Scientific Papers. Series B, Horticulture. Vol. LXII, 2018
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

RESEARCH ON THE EFFECT OF CLIMATE CHANGE ON THE PRODUCTION CAPACITY OF SOME SWEET POTATOES VARIETIES (*IPOMOEA BATATAS*) CULTIVATED ON PSAMOSOILS IN THE SOUTHERN AREA OF ROMANIA

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Abstract

Between 2015 and 2017, at the Research and Development Station for Plant Culture on Sands Dăbuleni, were studied three varieties of sweet potato to determine the influence of environmental factors on some plant metabolic processes and, consequently, on the production achieved. The varieties studied were Yulmi, Juhwangmi and KSP 1. The results revealed the influence of the variety, the planting season and the climatic conditions on the development of physiological processes, their intensity influencing the quantity and quality of production. The best results on the production were recorded at the variants cultivated under the climatic conditions of the 2016 year, detaching the variant cultivated with the Juhwangmi variety, with an average production of 43.6 tons. At Yulmi and KSP 1 varieties it was obtained the highest production at variants grown in the first epoch of 2016 year (May 10-15), respectively 34.3 tons at Yulmi variety and 31.7 tons at KSP 1 variety.

Key words: *climate change, foliar transpiration, photosynthesis, production, sweet potato.*

INTRUDUCTION

Sweet potato (*Ipomoea batatas* L.), the seventh most important food crop after wheat, rice, maize, potato, barley and cassava, is a staple food in many developing countries of the tropics and sub-tropics, and also serves as animal feed and raw material for several food and feed based industries (Ray and Ravi, 2005).

This New World crop has high biological efficiency of converting solar energy into edible energy (152 MJ/ha/day) in the form of tuberous (storage) roots and could

be the food for the ever growing human population in future (Ray and Tomlins, 2010).

Asia leads in area (60.75%) and production (86.89%) of sweet potato in the world. The world average sweet potato root yield was 13,729 kg/ha. However, the highest productivity of 19,634 kg/ha was found in Asia (FAOSTAT, 2008).

Sweet potato was first described by Linnaeus as *Convolvulus batatas* in 1753. However, in 1791 Lamarck classified this species within the genus *Ipomoea* on the basis of the stigma shape and the surface of the pollen grains. Therefore, the name was changed to *Ipomoea batatas* (L.) Lam.

Sweet potato was originally a herbaceous perennial but was domesticated as an annual and grows best in moderately warm temperature of 21-26^{o}C. It requires light textured soil with the optimum pH of 5.5-6.5 for good growth of the crop. At low pH sweet potato suffers aluminum toxicity.

Sweet potato is sensitive to alkaline and saline conditions (Dasgupta et al., 2006; Mukherjee et al., 2006).

A well distributed rainfall of 75-150 cm is favourable for its cultivation. It can tolerate drought to some extent but cannot withstand water logging. It requires plenty of sun shine, whereas shade causes reduction in yield. However, sweet potato is grown as intercrop under plantation/orchard crops with the motto of profit maximization and crop intensification (Nedunchezhiyan et al., 2007).

Excess of rainfall and cloudy conditions encourage vine growth and reduce storage root

yield. Dry season storage root yields were higher than rainy season yields (Nedunchezhiyan and Byju, 2005).
In Romania was introduced in 1954, and the result of the experiments performed by Maier I. was further amplified (Florescu, Maxim, Dragotă, Ciofu, Popescu) and allowed the acclimatization of this new species, as well as the establishment of sequences on the way of multiplication, planting periods, crop areas. In the current context of climate change, the importance of sweet potato cultivation lies both in the possibility of expanding culture in the areas where the potato is degenerating (Ruxandra Ciofu et al., 2003) and the need to diversify the vegetable variety with less known species but with a nutritional value which would make efficient use of the pedoclimatic conditions in southern Oltenia.

MATERIALS AND METHODS

At RDSPCS Dabuleni, 3 potato varieties were studied between 2015-2017 to determine the influence of environmental factors on plant metabolic processes and, consequently, on the production achieved.
The varieties studied were Yulmi, Juhwangmi and KSP 1. The experimental variants were cultivated according to the technology, namely in field with ridges, protected with transparent polyethylene mulch, in three planting epochs, at an interval of 10-15 days between epochs (Table 1), and water was provided by irrigation using the drip irrigation method.

Table 1. Experimental variants

Experimental variants			
Variety	Yulmi	Planting epoch	I (10-15 May)
	Juhwangmi		II (20-25 May)
	KSP 1		III (01-10 June)

For the analysis of the climatic conditions which influenced the sweet potato plants in the experimental field, were used the meteorological data recorded at the RDSPCS Dabuleni meteorological station. With the LC PRO + portable device were determined the diurnal variation of photosynthesis and foliar transpiration rate in different vegetation phenophases. Determinations have also been made on the commercial production obtained during the three years of study, depending on the variety and planting epoch.

RESULTS AND DISCUSSIONS

From the data presented in Table 2 it can be estimated that the three years under study (2015-2017) are different from the climatic point of view.
Analyzing the air temperature values, during the sweet potato growing season (May-September), there is a tendency to increase the average monthly temperature over the three years of study. It is also noted that the monthly average temperature of each year was higher than the average multiannual temperature. On the other hand, the maximum temperatures also increased steadily, in 2017 values exceeding 40°C in all summer months (June-August).
Heat temperatures have blocked physiological processes in sweet potato plants, negatively influencing the development of vegetation phenophases and the accumulation of starch in tuberous roots.
The atmospheric precipitations, as well as their relationship with foliar transpiration values, are of particular importance for the southern Oltenia sweet potato culture.
The precipitation recorded between May and September showed values between 227.8 mm in 2016 and 330.8 mm in 2015, unevenly distributed over the vegetation period and with variations from one month to the next. Throughout the analyzed period there is a significant reduction in the amount of precipitation in July, August and September. Although sweet potato is a drought-resistant species, heat temperatures correlated with a major lack of rainfall have led to droughts and have made it absolutely necessary the irrigation of crop.

Table 2. The variation of the main climatic elements during the growing season of sweet potatoes in the period 2015-2017

Year	Climatic element	Month				
		May	June	July	August	September
2015	Medium temperature (°C)	19.2	20.5	24.8	24.34	20.08
	Minimum temperature (°C)	8.6	10.2	12.5	12.9	7.8
	Maximum temperature (°C)	30.2	36.1	39.2	37.6	37.3
	Precipitations (mm)	52.4	134.2	11	48.4	84.8
	Atmospheric relative humidity (%)	73.04	73.77	62.92	68.21	77.30
2016	Medium temperature (°C)	16.8	23.6	24.8	23.5	20.4
	Minimum temperature (°C)	5.5	11	11.4	16.1	5.1
	Maximum temperature (°C)	32.9	37.3	38	38	34.1
	Precipitations (mm)	104.4	53.2	31.6	1	37.6
	Atmospheric relative humidity (%)	82.22	72.68	65	68.3	71
2017	Medium temperature (°C)	17.8	24	24.8	24.8	20.21
	Minimum temperature (°C)	4.7	12.9	13.3	11	6.7
	Maximum temperature (°C)	31.4	41.2	40.8	40.4	36.9
	Precipitations (mm)	78.6	17.4	120.8	28,8	18.2
	Atmospheric relative humidity (%)	77	67.05	65.01	63	66
Multiannual medium temperature (1956-2016)		16.8	21.6	23.1	22.4	17.8
Precipitations, multiannual total (1956-2016)		62.12	69.30	53.15	37.28	47.83

In the context of climate change, the results regarding physiological processes on sweet potato plants grown on sandy soils in southern Oltenia highlighted the following aspects:

Both the rate of photosynthesis and the foliar transpiration rate varied depending on the variety, the vegetation phenophase analyzed, the planting epoch and the climatic conditions present at the time of the measurements. From the data presented in Table 3 it can be noticed that in the phase of intense growth of the strains, there were no photosynthetic differences between the three studied varieties, the average values of this physiological process being between 20.29 µmol $CO_2/m^2/s$ at the Yulmi variety, respectively 22.55 µmol $CO_2/m^2/s$ at the KSP 1 variety. As regards the influence of the planting epoch on the photosynthesis in this vegetation phenophase, the results are easily differentiated according to the variety as follows: Yulmi variety has presented the best results at cultivation in first epoch (21.66 µmol $CO_2/m^2/s$); the Junhwangmi and KSP 1 varieties showed the highest photosynthetic yields at cultivation in the third epoch (21.8 µmol CO_2/m^2 /s, respectively 23.52 µmol $CO_2/m^2/s$). This can be explained by the fact that at the plants cultivated in the first epoch this vegetation phenophase coincides with the harshest period from the climatic point of wiew, high photosynthetic yields beeing presented only the drought-resistant varieties (in the present case the Yulmi variety).

Table 3. Variation of photosynthesis at sweet potato in the phenophase of intense growth of strains according to variety, planting epoch and the culture year

Variety	Year	Photosynthesis rate (µmol $CO_2/m^2/s$)			Average / Variety
		The first epoch May 10-15	The second epoch May 20-25	The third epoch June 01-10	
Yulmi	2015	22.32	16.90	16.02	18.41
	2016	18.33	13.26	12.72	14.77
	2017	24.34	29.42	29.33	27.69
Average/Epoch		**21.66**	**19.86**	**19.35**	**20.29**
Juhwangmi	2015	19.32	19.34	15.77	18.14
	2016	18.08	16.59	17.8	17.49
	2017	21.34	25.29	31.83	26.15
Average/Epoch		**19.58**	**20.40**	**21.80**	**20.59**
KSP 1	2015	22.20	15.95	25.43	21.19
	2016	15.28	20.82	17.82	17.97
	2017	28.96	29.18	27.33	28.49
Average/Epoch		**22.14**	**21.98**	**23.52**	**22.55**

The intensity of foliar transpiration is directly related to the temperature and hydrological deficit of atmospheric air. By decreasing the degree of saturation of air in water vapor, the water deficit and the intensity of foliar transpiration increase. Table 4 presents the variation of this physiological process in the phenophase of intense growth of strains according to variety, planting epoch and culture year. The most intensely has sweated the KSP

1 variety, with an average value over the three-year study of 5.47 mmol $H_2O/m^2/s$, but evaporated water was efficiently used because this variety also recorded the highest average value of photosynthesis. Regarding the influence of the planting epoch on the intensity of foliar transpiration (Table 4), it is observed that the highest values were recorded in the plants grown in the third epoch, indifferent to the variety. If we analyze the year's influence on transpiration, it is noticed that the highest values were recorded in the climatic conditions of 2017, this year being one of the droughts.

Table 4. Variation of foliar transpiration at sweet potato in the phenophase of intense growth of strains according to variety, planting epoch and the culture year

Variety	Year	Foliar transpiration rate (mmol $H_2O/m^2/s$)			Average / Year
		The first epoch May 10-15	The second epoch May 20-25	The third epoch June 01-10	
Yulmi	2015	6.56	3.90	4.67	5.04
	2016	3.65	3.64	2.45	3.24
	2017	3.46	5.72	9.67	6.28
Average/Epoch		**4.55**	**4.42**	**5.59**	**4.85**
Juhwangmi	2015	6.11	3.18	5.25	4,84
	2016	4.46	4.21	3.25	3.97
	2017	5.13	6.32	8.55	6.66
Average/Epoch		**5.23**	**4.57**	**5.68**	**5.16**
KSP 1	2015	6.30	3.75	6.46	5.50
	2016	3.44	5.57	3.14	4.05
	2017	6.01	6.15	8.46	6.87
Average/Epoch		**5.25**	**5.15**	**6.02**	**5.47**

In the root tuberosis phenophase, both physiological processes studied have reduced their intensity as a result of the maturation process of the plants (Table 5).

Remarkable are the results obtained in experimental year 2017, in this vegetation phenophase the values of photosynthesis and foliar transpiration beeing unusually large (comprised in the range 22.28-26.53 µmol $CO_2/m^2/s$, respectively 4.89-5.28 mmol $H_2O/m^2/s$).

Heat days, with temperatures exceeding 40°C in all the summer months (June to August), determined an increase in the physiological processes of sweet potato plants towards the end of the vegetation period when the climatic conditions became optimal.

This fact also had repercussions on the production, especially on the plants grown in the first epoch.

Table 5. Variation of photosynthesis and foliar transpiration at sweet potato in the root tuberosis phenophase according to variety, planting epoch and the culture year

Variety	Year	Photosynthesis rate (µmol $CO_2/m^2/s$)			Average / Year
		The first epoch May 10-15	The second epoch May 20-25	The third epoch June 01-10	
Yulmi	2015	10.17	10.6	13.89	11.55
	2016	17.77	14.76	10.4	14.31
	2017	15.68	24.09	27.08	22.28
Average/Epoch		14.54	16.48	17.12	**16.04**
Juhwangmi	2015	5.36	8.87	12.89	9.04
	2016	21.18	15.69	13.91	16.92
	2017	25.48	21.05	33.07	26.53
Average/Epoch		17.34	15.20	19.95	**17.5**
KSP 1	2015	6.64	8.91	11.2	8.91
	2016	19.19	12.71	14.75	15.55
	2017	22.93	19.44	27.48	23.28
Average/Epoch		16.25	13.68	17.81	**15.91**
Variety	Year	Foliar transpiration rate (mmol $H_2O/m^2/s$)			Average / Year
		The first epoch May 10-15	The second epoch May 20-25	The third epoch June 01-10	
Yulmi	2015	1.40	2.35	2.21	1.98
	2016	3.83	4.06	2.41	3.43
	2017	3.12	3.91	7.65	4.89
Average/Epoch		**2.78**	**3.44**	**4.09**	**3.43**
Juhwangmi	2015	1.34	2.13	1.76	1.74
	2016	4,33	4.24	2.63	3.73
	2017	4.27	5.04	6.53	5.28
Average/Epoch		**3.31**	**3.80**	**3.64**	**3.58**
KSP 1	2015	1.35	1.33	2.01	1.56
	2016	4.49	2.43	1.81	2.91
	2017	4.55	5.42	5.69	5.22
Average/Epoch		**3.46**	**3.06**	**3.17**	**3.23**

Analyzing the production of commercial tubers obtained at 120 days after the sweet potato planting in the experimental field, it note the importance of the variety, of planting epoch and the climatic conditions of the three years of study on the results obtained (Table 6). The best results on the production were recorded at the variants cultivated under the climatic conditions of the 2016 year, detaching the variant cultivated with the Juhwangmi variety, with an average production of 43.6 tons.

At Yulmi and KSP1 varieties it was obtained the highest production at variants grown in the first epoch of 2016 year (May 10-15), respectively 34.3 tons at Yulmi variety and 31.7 tons at KSP 1 variety. Analyzing the influence of the planting epoch on the production obtained, the best results were obtained when the sweet potato planting was done during May 20-25, with an average of 33.3 tons per hectare.

Table 6. Production results obtained at 120 days after planting of sweet potatoes, depending on variety, year and planting epoch

Variety	Year	Epoch I 10-15 May	Epoch II 20-25 May	Epoch III 10-15 June	Variety average kg/ha
Yulmi	2015	32200	26425	18550	25725
	2016	34300	33250	11550	26366.67
	2017	20800	25333.33	33400	26511,11
Epoch average/variety		**29100**	**28336.11**	**21166.67**	**26200.92**
Juhwangmi	2015	40250	41300	30800	37450
	2016	48066.67	56000	26845	43637.22
	2017	24933.33	44000	43000	37311.11
Epoch average/variety		**37750**	**47100**	**33548.33**	**39466.11**
KSP 1	2015	28233	22400	23800	24811
	2016	31733.33	25200	12810	23247.78
	2017	17333.33	26093	14933.33	19453.22
Epoch average/variety		**25766.55**	**24564.33**	**17181.11**	**22504**
Epoch average/ 3 years		**30872.18**	**33333.48**	**23965.37**	

CONCLUSIONS

The results obtained showed that sweet potato cultivated in drip irrigation conditions, successfully tolerates the thermo-hydric stress characteristic of the sandy soils area, the second planting epoch (May 20-25th) offering optimal conditions for the development of physiological processes in plants, regardless of variety. Very high temperatures during the vegetation period (which at the leaves level are with a few degrees higher than in the air), strong solar radiation, very low air humidity, have acted as dehydrating forces of the foliar apparatus, increasing water losses through foliar transpiration. Evaporated water was, however, used efficiently, as varieties with large water losses through foliar transpiration also recorded the highest CO_2 accumulations in the photosynthesis process.

The high photosynthetic yield places sweet potato among the most productive vegetable species grown on the sandy soils at Dabuleni. Although the climatic conditions were different, notable commercial productions were obtained in all the studied years, quantitatively detaching the Juhwangmi variety. Regarding the planting epoch, the best results were obtained at plants grown between May 20-25 (2^{nd} epoch), with an average of 33.3 tons per hectare.

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