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Influence of harvest time and cultivation sites on the productivity and quality of sweet potato

Alcinei M Azevedo[1]; Valter C Andrade Júnior[2]; Daniel JS Viana[2]; Ahmed YAM Elsayed[2,3]; Carlos E Pedrosa[2]; Irã P Neiva[4]; José A Figueiredo[2]

[1]UFV, Progr. Pós-graduaçao em Fitotecnia, 36571-000 Viçosa-MG; alcineimistico@hotmail.com; [2]UFVJM, Progr. Pós-graduação prod. vegetal, Campus JK**,** Rod. MGT 367 km 583, nº 5000, Alto da Jacuba, 39100-000 Diamantina-MG; valterjr@ufvjm.edu.br; djsviana@yahoo.com.br; carlosenrrik@yahoo.com; altairfig@yahoo.com.br; [3]ARC-HRI, Dept. of vegetable breeding, Giza, Egypt; ahmed.elsayed@ufv.br; [4]Instit. Fed. do Norte de Minas Gerais, Campus Almenara; iraagronomia@yahoo.com.br

ABSTRACT

Sweet potato is one of the most cultivated tuberous roots in tropical and subtropical regions permitting several ways of use. Despite its potential use, sweet potato has been little studied. We evaluated the performance of sweet potato roots, forage productivity and its silage at different harvesting times and cultivation environments and we identified the most superior clones under different soil and climatic conditions. Six sweet potato clones (BD-38, BD-45, BD-25, BD-31TO, BD-15 and BD-08) belonging to germplasm bank of UFVJM in addition to two standard cultivars Brazlândia Rosada and Princesa were grown in two cultivation sites (JK campus and Forquilha farm). The trial was conducted in split plots in randomized block design with three harvest times (120, 150 and 180 days after planting). The mean root weight obtained from Forquilha farm was on average 30.2% higher than those obtained from JK campus. Regardless the site, harvesting at 150 days after planting was the optimal time for maximizing root production. The irregularity of root shape increased when the harvesting date was postpone, probably due to greater exposure to environmental factors. Crude protein, fibers, ash and starch, were not affected by local x cultivar interaction except for starch content that depended on the clone and site interaction.

Keywords: *Ipomoea batatas*, harvest time, quality traits, crude protein.

RESUMO

Influência da época de colheita e locais de cultivo na produtividade e qualidade da batata-doce

A batata-doce é uma das raizes tuberosas mais cultivadas nas regiões tropicais e subtropicais para diversas formas de utilização. Apesar de ser uma das olerícolas de grande potencial de uso na alimentação humana, animal e industrial, tem sido pouco estudada. O objetivo deste trabalho foi avaliar o desempenho de clones de batata-doce quanto à produtividade e qualidade de raízes, ramas e silagem em diferentes tempos de colheita e ambientes de cultivo, e identificar os clones superiores cultivados em diferentes solos e condições climáticas. Seis clones de batata-doce (BD-38, BD-45, BD-25, BD-31TO, BD-15 e BD-08), pertencentes ao banco de germoplasma da UFVJM, além de duas cultivares (Brazlândia Rosada e Princesa) foram cultivados em dois ambientes de cultivo (campus JK e fazenda Forquilha). O experimento foi conduzido em parcelas subdivididas em blocos casualizados com três épocas de colheita (120, 150 e 180 dias após o plantio). O peso médio de raiz obtido na Fazenda Forquilha foi em média 30,2% maior que o obtido no campus JK. Independentemente do local, a colheita aos 150 dias após o plantio foi a época ideal para maximizar a produtividade de raízes. O formato das raízes foi mais irregular com o maior tempo de colheita, provavelmente, devido a maior exposição a fatores ambientais. A proteína bruta, fibras, cinzas e amido, não foram afetadas pela interação genótipo x ambiente, exceto o teor de amido que sofreu interação do clone com o ambiente.

Palavras-chave: *Ipomoea batatas*, época da colheita, características de qualidade, proteína bruta.

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Sweet potato (*Ipomoea batatas*) is one of the most valuable crops cultivated in the tropical and subtropical regions for diverse forms of use (Viana *et al*., 2011; Peixoto *et al*., 1999). Sweet potato is widely used as human food, for animal feeding and as raw material in food, cloth, paper, cosmetics, preparation of adhesives and as an important source of biofuel production currently (Viana *et al*., 2011; Cardoso *et al*., 2005). Sweet potato provides the highest dry matter content for human consumption; that's why it is preferred by consumers and processors of sweet potato (Rukundo *et al*., 2013). Being one of the oldest cultures in Brazil, sweet potato is quite widespread, mainly grown by small farmers. Its planted area is of 42 ha with an average yield of 11.84 t ha^{-1} (IBGE, 2010).

The low yield may be due to interacted factors as lack of proper cultural practices, the use of obsolete cultivars, susceptibility to pests and soil diseases, mainly chrysomelid insects, the root borer, and the root

knot nematodes (*Meloidogyne* spp.). For productive aptitude, different yields were reported. Azevedo *et al*. (2002) found productivity between 8.21 and 33.51 t ha^{-1}, Souza (2000) from 13.7 to 21.7 t ha^{-1}, Resende (2000) between 21.15 and 27.73 t ha^{-1} and 33.25 to 60.51 t ha^{-1} when harvested at 150 and 200 days after planting, respectively.

Andrade Júnior *et al*. (2009), evaluating sweet potato clones on the Alto Vale do Jequitinhonha, observed variations on the total yield (22.01 to 45.36 t ha^{-1}) at seven months after planting, especially for the clone BD-06 which showed higher production than the commercial cultivars Brazlândia Branca and Brazlândia Rosada.

The soil insects are the main responsibles for damages, affecting not only the productivity but also quality, conservation and marketable aspect of the sweet potato (Huang *et al*., 1986). In not well managed cultures, the damage caused by insects may reach losses of 60 to 100% of production (Vanderley *et al*., 2004).

Despite its potential use for human food, animal feeding and for industry, sweet potato has been little studied. Under adverse conditions of cultivation on small family farms as a staple food for poor communities, it is necessary to provide alternative resources that could play vital role in the human diet and animal feeding. This research was installed to maximize the productivity and quality of sweet potato through the selection of the most adequate harvest date and to investigate the effect of genotype x cultivation sites.

MATERIAL AND METHODS

Six clones of sweet potato (BD-38, BD-45, BD-25, BD-31TO, BD-15 and BD-08) belonging to germplasm bank of UFVJM (Federal University of Jequitinhonha and Mucuri Valleys) in addition to two standard cultivars (Brazlândia Rosada and Princesa) were grown in two cultivation sites. The first site was the JK campus (18°12'01''S, 43°34'20"W, altitude 1387 m) in a sandy soil. The second site was Forquilha farm (18°31'31"S, 43°51'19"W, 1219 m altitude) located in the District of Batatal, Diamantina, Minas Gerais state, Brazil. The trials were conducted in split plots in randomized block design (subplots) with three harvest times (120, 150 and 180 days after planting) with a total of 72 plots, each 4.5 m^2. The spacing was 1.0 m between rows and 0.30 m between plants. The sweet potato clones were assigned to main plots while the levels of Factor B (harvest times) were assigned to subplots.

Three months before planting, the clones were propagated in a greenhouse using vessels of 5 liters capacity for a period of one week. Branches with eight internodes were buried in a depth of 10-15 cm. The cultural practices were applied according to Filgueira (2008).

The productivity and quality characteristics of roots were evaluated in both sites. The total yield of roots was obtained by weighing all the roots of each portion of each treatment expressed as t ha^{-1}. Roots between 100 and 800 g were classified as marketable, eliminating the roots weighing less than 100 and above 800 grams or those cracked, deformed, green, brocaded or with veins.

The average weight of marketable roots was obtained by dividing the weight of marketable roots of each parcel by the number of marketable roots of the plot. The results were expressed in g/root. The root shape was determined by assigning scores from 1 to 5 as follows: 1= spindle-shaped root, regular, without any veins or cracks; 2= root shape considered good, close to fusiform, with some veins; 3= roots shaped uneven, with veins and very irregular; 4= very large roots, with veins and cracks, commercially undesirable, and 5= roots completely out of the commercial box, very irregular and deformed, with many veins and cracks.

To evaluate the reaction of clones to soil insects, we used scores from 1 to 5 where 1= roots free of insect damage; 2= roots with little damage, but the presence of some holes and galleries in the roots; 3= roots with damage without much eyestrain (presence of holes at a higher intensity); 4= roots with much damage, practically unsuitable for the market (presence of many galleries, and early rot holes); 5= roots completely unsuitable for commercial purposes.

For bromatological assessment, about 200 grams of roots were sampled, crushed and dried in an oven with forced air at 60±5°C. The samples were labeled and packed in plastic containers for further chemical analyzes. The crude protein content was determined by Kjeldahl distillation unit (semi-micro), according to AOAC (1990), the values being expressed in percentage of dry matter. Crude fiber was extracted by acid hydrolysis according to Von de Kamer & Ginkel (1952) method and determined by filtration. The ash was determined by burning the material in an oven at 550-660^{0}C, according to AOAC (1990) expressed as percentage of dry matter. The starch content was determined by enzymatic method 996.11 (AOAC, 1990) expressed in percentage of dry matter.

The data were subjected to analysis of variance and treatment means were compared using the Tukey test, adopting the 5% level of probability.

RESULTS AND DISCUSSION

No significant differences were observed among the clones by F-test for the total, marketable root production, average weight of marketable roots and roots shape on the campus JK. In the experiment conducted at Forquilha farm, significant differences were observed for all yield and root quality traits. As for the harvest time, significant difference was observed for all traits, except for insect resistance in two soil environmental conditions. There was no significant difference in the interaction clone x harvest time for the total and commercial yields of roots, average root weight and shape of marketable roots (JK campus). The interaction clone x harvest time was significant for the resistance to soil insects in the two cultivation sites and the roots shape only in Forquilha farm. For the crude protein, fiber, ash and starch, significant differences were observed between clones for variables crude protein and starch. The clone x site interaction

Table 1. Total and marketable yield of sweet potato at different harvest times in two locations (produtividade total e comercial de raízes de clones de batata-doce para diferentes épocas de colheita em dois ambientes). Diamantina, UFVJM, 2008.

Clones	Total yield of roots (t ha^{-1})							
	JK campus (days)			Forquilha farm (days)			Mean	
	120	150	180	120	150	180	JK campus	Forquilha farm
Braz. Rosada	5.92aB	15.78abA	8.30aAB	15.48aA	25.48bcA	23.48aA	10.00aB	21.48bcdA
Princesa	7.63aB	21.11aA	6.74aB	13.04aA	13.78cA	23.48aA	11.83aA	16.77bcdA
BD-08	8.80aA	8.41bA	7.18aA	14.45aA	16.89cA	24.48aA	8.13aB	18.61bcdA
BD-15	6.82aA	15.87abA	14.26aA	13.04aB	29.04abcAB	35.18aA	12.32aB	25.75abcA
BD-25	11.81aA	10.81abA	13.15aA	17.04aA	11.93cA	12.15aA	11.92aA	13.70cdA
BD-31TO	7.89aA	10.69abA	11.81aA	9.18aA	11.04cA	14.37aA	10.13aA	11.53dA
BD-38	9.35aA	12.96abA	11.78aA	15.41aB	42.07abA	32.15aAB	11.36aB	29.88abA
BD-45	10.25aA	15.48abA	10.81aA	22.04aB	51.04aA	34.96aAB	12.18aB	36.01aA
Mean	8.56B	13.89A	10.50B	14.96B	25.16A	25.03A	10.99B	21.72A
CV (%)							43.44	43.59
	Marketable yield of roots (t ha^{-1})							
Braz. Rosada	5.09aB	12.71aA	6.56aAB	13.11aA	16.15bA	22.22abA	8.12aB	17.16bcdA
Princesa	5.86aA	12.96aA	5.55aA	9.63aA	10.96bA	19.16abA	8.12aA	13.25cdA
BD-08	7.01aA	7.19aA	5.85aA	10.37aA	11.56bA	21.70abA	6.68aB	14.54cdA
BD-15	5.70aA	12.50aA	12.03aA	9.53aB	26.52abA	30.11abA	10.08aB	22.05abcA
BD-25	9.82aA	8.52aA	10.15aA	12.29aA	8.70bA	10.30bA	9.50aA	10.43cdA
BD-31TO	6.29aA	8.80aA	9.74aA	7.04aA	8.29bA	12.59abA	8.28aA	9.31dA
BD-38	8.25aA	8.37aA	8.30aA	13.04aB	38.81aA	31.52abA	8.31aB	27.79abA
BD-45	8.91aA	12.00aA	9.04aA	19.70aB	44.82aA	33.78aAB	9.98aB	32.77aA
Mean	7.12B	10.38A	8.40AB	11.84B	20.73A	22.67A	8.63B	18.41A
CV (%)							44	45.34

Mean values followed by the same lowercase letter in columns and uppercase in rows do not differ by Tukey test (5% probability) [valores médios seguidos por mesma letra minuscula na coluna e maiuscula na linha não diferem pelo teste de Tukey (5% de probabilidade)].

Table 2. Average weight of marketable roots of sweet potato obtained at different harvest times under two locations (peso médio de raízes comerciais de diferentes clones de batata-doce para diferentes épocas de colheita em dois ambientes). Diamantina, UFVJM, 2008.

Clones	Average weight of marketable roots (g)							
	JK campus (days)			Forquilha farm (days)			Mean	
	120	150	180	120	150	180	Campus JK	Forquilha
Braz. Rosada	144.96aA	270.31aA	280.56aA	289.38aB	352.11abcdB	493.67aA	231.94aB	378.39abA
Princesa	114.12aB	317.63aA	137.59aB	173.88aA	212.31cdA	263.91bA	189.78aA	216.70cA
BD-08	132.81aA	217.81aA	185.18aA	139.19aB	231.92bcdAB	274.81bA	178.60aA	215.31cA
BD-15	190.32aA	232.12aA	305.69aA	210.95aB	364.98abcA	360.25abA	242.71aA	312.06bcA
BD-25	181.12aA	233.56aA	275.48aA	217.53aA	181.50dA	290.56bA	230.05aA	229.86cA
BD-31TO	156.64aB	198.56aAB	318.20aA	185.64aB	202.39cdB	345.61abA	224.47aA	244.55cA
BD-38	164.36aA	263.27aA	325.73aA	242.02aB	520.60aA	481.37aA	251.12aB	414.66aA
BD-45	193.50aA	293.07aA	302.91aA	272.74aA	399.18abA	372.62abA	263.16aB	348.18abA
Mean	159.73B	253.29A	266.42A	216.42C	308.12B	360.35[a]	226.5B	294.96A
CV (%)							36.03	22.84

Mean values followed by the same lowercase letter in columns and uppercase in rows do not differ by Tukey test (5% probability) [valores médios seguidos por mesma letra minuscula na coluna e maiuscula na linha não diferem pelo teste de Tukey (5% de probabilidade)].

presented significant difference only for the variable starch content.

For the overall roots productivity in Forquilha farm (Table 1), no significant differences were observed between the clones for harvest times at 120 and 180 days after planting. On average, the harvest at 150 days provided a higher yield (13.89 t ha^{-1}). Regarding the

overall roots productivity in Forquilha farm, 120 days after harvest, the average yield was 14.96 t ha^{-1}. At 150 days after harvest, there was variation from 11.04 to 51.04 t ha^{-1} between clones. The clone BD-45 was the most yielding, but not differing significantly from the BD-38 and BD-15. The total yield of roots in Forquilha farm was, on average, almost twice the yield obtained in the JK campus, 10.99 and 21.72 t ha^{-1} respectively.

The marketable roots production ranged from 5.09 to 12.96 t ha^{-1} at JK campus and 7.04 to 44.82 t ha^{-1} in Forquilha farm (Table 1). The clone BD-45 showed the highest productivity of roots, 44.82 t ha^{-1} at 150 days after planting at Forquilha farm. The clones were similar in their marketable yield in JK campus on the different harvest times.

On Forquilha farm, a difference was observed between the yields of marketable roots in different harvest times and between harvest times. At 120 days of harvest, no differences were detected between yields of marketable roots over the clones. The clones BD-45, BD-38 and BD-15 were those with the highest marketable roots, with no differences among themselves, but higher than the other clones in the harvest carried out at 150 days. At harvest date of 180 days, the clone BD-25 had the same productivity for roots (10.30 t ha^{-1}).

No differences were observed between cultivation sites for the clones and BD-25, BD-31TO and Princesa concerning the productivity of marketable roots. For the other clones, marketable yield of roots obtained from the Forquilha farm was significantly higher than the yield obtained in the JK

Table 3. The root shape and resistance to insect of soil obtained from sweet potato harvested at different harvest times in two sites of growth (notas para formato e resistência a insetos de solo de raízes de diferentes clones de batata-doce para diferentes épocas de colheita em dois ambientes). Diamantina, UFVJM, 2008.

Clones	Root shape							
	JK campus (days)			Forquilha farm (days)			Mean	
	120	150	180	120	150	180	JK campus	Forquilha
Braz. Rosada	1.93aA	2.27aA	1.93aA	2.07bA	2.07abcA	2.97cdB	2.04aA	2.37dA
Princesa	1.93aA	2.47aA	2.47aA	1.73abA	1.90abcA	2.00abA	2.29aB	1.88bcA
BD-08	1.67aA	2.23aA	1.73aA	1.07aA	1.23aAB	1.73abB	1.88aB	1.34aA
BD-15	1.97aA	1.83aA	2.40aA	1.53abA	1.43abcA	3.57dB	2.07aA	2.18cdA
BD-25	1.47aA	2.10aA	1.70aA	1.43.abA	1.37abA	1.67abA	1.76aA	1.49abA
BD-31TO	1.70aA	2.70aB	2.77aB	1.80abAB	1.53abcA	2.30abcB	2.39aB	1.88bcA
BD-38	1.87aA	2.07aA	1.87aA	2.03bA	2.27cA	2.40bcA	1.93aA	2.23cdA
BD-45	1.87aA	2.13aA	1.97aA	1.67abA	2.10bcA	1.53aA	1.99aA	1.77abcA
Mean	1.80A	2.23B	2.10AB	1.67a	1.74A	2.28B	2.04B	1.89A
CV (%)							21.67	17.20
Resistance to soil insects								
Braz. Rosada	1.23abA	1.20abA	1.43abcA	1.33aA	1.93bcB	1.57abcAB	1.29aA	1.61bcB
Princesa	1.10aA	1.07aA	1.83bcdB	1.13aA	1.30abA	1.13abA	1.33aA	1.19aA
BD-08	1.20abA	1.23abA	1.03abA	1.40aA	1.13aA	1.17abA	1.16aA	1.23abA
BD-15	1.80abA	1.90bA	1.87cdA	1.73aB	1.00aA	1.53abcB	1.86bB	1.42abcA
BD-25	1.17aA	1.20abA	1.13abcA	1.17aA	1.00aA	1.10abA	1.17aA	1.09aA
BD-31TO	1.03aA	1.30abA	1.40abcA	1.07aA	1.07aA	1.00aA	1.24aA	1.04aA
BD-38	1.33abA	1.73abA	2.50dB	1.33aA	2.33cB	1.77bcA	1.86bA	1.81cdA
BD-45	2.00bB	1.07aA	1.00aA	1.70aA	2.53cB	2.03cAB	1.36aA	2.09dB
Mean	1.36A	1.34A	1.53A	1.36A	1.54A	1.41A	1.41A	1.44A
CV (%)							22.06	18.72

Root shape notes, where 1= spindle-shaped; 2= close to fusiform with some veins; 3= uneven with veins and very irregular; 4= very large with veins and cracks, commercially undesirable; 5= completely out of the commercial box, very irregular, deformed with many veins and cracks (notas de formato das raízes, onde 1= fusiforme; semelhante a fusiforme com algumas veias; 3= irregular e muito irregular com veias; 4= raizes muito grandes com veias e rachaduras, comercialmente inadequadas; 5= completamente fora do padrão comercial, muito irregular e deformadas, com muitas veias e rachaduras). Notes for resistante to soil insects, where 1= free of damage; 2= little damage but some holes and galleries present; 3= many holes and galleries; 4= very damaged, practically unsuitable for market; 5= completely unsuitable for market (notas para resistencia a insetos do solo, onde 1= livre de danos; 2= poucos danos, presença de alguns furos e galerias; 3= muitos furos e galerias; 4= muito danificados, praticamente inadequados ao comercio; 5= completamente inadequado à comercialização).
Mean values followed by the same lowercase letter in columns and uppercase in rows do not differ by Tukey test (5% probability) [valores médios seguidos por mesma letra minuscula na coluna e maiuscula na linha não diferem pelo teste de Tukey (5% de probabilidade)].

Table 4. Mean values (% of dry matter) of crude protein, crude fiber, ash and starch in dry matter of roots obtained from sweet potato grown in two cultivation sites [valores médios (em % de matéria seca) de proteína bruta, fibra bruta, cinzas e amido na matéria seca de raízes em clones de batata-doce em dois ambientes de cultivo]. Diamantina, UFVJM, 2008.

Clones	Crude protein		Crude fiber		Ashes		Starch	
	JK campus	Forquilha farm	JK campus	Forquilha farm	JK campus	Forquilha farm	JK campus	Forquilha farm
Braz. Rosada	4.09abA	5.33aA	6.98aA	5.87aA	2.97aA	3.74aA	56.80aA	44.76cB
Princesa	4.39abA	4.37aA	6.93aA	7.04aA	2.89aA	3.54aA	56.33aA	57.14abA
BD-08	3.83abA	3.36aA	6.12aA	7.02aA	2.64aA	3.04aA	60.56aA	54.60abA
BD-15	3.78abA	4.03aA	5.42aA	6.45aA	2.28aA	2.71aA	50.88aB	58.14aA
BD-25	2.75abA	3.18aA	5.90aA	5.68aA	2.99aA	2.97aA	47.84aA	50.82bcA
BD-31TO	2.02bA	2.37aA	7.34aA	5.35aB	2.93aB	3.99aA	55.39aA	51.04bcA
BD-38	5.34aA	4.01aA	7.99aA	7.47aA	3.28aA	3.31aA	47.60aA	45.89cA
BD-45	3.84abA	5.07aA	6.53aA	7.85aA	3.12aA	3.45aA	50.79aA	54.25abA
Mean	3.76A	3.97A	6.65A	6.59A	2.88B	3.34A	53.27A	52.08A
CV (%)	24.01	35.74	18.36	16.86	14.39	20.05	8.82	4.64

Mean values followed by the same lowercase letter in columns and uppercase in rows do not differ by Tukey test (5% probability) [valores médios seguidos por mesma letra minuscula na coluna e maiuscula na linha não diferem pelo teste de Tukey (5% de probabilidade)].

campus. The average productivity in Forquilha farm was more than twice as much the yield obtained in JK campus (18.41 and 8.63 t ha^{-1}, respectively).

Regarding the average weight of marketable roots, no difference was observed between the clones for the harvest time on the JK campus (Table 2). It's worth to note that the average weight of commercial roots increased with the later harvests which was expected.

The clones BD-45, BD-38, BD-15 and cultivar Brazlândia Rosada had the highest mean weight of marketable roots harvests at 150 and 180 days at Forquilha farm, with no differences among them. The clone BD-31TO had an average marketable weight of roots similar to clones BD-45, BD-38, BD-15 and cultivar Brazlândia Rosada harvested after 180 days.

The average weight of commercial roots at Forquilha farm was 216.42, 308.12 and 360.35 g for the harvests carried out at 120, 150 and 180 days, respectively; we also observed an increase in the value of average weight of commercial roots in later harvest dates.

For the feature root shape, all the clones conducted in JK campus showed root shape close to ideal for the marketable model (Table 3). All the clones showed notes for root shape inferior to 3.0, ranging from 1.47 to 2.77. The effect of harvest times on root shape presented significant difference only for clone BD-31TO which presented the best root shape harvested after 120 days. There was no significant difference between the harvests carried out at 150 and 180 days, and in these times, clone BD-31TO presented root shape notes of 2.70 and 2.77, respectively.

In the Forquilha farm, the clones showed root shape notes ranging from 1.07 to 3.57.

At harvesting date after 150 days, the clones BD-08, BD-25, BD-31TO, BD-15 and the cultivars Princesa and Brazlândia Rosada had roots with similar shape, with no significant difference between them. The clones BD-38 and BD-45, with root shape notes of 2.27 and 2.10, respectively, did not differ from each other, but were significantly higher than the other clones. At 180 days after planting, the clones BD-08, BD-25, BD, BD-31TO, BD-45 and Princesa were those with the lowest root shape notes, ranging from 1.53 to 2.30.

Regarding different harvest times, the best root shapes were obtained at 120 and 150 days of harvest, with no significant difference among the notes. The harvest at 180 days was the one with the highest shape notes (2.28). Comparing the different locations, there was no difference between clones in JK campus. In the Forquilha farm, clones BD-08, BD-25 and BD-45 showed the best root shapes with scores less than 1.80.

At 120 days after planting, the clone BD-45 showed to be the most susceptible one to attack by soil insects, but did not differ from the clones BD-15, BD-38, BD-08 and cultivar Brazlândia Rosada in the first cultivation site, JK campus (Table 3). After 150 days, clone BD-45 and Princesa were the most resistant, with notes 1.07, but similar to clones 31TO-BD, BD-25, BD-08, BD-38 and cultivar Brazlândia Rosada. At 180 days the clones BD-38, BD-15 and the cultivar Princesa were the most attacked by soil insects with notes 2.50, 1.87 and 1.83 respectively.

The clone BD-45 showed the lowest note for resistance to soil insects (1.00) and no statistical differences between clones BD-31TO, BD-25, BD-08 and cultivar Brazlândia Rosada were detected. The cultivar Brazlândia Rosada was found to be more resistant to soil insects in comparison to the cultivar Princesa with notes 1.43 and 1.83, respectively.

At Forquilha farm, 120 days after planting, no significant differences were observed between the clones for resistance to soil insects. At 150 days, the clones BD-25 and BD-15 showed to be highly resistant, but not significant

difference was observed on BD-31TO, BD-08 and the cultivar Brazlândia Rosada. At 180 days after planting, the BD-31TO, BD-25, BD-08, BD-15 and the cultivars Brazlândia Rosada and Princesa had the lowest rates for insect resistance and did not differ *per se*.

For crude protein, the clone BD-38 presented the highest content in JK campus, but was statistically similar to clones BD-45, BD-25, BD-15, BD-08 and Brazlândia Rosada and Princesa. In Forquilha farm, all clones had similar crude protein content. In relation to the locations of culture, the clones showed similar levels of crude protein.

Regarding the crude fiber content, all clones showed similar levels in the two cultivation sites (Table 4). Except for clone BD-31TO which exhibited higher crude fiber content in the JK campus (7.34%) than that obtained on Forquilha farm (5.35%). The clone BD-31TO presented higher ash content in Forquilha farm compared to JK campus (3.99% and 2.93%, respectively). The remaining clones showed similar levels on both sites.

For starch content, on JK campus, the clones showed a closed level ranging from 47.60 to 60.56%. In Forquilha farm, clone BD-15 had the highest starch content, but did not differ from the clones BD-45, BD-08 and cultivar Princesa. With the exception of Brazlândia Rosada cultivar and the clone BD-15, all other clones showed similar levels of starch in the two cultivation sites (Table 4).

Regardless of the site, it is advisable to indicate that harvesting at 150 days after planting is considered the optimal time for maximum roots productivity. This fact may be attributed to the decreasing risk of soil insects attack and inclement weather. Queiroga *et al*. (2007) recorded higher yields of roots (20.7 t ha^{-1}) on harvests at 155 days after planting, compared to 105 and 130 days. Cardoso *et al*. (2005) found maximum root yield of 28.5 t ha^{-1}, a much lower value than that obtained from clone BD-45, rated at Forquilha farm.

Brito *et al*. (2006) obtained maximum root yield of 14.96 t ha^{-1} at 120 days after planting, similar to Forquilha farm harvested at 120 days after planting and greater than the yield obtained in the JK campus (8.56 t ha^{-1}) at the same time. Andrade Junior *et al*. (2009), evaluating sweet potato clones harvested 210 days after planting in Diamantina, found total root yield ranging between 22.01 and 45.36 t ha^{-1}.

The average root weight obtained from Forquilha farm was on average 30.2% higher than that obtained from JK campus. Massaroto (2008) found average weight values of marketable roots from 233.7 to 889.0 g, results well above those found in this experiment. For shape, the Forquilha farm was the site that presented the lowest notes (1.89), significantly lower than the values obtained in JK campus (2.04) and closer to the fusiform shape, ideal for marketing.

When increasing harvesting time, the roots become more irregular shape, which is expected due to the fact that the roots stay longer in the soil, being exposed to different factors. Azevedo (1995) found significant differences between the clones with shape notes ranging from 1.90 to 3.67. Peixoto *et al*. (1999) found clones with root shape notes close to ideal, but several clones presented greater notes than 3.0. Cardoso *et al*. (2005) found root shapes ranging from 1.63 to 2.27.

In both experimental sites, the clones showed high to moderate resistance to soil insects with scores from 1.0 to 2.53. In JK campus, the clones BD-38 and BD-15 were more susceptible. In the Forquilha farm, clones BD-38 and BD-45 and cultivar Brazlândia Rosada were the most susceptible, with scores ranging from 1.61 to 2.09. The content of crude protein, crude fiber, ash and starch in the dry matter of roots were not affected by the local x cultivar interaction however further studies are required to confirm this fact.

In JK campus no significant differences were observed between clones for the total and commercial root yield. The clones BD-25, BD-38 and BD-45 at Forquilha farm had the highest total and marketable yield and should be harvested later. The Forquilha farm was the site where the sweet potato clones presented on average, the highest total and marketable roots and the highest average weight of roots in comparison to the other site. The crude protein, crude fiber, ash and starch in dry roots were not influenced by environmental conditions. All clones showed, on average, scores for resistance to soil insects below 2.0.

Sweet potato is very sensitive to environmental changes. Grüneberg *et al*. (2005) observed variations in the yield and stability in the multi-environmental trials of different genotypes of sweet potato. A significant genotypes x environment (G×E) interaction was reported for the mean storage root weight and storage root yield. However, the contribution of genotype main effects to the total variance was greater than the environment and G × E interaction effects (Caliskan *et al*., 2007). Crop growth and production are a result of the interactions of its genetic potential and environment. Crops perform well in environments in which they are adapted (Acquaah, 2007). The performance of genotypes is quantified in terms of a wide and specific adaptability and yield stability (Abidin *et al*., 2005). The wide adaptability is generally attributed to genotypes performing well over large areas and presenting high mean yields across different environments. The stability which can be static or dynamic is the ability of a genotype to perform consistently across a wide range of environments (Acquaah, 2007). Knowledge on the types of G×E interactions is very important before release to decide if a new variety has wide or specific adaptation (Grüneberg *et al*., 2005). The G×E interaction is a differential genotypic expression across multiple environments (Acquaah, 2007). It complicates the comparison of the performance of genotypes across environments when a high number of genotypes and locations are involved and quite often delays the selection process of a breeding program (Caliskan *et al*., 2007). Prior to the releasing of a new variety, genotypes of high yield potential should be evaluated at different locations and several years to identify their G×E interaction and yield stability (Acquaah, 2007). Therefore, breeders need robust researching methods to

estimate phenotypic stability and to analyze G×E interactions.

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REFERENCES

ABIDIN P; EEUWIJK F; STAM P; STRUIK P; MALOSETTI M; MWANGA R; ODONGO B; HERMANN M; CAREY E. 2005. Adaptation and stability analysis of sweet potato varieties for low input systems in Uganda. *Plant Breeding* 124: 491-497.

ACQUAAH G. 2007. Principles of plant genetics and breeding Oxford: Wiley-Blackwell.

ANDRADE JÚNIOR VC; VIANA DJS; FERNANDES JSC; FIGUEIREDO JA; NUNES UR; NEIVA IP. 2009. Selection of sweet potato clones for the region Alto Vale do Jequitinhonha. *Horticultura Brasileira* 27: 389-393.

Association of Official Analytical Chemists (AOAC). 1990. Official methods of analysis of the Association. 12 ed. Washington, 1140p.

AZEVEDO SM. 1995. *Avaliação de famílias de meio-irmãos de batata-doce (Ipomoea batatas L.) quanto à resistência aos nematóides de gênero Meloidogyne e insetos de solo*. Lavras: UFLA (Dissertação Mestrado).

AZEVEDO SM; MALUF WR; SILVEIRA MA; FREITAS JA. 2002. Reação de clones de batata-doce aos insetos de solo. *Ciência Agrotécnica* 3: 545-549.

BRITO CH; OLIVEIRA AP; ALVES AU; DORNELES CSM; SANTOS JF; NÓBREGA JPR. 2006. Produtividade da batata-doce em função de doses de K_2O em solo arenoso. *Horticultura Brasileira* 24: 320-323.

CALISKAN ME; ERTURK E; SOGUT T; BOYDAK E; ARIOGLU H. 2007. Genotype x environment interaction and stability analysis of sweet potato (*Ipomoea batatas*) genotypes. *New Zealalnd J Crop Hort.* 35: 87-99.

CARDOSO AD; VIANA AES; RAMOS PAS; MATSUMOTO SN; AMARAL CIF; SEDIYAMA T; MORAIS OM. 2005. Avaliação de clones de batata-doce em Vitória da Conquista. *Horticultura Brasileira*. 23: 911-914.

FILGUEIRA FAR. 2008. Novo manual de olericultura: agrotecnologia moderna na produção e comercialização de hortaliças. Viçosa: UFV. 402p.

GRÜNEBERG WJ; ZHANG; MANRIQUE K; HERMANN M. 2005. Genotype x environment interactions for a diverse set of sweet potato clones evaluated across varying ecogeographic conditions in Peru. *Crop Science* 45: 2160-2171.

HUANG SP; MIRANDA JEC; MALUF WR. 1986. Resistance to root-knot nematode in a Brazilian sweet potato collection. *Fitopatologia Brasileira*. 11: 761-767.

IBGE. Diretoria de Pesquisas, Departamento de Agropecuária, Lavoura Temporária 2010. Disponível em http://www.ibge.br. Acessado em 23 de dezembro de 2012.

MASSAROTO JA. 2008. Características agronômicas e produção de silagem de clones de batata-doce. Lavras: UFLA. 85p. (Tese doutorado)

PEIXOTO JR; SANTOS LC; RODRIGUES FA; JULIATTI FC; LYRA JRM. 1999. Seleção de clones de batata-doce resistente a insetos de solo. *Pesquisa Agropecuária Brasileira*. 3: 385-389.

QUEIROGA RCF; SANTOS MA; MENEZES MA; VIEIRA CPG; SILVA MC. 2007. Fisiologia e produção de cultivares de batata-doce em função da época de colheita. *Horticultura Brasileira*. 25: 371-374.

RESENDE GM 2000. Características produtivas de cultivares de batata-doce em duas épocas de colheita, em Porteirinha-MG. *Horticultura Brasileira* 18: 68-71.

RUKUNDO P; SHIMELIS H; LAING M; GAHAKWA D. 2013. Storage root formation, dry matter synthesis, accumulation and genetics in sweetpotato. *Australian Journal of Crop Science* 7: 2054-2061.

SOUZA AB. 2000. Avaliação de cultivares de batata-doce quanto a atributos agronômicos desejáveis. *Ciência Agrotecnica.* 4: 841-845.

VANDERLEY PA; BOIÇA JÚNIOR AL; WANDERLEY MJA. 2004. Resistência de cultivares de batata-doce a *Euscepes postfasciatus* Fairmaire (Coleoptera: Curculionidae). *Neotrop. Entomol*. 3: 371-377.

VIANA DJS; ANDRADE JUNIOR VC; RIBEIRO KG; PINTO NAVD; NEIVA IP; FIGUEIREDO JA; LEMOS VT; PEDROSA CE; AZEVEDO AM. 2011. Potencial de silagens de ramas de batata-doce para alimentação animal. *Ciência Rural*. 41: 1466-1471.

VON De KAMER SB; VAN GINKEL L. 1952. Rapid determination of crude fiber in cereals. *Cereal Chemistry* 4: 239-251.