SWEET POTATO, A PERSPECTIVE CROP FOR THE SANDY SOIL AREA IN ROMANIA

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Abstract

Due to the low natural fertility and climatic conditions characterized by excessive heat and insufficient precipitation, the sandy soils area in southern Oltenia can be characterized as a disadvantaged agricultural area, with farmers having a small variety of crops to ensure the exploitation of the soil in profitable conditions. In the context of climate change, in order to obtain high, safe and stable productions, it is necessary to choose the range of species and plant varieties with high adaptability to the climatic and soil conditions, in this context, Research-Development Station for Plants Culture on Sands Dăbuleni conducting research on the adaptability and profitability of sweet potato culture. Considering that in the tropical and subtropical regions completely replace the potato, F.A.O. mentions sweet potatoes on the 7th place in the world among agricultural crops. Currently, this culture is less known in Romania. With the increase in the import of vegetables, the interest of Romanian consumers for this species of tropical origin has increased. Taking into account these considerations, the researches aimed at establishing the technology of sweet potato cultivation on sandy soils and the biological and biochemical peculiarities of this species. The obtained results were similar to those in the literature, the differences being due to the studied genotypes and to the climatic conditions of the crop year. It is a drought resistant species with vigorous growth and high productivity (20-40 t / ha). Sweet potato is a species of perspective for Romanian vegetable growing, with special nutritional qualities and economically profitable.

Key words: sweet potato, sandy soils, production, profitability

Sweet potato (*Ipomoea batatas*), contrary to its novelty in the national landscape, is an important species at global level. Over the last decades, sweet potato production has placed the plant among the top 10 places as total production, but it is far better situated in tropical and developing countries. Asia leads in area (60.75%) and production (86.89%) of sweet potato in the world. The world average sweet potato root yield was 13729 kg/ha. However, the highest productivity of 19634 kg/ha was found in Asia (FAOSTAT, 2008 cited by Aurelia Diaconu *et al*, 2018).

In Romania, the sweet potato was introduced in 1954, with several technological sequences being established regarding the planting season, the favorable crop areas, etc., but so far it has not been cultivated on a large scale (Ciofu Ruxandra *et al*, 2003). The interest of Romanian consumers for this species of tropical origin has increased with the development of the import of vegetables, sweet potatoes being a vegetable plant with high nutritiv value.

Sweet potato is an important species from an economic point of view, China dominating the landscape of producing countries with relatively constant values every year, around 85% of world production. The edible organ consists of a tuberous root with the most varied shapes of sizes that in our country exceeded 5 kg (Maier I., 1963). Sweet potato is consumed similarly to potato *(Solanum tuberosum*), as well as preserved, in tropical and subtropical regions, completely replacing this vegetable. Valuable as a carbohydrate intake, because of its high starch content (where amylopectin is predominant), sweet potato is also used in the food and textile industry (Maier I. cited by Bodea C., 1984). The sugars content is about ten times lower than the starch content. Reducing sugars are present as traces, and dextrins are absent (Hammett H.L., 1961). The young leaves at the top of plants are often used as a vegetable, their high content in inorganic substances and organic compounds, of which vitamin B_2, giving them a special nutritional value (Bodea C., 1984).

Whereas sweet potato is a plant of tropical origin, it adapts well to the warm climate and grows best during the summer. It is sensitive to cold and should not be planted until the danger of frost has passed. The optimal temperature to achieve the best growth is between 21°C and 29°C, although it can tolerate temperatures between 18-35°C. At 0°C the sweet potato plants are destroyed. Environmental conditions during early

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growth influence the proportion of tuberous roots being formed, the number of which can be determined at 30 days after planting. Cold temperatures (22-24°C) and an adequate amount of potassium lead to rapid activity in the cambium and small lignification of the roots, a condition that promotes the development of tubers (Onwueme, 1978). Tuberous roots are sensitive to changes in soil temperature, depending on the stage of their development (Biswal, 2008). For root thickening it takes at least 4 months for a warm period with temperatures of 23-30 °C. In terms of moisture requirements are moderate, higher when depositing reserve substances in roots, when sweet potato requires 70-80% of field capacity. The lack of water determines the decrease in production and content of starch in the roots (Ciofu Ruxandra *et al*, 2003). Prefers light, sandy-clay soils, well drained, loose, fertile with a pH of 5.6-6.5, Biswal (2008) recommending an annual soil test before field preparation to assess its properties.

Climate changes, so discussed globally, are a real problem facing agriculture in Romania, especially agriculture in southern Oltenia, the sandy soils area being subject to a major risk of desertification. For this reason, the research specialists have focused on improving the range of species and varieties cultivated in this area. Taking into account the pedo-climatic peculiarities of the area of culture and the biological requirements of sweet potato plants, *Ipomoea batatas* was one of the species that Research – Development Station for Plant Culture on Sands Dabuleni introduced in its own research program, starting from the hypothesis that this species presents high potential for adaptation and real possibilities to be introduced into culture.

MATERIAL AND METHOD

Tests on sweet potato culture on sandy soils from Dabuleni began in 2012, but in 2015 was signed a Romanian-Korean Bilateral Collaboration Protocol for sweet potato, between the Research – Development Station for Plant Culture on Sands Dabuleni and the Gyeongbuk Province FTA Committee (GPFC) - South Korea, as a result of which the research area and the assortment of varieties were enriched.

The research carried out during 2015-2018 concerned:

- the behavior of sweet potato varieties under the pedo-climatic conditions specific to the southern Oltenia, the studied varieties being: *Yulmi, Juhwangmi, Hayanmi, KSP1, KSC1*;
- establishing the optimal planting age:
  - seedling tubers (obtained in the solar),
  - the shoots in the field;
- quantifying the interaction of environmental factors and their influence on the physiological processes of sweet potato plants;
- adaptability and photosynthetic capacity of varieties under thermo-hydric stress conditions;
- the dynamics of accumulations of dry matter in tubers;
- the quality of sweet potatoes obtained on sandy soils in southern Oltenia.

In order to determine the influence of the environmental factors on the main physiological processes carried out at the foliar level, photosynthesis, foliar transpiration, photosynthetic active radiation, leaf temperature and stomatal conductance were determined in daily variation, with the LC PRO+ Portable Photosynthesis System, the determinations being performed in several moments during the rooting process.

Weather data was recorded at the meteorological station of RDSPCS Dabuleni.

In the laboratory, the following determinations were made:

- water and total dry matter (%) – gravimetric method;
- soluble dry substance (%) – refractometric method;
- soluble carbohydrates (%) – Fehling Soxhlet method;
- C vitamin (mg/100 g fresh substance) – iodometric method;
- starch content (%) – gravimetric method.

The productivity of sweet potato plants was determined dynamically at 90, 100, 110 and 120 days after the planting of the shoots in the experimental field, depending on the variety and color of the mulch.

Applied field technology consisted of:

- Total herbicide with Glyphogan 4l/ha, 10-12 days before planting.
- Fertilized with 300 kg/ha of complex fertilizers of type 15:15:15, and in the vegetation the plant nutrition regime was completed by applying a mixture of 200 kg ammonium nitrate + 100 kg complex fertilizer type 15:15:15/ha.
- Manually planted, according to the experimental variants (on bilonated ground, covered with transparent mulch or smoky mulch).
- Dual Gold herbicide at 1.5 l / ha immediately after planting (within 5 days of field preparation)
- Combating monocotyledonous weeds was accomplished by herbicide cultivation with the *Pantera* product at a rate of 2 l / ha.
- A minimum 80% of the active humidity range is ensured by the two irrigation methods (drip irrigation and aspersion).

RESULTS AND DISCUSSIONS

From a climatic point of view, the analyzed period was different, both in terms of temperature and rainfall recorded (*table 1*). Climate data analysis revealed the trend of climate warming, with average temperatures higher than the average multiannual temperature throughout the analyzed period. The hottest months were July and August. Precipitation was unevenly distributed during the period under review, more abundant in May-July of 2018. Due to the very high temperatures and small amounts of precipitation or unevenly distributed, the drought was installed, the years 2016-2017 being the driest.

Table 1

Climate data recorded at the meteorological station of RDSPCS Dabuleni

Year	Climatic element	V	VI	VII	VIII	IX	X	Average/ Sum	Difference from multiannual average
2015	Average temperature (ºC)	19.2	20.5	24.8	24.3	20.8	11.2	20.1	3698.4 +230
	Rainfall (mm)	52.4	134.2	11.0	48.4	84.8	93.8	424.6	+115.88
2016	Average temperature (ºC)	16.8	23.6	24.8	23.5	20.4	10.8	20.0	3680 +211.6
	Rainfall (mm)	104.4	53.2	31.6	1.0	37.6	140.8	368.6	+59.88
2017	Average temperature (ºC)	17.8	24	24.8	24.8	20.2	13.4	20.8	3827.2 +358.8
	Rainfall (mm)	78.6	17.4	120.8	28.8	18.2	120.4	384.2	+75.48
2018	Average temperature (ºC)	20.7	22.5	23.6	25.1	19.6	13.4	20.8	3827.2 +358.8
	Rainfall (mm)	106.6	195.2	148.7	30	14.8	5.8	507.4	+198.68
Multiannual average	Average temperature (ºC)	16.8	21.6	23.1	22.4	17.8	11.4	18.9	3468.4
	Rainfall (mm)	62.39	68.46	54.24	33.20	47.35	43.08	308.72	

Under the climatic conditions of Romania, sweet potatoes do not produce seeds, being vegetatively propagated by cuttings. Consequently, choosing of tuberous roots used for planting is essential in obtaining vigorous and healthy shoots. In this respect, researches have been carried out on the production of shoots in the solar depending on the planting epoch, variety and size of the tuberous roots, being studied the physiological processes of photosynthesis and foliar transpiration.

Analyzing the influence of the variety on photosynthesis (*figure 1*), it was found that *KSC 1* variety showed the highest values both for the shoots planted in the first epoch and for the shoots planted in the 2nd epoch compared to the *KSP 1* variety. At the *KSP 1* variety, the most intense photosynthetic activity presented the shoots obtained from tubers with a diameter of 2 cm, at the first epoch, respectively the shoots obtained from tubers with a diameter of 3 cm, at the second planting epoch. In the *KSC 1* variety, the best results on photosynthetic activity were recorded at shoots obtained from tubers with a diameter of 3 cm, at this variant between the two planting epochs being very small differences (52.57 μmol $CO_2/m^2/s$ at the first epoch and 53.09 μmol $CO_2/m^2/s$ at the 2nd epoch).

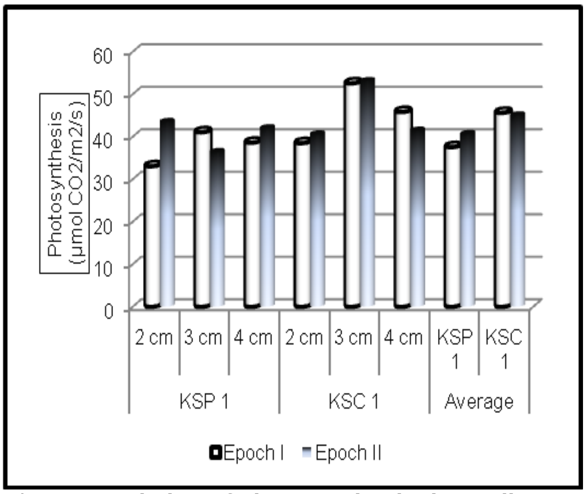

Figure 1 **Variation of photosynthesis depending on variety and planting epoch on sweet potato shoots obtained from tubers of different sizes (Ø)**

Analyzing variation of transpiration depending on the variety and planting epoch on sweet potato shoots obtained from tubers of different sizes (Ø), have been highlighted *KSC 1* shoots, which sweated more intensely. The results regarding the influence of the planting epoch on the transpiration have confirmed that the intensity of this physiological process was much higher in the plants of the 2nd epoch, and regarding the influence of the size of the planted tuber, the differences between the variants were not significant, ranging from 5.62 mmol $H_2O/m^2/s$ at shoots from tubers with a diameter of 2 cm and 6.23 mmol $H_2O/m^2/s$ at shoots from tubers with a diameter of 3 cm (*figure 2*).

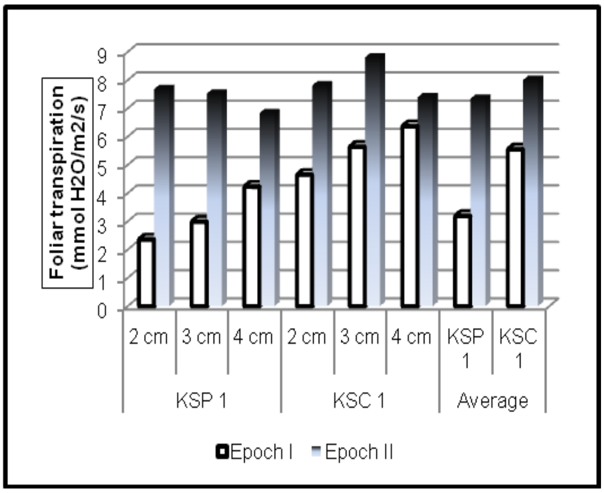

Figure 2 **Variation of transpiration depending on variety and planting epoch on sweet potato shoots obtained from tubers of different sizes (Ø)**

Between stomatal conductance and foliar transpiration at sweet potato shoots a distinctly significant correlation has been established, indicating that the intensity of foliar transpiration depends largely on the degree of opening and closing of the stomata. These movements of the stomata can also be correlated with the indirect action of light, given that in the light the stomata are opened and transpiration process intensifies (*figure 3*).

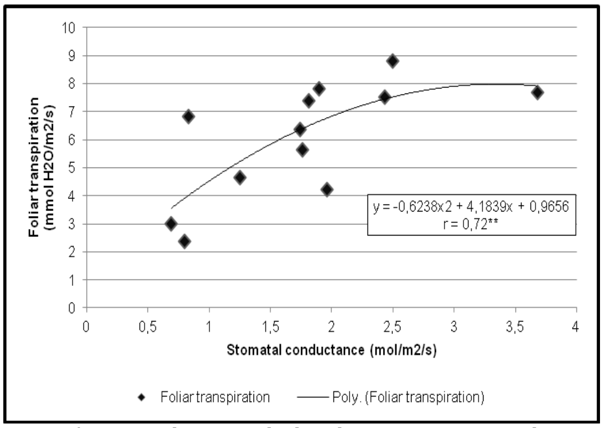

Figure 3 **The correlation between stomatal conductance and transpiration at sweet potato shoots**

Determinations of the physiological processes of photosynthesis and transpiration continued in the experimental field, their diurnal variation in dynamics being analyzed during the whole growth and development of the tuberous roots. Circadian changes of environmental factors (in the present case light and temperature) caused adaptive plant reactions (closure or opening of stomata), reactions reflected in the intensity of photosynthesis and foliar transpiration processes. Photosynthesis was carried out after a single-wave curve (*figure 4*), with the maximum value recorded in the vast majority of cases at 12 o'clock. At initiation of the tuberization of sweet potato roots, photosynthesis presented an average value of 34.63 µmol $CO_2/m^2/s$, maximum being reached on August 22 (44.09 µmol $CO_2/m^2/s$).

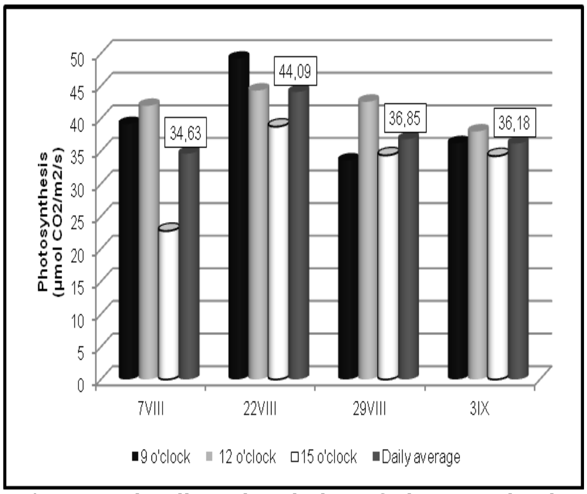

Figure 4. **The diurnal variation of photosynthesis during the tuberization of the roots**

The studied varieties differentiated from the photosynthetic point of view during the four determinations (*figure 5*). The lowest photosynthetic intensity was recorded at the *Yulmi* variety (average 29.09 µmol $CO_2/m^2/s$), and the most intense photosynthesized *KSC 1* variety (average 45.09 µmol $CO_2/m^2/s$).

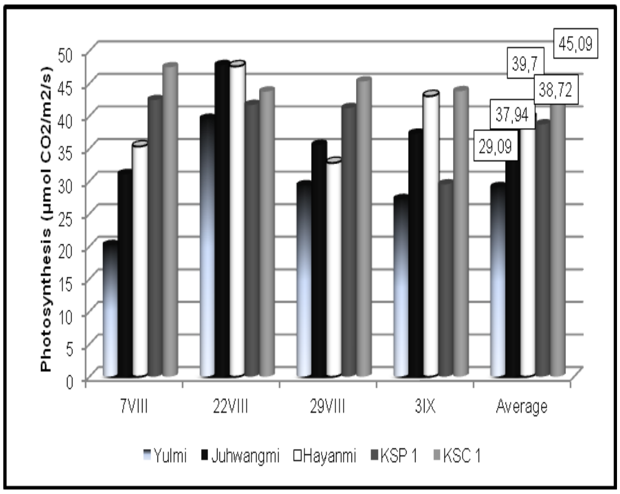

Figure 5. **Dynamics of photosynthesis according to variety**

The *Yulmi*, *Juhwangmi* and *Hayanmi* varieties presented their maximum photosynthetic on August 22, and the *KSP 1* and *KSC 1* varieties presented their maximum photosynthetic on August 7. Of note is the *KSC 1* variety, where the photosynthesis values did not fluctuate very much during August (43.76-47.48 μmol $CO_2/m^2/s$).

The foliar transpiration process presented a diurnal variation, closely related to the air temperature and the degree of opening of the stomata, with daily average values ranging between 5.67 - 8.51 mmol $H_2O/m^2/s$. The diurnal maximum was recorded at 15 o'clock at all times of the determinations (*figure 6*).

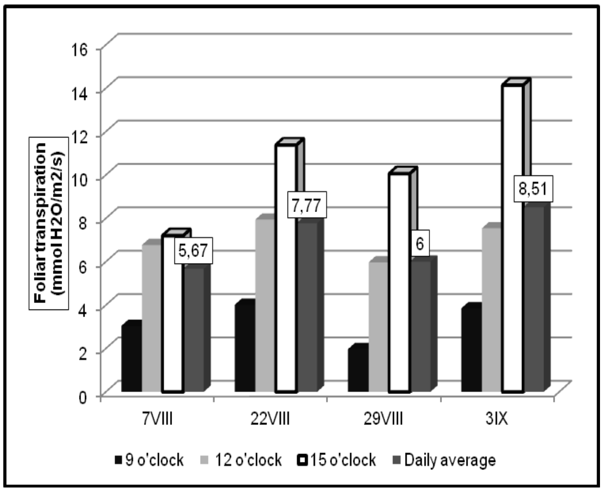

Figure 6 **The diurnal variation of transpiration during the tuberization of the roots**

Comparing to the intensity of photosynthesis, the foliar transpiration intensity did not show significant differences between studied varieties (7.11-7.46 mmol $H_2O/m^2/s$), slightly lower values only showing the Yulmi variety (5.71 mmol $H_2O/m^2/s$) (*figure 7*).

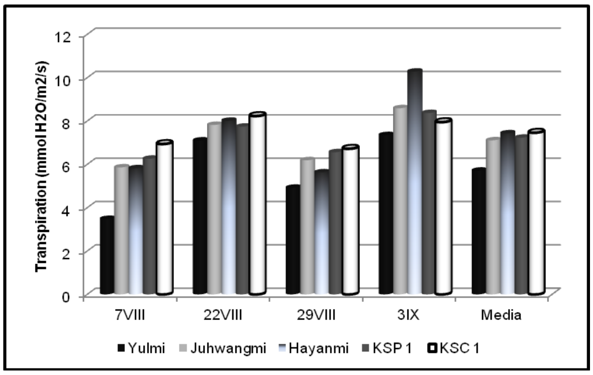

Figure 7 **Dynamics of transpiration according to variety**

To determine the production capacity of the five studied varieties, dynamic harvesting took place from 90 days after the planting of sweet potato shoots in the experimental field, the last harvest being carried out at 120 days after planting. On average, the highest yields were obtained at 120 days after planting the shoots. Analyzing the influence of the color of the mulch on the yield obtained, the best results were recorded at the plants grown on transparent mulch, *Yulmi* being the only variety with slightly higher production in the smoky mulch variant (*table 2*). Regarding the productivity of the studied varieties, the highest values of *Juhwangmi* variety (38533-44222 kg / ha) were found.

Table 2
Production of sweet potatoes (kg / ha) depending on the color of the mulch and the harvesting epoch

Variety	Smoky mulch				
	90 days	100 days	110 days	120 days	Ave-rage
Yulmi	14350	25655	24500	40950	26364
Juhwangmi	19250	33450	54250	47180	**38533**
Hayanmi	5250	11550	15610	27650	15015
KSP 1	6650	13650	29295	31885	20370
KSC 1	7455	11655	14805	21805	13930
Average	**10591**	**19192**	**27692**	**33894**	**22842**
	Transparent mulch				
	90 days	100 days	110 days	120 days	Av-erage
Yulmi	12600	23485	29505	34300	24973
Juhwangmi	23205	41475	64155	48055	**44222**
Hayanmi	11410	18760	21310	25830	19328
KSP 1	8750	16310	29400	31675	21534
KSC 1	6930	14700	24850	30345	19206
Average	**12579**	**22946**	**33844**	**34041**	**25853**

The results on the biochemical composition of sweet potato tubers obtained on sandy soils in southern Oltenia are presented in *table 3*.

Table 3
Biochemical composition of sweet potato tubers

Variety	Days from planting	Total dry matter (%)	Starch (%)	C Vitamin (mg/100 g f. subst.)
Yulmi	90	32.21	12.12	6.71
	100	41.62	12.22	11.00
	110	39.14	12.53	10.78
	120	37.67	15.23	7.52
Juhwang mi	90	29.20	13.10	8.00
	100	30.51	12.86	11.34
	110	31.76	13.50	10.45
	120	32.92	15.22	8.36
Hayanmi	90	32.77	12.66	7.26
	100	33.60	12.26	10.09
	110	40.06	12.93	9.90
	120	40.62	13.55	7.16
KSP 1	90	37.61	12.64	7.37
	100	40.39	13.60	10.96
	110	39.09	13.83	7.96
	120	32.26	13.82	8.52
KSC 1	90	37.39	12.21	7.40
	100	37.04	14.05	11.58
	110	37.65	13.80	10.34
	120	35.83	14.42	6.88

As regards the influence of the variety and the harvesting epoch on the accumulation of total dry matter in sweet potato tubers, the results showed that the *Yulmi* and *KSP 1* varieties showed the highest total dry matter content at 100 days after planting, variety *KSC 1* at 110 days after planting, and the *Juhwangmi* and *Hayanmi* varieties presented the maximum value at 120 days. The smallest total dry matter content was determined in the *Juhwangmi* variety (32.92%).

The sweet potato starch content presented an maximum at all varieties at 120 days after planting and the highest content was determined for the *Yulmi* (15.23%) and *Juhwangmi* (15.22%) varieties. The data obtained are similar to those in the literature, the differences being due to the studied genotypes and climatic conditions in the area of culture.

All varieties studied showed the maximum value of vitamin C content at 100 days after planting, values ranging from 10.09 mg for *Hayanmi* variety and 11.58 mg for *KSC 1* variety.

In order to better exploit the soils in southern Oltenia, plant species such as grain sorghum, peanuts, cowpea etc. were introduced into culture, plant species with high adaptability to the pedo-climatic conditions in this area and economically profitable , by the value of the realized profit. Calculating the economic efficiency of the sweet potato culture compared to these species (*table 3*) it was found that, although the costs of setting up and maintaining the crop are higher, the profit is clearly superior, the sweet potato culture being very cost-effective.

Table 3

Economic efficiency in sweet potato culture compared to other species grown on sandy soil

Species	Production (kg/ha)	Delivery price (lei/ kg)	Production value (lei / ha)	Expenses (thousand lei/ha)	Profit (lei/ha)
Sweet potato	**23864**	**5**	**119320**	**21975**	**97345**
Grain	2800	0.6	1680	1600	80
Rye	3000	0.6	1800	1400	400
Corn	5000	0.5	2500	1950	550
Grain sorghum	5000	0.5	2500	1600	900
Peanuts	2600	6	15600	2200	13400
Cowpea	2000	5	10000	2150	7850

CONCLUSIONS

1. Given the pedo-climatic peculiarities of the area and the biological requirements of the plant, sweet potato (*Ipomoea batatas*) can be considered a species with a high potential for adaptation to culture on sandy soils in southern Oltenia.

2. The values of the physiological indexes recorded in the sweet potato have shown that it easily adapts to the area's specific heat conditions, being a loving plant of heat and light.

3. The photosynthesis rate is maintained high throughout the day compared to other species (watermelons, peppers, potatoes) where the rate of photosynthesis drops sharply at 12-15 o'clock under the direct action of stressors.

4. The nutritional quality presented differentiated values depending on the variety and the crop year.

5. As compared to other plant species grown on sandy soils, sweet potato has a much greater economic efficiency.

6. Considering the level of production made in sweet potato cultivated between 2015 and 2018, it is necessary to continue the researches regarding the introduction of sweet potatoes (*Ipomoea batatas*) into the area of sandy soils in Romania.

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