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Productivity of three sweet potato cultivars: BRS Amélia, BRS Cuia and BRS Rubissol

Productividad de tres cultivares de batata: BRS Amélia, BRS Cuia y BRS Rubissol

Flavio da Silva Wolmann [1,2], *Divanilde Guerra* [1,3], *Eduardo Lorensi De Souza* [1,4], *Robson Evaldo Gehlen Bohrer* [1,5], *Ramiro Pereira Bisognin* [1,6], *Mastrangello Enivar Lanzanova* [1,7], *Danni Maisa da Silva* [1,8].

[1]State University of Rio Grande do Sul-UERGS. Rio Grande do Sul, Brazil. [2] flavio_virtual@yahoo.com , [3] divanilde-guerra@uergs.edu.br, [4] eduardo-souza@uergs.edu.br , [5] robson-bohrer@uergs.edu.br , [6] ramiro-bisognin@uergs.edu.br , [7] mastrangello-lanzanova@uergs.edu.br , [8] danni-silva@uergs.edu.br

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Abstract

The sweet potato (*Ipomoea batatas* L.) is a vegetable of great economic importance since it can be used for *in natura* consumption, for processing in agribusiness and/or biofuel production. The objective of this work was to evaluate the yield of three sweet potato cultivars: BRS Amelia, BRS Cuia and BRS Rubissol in the Northwest Region of Rio Grande do Sul. The experiment was conducted in the field for two consecutive years (harvests 2014/2015 and 2015/2016). The experimental design was in randomized blocks, evaluating 3 sweet potato cultivars for 2 agricultural years, with 4 replications. As results, it was observed that potato weights in the first year of study ranged from 272.0 g to 320.2 g. In the second year of evaluation, it ranged from 133.9 g to 247.1 g. In relation to the average productivity, the values obtained in the first year were 15.2 t ha^{-1} for BRS Amelia, 19.8 t ha^{-1} for BRS Cuia and 16.2 t ha^{-1} for BRS Rubissol. In the second year of evaluation, the values were 12.3 t ha^{-1} for BRS Amelia, 16.1 t ha^{-1} for BRS Cuia and 13.1 t ha^{-1} for BRS Rubissol. Cultivars presented yields higher than the national average from Brazil in the two evaluated years.

Keywords: *Ipomoea batatas* L., production, region.

Resumen

La batata (*Ipomoea batatas* L.) es una hortaliza de gran importancia económica ya que se puede utilizar para el consumo de natura, para el procesamiento en agronegocios y/o la producción de biocombustibles. El objetivo de este trabajo es evaluar el rendimiento de tres cultivares de batata: BRS Amelia, BRS Cuia y BRS Rubissol en la región noroeste de Rio Grande do Sul. El experimento se realiza en el campo durante dos años consecutivos (cosechas 2014/2015 y 2015/2016). El diseño experimental fue en bloques al azar, evaluando 3 cultivares de camote durante 2 años agrícolas, con 4 repeticiones. Como resultados, se observa que el peso de la papa en el primer año de estudio varía de 272.0 g a 320.2 g. En el segundo año de evaluación, varía de 133.9 g a 247.1 g. En relación con la productividad promedio, los valores obtenidos en el primer año fueron 15.2 t ha^{-1} para BRS Amelia, 19.8 t ha^{-1} para BRS Cuia y 16.2 t ha^{-1} para BRS Rubissol. En el segundo año de evaluación, los valores fueron 12.3 t ha^{-1} para BRS Amelia, 16.1 t ha^{-1} para BRS Cuia y 13.1 t ha^{-1} para BRS Rubissol. Los cultivares presentaron rendimientos más altos que el promedio nacional de Brazil en los dos años evaluados.

Palabras clave: *Ipomoea batatas* L., producción, región.

Introduction

Sweet potatoes (*Ipomoea batatas* L.) originate from Central and South America, being found from the Yucatan peninsula to Colombia; it is a tuberous root dicotyledonous, belonging to the family *Convolvulaceae*, which covers more than 1600 species (Silva *et al.* 2012; Echodu *et al.*, 2018).

China is currently responsible for 76 % of the 105 million tons produced annually in the world (Echodu *et al.*, 2018), being considered the largest producer of this tuber, followed by Nigeria, Tanzania, Ethiopia, Mozambique, and Indonesia (FAOSTAT, 2017). On the other hand, Brazil has a production of about 525 thousand tons in 40 thousand hectares (FAOSTAT, 2017; IBGE, 2018). The average productivity in Brazil was 14.1 Mg ha^{-1} in 2018, what is currently well below the crop's productive potential, with the predominance of local and unimproved varieties, which provide low yields, however with the Using proper management, levels of 25 to 30 t ha-1 can be easily reached in 4 to 5 months of cultivation (Silva *et al.*, 2015). In the country, sweet potatoes are broadly cultivated, with emphasis on the South and Northeast regions (Carvalho *et al.*, 2013).

In Brazil, the state of Rio Grande do Sul is the largest producer, with 31 % of the total area planted, concentrating approximately 32 % of the total potato production (Carvalho *et al.*, 2013).

Due to its tuberous roots, it is considered a vegetable and has great economic importance, being used for in natura commercialization, for processing in agribusiness and/or biofuel production (Echodu *et al.*, 2018; Souza *et al.*, 2020). In terms of nutritional status, culture plays a vital role in internal food supply and as a nutritional supplement in the diet of its inhabitants (Williams *et al.*, 2013), since it has a wide variety of compounds such as carotenoids, anthocyanins, polyphenols, phenolic acids, minerals, vitamins, and others; also it has antioxidant activity. These compounds can act on several biochemical reactions of the organism, contributing to the maintenance of the health of its consumer (Park *et al.*, 2014).

In spite of its importance, in the last decades, its cultivation has been developed with vegetative material selected by the producers themselves, through natural selection of genotypes with desirable agronomic characteristics, that is, using materials that have not gone through the genetic improvement process, thus presenting high genetic variability and the possibility of being contaminated with diseases, however, in most cases do not express, in total, their productive potential, because they are infected with viruses. Until 2015, there were only 24 cultivars registered with the Ministry of Agriculture, Livestock, and Supply (MAPA) (Silva *et al.*, 2015). The agricultural research companies play a fundamental role in the production of the sweet potato crop, as they develop and evaluate new cultivars, which must be resistant to pests and diseases, good productivity, rusticity, adaptability, besides the biofortification of nutrients, as well as genetic improvement between genotypes of industrial sweet potato with the objective of improving this culture to produce biofuel (Silva *et al.* 2015; Souza *et al.*, 2020).

In Rio Grande do Sul, Brazil, the Brazilian Agricultural Research Corporation (EMBRAPA) unity of Temperate Climate in Pelotas has characterized the germplasm of sweet potato existing in the Southern Region of Brazil, selected materials with high genetic and cultivation potential and produced the cultivars BRS Amélia, BRS Rubissol, and BRS Cuia. However, these cultivars have not been tested for productivity in the Northwest of the state. The objective of this work was to evaluate the productivity of three sweet potato cultivars: BRS Amélia, BRS Cuia, and BRS Rubissol in the Northwest region of Rio Grande do Sul.

Materials and Methods

Characterization of sweet potato cultivars. BRS Amélia has differentiated nutritional qualities. It is rich in provitamin A, being a source of proteins and anthocyanins and energy, due to the high levels of starch and glucose. It has a long elliptical shape, light pink peel with pinkish pigmentation. Average productivity is 32 tons per hectare (EMBRAPA, 2011).

BRS Cuia has vigorous plants, peel and cream pulp, but in different shades. Average productivity is 40 tons per hectare. It is excellent for domestic consumption, but due to the relatively large size of the potatoes, it shows good suitability for the industrial process, and can be used in the production of ethanol and medicinal alcohol. Potatoes have good uniformity, round shape with approximate dimensions of 15 cm by 20 cm. In food, it is a good source of proteins and anthocyanins and energy, due to the high levels of starch and glucose (EMBRAPA, 2011).

BRS Rubissol has vigorous plants, an intense purple peel (ruby-red) and a cream-colored pulp, tending to yellow. Average productivity is 40 tons per hectare. Potatoes show good uniformity, round-elliptical shape with approximate dimensions of 10 cm by 18 cm. It has excellent characteristics for table consumption and can also be used in industrial processing. It is very sweet and has a floury texture after cooking or roasting. In food, it is a good source of proteins and anthocyanins and energy, due to the high levels of starch and glucose (EMBRAPA, 2011).

In addition to using the root in human food, the three varieties of sweet potato can be fully used (root and aerial part of the plant) in human and animal food (cattle, swine, poultry, and fish). Also, its main characteristics are easy cultivation, resistance to major pests and diseases and adapting to various types of soils and climates (EMBRAPA, 2011).

Description of the study site and characterization of climate and soil. In this study, a field experiment (2014/2015 and 2015/2016) was conducted for two years by the State University of Rio Grande do Sul (Uergs), Brazil, Unit in Três Passos-RS, in the experimental area of Bom Progresso-RS, located at the State Technical School Barn (Etec), according to the coordinates: latitude -27.563509, longitude -53.859015.

The climate of the region is of the type Cfa according to the classification of Koppen, with annual average temperature around 19 °C, average rainfall between 1800 and 2000 mm and average altitude of 413 m. During the meteorological conditions provided, forecast and temperature were from the automatic station of Santo Augusto/RS and data recorded as the periods of conduction of this experiment, as seen in the figure of this experiment, as seen in Figure 1.

The soil of the experimental area is classified as Hapludox (Soil Survey Staff, 2014), and presented the following characteristics in the period before the beginning of the experiment: pH = 5.07; P = 5.9 mg dm^3; K = 47.6 mg dm^3; Ca = 1.7 cmol c/dm^3; Mg = 1.1 cmol c/dm^3; Al = 2.18 cmol c/dm^3; H + Al = 7.2 cmol c dm^3; soil organic matter (MOS) = 2.0 %, and clay = 70 %.

Experimental design, treatments and cultivars of sweet potato. The experimental design was a randomized complete block in 3 x 2 arrangement (3 sweet potato cultivars produced by the EMBRAPA (BRS Amélia; BRS Cuia e; BRS Rubissol) and 2 agricultural crops, with 4 replicates. The experimental plots/replicates were composed of land mounds in line with approximately 0.40 m of height each and 1 m of spacing between them; they were made with the aid of a mechanized mowing machine.

Conducting, handling and evaluating the experiment. The seedlings of the three varieties of sweet potato evaluated were transplanted using 6 plants per linear meter, spaced 0.25 m between plants and were obtained from the Brazilian Agricultural Research Corporation (EMBRAPA) unity of Temperate Climate in Pelotas, Rio Grande do Sul, Brazil.

Based on the results of the soil chemical analysis, the fertilization was applied to the sweet potato crop according to the recommendations of the manual of fertilization and liming for the states of Rio Grande do Sul and Santa Catarina (CQFS, 2016). Other cultural treatments followed the recommendations for the sweet potato crop. Weeding was manually performed.

The tubers in each plot from a useful area of 4.5 m^2 were harvested. At the time of collection, the collected tubers were cleaned, washed, dried in the sun and each weighed with a balance of 2000 g capacity. After that, the yield of tubers per hectare was calculated.

Statistical analyses. The results of tubers unit weight and productivity were submitted to analysis of variance and interaction test between cultivars and harvests with the complementary Tukey test at 5 % of error probability, for comparison of means, without data transformation, using of the procedures available in the SISVAR statistical package (Ferreira, 2011).

Results

Regarding the morphological characteristics, through visual observations it was possible to observe that the three cultivars presented parameters like those described in the literature for the shape and color of the peel (EMBRAPA, 2011).

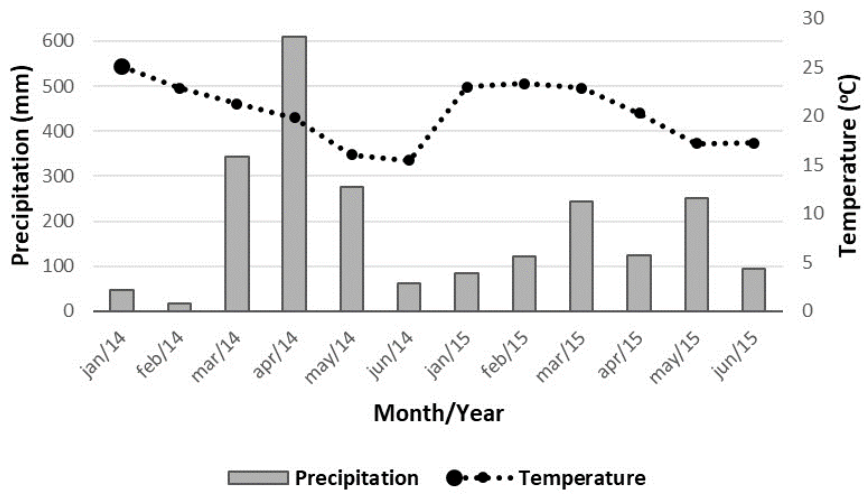

Figure 1. Monthly rainfall and temperatures observed during the study period.

Table 1 shows the results of tuberous root weight. The tuberous root weight varies in the 2014/2015 average from 272.0 g to 320.2 g in cultivars Amélia and Rubissol, respectively, without statistical differences between cultivars. In the 2015/2016 crop, the tuberous root weight varied between 133.9 g and 247.1 g in the cultivars Rubissol and Cuia, respectively. Cuia presented a statistically superior tuberous root weight than the cultivar Rubissol and statistically like the tuberous root weight of the cultivar Amélia. In this study, no interaction was observed between sweet potato cultivars and the two crop years in which the study was conducted.

The productivity of tuberous roots varied between 15.2 and 19.8 t ha^{-1} in the 2014/2015 crop and between 12.3 and 16.1 t ha^{-1} in the 2015/2016 crop for cultivars Amélia and Cuia, respectively (Table 2), with no differences in tuber production between cultivars, only between cropping cycles.

Table 1. Root weight of three sweet potato cultivars in two agricultural crops in Rio Grande do Sul (RS)-Brazil

Harvest/ cultivar	Amélia	Cuia	Rubissol
	Unit weight of tubers (g)		
2014/2015	272.0 aA	287.0 aA	320.2 aA
2015/2016	171.0 aAB	247.1 aA	133.9 aB

*Different uppercase letters in the column and different lowercase letters in the row indicate significant statistical difference by the Tukey test with 5 % probability of error (P = 0.05).

Table 2. Tuber yield of three sweet potato cultivars in two agricultural crops in Rio Grande do Sul (RS)-Brazil

Harvest/cultivar	Amélia	Cuia	Rubissol
	(t ha^{-1})		
2014/2015	15.2 aA	19.8 aA	16.2 aA
2015/2016	12.3 bA	16.1 bA	13.1 bA

*Different uppercase letters in the column and different lowercase letters in the row indicate significant statistical difference by the Tukey test with 5 % probability of error (P = 0.05).

Discussion

In this study, we observed variation between potato unit weight (Table 1). In relation to the agricultural year (harvests), the only cultivar that presented statistically significant differences between one year and the other was Rubissol, which obtained a larger unit weight of tubers in the 2014/2015 harvest (320.2 g) compared to the 2015/2016 harvest (133.9 g).

According to Filgueira (2008), the sweet potato is considered commercial when it presents roots with average mass ranging from 200 to 400 g. However, Resende *et al*. (2012) report that in Brazil there is not any official standard for the classification of sweet potato tubers. In addition, in the main Brazilian markets (Rio de Janeiro and São Paulo) there is an unofficial standard of tuberous root size classification, which is as follows: Larger than 400 g, Extra A-301 to 400 g, Extra B-201 to 300 g, Special-51 to 200 g, and Miscellaneous - 80 to 150 g. For this type of market, the potatoes should be smooth, well-shaped, elongated, and uniform, with diameter between 5 and 8 cm and length ranging between 12 and 16 cm for the Extra A classification.

The results observed in Table 1 reinforce the idea that even producing small potatoes, the important thing is that total productivity is high. A higher number of commercial roots is of significant importance since the tuberous roots comprise a high proportion of the total dry mass, and the increase in the total dry matter has a direct relation with the yield of the tuberous roots (Resende *et al*., 2012).

In the two years of study, in absolute numbers, the sweet potato cultivar Cuia showed the best results in tuber yield (Table 2), but did not show differences from the other potato cultivars. Results higher than these were observed by Andrade Júnior *et al*. (2012) evaluated the productivity of tuberose roots of sweet potato clones belonging to the germplasm bank of the Federal University of Jequitinhonha and Mucuri Valleys, together with commercial cultivars Brazlândia Roxa and Brazlândia Rosada, harvested six months after planting and productivity ranging from 8.0 to 29.5 t ha^{-1}. According to information from the Brazilian Institute of Research and Statistics (IBGE, 2018), the average yield of sweet potato crop has been increasing.

In 2018, Brazilian growers collected 14.1 t ha^{-1} (IBGE, 2018). In this study, values of up to 19.8 t ha^{-1} were obtained in the Cuia cultivar, with 5.7 t ha^{-1} above the national average. This may have occurred due to the adaptation of the different sweet potato cultivars in the study region, since sweet potatoes are a rustic, easy to maintain and drought tolerant crop, with a relatively low production cost, with investments minimum and high return. It is also one of the vegetables with the greatest capacity to produce energy per unit area and time (kcal/ha/day) (Miranda, 2012). Its economic and social importance is the result of rusticity, broad climatic adaptation and high capacity of energy production in a short period of time (Silva *et al*., 2015).

In Brazil, sweet potatoes are grown in all regions. Although well disseminated in the country, average productivity is considered very low compared to other countries (Silva *et al*., 2015). Among the reasons for this low productivity are the use of low yielding

varieties and the low technological level employed (Silva *et al.*, 2008). According to Miranda (2012), several factors are responsible for the low average Brazilian productivity, among them can be related the occurrence of diseases and pests, inadequate production technology and the lack of selected cultivars. However, productivity above 25.0 t ha^{-1} can be easily achieved, provided that the crop is conducted with adequate technology. Resende *et al.* (2012) evaluated eleven sweet potato clones in Petrolina, state of Pernambuco, Brazil, and obtained total root productivity ranging from 7.2 to 25.8 t ha^{-1}.

In the two years of evaluations of this study, no significant productivity differences were observed among the cultivars evaluated (Table 2). However, in the first year of evaluation the yields of the three sweet potato cultivars were statistically higher than in the second year of evaluation, obtaining an average of 3.2 t ha^{-1} more in the first year. These results may have been influenced by the climatic factors between the two years of evaluations, since the performance of cultivars and sweet potato clones regarding characters related to root yield may vary according to the environment, since they are quantitative and of strong environmental influence (Silva *et al.*, 2012). It is possible that the experiment with the highest potato yield is the first to have an experience for the greatest possible amount of rain, because in the first period of experience to be accumulated it was 1354 mm while in the second period of experience the accumulated in the same period was of only 921 mm, that is, it rained 433 mm less (Figure 1). When a 2-year averaging time is not expected, it is said that it was not the first to a month averaging was only one experience while it was planned. These response results may have higher productivity of individual tubers and total productivity since the average monthly temperature in the two years was similar, with 21 and 20 °C in the first and second years, respectively.

This variation in productivity in different agricultural years corroborates the results observed by Silva *et al.* (2015), which evaluated the commercial root mass of BRS Amelia, BRS Cuia and BRS Rubissol in the years 2012 and 2013 in Canoinhas, state of Santa Catarina, Brazil. The results obtained by these authors in the first year of evaluation were 19.7; 30.4, and 18.7 t ha^{-1} for the cultivars Amélia, Cuia, and Rubissol. In the second year of evaluation, productivity was 19.3; 20.6, and 31.5 t ha^{-1}, respectively.

These results in Table 2 can also be mainly associated with the precipitations that occurred in the two years of the experiment. According to Pedrosa *et al.* (2010) the total productivity of roots is dependent on the genotype, soil and climate conditions and cycle duration. Also, according to Cavalcante *et al.* (2009), the low national productivity is due to the low level of technology used, the lack of more productive varieties adapted to each growing region and the lack of adoption of appropriate agricultural practices and agricultural inputs. Note that even in the second year of the experiment, with lower rainfall, it was still possible to obtain yields similar to the national average of 14.1 t ha^{-1} or even higher in cultivar Cuia, which produced 16.1 t ha^{-1} (Table 2). These results demonstrate that the cultivars that were evaluated are well adapted to the study region. Other factors that may be associated with the results obtained in this study are the type of soil, climate and fertility of the study site. According to Miranda (2012), sweet potato develops well in any type of soil, however, light, loose, well-drained, medium to high fertility soils are considered ideal, well structured, and well aerated. In these soils the roots are more uniform and have little adherence to the earth on the surface, having a better appearance. The clay soils, as is the case of this study, excessively compacted, humid and cold, cause deformations in the tuberous roots, which can result in reduced productivity.

Currently, in Brazil, there are 24 registered sweet potato cultivars, but the cultivation of local and non-improved varieties is predominant, being the main factor responsible for the low yields. Therefore, to improve this condition, in addition to the correct management of planting, fertilization, and other cultural treatments, it is necessary to adopt more productive cultivars (Silva *et al.*, 2015).

In this study, the observation of genotype performance was conducted in two consecutive years (Tables 1 and 2). This analysis methodology is important for a more consistent determination of performance at a given location because sweet potato plants may perform differently according to the environment. According to Silva *et al.* (2012), the environmental influence on sweet potatoes is high and small changes in the environment, such as temperature, soil moisture or others may influence the expression of the productivity and quality of the tubers. According to Resende *et al.* (2012), the correct use of cultivar is one of the factors that contribute to the yield of the crop. The choice of cultivars, which meet the market demand for root quality to tolerate high temperatures and resistance to major diseases and pests, is essential to the success of cultivation.

In this context, the results were higher than the national average in most cultivars studied and in the two years evaluated, especially Cuia. This indicates a good adaptation of the three sweet potato cultivars evaluated in the Northwest region of RS, presenting themselves as good alternatives from the point of view of human and animal feeding and also perhaps for other purposes such as the production of biofuel, among others.

Conclusions

The cultivars BRS Amélia, BRS Cuia, and BRS Rubissol presented yields higher than the national average in the two evaluated years.

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