Volume 19(1), 79- 84, 2015
JOURNAL of Horticulture, Forestry and Biotechnology
www.journal-hfb.usab-tm.ro

Researches on the sweet potato (*Ipomea batatas* L.) behaviour under the soil and climatic conditions of the South-West of Romania

Dinu Maria[1*], Soare Rodica[2]

[1]University of Craiova, The Faculty of Agriculture & Horticulture, The Department of Horticulture and Food Science, 13 A.I.Cuza Street, 200858 Romania; [2]University of Craiova, Faculty of Agriculture &Horticulture, Libertatii Street, no 19, 200583, Craiova, Dolj, Romania

*Corresponding author. Email: dinumariana@hotmail.com

Abstract This study aims to present the role of sweet potato (*Ipomea batatas L.*) in human alimentation, specifically to present two new cultivars recently cultivated, their way of behaviour in the south-west of Romania, the biochemical composition of the tuberous roots and the productive potential of this species.

The sweet potato is appreciated for its very high nutritional value, both of the tubers and of the young aerial parts. The thickened roots rich in carbohydrates, starch, minerals (Ca, Mn, Cu Fe, P, K) and vitamins (ß-carotene, vitamin C, B6) can be used in various forms of meals: mashed sweet potatoes, soups, fries, desserts. Considering the qualities of these varieties, in The Didactic Research Station of the University of Craiova there was studied the behaviour of two cultivars of sweet potato, Pumpkin and Chestnut in terms of productive potential and biochemical composition, under the conditions in the south-west of Romania.

Within the experiment there were made observations on the way of plant growth: the number of stems in the bed, the average and total weight of haulm and the total quantity of vegetal material. We also observed the characteristics in terms of tuberous roots production, and the average number of the tuberous roots per bed, their dimensions and weight. The water content, the dry matter and soluble dry matter, the titratable acidity, the starch, total sugar and vitamin C content were determined and the yield was calculated. The study shows that the best productive performance was recorded in the Pumpkin cultivar, 53.3 t/ha, and in terms of chemical composition, the total sugar content and vitamin C content, the higher values were recorded in Chestnut, 14.1 %, 14.6 mg/100 g FW respectively.
The results of our study should determine the development of certain research activities at national multidisciplinary level which aim at improving the production technology, the storage, the post-harvest and processing technologies, and the quality of sweet potato and its value-added products.

Key words

sweet potato, cultivation, biochemical composition

The sweet potato (*Ipomea batatas L.*), or American potato belongs to the *Convolvulaceae* family and it is original from South America; it is cultivated on large areas in China, India, Japan, in south-eastern Asia and in Africa. It is also cultivated in southern Russia, the US, South America and even in the Mediterranean areas of Europe. This species is among the most important food crop in the world with more than 133 million tonnes in annual production (2; 3). Its culture can be found on all continents, in over 95 countries with an area of over 9.5 million hectares, the largest in China (22).

It replaces completely the potato in the subtropical and tropical regions. In our country there were carried out researches at the University of Agronomic Sciences and Veterinary Medicine Bucharest by Ruxandra Ciofu and the collective of the vegetable growing subject matter. Two cultivars Victoria IANB and Crux were created (10).

The sweet potato contains complex carbohydrates, especially simple sugars; the sweet potato glycemic index is quite high and it is therefore unsuitable for diabetics and overweight persons. The carbohydrate content is 20.1 g/100 g edible part of which 16.0 g is starch and 4.2 g are soluble sugars. The proteins are in small quantities, as well as fats. Instead the fibres are quite abundant making the sweet potato suitable for those suffering from constipation.

Regarding the minerals, the American potato is rich in potassium and magnesium. It has a high content of B6 vitamin and a remarkable content of vitamin A (18). This species is appreciated due to the thickened roots nutritional value, rich in carbohydrates, starch, mineral salts of potassium, calcium, phosphorus, magnesium, various organic acids, ß-carotene, vitamin E, C and A which can be used in various types of dishes (mashed potatoes, soups, fries, desserts) (5).

The rizoderm of the thickened roots has different colours (white, cream, yellow, orange, pink, red to purple.), and the pulp has shades of ivory, orange or purple-lilac (1; 3). The orange colour is given by the high content of ß-carotene: 11,500 mg per 100g of product, compared with only 6 mg contained by potatoes, and even with 40% more than carrots. The beta-carotene is converted by the human body into vitamin A, with beneficial effects on the immunity enhancement, skin health and membranes lining the nose, lungs and intestines. A sweet potato provides about half of the necessary nutritional vitamin E and contains significant amounts of other vitamins and minerals.

A 100 g of sweet potato has the following nutritional quality: 105 kcal energy; 2.22 g proteins; 74.43% water; 14.43% starch; 3.48% total sugar; 0.58% glucose; 1.10% cellulose. Due to the biochemical composition and large production per unit area (above 40 t/ha) it is a good source of food in many least developed countries with problems of nutrition (14; 19).

According to the estimations of the Center for Science in the Public Interest, the nutritional value of sweet potato is more impressive than the one of common potato. In comparison to the latter, the sweet potato has a much higher content of retinol equivalents, especially β-carotene. A study carried out in Uganda in 2012, which involved approx. 10,000 households showed that: "Only 10% of those who consume dark orange sweet potatoes suffer from vitamin deficit, retinol equivalents, while 50% of those who consume beige or pale yellow sweet potato have a significant hypovitaminosis"; this is explained by the higher content of β-carotene of dark orange sweet potatoes in comparison to the lighter ones (6).

Due to its high content in starch, the sweet potato is used in the alcoholic beverages industry (the spirits), food industry (flour of sweet potatoes, food dyes) and in the textile industry to dye the fabrics and to obtain the paper. In South America, the juice of red sweet potatoes, combined with lemon juice is used as a dye for fabrics.

There is no waste from this variety. The leaves and young shoots are used in human food and the older ones for the animal feed. It can also be used for ornaments and landscapes due to the variety of colours of the leaves and variety of forms or it can remain on the soil as a green carpet, the plant growing as haulm.

There are numerous studies which show that the sweet potato leaves are rich in anthocyanins and phenolic acids than most vegetables found on the market. These polyphenols have radical properties, scavenging activity, antimutagenic activity, anticancer, antidiabetes, and antibacterial activity, which may be helpful for maintaining human health (8).

The culture of sweet potato is very profitable and encouraged in many countries. The tobacco growers in eastern Kentucky found as an alternative the culture of sweet potato which is profitable and sought by consumers; the organic sweet potato is also currently produced in the state of Mississippi, especially used for baby food (20).

Because this culture is considered an important source of food security, with great potential to alleviate hunger in many countries in Africa, the State University of North Carolina will be funded by the Bill & Melinda Gates Foundation with over 12 million dollars to conduct studies to improve the technology of this species (21).

In Romania, the sweet potato is almost unknown by the population, the first investigations were carried out since 1954, when it was brought into the country and its behaviour was observed in specific temperate climate conditions in our country and there was established the technological sequences. The researches have shown that the sweet potato can be grown in Romania, especially on sandy soils in the south-west of the country (7). Also, the researches have continued at the University of Agronomic Sciences and Veterinary Medicine Bucharest and they were conducted by Ruxandra Ciofu and the collective of the vegetable growing subject matter (11;12).

Also, this culture is well suited for sandy soils from south-west of the country but also on other soil types. Therefore, the objective of this paper was to study the behavior of two cultivars of sweet potato under pedoclimatic conditions from south-western Romania.

Biological Material and Method

The experiment was placed in the didactic area of the Faculty of Agriculture and Horticulture, University of Craiova, Romania, on a reddish brown preluvosoil. The biological material was represented by two sweet potato cultivars originating in South Korea which are named Pumpkin and Chestnut. The main objective of the study was to test the behaviour of the two new cultivars introduced in Romania through a "Romanian-Korean Collaborative partnership for the sweet potato" which was signed between the Research - Development Center for Agricultural Plants on Sands Dăbuleni and Gyeongbuk Province FTA Committee (GPFC) –South Korea.

The culture was formed by cuttings obtained by forcing the tuberous roots in greenhouses, which were left two days after being removed from the

mother plants in ventilated rooms and then planted without previous rooting, as it has been done before in some tests in Romania. Regarding the soil, it should be sandy or loamy-sandy or allow good ventilation because the roots need oxygen in order to develop. The sweet potato does not support excessively humid soils.

The cuttings were planted on June 15 on high ridges of above 30 cm, at a distance of 70 cm between them and 40 cm between plants in rows resulting 33,333 plants/ha.

Regarding the culture technology there were applied 2 fertilizations with complex fertilizer 20-20-20 + micronutrients, 150 kg/ha, and the drip irrigation was performed in the case of moisture deficit. For weed control in the early stages of vegetation there was applied manual hoeing, after that the vegetative growth of sweet potatoes led to the soil cover, between plants and interventions were no longer needed. Also, 2 treatments were performed against the diseases attack with Topsin alternating with Bravo and for pests, with Actara alternating with Calypso.

After harvesting the roots, they were washed and placed in storage areas.

The experiment was arranged in randomized blocks, in four replications. There was taken as control the cultivars average. At harvest, there were made observations on the morphological characteristics of plants: the number of haulms in the bed, the average and total weight of the haulm and the total quantity of plant material, reported in tonnes per hectare. There were also observed the production characteristics: the average number of the tuberous roots per plant, their dimensions and weight. There was determined the water content, the S:U:T and S.U.S, titratable acidity, starch, total sugar and vitamin C content for the two cultivars and the yield was calculated.

The data were interpreted statistically and the analysis of variance was performed using ANOVA.

The roots moisture was determined by the gravimetric method, in order to calculate the S.U.T and to precisely compare the various biochemical components by reference to 100 g dry matter.

The titratable acidity- the principle of the method is the titration with a NaOH 0.1N standard volumetric solution in the presence of phenolphthalein as indicator.

The determination of total sugar content was made by refractometry using the refractometer Delta refractometer Bellingram Stanley DTD.

The vitamin C was determined by volume. The starch was determined polarimetrically using a Jasco P 2000 polarimeter and its content was reported to the dry matter of the samples.

Results and Discussions

The variability of climate in the south-west of Romania where summers are dry and hot offers favourable conditions for growing the sweet potatoes. In Romania, the sweet potato crop is at the beginning and could be a great alternative enriching the range of less cultivated species.

In the experiment located in the didactic field of the vegetable growing subject matter, observations and measurements on the vegetative growth of sweet potato (table1) for each cultivar were made on October 20. Thus, the Pumpkin cultivar recorded 8.5 stems/bed, which had a total mass of 1230 g and the average weight per each stem of 145 g, while the average number of stems of the Chestnut cultivar was smaller, 7.8 with a total mass of 800 g and an average weight of 102.5 g/stem. The Pumpkin cultivar plants were more vigorous with strong developed stems, which reached a production of 41 t/ha. The Chestnut cultivar haulms are less developed and the foliar system is smaller and less developed as well as the total production of stems, which was of 26.6 t/ ha (Table 1). Some authors (Zihin et all., 2011)(17) reported the stem length between 332.2 cm and 405.7 cm and stem number / plant, between 6.5 and 14.1.

Table 1

The influence of cultivar on plant growth of sweet potato (average values)

Cultivar	Morphological characteristics:			
	No./bed	Total weight g/bed	Average weight g/stem	t/ha
Pumpkin	8.5	1230	145	41.0
Chestnut	7.8	800	102.5	26.6

All this mass vegetative production in Romania is used in animal feed while in countries with a tradition of the sweet potato crop it is used in human food, prepared in various forms or in industry as dye (4).

The previous experiments have shown that the leaves of sweet potatoes have a high content of polyphenols, phenolic acids and anthocyanins, in relation to many vegetables. The leaves of this species contain at least 15 anthocyanins biologically active that have a significant drug amount for certain human diseases and can be also used as natural food dyes. These polyphenols have properties to capture the free radicals, antimutagenic, anticancer, antidiabetic and

antibacterial activity that can be useful for maintaining and promoting the human health (8).

The thickened roots had a very uneven development because during the plant vegetative development (July-August- September) the amount of rainfall in the area of culture was quite big but unevenly distributed, thus disfavouring the normal development of thickened roots and favouring the vegetative plant growth. Periodically we entered into the culture and the plants were moved in order to not form adventitious roots, but during the rains this process was heavier and this thing was observed in the crop.

For the studied sweet potatoes cultivars, the average number of thickened roots per storage was 4.0 for Pumpkin and 5.1 for Chestnut. The average weight of roots of the Pumpkin cultivar was 400 g and 210 g for the Chestnut cultivar (Table 2). In other studies (Zihin et all., 2011)(17) have been reported values for root number / plant from 5.1 to 11.5, and the weight of storage for root/plant from 504.8 to 738.8 g.

Table 2

The influence of cultviar on the main productivity characters

Cultivar	Productivity characters (medium values)		
	Number of storage root /plant	Weight of storage root /plant (g)	Weight of storage root (g)
Pumpkin	4,0	1600	400
Chestnut	5,1	1071	210

The sweet potato production for the two cultivars ranged between 35.6 t/ha and 53.3 t/ha, with an average per experiment of 44.5 t/ha, a relatively high level, given the conditions of culture, relatively low thermal regime and high rainfall during the growth and roots formation. According to the analysis of variance, considering as control the cultivars average, the Pumpkin cultivar had the highest production, the difference in yield being of 8.8 t/ha; thus it was statistically assumed at the distinct significant levels.

The Chestnut cultivar presented lower yields compared to the control plant, to the average of the two variants, the difference in production being of -8.9 t / ha which is distinct significantly negative (Table 3).

The two studied cultivars were tested in the Research - Development Center for Agricultural Plants on Sands Dăbuleni and they behaved very well, obtaining productions of over 30 tonnes/ha.

Table 3

The production of sweet potato for the studied cultivars in Banu Maracine DC

Cultivar	Production		± Difference from the control	Signification
	t/ha	%		
Pumpkin	53.3	119.7	8.8	xx
Chestnut	35.6	80	-8.9	00
Average of cultivars (control)	44.5	100.00	-	-

DL 1%=5.24 t/ha; DL 5%=3.16t/ha; DL 0.1%= 9.81 t/ha

The sweet potato tubers are mainly a source of energy due to their high content of carbohydrates, which is 80-90% of the dry weight. These carbohydrates consist of starch, sugar and small amounts of pectin, hemicelluloses and cellulose (9).

For the biochemical analysis of the two cultivars of sweet potato there were taken samples from each cultivar, from each repetition (Table 4). Thus, the water content varied between 67.10% and 70.05%, which was higher for the Chestnut cultivar and which is correlated with the content of the dry matter (32.90 and 29.95 respectively) values sustained also by other authors (13;16;18). Soluble dry matter had higher values for the Chestnut cultivar that, overall, recorded higher values for all the components than for the Pumpkin cultivar. In the literature, the dry matter content of fresh tubers ranged from 30% to 45%, values sustained also by other authors (13; 18).

Table 4

The biochemical composition of the tuberous roots of sweet potato depending on cultivar

Cultivar	Water (%)	Dry matter (%)	Soluble dry matter (%)	Titratable acidity (%)	Starch %	Total sugar (%)	Vitamin C (mg/100 g FW)
Pumpkin	67.10	32.90	11.5	0.28	31.94	13.2	12.9
Chestnut	70.05	29.95	13.1	0.26	32.00	14.1	14.6

The titratable acidity had values ranging between 0.28 and 0.26% and the starch content was above the values quoted in the literature, namely 31.94% for Pumpkin and 32.0% for Chestnut (14).

The total sugar had a value of 13.2% for Pumpkin and 14.1% for Chestnut, values that have been cited by other authors in different studies, (15; 16) existing American varieties containing over 38% (18). The sugar content can be highly variable, usually between 1 and 12% DM, but some American varieties contain up to 38% DM of sugars. The sugar composition of some variety, especially the sucrose values, provides a reliable indication of its sweetness (9).

The starch is the main carbohydrate (approximately 75% DM) and is highly resistant to amylase hydrolysis. The cooking increases the fraction of readily hydrolyzable starch of sweet potatoes from 4% to 55%. Regarding the starch of the studied cultivars, it recorded values between 31.94% at Pumpkin and 32% at Chestnut.

The total sugar recorded values ranging between 13.2 at Pumpkin and 14.1% at Chestnut. Various authors have shown that the relative composition of total sugar at the sweet potato ranged around 10%, depending on the variety and maturity of roots and on the storage time and culture area. Thus, the content ranged between 5.6% at the varieties grown in the Philippines, and 38.3% at the roots of sweet potatoes harvested in Louisiana (Truong et al., 1986 cited by Muşat C.C., 2013)(12), or between 6.3% and 23.6 % at the varieties grown in Puerto Rico (10).

The vitamin C content was 12.9 mg/100 g FW at the Pumpkin cultivar and 14.6 mg / 100 g FW at the Chestnut cultivar, values that demonstrate a strong antioxidant characteristic of this vegetable species which have adapted very well to the climatic conditions of our country (7).

Conclusions

From the obtained results regarding the behaviour of the two sweet potatoes cultivars under the conditions from the south-west of Romania, the following characteristics resulted:

- the average number of thickened roots per bed was 4.0 at Pumpkin and 5.1 at Chestnut;
- the average weight of a Pumpkin cultivar root was 400 g and 210 g for the Chestnut cultivar;
- the best yield was produced by the Pumpkin cultivar, 53.3 t/ha;
- in terms of chemical composition, the content of total sugar and vitamin C were higher in the Chestnut cultivar, of 14.1% and 14.6 mg/100 g FW .

The requirements of the sweet potato for the vegetation factors are met especially in the south-western part of Romania where this species can be successfully cultivated.

References

1.Abubakar, H. N., Olayiwola, I. O., Sanni, S. A. and Idowa, M. A. 2010. Chemical composition of sweet potatoes (*Ipomoea batatas L.*) dishes as consumed in Kware state, Nigeria. International Food Research Journal 17: 411- 416.

2.Adelia C. Bovell‐Benjamin.2007.Sweet Potato: A Review of its Past, Present, and Future Role in Human Nutrition.Advances in Food and Nutrition Research. Volume 52, pages 1-59

3.Aywa, A. K., Nawiri, M. P. and Nyambaka, H. N.,2013.Nutrient variation in colored varieties of Ipomea batatas grown in Vihiga County, Western Kenya. International Food Research Journal 20(2): 819-825

4.Bovell-Benjamin A., 2007.Sweet potato: a review of its past, present, and future role in human nutrition, Advances in Food and Nutrition Research 52: 1-59.

5.Ciofu Ruxandra şi colab., 2003. Tratat de Legumicultură, Ed. CERES, Bucureşti, pag.771.

6.Coghlan, A., 2012. Nutrient-boosted foods protect against blindness New Scientist, Health.

7.Drăghici Reta, Diaconu Aurelia, Drăghici Iulian, Toma Vasile, Croitoru Mihaela, Ploae Marieta, Dima Milica, Eun-Gi CHO, Jung-Sang KIM, 2013. Preliminary results on sweet potato (*Ipomoea batatas*) on sandy soils. Analele Universităţii din Craiova, seria Biologie, Horticultură, Tehnologia prelucrării produselor agricole, Ingineria mediului, vol.XVIII (LIV), pp.471-476.

8.Isiam, S.,2006. Sweetpotato (Ipomoea batatas L.) Leaf: Its Potential Effect on Human Health and Nutrition. Journal of Food Science,Volume 71, Issue 2, pages R13–R121.

9.Lebot,V., 2009. Sweet potato. In: Bradshaw JE (ed) Root and tuber crops. Handbook of plant breeding. Springer Sciences and Business Media, LLC2010, New York, NY 10013, USA, pp. 97-125.

10.Martin, F.W and Deshpande, S.N., 1985. Sugars and starches in a non-sweet potato compared to those of conventional cultivars. J.Agric. Univ. Puerto Rico 69 (3): 401-6.
11.Muşat C.C., 2010. Research on some technological defining sequence for culture of sweet potatoes(Ipomea batatas Poir). Analele Universităţii din Craiova Seria:Biologie ,Horticultură,Tehnologia prelucrării produselor agricole ,Ingineria mediului Vol. XV(XLXI), pag.354-359.
12.Muşat C.C., 2013.Cercetări privind utilizarea batatului (Ipomoea batatas Poir.) ca plantă legumicolă şi ornamentală în vederea extinderii în cultură în România. Teză de doctorat. USAMV Bucureşti.
13.Scott, G.J., 1992. Transforming traditional food crops: product development for roots and tubers, In:Scott, G.J., Wiersman, S., Ferguson, P.I. (Eds.), Product Development for Roots and Tuber Crops, vol.1, Asia.International Potato Center (CIP), Lima, Peru, pp.3-20.
14.S J Tian, J E Rickard, J M V Blanshard. 1991.Physicochemical properties of sweet potato starch. Journal of the Science of Food and Agriculture. Volume 57, Issue 4, pages 459–491.
15.Toru H. and Koji K.,1982.Accumulation of Sucrose in Gamma-Irradiated Sweet Potato Roots. Journal of Food Science.Volume 47, Issue 6, pages 2011–2014.
16.Zhang, Z., Wheatley, C.C., Corke, H.,2002.Biochemical changes during storage of sweet potato rots difering in dry matter content. Postharvest Biology and Technology 24 p-.317-325,
17.Zihin, Y.,Özlem,T.,Gülsüm, Ö.,2011.Determination of sweet potato [Ipomoea batatas(L.) Lam.] genotypes suitable to the Aegean region of Turkey. Turkish Journal of Field Crops, 2011, 16(1): 48-53
18.Sweet potato (Ipomoea batatas) tubers. http://www.feedipedia.org/node/5325
19.XXXX, 2008.Centro Internationale de la papa
20.XXXX. Lucrative sweet potatoes finding place on former tobacco acres.2014. Southeast FARM PRESS. Timely Reliable Information for Southeast Agriculture (http://southeastfarmpress.com/vegetables/lucrative-sweet-potatoes-finding-place-former-tobacco-acres)
21.XXXXX**.** NC State receives $12.4 million grant from Gates Foundation for sweet potato research. 2014 Southeast FARM PRESS. Timely Reliable Information for Southeast Agriculture. (http://southeastfarmpress.com/vegetables/).
22.XXX. FAO. 2005. Food and agricultural organization of the United Nations: Major food and agricultural commodities and procedures. Downloaded from http://www.fao.org/es/ess/top/commodity.