Prediction of genetic gains through selection of sweet potato accessions
Pablo F Vargas 1; Maria Eduarda F Otoboni 2; Beatriz G Lopes 3; Bruno E Pavan 2

1Universidade Estadual Paulista (UNESP), Registro-SP, Brasil; pablo.vargas@unesp.br; 2Universidade Estadual Paulista (UNESP), Ilha Solteira-SP, Brasil; eduarda.otoboni@unesp.br; be.pavan@unesp.br; 3Universidade de São Paulo (USP), Piracicaba-SP, Brasil; beatrizgl@usp.br

ABSTRACT

Due to the high genetic variability found in sweet potato and a low number of cultivars available on the market, there are opportunities for necessary improvements in crop breeding programs. The selection indexes are a favorable strategy to achieve higher yields through genetic gains obtained with the future population. Thus, the objective was to evaluate the selection gain of agronomic characters from sweet potato accessions for root production and dual-aptitude. 95 accessions and two commercial cultivars (Braslandia Branca and Brazlândia Roxa) were evaluated. A randomized block design with three replications of ten plants per plot was used. The index proposed by Mulamba & Mock was used to select superior individuals. The population evaluated showed high genetic variability providing considerable selection gains, being recommended some clones for tests of value for cultivation and use. The VR13-61 accession was the most recommended for root production and VR13-11 and VR13-22 for dual-aptitude.

Keywords: Ipomoea batatas, plant breeding, genetic variability.
MATERIAL AND METHODS

The accessions were collected in traditional communities of Vale do Ribeira, these being quilombos, Indigenous villages, and caçaicas communities. Accessions were also collected in peri-urban vegetable gardens where sweet potatoes are grown for subsistence and in small farms, from February to November, 2013. The Vale do Ribeira is characterized, according to Köppen’s classification, as Af climate, i.e. mild winters, hot and humid summers, and without a dry season.

In total, 95 sweet potato accessions were collected in seven municipalities of Vale do Ribeira. After collection and identification, the genetic material was taken to UNESP Campus of Registro. The accession’s field evaluation was carried out at the Experimental Farm of UNESP, in the municipality of Registro-SP (24°29'15"S, 47º50'37"W, 19 m altitude), between February and August, 2014.

The experimental design adopted was randomized blocks, with three replications. The experimental plot was composed of 10 plants in a single row, considering as useful area of the plot the eight central plants. The treatments consisted of 95 accessions and two commercial cultivars as controls, Brazlândia Branca and Brazlândia Roxa, thus totaling 97 genotypes.

The seedlings containing eight internodes were transplanted into the field in spacings between rows of 1 m and between plants of 0.25 m, totaling 40 thousand plants per hectare. The soil preparation, as well as the management and fertilization practices, were carried out according to the recommendations for the crop (Raij et al., 1997).

Plants were harvested five months after planting date. The characteristics evaluated were: 1) Total root production (TRP) (mass of all harvested roots in the plot and later converted to kg ha⁻¹); 2) Marketable root production (MRP) (root mass, with individual mass above 80 g, in the plot and later converted to kg ha⁻¹); 3) Total dry root mass production (DRM) [2 kg of root samples were dried in an oven at 65°C until constant mass (%); subsequently, the dry mass content was multiplied by the total root production]; 4) Total branch production (TBP) (obtained by cutting the branches and leaves at ground level, with subsequent weighing of the plot and converted to kg ha⁻¹); 5) Total dry branch mass production (DBM) [2 kg of shoot samples were crushed, then placed in an oven at 65°C until constant mass to determine the dry mass content (%); subsequently, the dry branch mass was multiplied by the total branch production].

Statistical analyzes were performed using the computer program Genes (Cruz, 2006, 2013). Each characteristic was subjected to analysis of variance using the statistical model

\[ Y_{ij} = \mu + g_i + b_j + e_{ij} \]

where: \( Y_{ij} \) is the value observed in the \( i \)-th genotype of the \( j \)-th block (\( j = 1, 2, 3 \); \( \mu \) is the general mean of the experiment; \( g_i \) is the effect of the \( i \)-th genotype; \( b_j \) is the effect of the \( j \)-th block; and \( e_{ij} \) is the experimental error associated with the observation \( Y_{ij} \).

Analysis of direct gains with the selection was carried out for the predicted gains. Also, the selection index proposed by Mulamba & Mock (1978) was employed according to the statistical model

\[ I_j = \sum n_{ij} \]

wherein: \( I_j \) is the index for the genotype \( j \); and \( n_{ij} \) is the classification number of character \( i \), for genotype \( j \) (França et al., 2016).

The index proposed by Mulamba & Mock (1978) hierarchized the genotypes ordering according to each desired character, and subsequently, the sum of the ranks based on the multiple characters evaluated was performed, thus obtaining the classification of the genotypes by ranks.

Economic weights were used to maximize the gains obtained, making the index as balanced as possible, to find the one that predicted the greatest genotypic gain. The values and signs of the economic weights were adopted according to the selection direction, assigning greater importance to more relevant economic and agronomic
characters, being positive when the selection is favorable and negative when the selection is against that specific character.

First, positive weights for root characters and negative weights for shoot parts were adopted, with weight 4 for total and marketable root production, 3 for dry root mass, and -1 for total root production and total dry branches mass production, to select superior accessions for root production. The negative score for shoot production was determined as this characteristic hinders the crop semi-mechanized harvesting process, thus, the identification of genotypes with good root production capacity and less shoot volume is a demand of the productive sector. In addition, there is no positive correlation between root and shoot production in the sweet potato crop (Azevedo et al., 2015). Then, positive weights were used for both characteristics, being 2 for root characters and 1 for shoot production, this time to select accessions that have dual-aptitude, i.e. productive both in shoot and in roots.

RESULTS AND DISCUSSION

All evaluated characteristics showed significant genetic variability between sweet potato accessions (Table 1), enabling gains with selection. The coefficients of variation of the analyzed variables ranged between 7.32 (TRP) and 12.17 (TBP), providing good experimental precision.

Significant genetic variances and low CV resulted in high magnitude broad-sense heritabilities for all characters (Table 1), ranging from 0.9881 (98.81%) to 0.9707 (97.07%), demonstrating that these characteristics are highly inheritable and easy to proceed with the selection in sweet potato accessions, which opens space for relevant gains in breeding programs. In sweet potatoes, broad-sense heritability is important because the effects of dominance and epistasis are maintained by vegetative propagation (Gonçalves Neto et al., 2012).

Other authors have also identified medium to high heritabilities for sweet potato accessions. Cavalcante et al. (2009) assessed the productive and genetic potentials of nine accessions and two commercial cultivars of sweet potato and obtained high heritability, however slightly inferior to the present study in total root production (95.39%) and total branch production (93.28%)

Carmona et al. (2015), in a genetic divergence study between sweet potato accessions, reported minor heritabilities, ranging from 59% to 85.42%.

The heritability is an important parameter, as it enables the prediction of the possibility of success with the selection since it reflects the proportion of the inherited phenotypic variation, i.e. it quantifies the reliability of the phenotypic value as an indicator of the reproductive value (Rodrigues et al., 2011). Also, along with the CVg/CVe ratio, the heritability measures the data reliability (Faluba et al., 2010).

Such experimental precision and high variability also provided high values of the ratio between the coefficients of genetic and environmental variation (CVg/CVe), the lowest being 3.32 for DRM and the highest being 5.26 for TRP (Table 1), which shows that the evaluated characters are ideal to be used in breeding programs, as they indicate that genetic causes are acting more than environmental ones. Gonçalves Neto et al. (2012) cite that CVg/CVe greater than 1 indicates high variability and a favorable situation for selection.

Gonçalves Neto et al. (2012) evaluated the correlation between characters and estimation of population parameters in sweet potatoes, obtained CVg/CVe above 1 in total root production (3.34), but the value was lower than in this study. Azevedo et al. (2015) studied the agronomic performance and genetic parameters in sweet potatoes and observed CVg/CVe higher than 1 only for marketable root production (1.08). Carmona et al. (2015), in a study of genetic divergence between sweet potato accessions, reported CVg/CVe values lower than that obtained in the present study for total and marketable production of sweet potato roots, being 1.05 and 0.93, respectively.

Little genetically-improved species, as in the case of sweet potatoes, tend to present high genetic variability, indicating that the crop has a high potential for exploration for future breeding programs. According to Azevedo et al. (2015), the expressive genetic variability found in sweet potatoes provides a large number of genotypes to be tested and evaluated to obtain new cultivars through selection and genetic improvement, thus constituting continuous and dynamic work. Oliveira et al. (2012) report that studies on genetic variability and divergence are essential to advance new selection cycles, in addition to assisting in the identification and relationship between parents.

Table 1. Estimates of genetic parameters and direct gains with selection in characters of sweet potato accessions. Registro, UNESP, 2020.

| Parameters | TRP¹ | MRP² | DRM³ | TBP⁴ | DBM⁵ |
|-----------|------|------|------|------|------|
| σ²     | 0.9881 | 0.9858 | 0.9707 | 0.9769 | 0.9772 |
| h²     | 38.51 | 42.16 | 33.41 | 45.73 | 42.85 |
| CVg%   | 5.26 | 4.81 | 3.32 | 3.75 | 3.78 |
| CVg/CVe | 22.0 | 22.4 | 4.3 | 49.3 | 6.6 |
| GS     | 97.37 | 105.21 | 66.48 | 141.64 | 125.55 |
| Average | 22662.09 | 21351.31 | 6577.91 | 34838.61 | 5310.91 |

σ²=genetic variance; h²=heritability; CVg=genotypic coefficient of variation; CVg/CVe=relative coefficient of variation between CVg and CVe (experimental coefficient of variation); GS=selection gain; GS%=selection gain (percentage), given by SG%/SG = (mean gain)*100. ¹Total root production (t ha⁻¹); ²Marketable root production (t ha⁻¹); ³Total dry root mass production (t ha⁻¹); ⁴Total branch production (t ha⁻¹); ⁵Total dry branch mass production (t ha⁻¹); **significant at 1%.
The estimates of selection gains exceeded 100% for marketable root production (105.21%), total branch production (141.64%), and total dry branch mass production (125.55%) (Table 1). In addition to the other characters showing positive selection gains, the high expectation of genetic gains corroborates with the other parameters analyzed, providing high-magnitude selection gains that would even double the marketable root production.

To be launched, a cultivar must have a series of desirable attributes simultaneously, which suggests that the selection of a single characteristic does not match the reality of modern agriculture. Thus, multivariate selection using selection indexes is an adequate tool to achieve these objectives, assuming that the adoption of selection indexes tends to provide balanced gains for all studied characters, which facilitates the data systematization, interpretation, and selection.

The Mulamba & Mock index enabled the identification of genetic gains favorable to the direction of selection for all studied characters (Tables 2 and 3). When the selection aimed only at root production gains, these were positive, and negative for branches. Growers who only aim at root production are often not interested in high-branch producing genotypes. When the selection was for double-use, looking for materials that present good production both in roots and in shoot parts, this being destined for animal feed, the index also provided gains in all characteristics, demonstrating the high efficiency of selection indexes for selection of sweet potato accessions.

The efficiency of the index proposed by Mulamba & Mock has been reported in several crops, such as potato (Terres et al., 2015), acid passion fruit (Rosado et al., 2012), yellow passion fruit (Krause et al., 2012), papaya (Vivas et al., 2012), and coffee (Carias et al., 2016), which makes its use reliable by providing the selection of genotypes with more balanced agronomic characteristics, meeting the demand of both farmers and consumers.

**Selection of sweet potato accessions for root production**

Considering the selection of accessions only for root production, with no interest for gains for shoot production, there were positive gains in total root production, marketable root production, and total dry root mass production. Total branches production and total dry branch mass production

---

**Table 2.** Estimated gains through the selection for the characters TRP, MRP, DRM, TBP, and DBM, and classification of the five best sweet potato accessions for root production submitted to the analysis of selection gains according to the index proposed by Mulamba & Mock (1978) and the result of the two commercial cultivars. Registro, UNESP, 2020.

| Estimated gains | TRP₁ | MRP² | DRM³ | TBP⁴ | DBM⁵ |
|----------------|------|------|------|------|------|
| DS             | 15.10| 15.20| 2.40 | -1.00| -0.40|
| GS             | 14.90| 15.00| 2.40 | -1.00| -0.40|
| GS%            | 65.91| 70.31| 36.79| -2.95| -7.61|

| Rank | Selected accessions |
|------|---------------------|
| 1º   | VR13-52             |
|      | 33.7                |
| 2º   | VR13-31             |
|      | 27.9                |
| 3º   | VR13-48             |
|      | 33.5                |
| 4º   | VR13-61             |
|      | 47.6                |
| 5º   | VR13-44             |
|      | 46.0                |

| Average | 37.7       |
|         | 36.5       |
|         | 9.0        |
|         | 33.7       |
|         | 4.8        |

| Brazilândia Branca | 32.4 |
| Brazilândia Roxa   | 27.6 |

| DS= Selection differential (t ha⁻¹); GS= selection gain (t ha⁻¹); GS%= selection gain (%), given by SG% = SG / (mean gain)*100; ¹Total root production (t ha⁻¹); ²Marketable root production (t ha⁻¹); ³Total dry root mass production (t ha⁻¹); ⁴Total branch production (t ha⁻¹); ⁵Total dry branch mass production (t ha⁻¹). |

---

**Table 3.** Estimated gains through the selection for the characters TRP, MRP, DRM, TBP, and DBM, and classification of the five best sweet potato accessions for dual-aptitude submitted to the analysis of selection gains according to the index proposed by Mulamba & Mock (1978) and the result of the two commercial cultivars. Registro, UNESP, 2020.

| Estimated gains | TRP¹ | MRP² | DRM³ | TBP⁴ | DBM⁵ |
|----------------|------|------|------|------|------|
| DS             | 13.00| 12.80| 3.30 | 2.30 | 3.10 |
| GS             | 12.80| 12.60| 3.20 | 22.80| 3.00 |
| GS%            | 56.90| 59.16| 49.92| 58.53| 58.18|

| Rank | Selected accessions |
|------|---------------------|
| 1º   | VR13-22             |
|      | 35.3                |
| 2º   | VR13-11             |
|      | 44.6                |
| 3º   | VR13-41             |
|      | 35.4                |
| 4º   | VR13-31             |
|      | 27.9                |
| 5º   | VR13-84             |
|      | 35.2                |

| Average | 35.7       |
|         | 34.1       |
|         | 9.9        |
|         | 58.2       |
|         | 8.4        |

| Brazilândia Branca | 32.4 |
| Brazilândia Roxa   | 27.6 |

| DS= Selection differential (t ha⁻¹); GS= selection gain (t ha⁻¹); GS%= selection gain (%), given by SG% = SG / (mean gain)*100; ¹Total root production (t ha⁻¹); ²Marketable root production (t ha⁻¹); ³Total dry root mass production (t ha⁻¹); ⁴Total branch production (t ha⁻¹); ⁵Total dry branch mass production (t ha⁻¹). |
showed negative gains, which is the objective at the moment. Marketable root production was the variable with the highest selection gain (70.31%), followed by total root production with 65.91% (Table 2).

The selection differential consists of the difference between the average of the original population and the average of the improved population, the gain obtained is directly related to this differential. Among genotypes with aptitude only for root production, the selection differential ranged from 15.2 to -1.0 (Table 2), with negative results for total branch production and total dry branch mass production, since a priori, it aimed at the lowest possible production of part of the access area.

The indices are used for genotype selection based on multiple characters. However, when necessary, there is the possibility of obtaining negative genetic gains in an individual character that is not currently desired (Krause et al., 2012). Therefore, aiming at the negative gain in the shoot part, among the 97 accessions, the five most productive in root characters were selected: VR13-52, VR13-31, VR13-48, VR13-61, and VR13-44, presented in Table 2.

The two commercial cultivars Brazlândia Branca and Brazlândia Roxa were not selected according to the selection index adopted. As for root production, the cultivar Brazlândia Roxa was inferior to the accessions selected in two of the targeted characteristics for the moment, TRP and DRM, being superior to the accession VR13-31 only in MRP. The cultivar Brazlândia Branca was slightly superior to VR13-31 in TRP and MRP. Even though presenting results similar to some of the selected accessions, both commercial cultivars demonstrate good shoot production and considering that the selection was carried out, in this context, only for root production with the minimum of shoot part possible, they were not selected. Also, the average of the selected accessions was superior to the commercial cultivars in all root characters. In view of this, having demonstrated the commercial potential of the accessions selected for root production, they can be recommended to compose sweet potato breeding programs aiming at tests of value for cultivation, to ultimately obtain new commercial cultivars.

Accessions VR13-61 and VR13-44 were significantly superior to the commercial cultivars studied, with almost 20 t ha⁻¹ difference between the cultivar Brazlândia Roxa and access VR13-61.

Despite the high potential sweet potato production, the Brazilian yield is around 12 t ha⁻¹, indicating the superiority of the population selected in the present study as the access with the lowest MRP reached 26.7 t ha⁻¹, i.e. 14 t ha⁻¹ more than the Brazilian average. The access with the best performance obtained 47.2 t ha⁻¹, representing 35 t ha⁻¹ more than the national average.

The average of the selected population (Table 2) was higher than the general average (Table 1) for the three root characters evaluated, with gains of 14.9 t ha⁻¹ in TRP, 15.0 t ha⁻¹ in MRP, and 2.4 t ha⁻¹ in DRM proving the positive gains.

Among the five selected accessions, the total root production ranged from 27.9 to 47.6 t ha⁻¹, whereas the accessions with the lowest and highest results were, respectively, VR13-31 and VR13-61 (Table 2). The same occurred for marketable root production. Andrade Júnior et al. (2012) evaluated 12 sweet potato accessions and reported inferior total root production, with only one accession having a higher yield than those selected in the present study. Silva et al. (2015) assessed the performance of sweet potato cultivars and found inferior results in the two-year study, with an average of 21.2 t ha⁻¹ in 2012 and 23.6 t ha⁻¹ in 2013.

As for MRP, Andrade Júnior et al. (2012) demonstrated lower average results, ranging from 8.0 to 29.5 t ha⁻¹, and only one of the accessions outperformed those in this study. For DRM, the authors found considerably lower results, ranging from 1.2 to 3.5 t ha⁻¹. Gonçalves Neto et al. (2012) evaluated 39 sweet potato genotypes and reported an average of 8.9 t ha⁻¹ for dry root mass.

For total branches production (Table 2), the best performances were the accessions VR13-31 with 48.8 t ha⁻¹ and VR13-52 with 43.8 t ha⁻¹. For total dry branch mass production, the accession that presented the best result was VR13-31 with 7.9 t ha⁻¹.

Comparing each characteristic with their respective averages among the selected accessions, VR13-61 and VR13-44 were the only ones that obtained values higher than the total average concerning the total and commercial root production. However, in DRM, TBP, and DBM, VR13-61 and VR13-44 showed averages below the general average. As in this first selection the objective was to obtain as little shoot part as possible, the two accessions are promising, even though both show results below the average for dry root mass.

For root production (total, marketable, and total dry mass), VR13-61 is the most promising accession, as it obtained better results in total and marketable root production, and placing third for total dry root mass, in addition to being the selected accession that presented lower results in shoot characters.

Selection of sweet potato accessions for dual-aptitude

The selection for dual-aptitude aimed to identify genotypes with good performance for both root and shoot production. The shoot production is destined for animal feed. There were positive gains in all the evaluated characters (Table 3). Total branch production presented the highest gain, 65.53%, followed by marketable root production with 59.16%. The lowest gain was observed for dry root mass, with 49.92% (Table 3).

About root production selection, the five best among the 97 accessions were selected for dual-aptitude, namely: VR13-22, VR13-11, VR13-41, VR13-31, and VR13-84.

No negative results were verified for the selection differentials (Table 3), which was desirable as accessions were selected for dual-aptitude seeking positive gains in all the evaluated characters, both in root and shoot production, differently than what was
previously presented when promising accessions were sought only for root production (Table 2).

Once again, VR13-96 and VR13-97, the commercial cultivars were not selected among the accessions with dual-aptitude. When compared with those selected, VR13-97 performed lower in all root production characters, but higher in shoot production (TBP) than three accessions, VR13-84, VR13-31, and VR13-41, however, with results lower than the average of the selected accessions.

The accession VR13-31 was the only one selected for both root production (Table 2) and dual-aptitude (Table 3). Among the selected accessions, VR13-11 with 44.6 t ha⁻¹ was the best for total production and total dry branch mass and VR13-31, VR13-61 and VR13-22 are promising. Once again, VR13-96 and VR13-41 showed higher in shoot parts. As for the selection for dual-aptitude, VR13-11 and VR13-22 are promising.

**ACKNOWLEDGMENTS**

This research was supported by grant 2012/08763-0, FAPESP (São Paulo Research Foundation), and by CAPES (Coordination for the Improvement of Higher Education Personnel) through granting of a master’s scholarship.

**REFERENCES**

ANDRADE JÚNIOR, VC; PEREIRA, RC; DORNAS, MFS; RIBEIRO, KG; VALADARES, NR; SANTOS, AA; CASTRO, BMC. 2014. Produção de silagem; composição bromatológica e capacidade fermentativa de ramas de batata-doce emurecidas. Horticultura Brasileira 32: 91-97.

CARIAS, CMOM; GRAVINA, GA; FERRÃO, MAG; FONSECA, AFA; FERRÃO, RG; VIVAS M; VIANA AP. 2016. Predição de ganhos genéticos via modelos mistos em progenitores de café comilon. Coffee Science 11: 39-45.

CARMONA, PAO; PEIXOTO, JR; AMARO, GB; MENDONÇA, MA. 2015. Diversidade genética entre acessos de batata-doce utilizando descritores morfoagronômicos das raízes. Horticultura Brasileira 33: 241-250.

CRAUSE, W; SOUZA, RS; NEVES, LG; CARVALHO, MLS; VIANA, AP; FALEIRO, FG. 2012. Genootypes selected for dual-aptitude. VR13-11 was the only accessional average for dry root mass, with 12.4 t ha⁻¹.

As for shoot production, VR13-22 averaged higher in total branch production and total dry branch mass production, with 88.2 and 12.3 t ha⁻¹, respectively. Andrade Júnior et al. (2014), in a study with sweet potato branches, reported lower dry mass production, with an average of 6.4 t ha⁻¹.

Considering the average of each accession for each characteristic, and comparing them with the general average, VR13-11 was the only superior in total and marketable root production, raising the general average for demonstrating considerable superiority to the other accessions in these characters. For dry root mass and total branch production, VR13-22 and VR13-11 were superior to the other accessions, presenting average higher than the general average. VR13-22 was also higher than the general average in total dry branch mass production, together with VR13-41.

The studied population showed high genetic variability, providing considerable selection gains. The selected accessions showed expressive results for yield, which indicates good potential as parents to be adopted in breeding programs.

In general, the selected accessions were superior to commercial cultivars, being recommended for tests of value for cultivation and use for possible cultivars release. Among the selected accessions, VR13-61 is the most recommended for root production, because in addition to showing superiority in root characteristics, it was the least productive in shoot parts. As for the selection for dual-aptitude, VR13-11 and VR13-22 are promising.

**REFERENCES**

ANDRADE JÚNIOR, VC; PEREIRA, RC; DORNAS, MFS; RIBEIRO, KG; VALADARES, NR; SANTOS, AA; CASTRO, BMC. 2014. Produção de silagem; composição bromatológica e capacidade fermentativa de ramas de batata-doce emurecidas. Horticultura Brasileira 32: 91-97.

CARIAS, CMOM; GRAVINA, GA; FERRÃO, MAG; FONSECA, AFA; FERRÃO, RG; VIVAS M; VIANA AP. 2016. Predição de ganhos genéticos via modelos mistos em progenitores de café comilon. Coffee Science 11: 39-45.

CARMONA, PAO; PEIXOTO, JR; AMARO, GB; MENDONÇA, MA. 2015. Diversidade genética entre acessos de batata-doce utilizando descritores morfoagronômicos das raízes. Horticultura Brasileira 33: 241-250.
Prediction of genetic gains through selection of sweet potato accessions

RAPD. Revista Brasileira de Fruticultura 34: 216-226.
RAIJ, BV; CANTARELLA, H.; QUAGGIO, JA; FURLANI, AMC. 1997. Recomendações de adubação e calagem para o estado de São Paulo, 2 ed. Campinas: Instituto Agronômico & Fundação IAC. 285p. (Boletim Técnico, 100).
RODRIGUES, F; PINHO, RGV; ALBUQUERQUE, CIB; PINHO, EVRV. 2011. Index of selection and estimation of genetic and phenotypical parameters for traits related with the production of vegetable corn. Ciência e Tecnologia 35: 278-286.
ROSADO, LDS; SANTOS, CEM.; BRUCKNER, CH; NUNES, ES; CRUZ, CD. 2012. Simultaneous selection in progenies of yellow passion fruit using selection indices. Revista Ceres 59: 95-101.
SILVA, GO; SUINAGA, FA; PONIJALEKI, R; AMARO, GB. 2015. Desempenho de cultivares de batata-doce para caracteres relacionados com o rendimento de raiz. Revista Ceres 62: 379-383.
TERRES, LR; LENZ, E; CASTRO, CM; PEREIRA, AS. 2015. Estimativas de ganhos genéticos por diferentes índices de seleção em três populações híbridas de batata. Horticultura brasileira 33: 305-310.
VIVAS, M; SILVEIRA, SF; PEREIRA, MG. 2012. Prediction of genetic gain from selection indices for disease resistance in papaya hybrids. Revista Ceres 59: 781-786.