# Evaluation of the sweet potato cultivars, in Nova Xavantina - Mato Grosso, Brazil

# Avaliação de cultivares de batata-doce em Nova Xavantina - Mato Grosso, Brasil

DOI:10.34117/bjdv8n7-070

Recebimento dos originais: 23/05/2022
Aceitação para publicação: 30/06/2022

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**ABSTRACT**

Sweet potato is one of the world's most important crops, given its high productivity and short growing cycle, being ready for harvest in 150–180 days. It is also considered to be a viable alternative to sugarcane for the production of ethanol. The present study investigated the productivity of five sweet potato cultivars, their potential for the production of ethanol, and their resistance to insects pests. The study was conducted in an experimental plot in the municipality of Nova Xavantina, in the state of Mato Grosso, central Brazil. The experimental design was based on randomized blocks with four repetitions, 40 plants per plot, and five treatments, which were the different sweet potato cultivars (Vilma, Carolina Vitória, Nataly, Amanda, and Duda) earmarked for the production of ethanol. Under the conditions of the experiment, the Nataly cultivar presented the best results in terms of the biomass produced, resistance to ground-dwelling insect pests, and productivity, and was thus the sweet potato cultivar considered to be most appropriate for the production of ethanol in the study region.

**Keywords:** biofuel, ethanol, *Ipomoea batatas* (L.) Lam.

**RESUMO**

A batata-doce está entre as culturas de maior importância no mundo, por apresentar ciclos curtos, estando apta para colheita entre 150 e 180 dias após a semeadura (DAS) e proporcionar elevada produção, tem sido então considerada como alternativa para produção de etanol. O presente trabalho tem como objetivo analisar o potencial de produtividade, produção de etanol e resistência ao ataque a insetos de cinco cultivares de batata-doce, em Nova Xavantina-MT. O experimento foi conduzido em área experimental no município de Nova Xavantina. O delineamento utilizado foi de blocos casualizados com quatro repetições, 40 plantas por parcela e cinco tratamentos, que consistiram nas cultivares de batata-doce (Vilma, Carolina Vitória, Nataly, Amanda e

Duda) voltadas para a produção de etanol. Nas condições do experimento, verificou-se que a cultivar Nataly apresentou melhores resultados em relação ao teor de biomassa, resistência ao ataque de insetos do solo e produtividade sendo a cultivar mais indicada para produção de etanol na região.

**Palavras-chave:** biodiesel, etanol, *Ipomoea batatas* (L.) Lam.

## 1 INTRODUCTION

Sweet potato, *Ipomoea batatas* (L.) Lam., is one of the world's most important crops (International Potato Center, 2017), with an annual production of approximately 133 million tons, being ranked sixth behind rice, wheat, potato, corn, and cassava. The production of fresh mass is high, in particular in developed countries, and this plant is cultivated in more than 100 developing countries, reflecting its global economic value.

China is the world's principal producer, with an annual sweet potato crop of more than 107 million tons, approximately 82.3% of the total (FAO, 2016). In South America, Brazil is the second largest producer, with an annual crop of 542,380 tons, produced on 43,161 hectares. The Brazilian Northeast is the primary sweet potato-producing region, with 44.2% of the total area planted with this crop (IBGE, 2017).

Sweet potato is an economically important crop, in particular in areas with soils of low fertility. As a robust and resistant crop with many different uses, sweet potato plays a prominent role in the Brazilian economy, ranging from subsistence agriculture to industrial applications (Brito et al., 2005).

As it is ready for harvest in 150–180 days after planting and is highly productive, the sweet potato is considered to be an important potential alternative for the production of ethanol. The potential of this crop for ethanol production was discovered in the 1970s, although it was not viable at the time due to the lack of raw material, given that the productivity of 8–9 t $ha^{-1}$, at that time, did not cover the additional costs of production. Given this, the use of the plant for the production of ethanol was considered unviable (Araujo *et al*., 1978).

While the cultivation of sweet potato has a long history in Brazil and it is a relatively low-cost crop, it is still produced primarily by smallholders. Sweet potato is nevertheless considered to be an extremely efficient crop for transformation of the biomass into ethanol, a good quality product that does not impact the environment (Cardona et al., 2014). This reinforces the need for a more systematic analysis of the production of this crop, and the development of the technological and scientific mechanisms necessary for the harvesting of a larger quantity of biomass with a more efficient system of production (Momenté et al., 2012).

Given the potential of the sweet potato for the production of biomass, researchers from the Laboratory of Energy Production Systems from Renewable Resources at the Federal University of Tocantins (LASPER/UFT) established a program for the development of cultivars destined specifically for the production of ethanol. After many years of tests, the Federal University of Tocantins (UFT), in a partnership with the AENBIO (Alcohol-Energy-Nutrition-Biodiesel) presented this new technology with the aim of providing a better economic and social integration of family farmers, based on sustainable techniques, in the Brazilian state of Tocantins, with potential applications in other regions of the country (Silveira, 2012).

As Fernando Pimentel (2014) pointed out, the quest for alternative sources for the production of ethanol has become a worldwide priority, given the evidence of climate change and the imminent exhaustion of petroleum reserves, by around 2050. This should further reinforce the status of Brazil as a major supplier of raw material for the production of biofuels.

Some of the cultivars developed by the Federal University of Tocantins are highly productive, providing the raw material for the production of 120–199 liters of ethanol per ton of root, that is, 4615 to 10,467 liters of ethanol per hectare. The residues of this process are also usable. The processing of each ton of fresh root can produce as much as 150 kg of protein-rich residue, which can be used as animal feed in either fresh or dried form (Boletim Técnico, 2014).

The technical assessment of the Brazilian National Petroleum Agency (ANP), published as resolution no. 36 of 2012, indicates that the ethanol produced from sweet potato is of high quality, and can be utilized by the high quality alcohol industry for the production of fine beverages and cosmetics, as well as pharmaceutical products. This is an important consideration, given that Brazil currently imports 75% of its fine ethanol, which is produced from cereals.

Ethanol produced from sweet potato has a mean cost of R$0.32 per liter, whereas that produced from sugarcane costs R$0.27 (Tavares, 2006). A farm-based mini-refinery can produce 1200 liters per day, generating an income of R$690.71 per month which, together with the income from the farming cycle, can provide a monthly income of R$1071.46, covering the production costs of the crop.

Magalhães et al. (2012) concluded that the production of ethanol from sweet potatoes, while economically viable, may have a number of disadvantages in comparison with sugarcane, which can be processed on a larger scale, making it more profitable. The production of sugarcane may be less sustainable than that of sweet potato, however, given aspects such as the traditional burn-off of the crop applied prior to manual harvesting. In this context, the present study investigated the productivity, potential ethanol production, and resistance to insect pests of five sweet potato cultivars in the municipality of Nova Xavantina, in Mato Grosso, central Brazil.

## 2 MATERIAL AND METHODS

The experiment was conducted in 2012 at the Olhos D'Água experimental farm (14º41'09" S, 50º20'09") in the municipality of Nova Xavantina, Mato Grosso, Brazil (IBGE, 2011). The soils are predominantly yellow-red latosols, and the local climate is tropical hot sub-humid, with a four-month dry season between May and August. Mean annual precipitation is 1750 mm, with intense rains in December, January, and February. Mean annual temperature is 24ºC, with a maximum of 38ºC (Marimon et al., 2010). The results of the chemical analysis of the soil were as follows: pH ($CaCl_2$) = 4.5; P = 4.4 mg $dm^{-3}$; K = 9.4 mg $dm^{-3}$; Ca = 1.55 cmolc $dm^{-3}$; Mg = 0.5 cmolc $dm^{-3}$; Al = 0.2 cmolc $dm^{-3}$; H+Al = 4.07 cmolc $dm^{-3}$; SB = 2.42 cmolc $dm^{-3}$; t = 2.62 cmolc $dm^{-3}$; T = 6.45 cmolc $dm^{-3}$; m = 7.61 % ; V = 37.45 % ; MO = 26.52 g $kg^{-1}$ ; sand = 549.5 g $kg^{-1}$; silt = 91.5 g $kg^{-1}$; clay = 359 g $kg^{-1}$.

The study was based on the planting of sweet potato cuttings obtained from the experimental campus of Aldo Biodiesel Ltd. in Tangará da Serra, Mato Grosso (Brazil), where a number of cultivars have been developed through a partnership with the Federal University of Tocantins (UFT). Five cultivars were assessed in the present study – Amanda, Duda, Carolina Vitória, Vilma, and Nataly. The experimental plots were ploughed and harrowed, and the soil was then furrowed to form the planting lines. The plots were prepared with 0.94 t $ha^{-1}$ of lime (PRNT 90%) and fertilised with N-P-K, which was applied to the lines, using the commercial 4-14-8 formula (500 Kg $ha^{-1}$) at the time of planting. A cover of 166.7 Kg $ha^{-1}$ of KCl was also applied.

The experimental design involved random blocks of five treatments and four repetitions. The plants were spaced 0.4 m apart, with 0.8 m between rows, which each contained 40 plants. The plots were drip irrigated, with each plant being provided 18 mm of water per day, in three bouts (morning, afternoon, and night). The plots were weeded manually 30 and 60 days after planting.

The crop was harvested 150 days after planting, to standardize the procedure. Once harvested, the following parameters were determined for the roots:

**a) Total productivity of roots (t ha$^{-1}$):** The total productivity of roots was estimated by weighing five plants from each treatment in each plot. The results were extrapolated to provide a standardized measure of productivity, in tons per hectare (t ha$^{-1}$).

**b) Dry mass of roots (t ha$^{-1}$):** The roots were cut up, placed in paper bags, and then dried in a forced air circulation oven at a temperature of 85ºC until reaching a constant weight. Once dried, the samples were weighed and the dry mass of the roots was calculated.

**c) Starch content of the roots (%):** The starch content was determined by sampling the roots 150 days after planting. A sample of approximately 200 grams was extracted from the roots of each cultuvar, macerated, and dried in a forced air circulation oven at a temperature of 85ºC. The samples were then labelled and stored in paper bags before being sent to the Plante Certo Laboratory in Várzea Grande, Mato Grosso (Brazil), for the analysis of their starch content.

**d) Production of starch per hectare:** The production of starch per hectare was calculated by multiplying the percentage starch content, recorded by the Plante Certo Laboratory, by the fresh mass produced by each of the five cultivars investigated in the present study.

**e) Potential ethanol production (L ha$^{-1}$):** The potential for the production of ethanol was determined based on the mean production of starch per hectare. Machado (2006) established that a ton of starch can be used to produce 730 liters of ethanol. The results were given in L ha$^{-1}$.

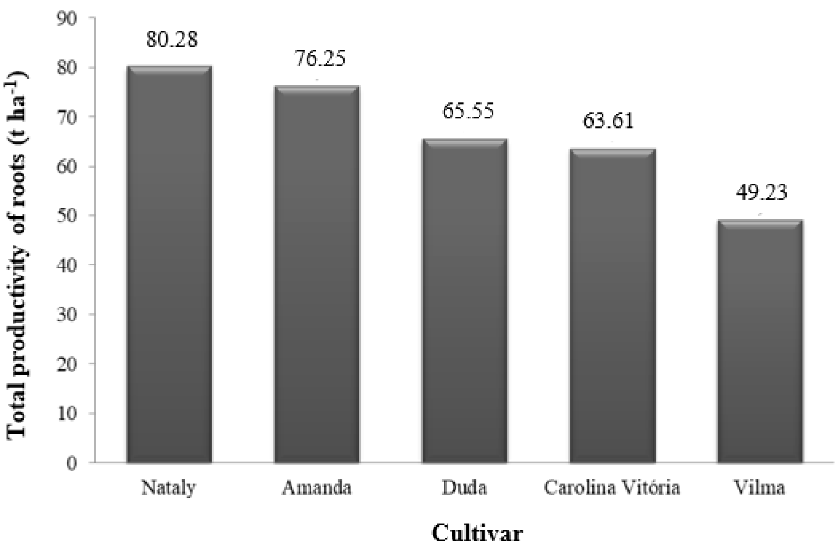
**f) Incidence of damage from soil-dwelling insects:** The incidence of insect damage to the roots was scored on a scale of 1 (no damage) to 5 (maximum damage), as in França (1995), where: 1 = root completely free of insect damage; 2 = root with some damage, including mining and holes; 3 = root with damage observed easily by the naked eye (more intense presence of mining and holes); 4 = root damaged extensively (widespread mining and holes, and initial rotting), and 5 = root covered completely with mining, holes, and advanced rotting. Cultivars with scores of 1 and 2 were considered to be resistant, those with a score of 3, moderately resistant, and those with scores of 4 and 5, susceptible to insect damage (Peixoto et al., 1999).

The data were analyzed using an Analysis of Variance (ANOVA), with the significance of pairwise differences being verified using Tukey's test. A 5% significance level was considered for these analyses, which were run in SISVAR 5.0.

## 3 RESULTS AND DISCUSSION

The mean total productivity of roots was 66.98 t ha$^{-1}$, ranging from 46.23 t ha$^{-1}$ in the Vilma cultivar to 80.28 t ha$^{-1}$ in the Nataly cultivar (Figure 1). The Nataly cultivar had a growing cycle of 150–180 days. While no specific information is available on the Vilma cultivar, its low productivity, recorded during the experiment, may indicate that it has a longer growing cycle, of more than 180 days.

Figure 1. Total productivity of roots by five sweet potato cultivars in Nova Xavantina, Mato Grosso, Brazil.




Vieira et al. (2015) recorded an estimated productivity of 32.17 t ha$^{-1}$ for the Nataly cultivar, a value lower than that obtained in the present study. Momenté et al. (2012) concluded that the cultivars most recommended for the production of ethanol are determined by the region, planting period, soil fertilization, the use of the crop, and the chemical composition of the soil. However, few studies have investigated which sweet potato cultivars may be most suitable for the different regions of Brazil. This hampers the comparative analysis of the relative suitability of the different varieties for the production of ethanol. Even so, the Amanda cultivar produced a mean of 76.23 tons of potato per hectare, a value much higher than that recorded for the same variety (47.20 t ha$^{-1}$) by Vieira (2014) in Tangará da Serra, Mato Grosso, and slightly lower than that (mean of 65.5 t ha$^{-1}$) registered by Rizollo (2014) in Tocantins.

The Amanda, Nataly and Duda cultivars had the highest starch content, the greatest production of starch per hectare, and the highest potential for the production of ethanol (Table 1). Amanda had the highest starch content (21.50%) of the five cultivars, followed by Nataly (18.10%) and Duda (16.93%), with the potential for the production of 11,964.70, 10,606.90, and 8103.00 L ha$^{-1}$ of ethanol, respectively. By contrast, the Vilma and Carolina Vitória cultivars returned the lowest values, with a starch content of 4.87% and 4.41%, respectively, and potential ethanol production of 3555.10 and 3219.30 L ha$^{-1}$. Resende (2000) concluded that the varieties of sweet potato most suitable for the production of ethanol, based on a production of 158 L of ethanol per ton of processed roots, should produce between 7078.4 and 15,484.0 liters of ethanol per hectare, a range consistent with the results of the present study for the most productive cultivars (Table 1).

Table 1. Mean production of roots (% dry matter), starch (t ha$^{-1}$), and the potential for the production of ethanol (L ha$^{-1}$) in five sweet potato cultivars, Nova Xavantina, Mato Grosso, Brazil.

| **Cultivar** | **Starch (% dry matter)** | **Production of starch (t ha$^{-1}$)** | **Potential ethanol production (L ha$^{-1}$)** |
|---|---|---|---|
| Nataly | 18.10 | 14.53 | 10,606.90 |
| Amanda | 21.50 | 16.39 | 11,964.70 |
| Duda | 16.93 | 11.10 | 8103.00 |
| Vilma | 9.90 | 4.87 | 3555.10 |
| Carolina Vitória | 6.94 | 4.41 | 3219.30 |
| **Mean** | 14.67 | 10.26 | 7489.80 |

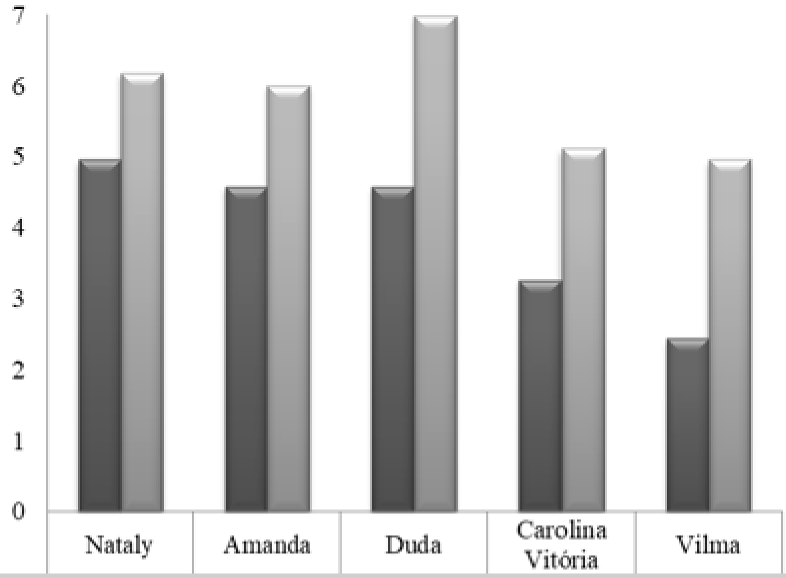
Miranda (1986) recorded a starch content of approximately 60%. Pessoa Júnior (2012) tested different sweet potato cultivars, planting periods, and sites, and found a similar starch content, of 47.60–60.56%. In both cases, the values were well above those recorded in the present study in Nova Xavantina, which ranged from 6.94% to 21.50%.

Potatoes contain 15–18% of fermentable material, whereas sweet potatoes contain approximately 22% of starch and 5–6% of reducing sugars, and cassava is 30–35% starch (Resende, 2000). All this starchy material is a traditional source of alcohol. On average, one ton of potatoes can be used to produce 85–95 liters of alcohol, whereas a ton of sweet

ISSN: 2525-8761

potato can produce as much as 150 liters. High productivity sugarcane (100 t ha$^{-1}$ of stems and 90 L of ethanol per ton) can produce up to 9000 L ha$^{-1}$ of ethanol over a yearly cycle. This indicates that sweet potato is superior to sugarcane for the production of ethanol, considering the varieties most suitable for this process, and should be considered a viable alternative for the production of biofuels in the Nova Xavantina region, in particular for family farmers. The mean dry mass produced by the different cultivars ranged from 2.44 to 4.96 t ha$^{-1}$, corresponding to 4.96–6.18% of the dry mass of the roots (Figure 2).

Figure 2. Mean dry mass of the roots (in t ha$^{-1}$ and %) of the five sweet potato cultivars analyzed in Nova Xavantina, Mato Grosso, Brazil.




| | Nataly | Amanda | Duda | Carolina Vitória | Vilma |
|---|---|---|---|---|---|
| Dry mass (t/ha) | 4.96 | 4.58 | 4.58 | 3.26 | 2.44 |
| Mass % | 6.18 | 6.01 | 6.99 | 5.12 | 4.96 |

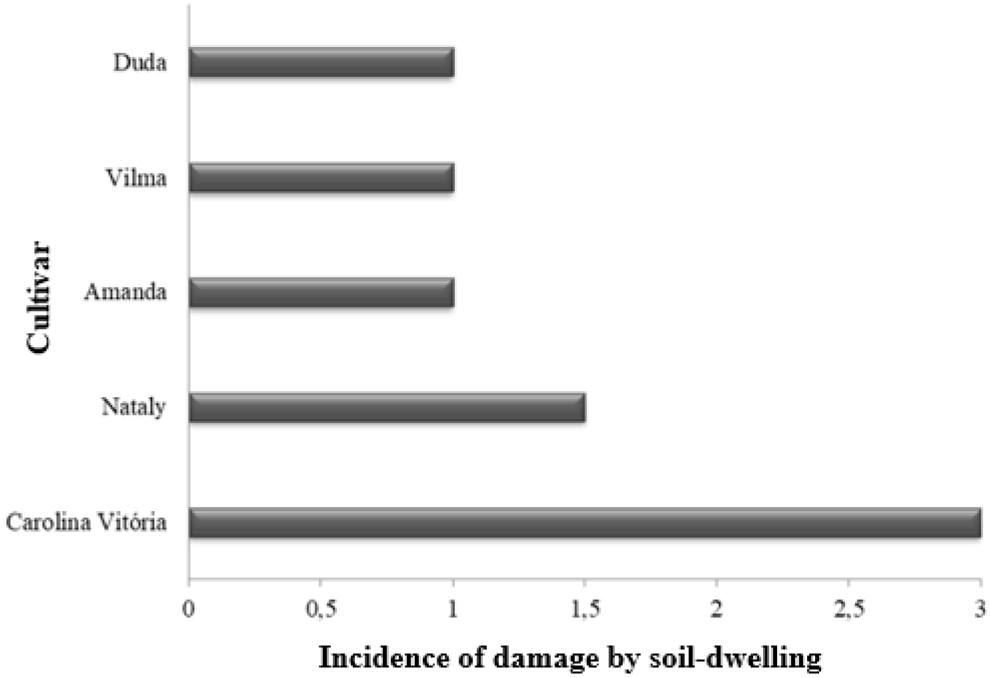
In terms of dry mass, the Nataly, Amanda, and Duda cultivars were the most productive (Fig. 2), while Carolina Vitória and Vilma produced much less dry mass. In addition to its performance in the production of dry mass of roots (4.96 t ha$^{-1}$ or 6.18%), the Nataly cultivar also returned the best mean productivity of roots. The Vilma cultivar was the least productive in terms of either the dry mass of roots (2.44 t ha$^{-1}$ or 4.96%) or the roots themselves. These results indicate that the most productive cultivars are those with the most light-colored pulp (white, cream or yellow), which is consistent with the findings of Silveira et al. (2014).

In the experiment of Silveira et al. (2014), the Amanda cultivar produced 40.4% of root dry mass, a better performance than that recorded in the present study. Momenté et al. (2012) identified 30 sweet potato cultivars suitable for the conditions prevailing in the Brazilian state of Tocantins, with the potential for a high production of biomass per hectare, indicating that they are promising options for the cultivation of raw materials for the production of alcohol. This study recorded a productivity of dry mass of between 34.57% and 38.05%.

The selection of the sweet potato cultivars to be planted for the production of ethanol should be determined by the productivity of root dry mass and the starch content. The higher the values recorded for these parameters, the greater the potential of the cultivar for the production of ethanol (Rizollo, 2014).

The Carolina Vitória cultivar, which has a white skin, suffered the highest mean level of insect attack, with a score of 3 (Figure 3). In other words, this variety has a low resistance to insect damage, whereas the other four cultivars (Nataly, Amanda, Vilma, and Duda), which have purple skin, had minimum scores (Figure 3), which indicates that they are resistant to ground-dwelling insect pests.

Figure 3. Incidence of damage caused by soil-dwelling insects (scores of 1–5) to five sweet potato cultivars in Nova Xavantina, Mato Grosso, Brazil.




The analysis of insect damage indicates that the white-skinned cultivar (Carolina Vitória) is more susceptible to attack by soil-dwelling insects than the purple-skinned varieties, which are more resistant. This difference in susceptibility is an important consideration for the selection of cultivars, which should preferentially have an insect damage score of less than 2. The use of pesticides is not recommended (Miranda, 1986; Jones et al., 1986; Peixoto et al., 1999), given their negligible effectiveness and impact on production costs. As an alternative, a bank of germoplasm of pest-resistant sweet potato cultivars has been established, as a means of amplifying the genetic variability of the crop, offering more resistant and productive cultivars. The findings of the present study are consistent with those of the previous study of França (1983), which showed that purple-skinned cultivars tend to be more resistant to soil-dwelling insect pests.

## 4 CONCLUSIONS

Under the experimental conditions evaluated in the present study, the Nataly sweet potato cultivar presented the best results in terms of the production of biomass, resistance to damage from soil-dwelling insects, and overall productivity, and was thus the variety most suitable for cultivation in the study region.

## ACKNOWLEDGMENTS

We are grateful to the CNPq for financial support; Nucleo de Estudos, Pesquisa e Extensão em Agroecologia (NEPEA) and Unemat for the technical support in conducting the experiment.

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