Pak. J. Bot., 51(2): 617-622, 2019. DOI: 10.30848/PJB2019-2(26)

DYNAMICS OF THE PRODUCTION PROCESS OF SWEET POTATO CULTIVATED IN THE SANDY SOIL CONDITIONS IN ROMANIA

AURELIA DIACONU[1], RETA DRAGHICI[1*], MIHAELA CROITORU[1], IULIAN DRAGHICI[1], MILICA DIMA[1], ALINA NICOLETA PARASCHIV[1] AND GHEORGHE COTEȚ[1]

[1]Research Development Station for Plant Culture on Sands Dabuleni, Călărași. 220170, Romania
**Corresponding author's email: retadraghici@yahoo.com*

Abstract

Sweet potato or bathe [*Ipomoea batatas* (L.) Lam], a drought-tolerant plant, originates in Central America and now cultivated on large areas in China, India, Japan, Africa, the US, Mediterranean areas of Europe in a soil having moderate fertility. In Romania there are about 439,000 ha of sandy areas and due to more and more frequent changes of climate, it is necessary to find some species and varieties, which can withstand the thermohydric stress. In this respect, during the period 2015-2017, at Dăbuleni, located in southern Oltenia, Romania we have studied five sweet potato varieties of Korean origin, with different growing seasons, (Yulmi, Juhwangmi, Hayanmi, KSP 1 and KSC 1), in order to determine the plant's reaction to the color of the mulch used to protect the soil and the time of harvesting. The results showed that most of the genotypes had reached a maximum production potential at 120 days from the planting of the shoots in the field (24232.1-37746.1 kg / ha, in the variants with transparent mulch and 22327-38587.7 kg / ha, in the variants with smoky mulch). The exception is the Juhwangmi variety, which, being earlier, achieved the maximum yield when the harvest was carried out 110 days after planting, irrespective of the color of the mulch (47044,4-48285 kg / ha). Harvesting sweet potato varieties outside the optimal age of the plant maturity, results in the reduction of production and the depreciation of its quality, having negative repercussions in winter storage.

Key words: Sweet potato, Tuber, Physiology, Production, Quality.

Introduction

Sweet potato (*Ipomoea batatas* [L.] Lam) is a species of major importance in many tropical countries. It is resistant to drought, with vigorous growth and high productivity, adapted to sandy soils (Iamandei *et al*., 2014, Diaconu *et al*., 2016). Under prolonged drought conditions, it may survive longer periods of time but it can resume its growth when sufficient rainfall occurs (Kareem I., 2013, Drăghici *et al*., 2013). Statistical data shows that areas with this crop have grown over the years, and according to the latest FAO statistics, world production of sweet potatoes is about 107 million tonnes per year (Kenneth, 2012). Due to the nutritional quality of nutrients and fibers (of which 40% soluble fiber, which helps to lower sugar and cholesterol in the blood), sweet potato is the ideal food for diabetics, pregnant women and children (Betty, 2011). The orange and yellow varieties have a high content of beta-carotene, the precursor of vitamin A. Therefore, it is encouraged to cultivate these genotypes in Africa, where the deficiency of this vitamin creates great health problems (Ji-Myoung *et al*., 2011, Wariboko *et al*., 2014). Ukom *et al*. (2009) showed that vitamin C was mainly altered by the genetic characteristics of varieties, whereas Barbara (2014), demonstrated that the differences in the chemical composition of tubers were conditioned by phenotypic variability of tubers and variations in climatic conditions. Research conducted in Nigeria by Etela & Kalio (2011), highlighted the importance of the sweet potato harvesting season, and the results showed that biomass production was declined with increase of the planting period from 12 to 20 weeks, while the tuberous roots production was maximally 20 weeks after planting. The importance of the variety in setting the harvesting epoch is also underlined by Ramirez (1992) and is a concern in optimizing the production capacity of the variety at the time of harvesting. At national level, research on sweet potatoes is relatively recent, highlighting the good suitability of the sandy soil area for the biological requirements of this plant. The scientific novelty of the research is to determine the optimum harvest time, depending on the variety biology and the method of planting sweet potato shoots (the color of PE film used as a mulch), and the correlation of these factors with the production of tubers and their quality. Starting with these premises, the aim of our research was to determine the optimum time for harvesting some sweet potato varieties in the sandy soils in southern Oltenia, Romania.

Materials and Methods

Location and methods of the experiment: Research of the sweet potato culture was conducted during 2015-2017 at the Development Research Station for Plant Culture on Sands Dabuleni, located on the sands of Oltenia southern, Romania. The experiment was carried out on a sandy, poorly supplied nitrogen, well supplied with phosphorus, reduced to a medium supplied with potassium, low in organic carbon, and a weakly acidic pH to neutral. Thus, the extractable phosphorus exhibited values between 73 ppm and 103 ppm, the exchangeable potassium content ranged from 59 ppm to 94 ppm, organic carbon exhibited values in the range of 0.12-0.48% and the pH of the soil oscillated between 5.6 and 6.93, values that showed a moderately acidic reaction to neutral. The research aimed to establish the harvest time for different varieties of sweet potatoes, of Korean origin. The experiment was based on the three-factor subdivision parcel method. The factors studied were:

Factor A. Soil protection method: Transparent white polypropylene film and smoky foil Factor B. Variety: Yulmi, Juhwangmi, Hayanmi, KSP 1 and KSC 1;

Factor C. Harvest time: 90, 100, 110 and 120 days after planting.

Method of obtaining the biological material (shoots) used for planting: The experiment was established in the field, through shoots obtained by planting sweet potato tubers in a dual-shielded solar plant between March 20-25. The shoots were harvested at 35-40 days of vegetation (May 10-15), stored for 24 hours at room temperature (20°C), and were planted in the field, on billy ground, mulched with polypropylene foil and drip irrigation on 2nd day, after 17 hours.

Observations and determinations: At the stage of root tubers the rate of photosynthesis, active radiation in photosynthetic (ARP) was determined along with the rate of perspiration at the leaf level. Physiological determinations were performed with the LCpro + Portable Photosynthesis System in 3 moments of the day (9, 12 and 15 hours). At harvest, the production of tubers was determined from a quantitative and qualitative point of view (water content and total dry substance (%) by gravimetric method; soluble dry matter content (%) by refractometric method; total carbohydrate content (%) by Fehling Soxhlet method; vitamin C content (mg / 100g s.p.) by iodometric method; starch content (%) by gravimetric method).

Statistical analysis: The results were statistically analyzed and interpreted using the variance analysis and mathematical functions.

Results and Discussions

The physiological reaction of sweet potato varieties depending on experimental technological factors: The determinations of the physiological processes (photosynthesis and foliar sweating rate) carried out during tuberization of the root of sweet potato plants revealed the particularities of the variety and color of the mulch. There is a diurnal variation of physiological processes in relation to the environmental conditions at the foliar surface (temperature and active radiation in photosynthesis). The photosynthesis rate in the five varieties of sweet potato recorded a diurnal variation, correlated positively with the photosynthetic radiation values (Table 1).

The daily average of plant photosynthesis highlighted the Juhwangmi variety with a 21.18 µmol CO_2 / m^2 / s, in the white transparent mulch. Analyzing the average influence of mulch on photosynthesis, a better utilization of the microclimate created by the transparent white mulch (19,25 µmol CO_2 / m^2 / s) was observed. Under the conditions of sandy soils from Romania, the early age of the variety in most plants, including sweet potatoes, is a significant character to avoid drought from the maximum dry accumulation period. The results obtained in our experiment are correlated with the results obtained by Ravi & Saravanan (2001) and Suravoot *et al*., (2014), showing higher values of photosynthesis rate at a lower soil moisture deficiency. The stressful factors in the sandy soils area, especially the water and thermal regime, have influenced the foliar sweating of sweet potato plants (Table 2). The foliar sweating rate, had a diurnal variation dependent on the variety, the color mulch and the temperature at the time of determination, which was recorded in the measurement chamber of the device LCpro + Portable Photosynthesis System.

Daily averages of foliar sweating, the planting of the white transparent mulch ranged between 3.20 mmol H_2O / m^2 / s (KSC 1) and 4.49 mmol H_2O / m^2 / s (KSP 1) and planting the mulch smoky were in the range of 3.76 mmol H_2O / m^2 / s (Yulmi) -5.31 mmol H_2O / m^2 / s (Juhwangmi). Compared to the perspiration values recorded on white mulch planting, sweet potato plants from mulch smoked variants recorded a 13% increase in foliar sweat intensity, due to the reflection of the solar radiation by the smoky color of the mulch inside the foliar appliance, thus achieving a deficient microclimate with high temperatures. Between the physiological processes of the sweet potato plant, respectively, the foliar sweating and the photosynthesis of the plant were recorded in the 5 varieties of sweet potato at the root tuberosis, is a significant positive functional relationship (r = 0.905*). The graphical representation highlights the maximum accumulation of dry matter in the Juhwangmi variety, which has effectively used the lost water in the sweat process (Fig. 1).

Table 1. Diurnal variation of the photosynthesis plant in some varieties of sweet potato in the root tubers phase (70 days after planting).

Color mulch	Varieties	A.R.P. (µmol/m^2/s)	Photosynthesis rate (µmol CO_2/m^2/s)	A.R.P. (µmol/m^2/s)	Photosynthesis rate (µmol CO_2/m^2/s)	A.R.P. (µmol/m^2/s)	Photosynthesis rate(µmol CO_2/m^2/s)	The daily average of photosintesis
		9 o'clock		12 o'clock		15 o'clock		
Transparent white	Yulmi	750	16.65	1338	17.36	964	19.32	17,77
	Juhwangmi	650	17.79	1255	27.04	1052	18.71	21,18
	Hayanmi	843	20.64	1235	26.81	1081	15.57	21,01
	KSP 1	897	16.16	1410	24.81	1026	16.6	19,19
	KSC 1	789	16.16	1270	19.44	943	15.66	17,08
Average varieties		**785,8**	**17.48**	**1301.6**	**23.092**	**1013.2**	**17.172**	**19.25**
Smoky	Yulmi	827	24.36	1338	17.35	1067	9.54	17,08
	Juhwangmi	812	16.83	1328	21.94	1090	19.61	19,46
	Hayanmi	673	12.69	1387	20.15	1119	16.49	16,44
	KSP 1	969	11.2	1160	25.3	1018	18.13	18,21
	KSC 1	719	6.31	1475	25.99	1026	12.83	15,04
Average varieties		**800**	**14.278**	**1337.6**	**22.146**	**1064**	**15.32**	**17.24**
Temperature at the surface of the leaf (°C)		28,6-29,9		34.1-36.9		32.5-35.1		

Table 2. Diurnal variation of the foliar sweating, to certain sweet potato varieties in the root tubers phase (70 days after planting).

Color mulch	Varieties	ºC	Foliar sweating (mmol $H_2O/m^2/s$)	ºC	Foliar sweating (mmol $H_2O/m^2/s$)/s)	ºC	Foliar sweating (mmol $H_2O/m^2/s$)	The daily average of foliar sweating (mmol $H_2O/m^2/s$)
		9 o'clock		12 o'clock		15 o'clock		
Transparent white	Yulmi	28.6	3.16	34.1	5.11	32.5	3.22	3,83
	Juhwangmi	28.6	3.12	34.5	5.95	32.9	3.92	4,33
	Hayanmi	28.8	2.98	34.6	4.35	33.0	3.13	3,48
	KSP 1	29.0	2.96	35.8	7.18	33.3	3.33	4,49
	KSC 1	29.1	2.69	35.9	4.51	33.8	2.40	3,20
Average varieties		**28,82**	**2.982**	**34.98**	**5.42**	**33.1**	**3.2**	**3.866**
Smoky	Yulmi	29.4	3.20	35.9	5.84	34.1	2.24	3,76
	Juhwangmi	29.5	3.46	36.5	7.02	34.5	5.47	5,31
	Hayanmi	29.7	3.53	36.6	5.17	34.7	3.95	4,21
	KSP 1	29.9	3.03	36.7	6.42	34.9	3.79	4,41
	KSC 1	29.9	1.73	36.9	7.19	35.1	3.55	4,15
Average varieties		**29,68**	**2.99**	**36.52**	**6.328**	**34.66**	**3.8**	**4.368**

Table 3. Influence of harvesting time on the yield obtained in some varieties of sweet potato (average 2015-2017)

Variety	No days from planting to harvesting			
	90 (control variant)	100	110	120
Yulmi	18058.5	27388.3	26809.2	31433.4
Juhwangmi	23825.8	38247.5	47664	38166.9
Hayanmi	7898.9	13570	18286.7	24232.1
KSP 1	8943.6	10691.6	24129.8	27259.95
KSC 1 (control variant)	7151.5	12565.9	23548.1	24333.3

LSD 5% = 4358.4 kg/ha; LSD 1%=5796.7 kg/ha; LSD 0.1%= 7540.1 kg/ha

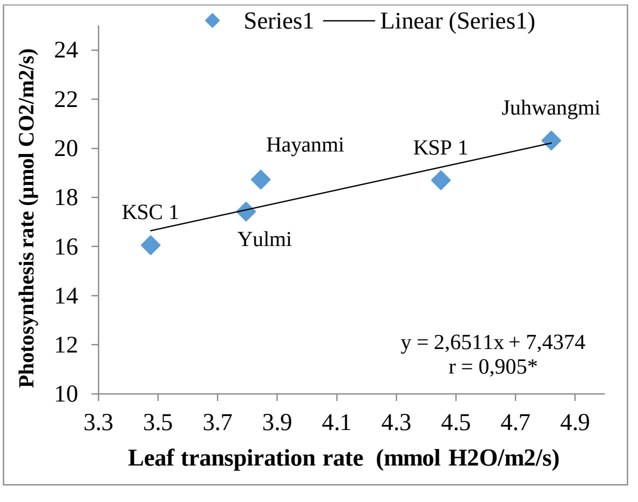

Fig. 1. Correlation between foliar sweating and photosynthesis, registered of some varieties of sweet potato in the root tubers phase.

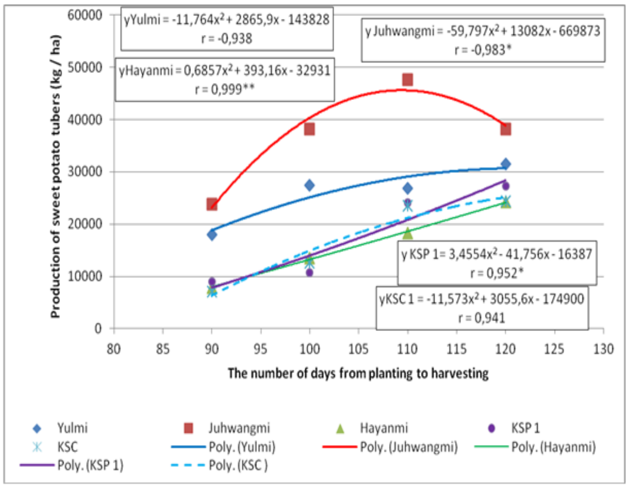

Fig. 2. Correlations between harvesting and tuber production to some varieties of sweet potato.

Productivity of sweet potato varieties depending on experimental technological factors: The optimum harvesting time for sweet potatoes is an important factor that plays an essential role in achieving high quality and high quality production and largely depends on the biology of the variety (Table 3). The maximum production potential of sweet potato varieties, tested under ecological conditions at Dabuleni, was recorded by most varieties, 120 days after planting, with the exception variety Juhwangmi which was earlier. The highest production was achieved at 110 days after planting. The delay in harvesting in this variety led to a decrease in production of 8831.2 kg / ha, very statistically significant. Research conducted in Nigeria by Etela and Kalio (2011), highlights the importance of the sweet potato harvesting season, and the results showed that biomass production was decreased with the increase of the planting period from 12 to 20 weeks, while production of tuberous roots was recorded maximum 20 weeks after planting. Also, the research carried out in Canada by David Wees *et al.*, (2016), highlighted the different fluctuations in the harvesting season of two varieties of sweet potato: Beauregard and Georgie Jet. Thus, maximum commercial production of the variety Beauregard was recorded in late September and to the Georgia Jet variety in early October. In order to increase the adaptability of the sweet potato plant to deficient climate and soil conditions in Africa, intensive work is being done on plant breeding, by getting the genotypes with cream or orange pulp, depending on the requirements of the fermiers (Laurie & Magoro, 2008). Analyzing the influence of the interaction of the experimental factors, it shows the Juhwangmi variety, which recorded the highest tuber production (48285 kg / ha) in the transparent transparent mulch and harvested 110 days after planting (Table 4). Regardless of the mulch color used in planting, and the harvesting season, the experimental sweet potato genotypes are statistically differentiated. Juhwangmi and Yulmi varieties exceeded the production of the control variety (KSC 1), but the largest differences (16674.3-23450 kg / ha), statistically very significant, were recorded in the Juhwangmi variety.

Table 4. Evalution of the tubers yield obtained at the some sweet potato varieties, according harvesting time and mulch protection (2015-2017).

Variety	Transparent white mulch				Smoky mulch			
	No days from planting to harvesting							
	90	100	110	120	90	100	110	120
Yulmi	16700	24578.3	29707.2	29100	19416.7	30198.3	23911.1	33766.7
Juhwangmi	23290.5	38648.3	48285	37746.1	24361.11	37846.7	47044.4	38587.8
Hayanmi	8081.1	16550	18286.7	24232.1	7716.7	10590	17608.9	22327.7
KSP 1	7998.3	10433.3	23816.7	25780.4	9888.9	10950	24442.8	28739.3
KSC 1 (control variant)	6276.7	14756 7	23394.4	24723.3	8025.6	10375	23701.7	23943.3

LSD 5%= 3397.91 kg/ha; LSD 1%= 4530.54 kg/ha; LSD 0.1%= 5899.85 kg/ha

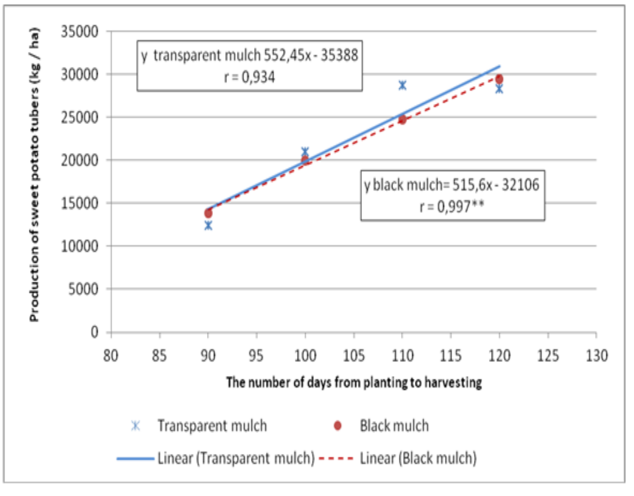

Fig. 3. Evalution of yield dynamics on sweet potato, depending on the method of soil protection.

The mathematical correlation between the time of harvest, represented by the number of days from planting and tuber production, determined by the second degree polynomial functions (Fig. 2), reveals negative correlation coefficients for the Yulmi, Juhwangmi and KSC 1 varieties and positive for Hayanmi and KSP 1 varieties. The very good functional relationship between harvesting and tuber production is highlighted by significantly positive values for the late varieties, (KSP 1 and Hayanmi) and significant negative values for the Juhwangmi, early variety. The delay in harvesting leads not only to the decrease in production but also to its depreciation, with negative repercussions in the winter storage process. The dynamic evolution of sweet potato production does not differ according to the color of the mulch (Fig. 3).

The effect of different types of mulch was highlighted by Rebecca (2015) and Hochmuth & Howell (1983), and correlated with the yield obtained by variety.

The production of sweet potato tubers correlates positively (r = 0.997 **) with the harvest time when the soil protection was made with smoky mulch and insignificant in the transparent white mulch variant (r = 0.934).

Tuber quality according to experimental technological factors: The nutritional quality of sweet potatoes was influenced by the harvest, variety, and climatic conditions of the experimental period. The results for the accumulation of the total dry substance, depending on the variety studied, are shown in Fig. 4. The total dry matter content is differentiated according to the time of the variety and the harvesting period. The Yulmi variety showed the highest total dry matter content of 41.62% at 100 days after planting, and the Juhwangmi, Hayanmi, KSP 1 and KSC 1 varieties showed a maximum of 110 and 120 days. The smallest total dry matter content was determined in the Juhwangmi variety (32.92%). This orange pulp variety showed the largest tuber size, but with a very large amount of water (67.08%). has a dry total content ranging between 34.30-37.48%, 19.69-29.91% and 30-39%.

The starch content of sweet potato tubers, in sandy soils of south Romania conditions (Dabuleni, showed a continuous accumulation up to 120 days after planting, when the average obtained in the five varieties was 14.45%. Similar researches were conducted in Pakistan and India and reported a sweet potato starch content between 14.70% to 25% (Kareem, 2013, Ukom *et al.*, 2009). The starch content of potato tubers is influenced by the variety and harvesting period (Fig. 5). This quality index showed a maximum of all varieties at 120 days after planting, and the highest content was determined for the Yulmi variety (15.23%) and the Juhwangmi variety (15.22%). 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. The vitamin C content is very variable (Fig. 6), and the highest amount was determined 100 days after planting (the average of varieties being 10, 99 mg / 100g of fresh substance). At this harvesting phase, the highest amount of vitamin C (11.58 mg / 100 g s.p.) was determined in the KSC 1 variety, and the lowest, 10.09 mg / 100 g s.p., was recorded in the Hayanmi variety. Barbara *et al.*, (2014) reported vitamin C content between 20 and 24 mg / 100 g of fresh substance for some varieties of sweet potatoes grown in Poland and Otieno *et al.*, (2008) showed a content of 16.13-23.42 mg / 100g. Collins & Walter (1982) reported vitamin C content between 1.7 and 17.4 mg / 100 g of fresh substance in a total of 45 sweet potato genotypes in North Carolina.

In Kenya, the results obtained in sweet potato by Aywa *et al.*, (2013) showed a vitamin C content of between 4.85 and 5.73 mg / 100g of fresh substance.

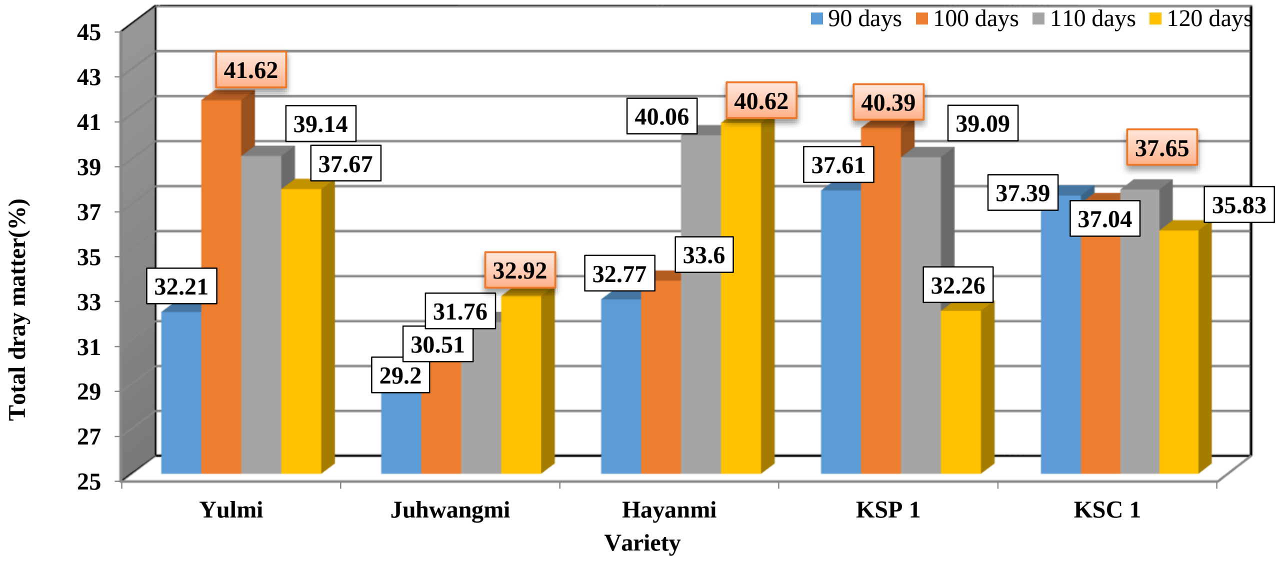

Fig. 4. Influence of the variety and harvest times on the total dry matter accumulation in sweet potato tubers.

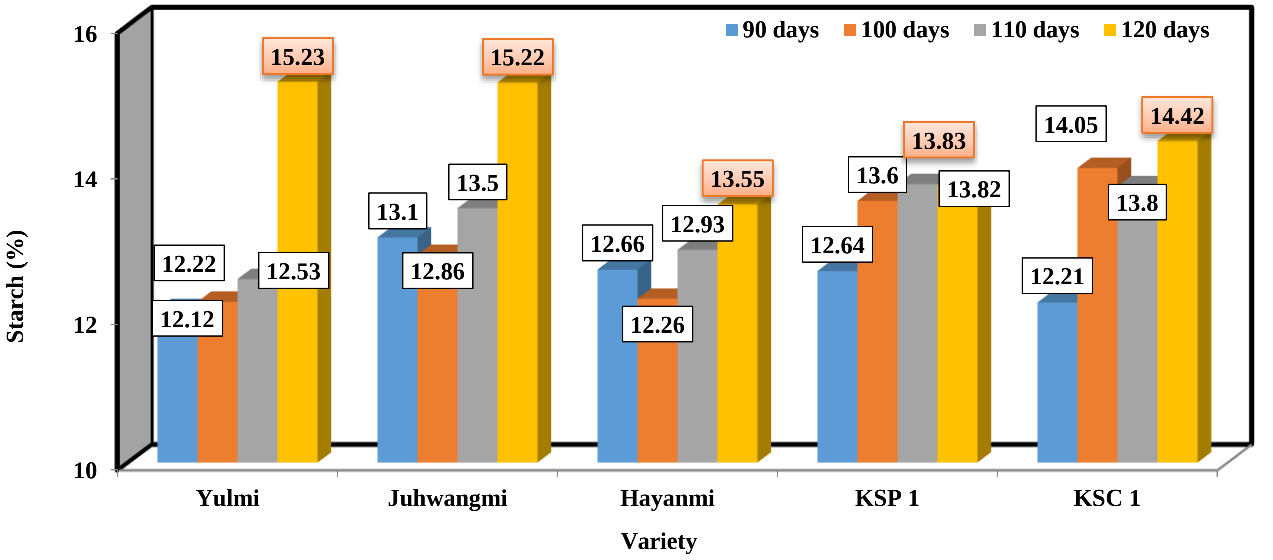

Fig. 5. Influence of the type of varieties and harvesting time on the accumulation of starch in sweet potato tubers.

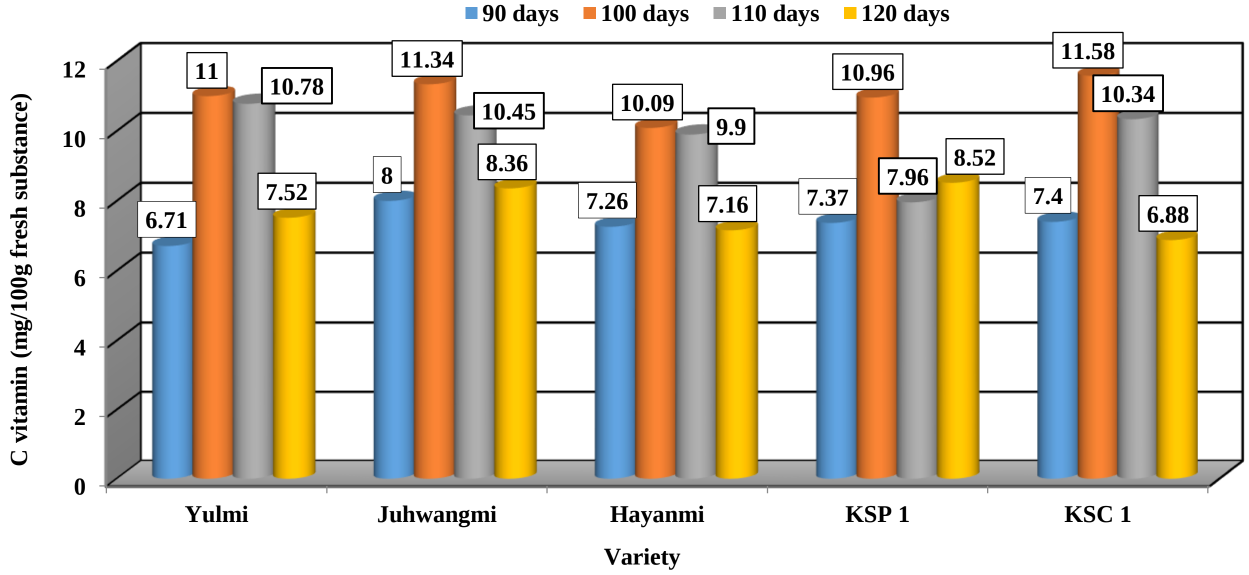

Fig. 6. The influence of the variety and harvest times on the accumulation of C vitamin in sweet potato tubers.

Conclusions

The sweet potato makes efficient use of the microclimate created by white billy coating with transparent white mulch, where photosynthesis values were recorded an average of 19.25 µmol / m^2 / s, and plant sweat was decreased by 13% compared to the use of smoky colorful mulch.

The maximum production potential of the sweet potato varieties tested under ecological conditions at Dabuleni was recorded by most varieties 120 days after planting (24333,3-38166,9 kg / ha), except for the Juhwangmi variety, which showed the highest production at 110 days from planting (47664 kg / ha).

The delay in harvesting leads not only to the decrease in production but also to its depreciation, with negative repercussions in the winter storage process.

The studied varieties behaved differently according to the quality of the tubers, depending both on the time of the variety and on the conditions of culture and climatic conditions.

The Yulmi variety depicted the highest total dry matter content of 41.62% 100 days after planting, and the Juhwangmi, Hayanmi, KSP and KSC varieties showed a maximum of 110 and 120 days.

All experimental sweet potato varieties showed increases in starch content up to 120 days after planting, and the maximum was determined for Yulmi (15.23%) and Juhwangmi (15.22%).

The vitamin C content recorded an ascending trend of accumulation in sweet potato tubers up to 100-110 planting days, after which it started to fall.

Acknowledgements

This research activity was carried out with the support of the Ministry of Agriculture and Rural Development, Romania, through the ADER Sectorial Program 2015-2018 and was funded by the ADER Project 2.2.2./22.10.2015.

References

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

Barbara, K.M., B. Sawicka, J. Supski, T. Cebulak and K. Paradowska. 2014. Nutrition value of the sweet potato (*Ipomoea batatas* (L.) Lam) cultivated in south–eastern Polish conditions, *Int. J. Agron. & Agri. Res.*, 4(4): 169-178.

Betty, J.B. 2011. Evaluating Sweet Potato as an Intervention Food to Prevent Vitamin A Deficiency. *Compreh. Rev. in Food Sci. & Food Safety*. 10(2): 118-130.

Collins, W.M. and Walter. 1982. Potențial for Increasing Nutrițional value of sweet potatoes. Proccedings of the first Internațional Simposium, Asian Vegetable Research and Development Center Shanhua, Tainan, Taiwan, China, Publication. No. 82-172: 355-363.

David, W., P. Seguin and J. Boisclair. 2016. Sweet potato production in a short-season area utilizing black plastic mulch: effects of cultivar, in-row plant spacing, and harvest date on yield parameters. Canada. *J. Plant Sci.*, 96: 139-146.

Diaconu, A., C. Eun-Gi, D. Reta, C. Mihaela, P. Marieta, I. Drăghici and D. Milica. 2016. The behavior of sweet potato (Ipomoea batatas) in terms psamosoils in southern Romania. *Scientific Papers. Series B. Hort.*, Vol. LX: 167-174.

Draghici, R., D. Aurelia, I. Draghici, V. Toma, C. Mihaela, P. Marieta, D. Milica, C. Eun-Gi and J.S. Kim. 2013. Preliminary results on sweet potato (*Ipomoea batatas*) on sandy soils. *Annals of Univ. Craiova, Series: Biology, Horticulture, Agricultural Products Processing Technology, Environmental Engineering*, Vol. XVII(LIV): 1453-1275.

Etela, I. and G.A. Kalio. 2011. Yields components and 48-h rumen dry matter degradation of three sweet potato varieties in N'Dama steers as influenced by date of harvesting. *J. Agri. & Soc. Res.*, 11(2): 15-21.

Hochmuth, J.G. and J.C. Howell. 1983. Effect of black plasticmulch and raised beds on sweet potato growth and root yield in a northern region. *Hort. Sci.*, U.S.A., Massachusetts, 18: pp. 467-468.

Iamandei, M., D. Reta, D. Aurelia, I. Drăghici, D. Milica and C. Eun-Gi. 2014. Preliminary data on the arthropod biodiversity associated with sweet potato (*Ipomoea batatas*) crops under sandy soils conditions from southern Romania. *Romanian J. for Plant Protec.*, 7: 98-102.

Ji-Myoung, K., S.J. Park, C.S. Lee, C. Ren, S.S. Kim and M. Shin. 2011. Functional properties of different Korean sweet potato varieties. *Food Sci. & Biotechnol.*, 20(6): 1501-1507.

Kareem, I. 2013. Fertilizer treatment effects on yield and quality parameters of sweet potato (*Ipomoea batatas*). *Res. J. Chem. & Environ. Sci.*, Online ISSN 2321-1040 http://www.aelsindia.com, 1(3): 40-49.

Kenneth, V.A.R. 2012. Tuber quality and yield of six sweet potato varieties evaluated during 2012. *Gladstone Road Agricultural Centre Crop* Research Report Nassau, Bahamas no. 13: 2-13.

Laurie, S.M. and M.D. Magoro. 2008. Evaluation and release of new sweet potato varieties through farmer participatory selection, *Afr. J. Agri. Res.*, 3(10): 672-676.

Otieno, K., L.O. Okitoi, P.J. Ndolo and M. Potts. 2008. Incorporating dried chipped sweet potato roots as an energy suplement in diets for dairy cows: experiences with on-farm dairy cattle feeding in western Kenya. *Livestock Res. for Rural Develop.*, 20(6): ISSN 0121-3784.

Ramirez, G.P. 1992. Cultivation, harvesting and storage of sweet potato products. In*: Roots, Tubers, Plantains and Bananas in Animal Feeding. FAO, Rome, M-23*, 95: 203-215.

Ravi, V. and R. Saravanan. 2001. Characteristics of photosynthesis and respirations in cassava and sweet potato. *Ind. J. Root Crops*, 27: 258-261.

Rebecca, G.S. 2015. Performance of Sweet potato Cultivars Grown Using Biodegradable Black Plastic Mulch in New Hampshire, *Hort. Technol.*, 25(3): 412-416.

Suravoot, Y., T. Samphumphuang, C. Theerawitaya and S. Cha-um. 2014. Physio-morphological responses of sweet potato [*Ipomoea batatas* (L.) Lam.] genotypes to water-deficit stress. Thailand. *Plant Omics J.*, 7(5): 361-368.

Ukom, A.N., P.C. Ojimelukwe and D.A. Okpara. 2009. Nutrient composition of selected sweet potato [*Ipomea batatas* (L.) Lam] varieties as influenced by different levels of nitrogen fertilizer application. *Pak. J. Nutr.*, 8(11): 1791-1795.

Wariboko, C. and I.A. Ogidi. 2014. Evaluation of the performance of improved sweet potato (*Ipomoea batatas* (L.) Lam) varieties in Bayelsa State, Nigeria. *Afr. J. Environ. Sci.. & Technol.*, 8(1): 48-53.

(Received for publication 2 February 2018)