 b | 1.0707 d | 3.2 a | 2.2 b |
| 8- EOA-256 x Bulk | 25 chc | 309 c | 564 a | 704 d | 63 c | 76 a | 62 d | 35 d | 115 b | 109 c | 1.0619 d | 1.0770 a | 1.0769 c | 2.5 b | 2.0 c |
| 1- Atlantic x OMM-47 | 25 chc | 309 c | - | 825 c | 78 b | - | 84 a | 44 c | - | 139 b | 1.0699 c | - | 1.0873 b | - | 2.2 b |
| 3- Delta x OMM-115 | 25 chc | 299 c | - | 807 c | 78 b | - | 80 a | 39 d | - | 139 b | 1.0631 d | - | 1.0740 c | - | 2.8 a |
| 2- Atlantic x OMM-91 | 25 chc | 349 b | 817 a | 822 c | 83 b | 83 a | 82 a | 45 c | 144 a | 136 b | 1.0638 d | 1.0780 a | 1.0775 c | 3.2 a | 2.5 a |
| 6- EOA-252 x Bulk | 25 chc | 219 d | - | 536 e | 59 d | - | 67 c | 32 e | - | 108 c | 1.0646 d | - | 1.0769 c | - | 1.9 c |
| 14- EOA-175 x Bulk | 25 chc | 174 d | - | 581 e | 55 d | - | 61 d | 29 e | - | 100 c | 1.0648 d | - | 1.0841 b | - | 1.5 d |
| 18- EOA-243 x Bulk | 25 chc | 276 c | 585 a | 769 c | 63 c | 55 b | 57 d | 32 e | 115 b | 114 c | 1.0676 d | 1.0760 b | 1.0773 c | 2.0 b | 1.7 d |
| 23- EOA-264 x Bulk | 25 chc | 188 d | 641 a | 712 d | 58 d | 61 b | 66 c | 33 e | 128 b | 116 c | 1.0651 d | 1.0730 b | 1.0755 c | 2.2 b | 1.6 d |
| 24- EOA-268 x Bulk | 25 chc | 328 c | 701 a | 871 b | 67 c | 67 b | 68 c | 28 e | 118 b | 114 c | 1.0698 c | 1.0840 a | 1.0837 b | 2.3 b | 1.9 c |
| 20- EOA-268 x Panda | 12.5 chc | 499 a | 708 a | 847 c | 80 b | 61 b | 63 d | 38 d | 113 b | 112 c | 1.0814 a | 1.0790 a | 1.0790 c | 2.5 b | 1.8 d |
| 26- EOA-268 x Premiere | 12.5 chc | 396 b | 770 a | 790 c | 79 b | 81 a | 69 c | 35 d | 129 b | 110 c | 1.0729 b | 1.0870 a | 1.0842 b | 3.0 a | 1.8 d |
| 22- EOA-264 x Panda | 12.5 chc | 413 b | 819 a | 779 c | 87 a | 74 a | 68 c | 45 c | 133 a | 119 c | 1.0789 a | 1.0860 a | 1.0845 b | 2.5 b | 2.1 c |
| 7- EOA-134 x Atlantic | 12.5 chc | 413 b | 914 a | 759 c | 81 b | 83 a | 69 c | 43 c | 137 a | 120 c | 1.0676 d | 1.0800 a | 1.0846 b | 2.7 a | 2.2 b |
| 15- EOA-175 x Atlantic | 12.5 chc | 285 c | 748 a | 897 b | 90 a | 83 a | 81 a | 35 d | 148 a | 140 b | 1.0667 d | 1.0830 a | 1.0832 b | 2.8 a | 2.6 a |
| 11- EOA-31 x Premiere | 12.5 chc | 419 b | 700 a | 594 e | 89 a | 79 a | 64 d | 50 b | 127 b | 108 c | 1.0753 b | 1.0820 a | 1.0853 b | 3.2 a | 2.3 b |
| 4- EOA-14 x Premiere | 12.5 chc | 307 c | 807 a | 887 b | 80 b | 78 a | 73 b | 39 d | 131 b | 120 c | 1.0735 b | 1.0790 a | 1.0840 b | 2.2 b | 2.0 c |
| 9- EOA-268 x Atlantic | 12.5 chc | 349 b | 759 a | 800 c | 85 a | 83 a | 78 b | 45 c | 134 a | 125 c | 1.0733 b | 1.0810 a | 1.0847 b | 2.7 a | 2.0 c |
| 16- EOA-02 x Atlantic | 12.5 chc | 332 c | 590 a | 714 d | 93 a | 74 a | 77 b | 51 b | 128 b | 130 c | 1.0760 b | 1.0820 a | 1.0873 b | 2.8 a | 2.1 c |
| 17- EOA-252 x Panda | 12.5 chc | 269 c | - | 781 c | 67 c | - | 70 c | 37 d | - | 117 c | 1.0741 b | - | 1.0832 b | - | 1.9 c |
| 5- EOA-19 x Atlantic | 12.5 chc | 398 b | 697 a | 951 a | 88 a | 78 a | 81 a | 50 b | 137 a | 143 b | 1.0724 b | 1.0830 a | 1.0905 b | 2.8 a | 2.5 a |
| 28- EOA-134 x Premiere | 12.5 chc | 244 d | - | 798 c | 74 b | - | 84 a | 38 d | - | 138 b | 1.0809 a | - | 1.0878 b | - | 2.4 a |
| 25- EOA-269 x Atlantic | 12.5 chc | 278 c | - | 1050 a | 86 a | - | 89 a | 46 c | - | 208 a | 1.0698 c | - | 1.1031a | - | 1.7 d |
| 27- EOA-84 x Atlantic | 12.5 chc | 290 c | 712 a | 887 b | 91 a | 86 a | 87 a | 54 a | 148 a | 164 b | 1.0667 d | 1.0810 a | 1.0796 c | 1.5 b | 1.9 c |
| 19- EOA-31 x Atlantic | 12.5 chc | 244 d | 526 a | 677 d | 80 b | 83 a | 70 c | 49 b | 133 a | 117 c | 1.0732 b | 1.0870 a | 1.0836 b | 3.0 a | 2.3 b |
| 33- E0A-02 X Premiere | 12.5 chc | - | 652 a | - | - | 80 a | - | - | 132 a | - | - | 1.0810 a | - | 2.8 a | - |
| 21- Contenda x Chiquita | 0 | 459 a | 970 a | 1004 a | 87 a | 78 a | 82 a | 54 a | 133 a | 143 b | 1.0614 d | 1.0680 c | 1.0696 d | 3.0 a | 2.6 a |
| 29- Chiquita x Atlantic | 0 | 355 b | 933 a | 852 c | 78 b | 87 a | 86 a | 47 c | 157 a | 151 b | 1.0647 d | 1.0690 c | 1.0785 c | 3.2 a | 2.5 a |
| 39 - Aracy x Atlantic | 0 | - | 799 a | - | - | 84 a | - | - | 139 a | - | - | 1.0800 a | - | 3.2 a | - |
| 40 - Aracy x Desiree | 0 | - | 604 a | - | - | 72 a | - | - | 143 a | - | - | 1.0730 b | - | 3.0 a | - |
| 35 - Chiquita x Aracy | 0 | - | 778 a | - | - | 77 a | - | - | 127 b | - | - | 1.0740 b | - | 3.5 a | - |
| 36 - Itararé x Atlantic | 0 | - | 771 a | - | - | 85 a | - | - | 167 a | - | - | 1.0770 a | - | 2.7 a | - |
| 41 - Mantiqueira x Panda | 0 | - | 827 a | - | - | 77 a | - | - | 133 a | - | - | 1.0780 a | - | 3.2 a | - |
| 37 - Panda x Aracy | 0 | - | 659 a | - | - | 64 b | - | - | 119 b | - | - | 1.0820 a | - | 2.7 a | - |
| 38 - Panda x Atlantic | 0 | - | 803 a | - | - | 69 b | - | - | 134 a | - | - | 1.0820 a | - | 3.0 a | - |
| 34 - Panda x Chiquita | 0 | - | 887 a | - | - | 76 a | - | - | 132 a | - | - | 1.0800 a | - | 3.7 a | - |
| Monalisa | | 542 a | 800 a | 1274 | 87 a | 74 a | 72 | 57 a | 151 a | 148 | 1.0522 f | 1.0660 c | 1.0610 | 5.0 a | 3.8 |
| Achat | | 364 b | - | 439 | 59 d | - | 43 | 31 d | - | 118 | 1.0565 e | - | 1.0650 | - | 1.7 |
| General Mean | | 350 | 730 | 809 | 73 | 76 | 70 | 44 | 133 | 124 | 1.0687 | 1.0785 | 1.0796 | 2.8 | 2.2 |
| $CV_e$ (%) | | 40.24 | 22.35 | 22.50 | 19.00 | 9.68 | 16.64 | 19.56 | 9.67 | 33.02 | 0.51 | 0.32 | 1.01 | 16.32 | 17.74 |
| $h^2_a$ | | 0.90 | 0.32 | 0.91 | 0.93 | 0.77 | 0.97 | 0.95 | 0.67 | 0.86 | 0.96 | 0.83 | 0.93 | 0.80 | 0.95 |
| $b = (CV_G/CV_e)$ | | 3.07 | 0.40 | 2.22 | 3.74 | 1.04 | 4.26 | 4.89 | 0.82 | 1.79 | 4.78 | 1.41 | 2.53 | 1.18 | 3.08 |

[1/] chc: *Solanum chacoense*; adg: *S. tuberosum* ssp. *andigena* and phu: *S. phureja*. Means followed by the same letters for each column did not differ by the Scott and Knott test (P<0,05).

and Premiere cultivars showing lower percentage (12.5%) of the *S. chacoense* species genome presented higher specific gravity than the Achat and Monalisa controls. The parental clones of the families also presented high specific gravity values.

The plant vegetative cycle family means were similar and were not distinctly grouped by the Scott and Knott test (data not shown). Among the latest and earliest

**Table 3.** Means of the control cultivar and the best forty clones selected by the Mulamba and Mock (1978) index for tuber yield, percentage of large tubers, average weight of large tubers, tuber appearance and tuber specific gravity. Lavras, 2000 [1/].

| Clone | Tuber Yield (g/plant) | % of large tubers | Average weight of large tubers | Tuber appearance | Tuber specific gravity |
|---|---|---|---|---|---|
| 29.14 | 1429 a | 95 a | 175 a | 3.0 a | 1.0820 a |
| 5.05 | 1364 a | 92 a | 164 a | 2.7 a | 1.0910 a |
| 5.04 | 1279 a | 92 a | 174 a | 2.5 a | 1.1010 a |
| 9.04 | 1312 a | 94 a | 174 a | 2.5 a | 1.0870 a |
| 4.20 | 1358 a | 87 a | 142 a | 2.5 a | 1.0870 a |
| 20.01 | 1379 a | 82 a | 132 a | 2.7 a | 1.0840 a |
| 1.26 | 1272 a | 93 a | 170 a | 2.5 a | 1.0940 a |
| 20.07 | 1309 a | 74 a | 104 a | 2.5 a | 1.0980 a |
| 31.03 | 1506 a | 76 a | 120 a | 2.7 a | 1.0750 b |
| 43.14 | 1365 a | 81 a | 130 a | 2.5 a | 1.0760 b |
| 21.12 | 1319 a | 89 a | 122 a | 2.7 a | 1.0740 b |
| 10.20 | 1309 a | 85 a | 136 a | 3.0 a | 1.0770 b |
| 42.15 | 1459 a | 70 b | 106 a | 2.8 a | 1.0710 b |
| 2.08 | 1200 a | 96 a | 151 a | 2.8 a | 1.0860 a |
| 28.06 | 1183 a | 92 a | 172 a | 3.2 a | 1.0940 a |
| 10.22 | 1297 a | 84 a | 149 a | 2.5 a | 1.0740 b |
| 12.37 | 1377 a | 81 a | 141 a | 2.7 a | 1.0600 b |
| 10.31 | 1333 a | 83 a | 140 a | 3.3 a | 1.0640 b |
| 7.06 | 1193 a | 84 a | 180 a | 2.8 a | 1.0900 a |
| 3.18 | 1237 a | 91 a | 144 a | 3.3 a | 1.0710 b |
| 10.24 | 1212 a | 86 a | 142 a | 2.5 a | 1.0820 a |
| 4.30 | 1207 a | 91 a | 145 a | 2.5 a | 1.0760 b |
| 21.16 | 1253 a | 87 a | 148 a | 2.7 a | 1.0690 b |
| 30.04 | 1195 a | 81 a | 251 a | 3.3 a | 1.0800 b |
| 5.20 | 1123 a | 93 a | 144 a | 2.5 a | 1.0810 b |
| 7.19 | 1137 a | 87 a | 107 a | 2.7 a | 1.0810 b |
| 15.18 | 1084 b | 91 a | 146 a | 3.0 a | 1.0960 a |
| 17.08 | 1138 a | 76 b | 123 a | 2.7 a | 1.0880 a |
| 4.14 | 1095 b | 87 a | 122 a | 2.7 a | 1.0950 a |
| 7.28 | 1174 a | 72 b | 119 a | 2.5 a | 1.0790 b |
| 24.21 | 1117 a | 75 b | 108 a | 3.0 a | 1.0920 a |
| 5.24 | 1054 b | 91 a | 139 a | 2.8 a | 1.0970 a |
| 30.12 | 1102 b | 84 a | 126 a | 2.5 a | 1.0820 a |
| 5.14 | 1093 b | 83 a | 108 a | 2.8 a | 1.0850 a |
| 19.02 | 1077 b | 83 a | 137 a | 2.5 a | 1.0850 a |
| 29.17 | 1061 b | 90 a | 151 a | 2.7 a | 1.0830 a |
| 9.07 | 1023 b | 79 b | 116 a | 2.8 a | 1.1030 a |
| 21.20 | 1057 b | 80 a | 128 a | 2.5 a | 1.0830 a |
| 5.06 | 1033 b | 71 b | 108 a | 2.8 a | 1.1020 a |
| 3.29 | 1056 b | 90 a | 154 a | 3.5 a | 1.0710 b |
| Monalisa | 1274 a | 72 b | 148 a | 3.8 a | 1.0610 b |
| General Mean | 809 | 70 | 124 | 2.2 | 1.0796 |

[1/] Means followed by the same letters for each column did not differ by the Scott and Knott test (P<0,05).

clones are those derived from different types of families, and there was no tendency to different behavior of the different genomic compositions. There were early and late maturing clones in Maria da Fé ranging from 73 to 132-day cycle after emergence. The means of the controls were 92 and 80 days for Monalisa and Achat, respectively.

The general tuber appearance was assessed in the experiments in Lavras (Table 2). The general mean in both experiments was very low and the families derived from crosses involving only *S. tuberosum* did not present an appearance score comparable to that of the

**Table 4.** Means of the control cultivars and the best forty clones for tuber yield, percentage of marketable tubers, average weight of marketable tubers, tuber specific gravity, and vegetative cycle. Maria da Fé, 1999-2000.

| Clones | Tuber Yield (g/plant) | % of marketable tubers | Average weight of marketable tubers (g) | Tuber specific gravity | Vegetative cycle (days) |
|---|---|---|---|---|---|
| 3.29 | 707 | 100 | 60 | 1.0672 | 96 |
| 4.01 | 870 | 96 | 71 | 1.0860 | 101 |
| 5.16 | 645 | 93 | 68 | 1.0713 | 93 |
| 7.06 | 1320 | 90 | 79 | 1.0844 | 94 |
| 8.18 | 811 | 71 | 53 | 1.0741 | 91 |
| 10.08 | 641 | 74 | 29 | 1.0664 | 80 |
| 10.17 | 745 | 92 | 33 | 1.0700 | 86 |
| 10.19 | 682 | 72 | 32 | 1.0767 | 91 |
| 10.21 | 632 | 75 | 32 | 1.0743 | 100 |
| 11.25 | 628 | 100 | 72 | 1.0773 | 91 |
| 11.28 | 753 | 92 | 59 | 1.0864 | 88 |
| 11.30 | 820 | 93 | 50 | 1.0751 | 91 |
| 12.19 | 711 | 100 | 63 | 1.0692 | 86 |
| 12.33 | 645 | 99 | 54 | 1.0732 | 93 |
| 13.18 | 670 | 93 | 43 | 1.0682 | 94 |
| 13.27 | 628 | 97 | 59 | 1.0845 | 91 |
| 16.01 | 807 | 100 | 71 | 1.0863 | 94 |
| 16.08 | 672 | 99 | 76 | 1.0733 | 117 |
| 16.21 | 907 | 100 | 51 | 1.0675 | 116 |
| 17.02 | 678 | 81 | 44 | 1.0712 | 88 |
| 17.30 | 699 | 72 | 39 | 1.0750 | 94 |
| 20.01 | 641 | 95 | 63 | 1.0869 | 101 |
| 20.08 | 686 | 73 | 38 | 1.0794 | 101 |
| 20.14 | 991 | 99 | 56 | 1.0836 | 96 |
| 20.21 | 770 | 72 | 36 | 1.0876 | 101 |
| 21.21 | 1278 | 72 | 59 | 1.0783 | 91 |
| 22.07 | 641 | 90 | 63 | 1.0753 | 101 |
| 22.08 | 728 | 96 | 71 | 1.0915 | 101 |
| 22.10 | 1236 | 81 | 69 | 1.0794 | 91 |
| 22.12 | 1070 | 86 | 41 | 1.0837 | 84 |
| 22.14 | 853 | 94 | 61 | 1.0748 | 89 |
| 25.11 | 836 | 80 | 68 | 1.0775 | 98 |
| 26.07 | 907 | 100 | 53 | 1.0779 | 96 |
| 26.08 | 674 | 79 | 30 | 1.0731 | 91 |
| 27.10 | 1107 | 94 | 91 | 1.0745 | 96 |
| 30.02 | 907 | 95 | 56 | 1.0663 | 86 |
| 30.01 | 853 | 98 | 47 | 1.0850 | 86 |
| 30.06 | 753 | 77 | 49 | 1.0718 | 88 |
| 31.09 | 857 | 89 | 40 | 1.0671 | 96 |
| Monalisa | 542 | 87 | 57 | 1.0522 | 93 |
| Achat | 364 | 59 | 31 | 1.0565 | 80 |
| General Mean | 350 | 40 | 44 | 1.0687 | 94 |

control Monalisa. Their scores, however, were generally uniform, with clones presenting less variation in shape, color and periderm type than the family standard. Some families derived from *S. chacoense*, specially those with 25% of the genome from this species, presented poor appearance with undesirable tuber color and deep eyes.

Table 3 shows the means for some traits of the 40 best clones selected based on the Lavras experimental data. The Mulamba and Mock index (1978) was used due to its simplicity and efficiency compared to other indexes used for the potato crop (Barbosa and Pinto, 1998). The most interesting clone traits observed were tuber yield and tuber specific gravity. The appearance scores were considered reasonable, as they are derived from exotic species. Many clones also presented high tuber yield in Maria da Fé (Table 4), such as clones 3.29, 4.30, 7.06 and 10.31. Clones showing high tuber yield, high tuber specific gravity, good percentage of large tubers and tuber appearance could be selected from families of the different genomic compositions tested.

Heterosis in the crosses between *S. tuberosum* cultivars and exotic species is often reported in the literature (Cubillos and Plaisted, 1976; Tarn and Tai, 1977; De Jong and Tai, 1977; Hoopes et al., 1980; Munoz and Plaisted, 1981; Ortiz et al., 1991; Darmo and Peloquin, 1991). Buso et al., (1999b) detected clones with 25% *S. chacoense* genome with excellent agronomic traits and appearance within the standards for the *S. tuberosum* cultivars. Thill and Peloquin (1995) found clones from families with 25% S. tarijense germplasm showing good frying quality and higher yield than the Atlantic cultivar.

In all experiments of the present study, families obtained by intercrossing EOA clones (25% *S. chacoense*) and those with 50% of the *ssp. andigena* genome showed poor performance. Some authors state that the low yield performance is, in some cases, due to the high percentage of non-adapted genome in the hybrid and to the fact that heterosis is not always useful for tuber yield in small size tubers (Bani-Aameur et al., 1991; Yerk and Peloquin, 1990; McHale and Lauer, 1981b; Tarn and Tai, 1977).

There was good performance from the families with 25%, 12.5% and 0% of exotic genome in all the experiments. The importance of the backcrosses was shown by the behavior of some families derived from backcrossing of the EOA clones (25% *S. chacoense*) and ELS clones (50% *ssp. andigena*) to adapted materials. The choice of the diploid parents is also an important aspect to be taken into account for successful selection in hybrid populations. Darmo and Peloquin (1991) showed from studies on combining ability that some diploid clones had good combining ability with tetraploid *S. tuberosum* cultivars for several traits, including tuber yield and tuber appearance. Several authors have found high yielding clones with good tuber appearance derived from hybrid families between *S. tuberosum* and non-adapted species. *S. tuberosum* and *S. acaule* hybrid presented similar appearance to that shown by tetraploid cultivars (Watanabe et al., 1994). The presence of many clones with an undesirable tuber appearance and some families with low tuber yield found here, reinforce the idea of a more careful choice of parents. Regarding tuber appearance, the comparisons with studies carried out abroad should be regarded with caution, as the requirement for this trait varies among consumers in different countries. The control used in the present study was the Monalisa cultivar that presents tubers with shiny, smooth yellow skin, which is well accepted by Brazilian consumers. In the USA, where some of the quoted studies were carried out, the cultivars with rough skin are not rejected since most of the potato production is industrially processed and the shape, eye depth and internal quality of the tubers are more important factors. The clones selected in the present study should be backcrossed again with the *S. tuberosum* species to maintain the high tuber specific gravity, but improving tuber appearance.

## RESUMO


### Performance agronômica de híbridos interespecíficos de batata

Avaliaram-se híbridos resultantes do cruzamento entre cultivares de batata *Solanum tuberosum* L. com clones de *S. tuberosum* ssp. *andigena, S. chacoense e S. phureja.* Híbridos com diferentes proporções do genoma das espécies exóticas (50, 25 e 12,5%) foram comparados com famílias oriundas do cruzamento somente entre cultivares de *S. tuberosum*. Realizaram-se três experimentos em duas localidades do sul de Minas, um em delineamento de blocos aumentados e dois em látice, para avaliação dos clones e das famílias. As famílias com maior porcentagem do genoma das espécies exóticas apresentaram menor produção de tubérculos, menor porcentagem de tubérculos graúdos e menor peso médio de tubérculos. A principal limitação de alguns híbridos foi a aparência de tubérculos, observando-se alta freqüência de clones com tubérculos de aspecto

indesejável. Foi possível selecionar clones oriundos de diferentes composições genômicas com alta produção, boa percentagem de tubérculos graúdos, alto peso específico de tubérculos e boa aparência de tubérculos.

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