horticultura brasileira

Scientific Communication

MELLO, AFS; SOUZA, MB; SILVA, GO; PEDROSO, MTM; SANTIAGO, AV; CARVALHO, JLV. Sweetpotato as an alternative crop for vegetable growers in Marabá-PA. *Horticultura Brasileira* v.41, 2023, elocation e2582. DOI: http://dx.doi.org/10.1590/s0102-0536-2023-e2582

Sweetpotato as an alternative crop for vegetable growers in Marabá-PA

Alexandre FS Mello [1]*; Mazilene B de Souza [2]; Giovani O da Silva [1]; Maria Thereza M Pedroso [1]; Alailson V Santiago [2]; José Luiz V de Carvalho[3]

[1]Embrapa Hortaliças, Brasília-DF, Brasil; alexandre.mello@embrapa.br (*corresponding author); giovani.olegario@embrapa.br; maria.pedroso@embrapa.br. [2]Embrapa Amazonia Oriental, Belém-PA, Brasil; mazillene.borges@embrapa.br; alailson.santiago@embrapa.br;. [3]Embrapa Tecnologia de Alimentos, Guaratiba-RJ; jose.viana@embrapa.br

ABSTRACT

The north region of Brazil has been experiencing agricultural and urban expansion leading to the need for economic alternatives to reduce deforestation and to increase food supply. One possibility is the cultivation of vegetables that are easily grown such as the sweetpotato. The objective of this work is to assess the performance of sweetpotato genotypes in three different planting seasons in Marabá, Brazil. Sweetpotato genotypes were evaluated using randomized block experimental design and at harvest time the final plant stand and the commercial root production were evaluated. Clone 11 was the most productive one in all planting dates, with commercial yield ranging from 80.4 to 127 t/ha. Canadense also was very productive and among the top yielding genotypes. CIP BRS Nuti's commercial yield was similar to Beauregard's in the two initial growing seasons but higher in the third planting cycle. The first season, that had high moisture during harvest time, presented the lowest root quality. However, in general, all cultivars performed well, being good options for growers to produce a food source with high quality and yield in small areas.

Keywords: *Ipomoea batatas*, Amazon region, biofortification, betacarotene.

RESUMO

Batata-doce como cultura alternativa para horticultores de Marabá-PA

A região norte do Brasil vem passando por uma expansão agrícola e urbana demonstrando a necessidade de alternativas econômicas para reduzir o desmatamento e aumentar a oferta de alimentos. Uma possibilidade é o cultivo de hortaliças de fácil cultivo como a batata-doce. O objetivo deste trabalho é avaliar o desempenho de genótipos de batata-doce em Marabá, Brasil em três épocas diferentes. Os genótipos foram plantados em blocos casualizados e na época da colheita, foram avaliados o número e plantas e a produção comercial de raízes. O clone 11 foi o mais produtivo em todas as épocas de plantio, com produtividade comercial variando de 80,4 a 127 t/ha. O genótipo denominado Canadense também apresentou produtividade elevada. A produtividade comercial da cultivar CIP BRS Nuti foi semelhante à da Beauregard nas duas safras iniciais, mas maior no terceiro ciclo de plantio. A primeira época de plantio, apresentou alta umidade na época da colheita, prejudicando a qualidade das raízes. Porém, de maneira geral, todas as cultivares tiveram bom desempenho, sendo boas opções para os produtores produzirem uma fonte de alimento com alta qualidade e rendimento em pequenas áreas.

Palavras-chave: *Ipomoea batatas*, região Amazônica, biofortificação, betacaroteno.

Received on February 6, 2023; accepted on July 7, 2023

The state of Pará is the second largest Brazilian state in the Amazon region. Formerly covered by a dense forest, it experienced the expansion of soybean cultivation from the mid-1990s onwards. This caused dynamic and controversial economic, social and environmental impacts in the area surrounding Marabá city (Homma *et al.*, 2019). The economic expansion of recent years has attracted migrants, increasing the deforestation, expanding the population, and leading to a need to increase the food supply and search for economic alternatives to reduce deforestation in the region (Homma *et al.*, 2019).

As a potential center of origin for sweetpotato (*Ipomoea batatas*) (Roullier *et al.,* 2013), the northern region of Brazil has climatic conditions that are good for this crop, which is among the most important roots in the regional diet (Tomchinsky *et al.*, 2021). Sweetpotato cultivation seems to be particularly important among the Krahô indigenous people, who have cosmology and cultural practices associated with this plant (Tomchinsky *et al.*, 2021).

However, considering the climatic adaptation and potential of this crop and cultural and diet importance, the crop area and yield are much lower than in other Brazilian regions. In 2020 the northern region production area was 922 ha, which corresponds to only 1.6% of the total Brazilian planted area. The average yield of 9.2 t/ha, is much lower than the Brazilian average of 13.4 t/ha (IBGE, 2022) or the crop potential of 40 t/ha (Cecílio Filho *et al.*, 2016).

The lower yield in many Brazilian regions is due to the cultivation of local and non-improved varieties and a lower level of technology (Cecílio Filho *et al.*, 2016, Vargas *et al.*, 2018). Therefore, in order to improve this condition, correct crop handling, fertilization and other cultural treatments and the adoption of more productive cultivars are required.

Because the sweetpotato crop is restricted to only 25 ha in Pará state (IBGE, 2022) and root yield may vary according to the environment (Afolabi *et al.*, 2019), efforts to introduce new varieties of sweetpotatoes and studies to elucidate the seasonality of this crop in that region are important. The objective of this work is to assess the performance of four sweetpotato genotypes at three planting dates in Marabá-PA, Brazil.

MATERIAL AND METHODS

Experiments were implemented at a commercial vegetable grower's field in Marabá-PA, Brazil (05°15'26.4"S, 49°04'6.1"W, 78 m altitude). Plantings were done in three different growing seasons (October 10, 2019, March 10, 2020 and July 7, 2020) with harvesting at March 11, 2020, July 8, 2020 and November 17, 2020). The site had soil with 15, 82.5 and 25 g/kg of clay, sand and silt respectively. Aw is the predominant climate of the region in a tropical zone with dry winter, high seasonal precipitation, and low water deficit (Alvares *et al.*, 2013).

Four sweetpotato genotypes were evaluated. CIP BRS Nuti is a new orange flesh cultivar, with high betacarotene content, registered for production in Brazil in 2021 (Mello *et al.*, 2022). Beauregard, of American origin, was released in that country in 1987, and registered by Embrapa in 2010 as a cultivar that was tested and found appropriate for some Brazilian cropping conditions (Rolston *et al.*, 1987). This cultivar has a pinkish peel, fully elliptical roots, and intense orange flesh. Therefore, it is a potential source of carotenoids, in addition to having high yield potential and early production (Schultheis *et al.*, 1999). Additionally, a purple skin, orange flesh clone imported from the International Potato Center (CIP), clone 11, and one genotype commonly planted in the southeast and the central west of Brazil known as Canadense were included. This last genotype is known to have a purple skin and cream flesh. The average dry matter of the tested genotypes is 25, 23, 23 and 25% respectively.

Fertilization was done according to soil analysis using three separate applications of N (20 kg/ha) and K_2O (20 kg/ha) using the formula NPK 20:00:20 at 10, 20 and 45 days post planting. Weeding was conducted twice, manually using a hoe. No insecticides, herbicides or fungicides were applied. The planting areas were prepared by plowing and harrowing, followed by construction of ridges 30 cm high. Virus-free sweetpotato slips with nine nodes were used for planting; four nodes were planted longitudinally below the soil, and five above. Experimental plots were sprinkle irrigated according to soil moisture.

Daily meteorological data were recorded during the period from October, 2019 to November, 2020, by the surface meteorological station (code A240) of the National Institute of Meteorology, located in the city of Marabá-PA (05°35'S, 49°15'W and 95 m altitude). The average annual rainfall historically recorded in the Marabá municipality is 1,899.2 mm. However, as a striking feature of the Amazon region, this distribution is not homogeneous, with the largest volumes being concentrated in the months of February and March, and the smallest volumes between July and August (Figure 1).

At harvest time the number of plants in each plot was counted (plant stand), and the commercial and noncommercial root productions were evaluated. Commercial roots are ≥10 cm length and ≥5 cm diameter, with no contortions, cracks or prominent veins.

The design was a four-replicate randomized block design. Each experimental plot had two rows with thirteen plants per row (26 plants/plot) spaced 75 cm between rows and 40 cm between plants (33,333 plants/ha), with an external edge row in each block that was not evaluated. The resulting data underwent individual and pooled analysis of variances, and the means were grouped by Scott and Knott at 5% probability, using GENES statistical software.

RESULTS AND DISCUSSION

The analysis of pooled variances identified significant effects of the interaction of genotypes and planting date for all traits evaluated except plant stand. Therefore, the planting date differently and significantly influenced the expression of all the root yield characteristics, but not the plant survival rate of the genotypes (Data not shown).

The coefficient of genetic variation (CVg) measures the experimental variation due to genetic causes, and the

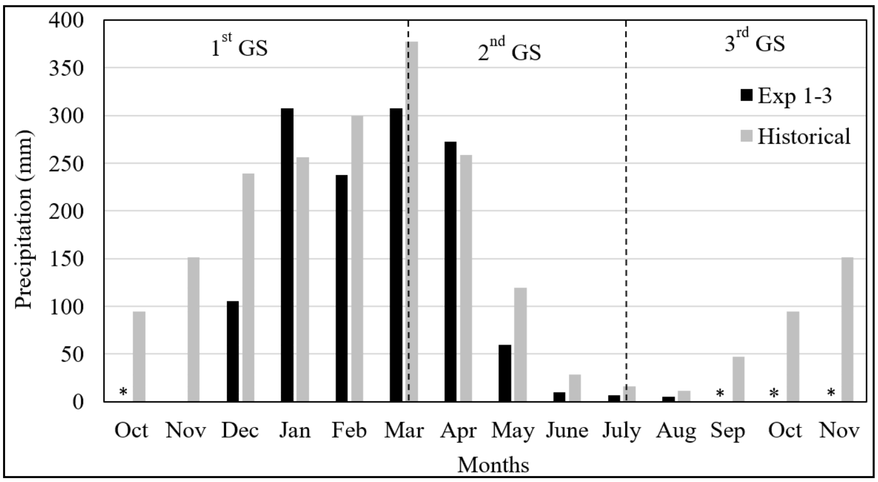

Figure 1. Accumulated month precipitation during the three sweetpotato growing seasons (GS) at Marabá-PA from Oct 2019 to Nov 2020 in comparison to historical data from 1981-2010 (INMET, 2022a). *Missing data from the meteorological station (INMET, 2022b). Brasilia, Embrapa Hortaliças, 2019-2020.

coefficient of variation (CV) estimates the influence of the environment on the experimental variation. The rate between (CVg/CV) were greater or close than one for all characters evaluated except for non-commercial yield in the first trial. These findings indicate greater importance of genetic causes in the expression of the characters in comparison to environmental effects, and that the environmental and experimental conditions were favorable to the achievement of greater reliability of the results.

For all planting dates and genotypes the yield of commercial roots was higher than the national average (13.4 t/ha) or that for the Northern region average (9.2 t/ha) (IBGE, 2022); indicating that these genotypes can be good options for vegetable growers, and that the crop could be profitable for cultivation in that region (Table 1).

Environmental conditions can directly affect sweetpotato root yield. The Marabá region has an altitude similar to the northeast and northwest regions of São Paulo, two of the major sweetpotato producing regions in Brazil. However, the annual rainfall of 1900-2200 mm in this region is much higher than that observed in the majority of the sweetpotato producing regions in the southeast and northeast of the country which are below 1,300 mm annually (Alvares *et al.*, 2013; IBGE, 2022). The annual average mean temperature of Marabá region also is much higher than that observed in the main sweetpotato producing regions (Alvares *et al.*, 2013; IBGE, 2022).

The meteorological station in Marabá-PA is set up to automatically record meteorological information hourly. Temperature data were properly recorded for the two initial growing seasons (GS) with more than 99% of the expected evaluations recorded. During the third GS only 18.7% of the expected readings were recorded. Precipitation data was properly recorded only for the second GS (99.5% of the expected readings). Due to these limitations, historical data for the region were included in the evaluations to enable a better understanding of the climatic conditions of the region and potential relation with sweetpotato production (Figures 1 and 2) (INMET, 2022a).

Clone 11 was the most productive sweetpotato genotype for all planting dates, with commercial yield ranging from 80.4 to 127 t/ha, and with the first and the third planting GS being more productive than the second (Table 1). The white fleshed Canadense also was very productive and among the top yielding genotypes (Table 1). The commercial yield of CIP BRS Nuti was similar to Beauregard in the two initial GS but showed greater yield than Beauregard in the third GS, which was the driest and warmest period of the year in that region (Figures 1 and 2).

The commercial root yield was higher than the average commercial production areas likely because the experiments were done with virus-free slips, weed and diseases control, and also with sweetpotato improved cultivars.

Plant survival and development in the field is a characteristic related to environment adaptation, because it can be directly influenced by climate conditions such as soil moisture (Thompson *et al.*, 2017) and temperature (Wijewardana *et al.*, 2018),

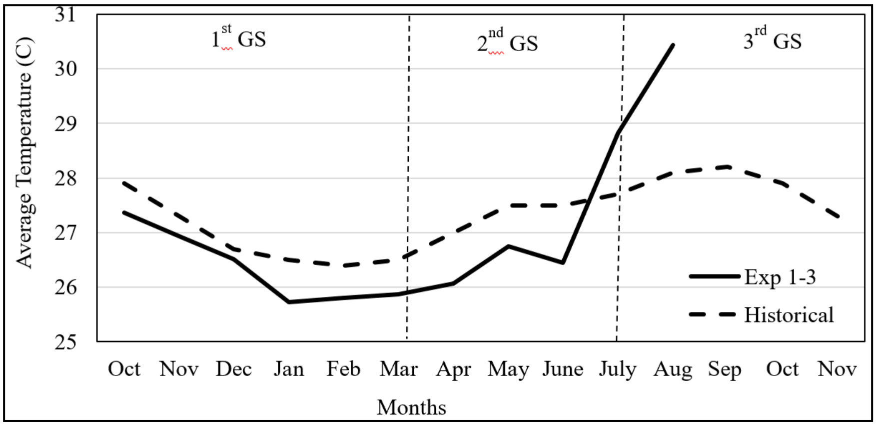

Figure 2. Average monthly temperature during the three sweetpotato growing seasons (GS) at Marabá-PA from Oct 2019 to Nov 2020 in comparison to historical data from 1981-2010 (INMET, 2022a). *Data not recorded at the meteorological station from September through November 2020 (INMET, 2022b). Brasilia, Embrapa Hortaliças, 2019-2020.

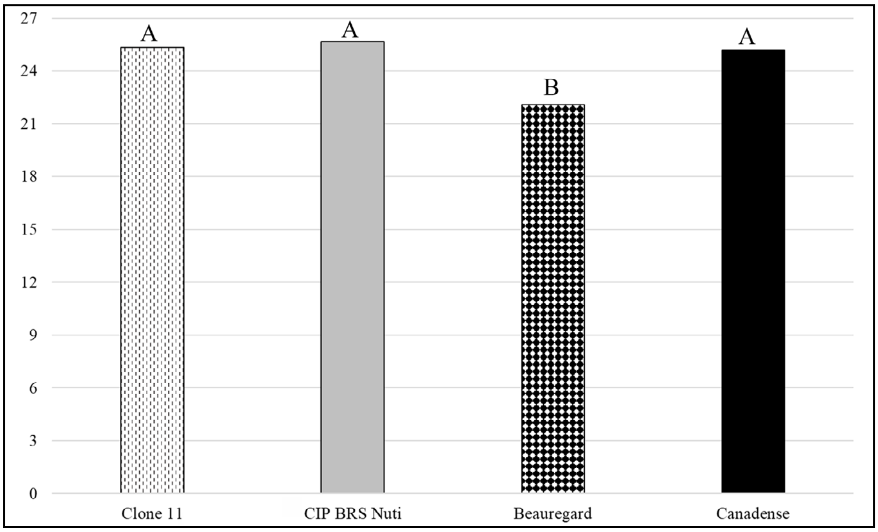

Figure 3. Number of plants of four sweetpotato genotypes evaluated in Marabá-PA at harvest time in three different growing seasons during 2019 and 2020. Initial stand per plot was 26 plants. Different letters indicate $p<0.05$ by Scott and Knott. Brasilia, Embrapa Hortaliças, 2019-2020.

as well as genetic characteristics of different cultivars (Wees *et al.*, 2016). In the current study, plant survival was homogenous among the three GS and therefore, the data are presented as an average of the three experiments (Figure 3). Beauregard had the lowest plant stand among the evaluated genotypes, with an average loss of 15.5% of the initial slips planted (Figure 3). Beauregard is known to have lower vine vigor than other cultivars (Mussoline & Wilkie, 2016; Wees *et al.*, 2016), and this characteristic very likely was the one responsible for this lower plant stand in comparison to other genotypes in the extreme weather conditions of the north region of Brazil.

Despite the overall great yield performance obtained in the experiments, the first GS presented some unusual circumstances. In this experiment, harvested roots presented sunken lesions similar to the symptoms caused by chilling injury (Clark *et al.*, 2013). Additionally, root skin seemed to be softer than during the following experimental GS, indicating high moisture during harvest time. Historically, March is the rainiest month of the year (Figure 1). Particularly, the precipitation during the two weeks prior to harvesting of the first experiment was 169 mm, which very likely caused this symptom on the roots. After manual washing, some of the roots from the first GS had skinning that can be directly associated with reduced shelf-life because it favors the exposure of the root to pathogens and insects. This issue was predominantly observed in clone 11.

Table 1. Commercial root yield (t/ha) of four sweetpotato genotypes evaluated in Marabá-PA at three planting dates in 2019 and 2020. Brasilia, Embrapa Hortaliças, 2019-2020.

Genotypes	**Season 1**	**Season 2**	**Season 3**
Clone 11	104.5 A a	80.4 B a	127.0 A a
CIP BRS Nuti	61.7 A b	51.1 A b	47.4 A b
Beauregard	73.2 A b	35.9 B b	28.0 B c
Canadense	87.1 A a	67.8 A a	63.0 A b
CV (%)	23.29	20.76	23.57
CVg/CV	0.83	1.50	2.69

*Commercial root yield converted to the initial plant population of 33,333 plants/ha. CV (%) = environmental coefficient of variation. CVg/CV= rate between genetic coefficient of variation and environmental coefficient of variation. Means followed by different capital letters in the line and lowercase letters in the column, differ by Scott and Knott at $p<0.05$.

As most of the vegetable growers in the Marabá region commercialize their products to intermediates that re-sell the vegetables to the final consumers within two days post-harvest, this issue is not a major threat to sweetpotato commercialization. However, to enable commercialization at the supermarket level, where roots will be available to consumers for long periods of time, harvesting procedures should be improved. As part of these procedures, growers should avoid harvesting during intense rainy periods or select areas with better drainage systems that enable better skin establishment plus avoid skinning and other postharvest issues.

Unlike other countries where commercial sweetpotato root attributes are well established and homogeneously used across the country (Bonte *et al.*, 2014), in Brazil the commercial success of sweetpotato roots varies according to local preferences. Therefore, the use of the total root production as part of the evaluation process is very important. Noncommercial roots, for example, can be used for animal feed directly or semi processed (Dom *et al.*, 2017). CIP BRS Nuti had the highest noncommercial root yield, being significantly different from the other genotypes during the third GS (Table 2). During the three GS, the great majority of noncommercial roots of this cultivar consisted of roots with the proper shape but lighter than 100 grams. Therefore, this might suggest that if allowed to grow longer, CIP BRS Nuti might have a much greater commercial yield.

Cultivars with orange flesh such as Beauregard, clone 11 and CIP BRS

Table 2. Noncommercial and total root yield of four sweetpotato genotypes evaluated at Marabá-PA in three planting seasons in 2019 and 2020. Brasilia, Embrapa Hortaliças, 2019-2020.

Genotypes	NCY (t/ha)			TY (t/ha)		
	Season 1	**Season 2**	**Season 3**	**Season 1**	**Season 2**	**Season 3**
Clone 11	0.1 B a	0.1 B a	3.6 A c	105.8 B a	83.6 B a	134.3 A a
CIP BRS Nuti	0.1 B a	0.4 B a	13.9 A a	61.8 A b	51.6 A b	63.2 A b
Beauregard	0.1 B a	0.2 B a	4.2 A c	75.4 A b	39.7 B b	42.3 B c
Canadense	0.1 B a	0.3 B a	6.3 A b	88.1 A a	68.1 A a	74.4 A b
CV (%)	170.0	29.8	31.9	21.4	20.1	20.9
CVg/CV	0.00	2.11	2.05	0.93	1.49	0.98

NCY= Sweetpotato roots with deformed shape, excessive insect damage or weight less than 100 grams. TY= Sum of noncommercial and commercial sweetpotato yield. CV (%)= environmental coefficient of variation. CVg/CV= rate between genetic coefficient of variation and environmental coefficient of variation. Means followed by different uppercase letters in the line and lowercase in the column, differ by Scott and Knott at $p<0.05$.

Nuti could have also an important social relevance. Orange flesh in sweetpotatoes is a strong evidence of high betacarotene content, a precursor of vitamin A in human body (Tanaka *et al.*, 2017). The lack of vitamin A can lead to health problems including fetus malformation, and blindness or poor nutrition in children (Moura *et al.*, 2015; Laurie *et al.*, 2015; Wiseman *et al.*, 2017). Studies in the north region of Brazil show that approximately 7.8 and 8.6% of the children aged 6-23 months and 24-59 months respectively, suffer from vitamin A deficiency (ENANI, 2022). Therefore, the introduction of betacarotene-rich sweetpotatoes in that region could be of great interest for the diversification of the local diet.

The result obtained and the information presented in this study indicate that all the evaluated sweetpotato genotypes performed well, being good options for growers to produce a source of food with high quality and high root yield in commercial areas, considering the environmental particularities of the different seasons and characteristics of the genotypes.

ACKNOWLEDGMENTS

This work was supported by the Harvest Plus Program (grant number 2014H6332, EMB) and project Hortamazon Agreement BNDS/Amazon Fund (grant number 15.2.0897.2). We thank Mrs. Adriana Lopes da Silva for the great field support and the kind manuscript review done by Dr. Mary Shaw.

REFERENCES

AFOLABI, M; BELLO, B; AGBOWURO, G; AREMU, C; AKORODA, M. 2019. Diallel analysis of sweet potato [*Ipomoea batatas* (L.) Lam] genotypes for combined beta carotene and dry matter content in southern Guinea Savanna, Nigeria. *Journal of Agriculture and Ecology Research International* 19: 1-9.

ALVARES, CA; STAPE, JL; SENTELHAS, PC; GONÇALVES, JLM; SPAROVEK, G. 2013. Köppen's climate classification map for Brazil. *Meteorologische Zeitschrift* 22: 711-728.

BONTE, DR; CLARK, CA; SMITH, TP; VILLORDON, AQ; STODDARD, CS. 2014. 'Burgundy' Sweetpotato. *HortScience Horts* 49: 669-671.

CECÍLIO FILHO, AB; NASCIMENTO, SM; SILVA, AS; VARGAS, PF. 2016. Agronomic performance of sweet potato with different potassium fertilization rates. *Horticultura Brasileira* 34: 588-592.

CLARK, CA; FERRIN, DM; SMITH, TP; HOLMES, GJ. 2013. *Compendium of sweetpotato diseases, pests, and disorders*. St. Paul, MN: The American Phytopathological Society (APS). 160p.

DOM, MT; AYALEW, WK; GLATZ, PC; KIRKWOOD, RN; HUGHES, PE. 2017. Nutrient utilisation in grower pigs fed a protein concentrate blended with sweet potato roots either boiled or ensiled with or without vines. *Animal Production Science* 57: 1645-1652.

ENANI. 2022. *ENANI- National study of infant food and nutrition.* Available at: https://enani.nutricao.ufrj.br/index.php/relatorio-3-micronutrientes/. Acessed March 28, 2022.

HOMMA, AKO; LIMA, JRF; VIEIRA, PA. 2019. Structural heterogeneity in rural Brazil: three regional cases. In: BUAINAIN, AM; LANNA, R; NAVARRO, Z (eds). *Agricultural Development in Brazil: the rise of a global agro-food power*. London, UK, Routledge. p.189-207.

IBGE. 2022. *Produção agrícola municipal*. Available at: https://sidra.ibge.gov.br/pesquisa/pam/tabelas. Acessed March 10, 2022

INMET. 2022a. *Climatological Brazilian conditions - 1981-2010.* Available at: https://portal.inmet.gov.br/normais. Acessed March 22, 2022

INMET. 2022b. *Metereological stations data table.* Available at: https://tempo.inmet.gov.br/. Acessed March 22, 2022

LAURIE, S; FABER, M; ADEBOLA, P; BELETE, A. 2015. Biofortification of sweet potato for food and nutrition security in South Africa. *Food Research International* 76: 962-970.

MELLO, AFS; SILVA, GO; SILVA, J; SAMBORSKI, T; FERREIRA, JC; CARVALHO, JLV; NUTI, MR; SIQUIEROLI, ACS; BRAGA, MB; DIAZ, FCT; GRÜNEBERG, W. 2022. 'CIP BRS Nuti': a new orange flesh sweetpotato cultivar. *HortScience* 57: 376-378.

MOURA, FF; MILOFF, A; BOY, E. 2015. Retention of provitamin A carotenoids in staple crops targeted for biofortification in Africa: cassava, maize and sweet potato. *Critical Reviews in Food Science and Nutrition* 55: 1246-1269.

MUSSOLINE, W; WILKIE, A. 2016. Feed and fuel: The dual-purpose advantage of an industrial sweetpotato. *Journal of the Science of Food and Agriculture* 97: 1567-1575.

ROLSTON, LH; CLARK, CA; CANNON, JM; RANDLE, WM; RILEY, EG; WILSON, PW; ROBBINS, ML. 1987. Beauregard sweetpotato. *Hortscience* 22: 1338-1339.

ROULLIER, C; DUPUTIÉ, A; WENNEKES, P; BENOIT, L; FERNÁNDEZ BRINGAS, VM; ROSSEL, G; TAY, D; MCKEY, D; LEBOT, V. 2013. Disentangling the origins of cultivated sweet potato (*Ipomoea batatas* (L.) Lam.). *Plos One* 8: e62707.

SCHULTHEIS, JR; WALTERS, SA; ADAMS, DE; ESTES, EA. 1999. In-row plant spacing and sate of harvest of `Beauregard' sweetpotato affect yield and return on investment. *HortScience* 34: 1229-1233.

TANAKA, M; ISHIGURO, K; OKI, T; OKUNO, S. 2017. Functional components in sweetpotato and their genetic improvement. *Breeding Science* 67: 52-61.

THOMPSON, WB; SCHULTHEIS, JR; CHAUDHARI, S; MONKS, DW; JENNINGS, KM; GRABOW, GL. 2017. Sweetpotato transplant holding duration effects on plant survival and yield. *HortTechnology* 27: 818-823.

TOMCHINSKY, B; GONÇALVES, GG; FERREIRA, AB. 2021. Food composition data: edible plants from the Amazon. In: JACOB, MCM; ALBUQUERQUE, UP (eds). *Local food plants of Brazil*. Cham, Springer International Publishing. p. 271-295.

VARGAS, PF; ENGELKING, EW; ALMEIDA, LCFD; FERREIRA, EA; CHARLO, HCDO. 2018. Genetic diversity among sweet potato crops cultivated by traditional farmers. *Revista Caatinga* 31: 779-790.

WEES, D; SEGUIN, P; BOISCLAIR, J. 2016. Sweet potato production in a short-season area utilizing black plastic mulch: effects of cultivar, in-row plant spacing, and harvest date on yield parameters. *Canadian Journal of Plant Science* 96: 139-147.

WIJEWARDANA, C; REDDY, K; GAO, W. 2018. Low and high-temperature effects on sweetpotato storage root initiation and early transplant establishment. *Scientia Horticulturae* 240: 38-48.

WISEMAN, EM; BAR-EL DADON, S; REIFEN, R. 2017. The vicious cycle of vitamin A deficiency: A review. *Critical Reviews in Food Science and Nutrition* 57: 3703-3714.