Plant and Soil Science

Journal homepage: https://agriculturalscience.com.ua/en
Plant and Soil Science, 12(1), 112-119
Received xx.xx.2020 Revised xx.xx.2021 Accepted xx.xx.2021

UDC 635.2:635.03

DOI: 10.31548/agr2021.01.0112

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The Efficiency of Different Methods of Growing Sweet Potato (*Ipomoea batatas*) Planting Material

Abstract. The purpose of the study was to determine the efficiency of different methods of obtaining sweet potato planting material (through potted seedlings or unrooted cuttings) in the conditions of the Left-Bank Forest-Steppe of Ukraine. Research methods: field, laboratory, calculation and statistical. The potting method facilitates the formation of more developed plants (with an increased number of shoots per plant and their total length). Slips as a method of obtaining planting material for sweet potatoes provides more intensive growth rates, the formation of tuber yields at the level of 14.8 t/ha with a high content of dry matter (13.8%), starch (10.7%) and vitamin C (5.33 mg/100 g). When using potted seedlings, some sweet potato bushes are found to have deformed tubers (3.5%), but the proportion of bushes that do not form tubers at all decreases (8.3% compared to 10.0% when using slips)

Keywords: sweet potatoes, method of growing planting material, yield, product quality, slips, potted seedlings

Suggested Citation:
Kuts, O.V., Mykhailyn, V.I., Semenenko, I.I., & Shevchenko, S.V., (2021). The efficiency of different methods of growing sweet potato (*Ipomoea batatas*) planting material. *Plant and Soil Science*, 12(1), 112-119. doi: 10.31548/agr2021.01.112.

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RELEVANCE

Sweet potato is a fairly widespread crop in the world, cultivated in more than 100 countries across an area of more than 8.5 million hectares. Annual global production reaches 106.5 million tons, which ranks third among tuberous plants after potatoes and cassava (Woolfe, 2008; Ramirez R., 1991).

In African countries, it is cultivated as a crop preventing hunger and for vitamin A deficiency (Ankumah, Khan, Mwamba, Kpomblekou, 2003), which makes it a valuable dietary food product, sometimes as a staple, but usually as an alternative food (Nicanor, George, Michael, 2015; Heritier *et al*, 2018). Sweet potatoes are characterized by high yields and pleasant taste; they contain a large amount of potassium, antioxidants, vitamins A and C, group B (B_1, B_2, B_3, B_6, folic acid), phosphorus, and magnesium. Sweet potato tubers are high in complex carbohydrates and fibre (Rees *et al*, 1998; Rosas-Ramirez, Pereda-Miranda, 2013; Sochinwechi, Dilip, Ramasamy, 2017; Dinu, Soare, Babeu, Hoza, 2018).

ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Sweet potatoes are propagated both generatively and vegetatively. The first method is of interest only to geneticists and breeders. Vegetative propagation using slips (cuttings or unrooted shoots) is the most common form of propagation. Slips (cuttings) are planted immediately or no later than four days after cutting; the material for planting should be undamaged by diseases and pests to prevent their transfer to the main crop area (Youg, 1961; Lencha, Birksew, Dikale, 2016; Zebarth, Arsenaut, Sanderson, 2006).

The results of studies conducted in Ghana have shown that the use of sweet potato tubers with 5-6 nodes results in a positive trend towards an increase in the number and weight of marketable tubers and tuber length compared to cuttings with 4 nodes. A significant increase in the biometric parameters of sweet potato plants and yield was also achieved using apical cuttings compared to cuttings obtained from semi-lignified shoots (Essilfie, Dapaah, Tevor, Darkwa, 2016). The advantage of apical (non-lignified) cuttings as planting material for sweet potato has been proven in other studies (Belehu, 2003; Ravi and Indira, 2010; Atu, 2014; Lencha, 2016).

According to F.M. Amoah (1997), with sufficient potassium nutrition ($K_{60\text{-}120}$), it is effective to use sweet potato blinds with 5-7 nodes as planting material, the use of which provides a significant increase in leaf surface area, leaf weight per plant, yield of marketable tubers, etc. Research by Ethiopian scientists showed that cuttings with 9 nodes (compared to cuttings with 5 and 7 nodes) were more preferable for planting, which ensured an increase in the number of tubers in the bush, an increase in the total yield and a yield of marketable tubers (Nebiyu &Getachew, 2015). According to the results of research by D. Markos & G. Loha (2016), using sweet potato cuttings of 30-40 cm in size together with other technological measures results in a tuber yield of 50-60 t/ha.

To obtain the maximum number of cuttings (slips) in Ukraine, sweet potato tubers are germinated in greenhouses starting in January and February. To maximise shoot growth, a hot, humid environment is created in the greenhouse (temperature in the range of 22-28°C, air humidity – 85-90%). There are two methods of obtaining planting material: gradual cutting (apical shoots with 5-6 nodes) and planting them in pots or cassettes with a volume of at least 250 ml, or the formation of longer shoots of sweet potatoes and their cutting on the day of planting. In the Forest-Steppe of Ukraine, sweet potatoes are planted in the second or third decade of May, when the threat of frost has passed. At the same

time, the air temperature is expected to be at least 15-17°C (Potopalsky and Yurkevich, 2005).

Each of the above methods of obtaining planting material has its own advantages and disadvantages. For growing sweet potato seedlings through pots or cassettes, more cuttings can be obtained from one tuber, but this method is more resource- and labour-intensive and often causes the formation of more deformed tubers (bending of roots in a small volume of the substrate). The second method is much less expensive, but the yield of planting material is reduced by 20-40%.

The purpose of the study is to determine the efficiency of different methods of obtaining sweet potato planting material (through potted seedlings or unrooted cuttings) in the conditions of the Left-Bank Forest-Steppe of Ukraine.

MATERIALS AND METHODS

The research was conducted during 2019-2020 in the laboratory of agrochemical research and product quality of the Institute of Vegetable and Melon Growing of the National Academy of Sciences of Ukraine. The soil of the experimental plot is a typical low-humus light loamy chernozem on loess loam (the arable layer (0-25 cm) contains 4.3% humus; hydrolysable nitrogen – 139.0 mg/kg; mobile phosphorus – 106-119 mg/kg and exchangeable potassium – 93 mg/kg of soil; hydrolytic acidity – 2.8 mEq per 100 g of soil; pH of salt extract – 5.7; the sum of absorbed bases – 26.0 mEq per 100 g of soil).

Sweet potato tubers were placed in boxes with a substrate for growing seedlings in the first and second ten-day period of February, submerged halfway into the substrate. The temperature in the greenhouse was maintained at 22-24°C, the humidity was 75-85%, and the substrate was regularly irrigated. Periodically (once every 20-25 days), plants were treated with biological products to optimise nutrition and prevent the development of diseases (HelpRost vegetable, 10 ml/l; Phytohelp, 15 ml/l; Liposam, 5 ml/l).

The research studied two ways to obtain planting material:

1) through potted seedlings – gradual (during March - April) cutting of apical shoots with 5 nodes and planting them in 400 ml pots, where the cuttings are then rooted and grown (irrigation and fertilisation according to the system used on mother plants);

2) through slips (unrooted cuttings) – long shoots are formed in half of the boxes with uterine tubers, which are cut into slips with 5 knots on the day of planting seedlings in the field.

Planting of both potted seedlings and slips was carried out in the third ten-day period of May according to the planting scheme (90+50) x 25 cm (58 thousand pcs/ha) with the background use of fertilisers ($N_{370}P_{370}K_{450}$), drip irrigation and mulching of the soil with straw. The research was performed using the sweet potato variety Slobozhansky Rubin following generally accepted methods (Dospekhov, 1985; Bondarenko and Yakovenko, 2001). The total area of the plot was 33.6 m^2, the accounting area was 21 m^2, and the replication was four times.

RESULTS AND DISCUSSION

It was established that in terms of biometric parameters in the first half of the growing season, sweet potato plants grown from unrooted cuttings ("slips") were inferior to plants from potted seedlings (Table 1). Thus, in the middle of the period of development of sweet potato plants (July), the number of shoots on plants grown from the slips was 2.1 pcs./plant with a total shoot length of 78.3 cm/plant. On sweet potato plants grown from potted seedlings, the number of shoots was 3.2 pcs./plant, the total length of shoots was 96.9 pcs./plant. A similar pattern is observed over the years of research. During the period of active formation and growth of

tuber mass (August), this trend persists, but the difference between the variants decreases, indicating a more intensive development of plants from non-rooted cuttings.

Table 1. Biometric parameters of sweet potato plants by different methods of seedling production (2019-2020)

Method of obtaining sweet potato seedlings	Biometric parameters of plants					
	Number of shoots, pcs./plant			Total length of shoots on the plant, cm		
	2019	2020	average	2019	2020	average
First ten-day period of July						
Potted seedlings	1.45	5.0	3.2	75.6	275.2	96.9
Slips	1.20	3.0	2.1	48.1	145.6	78.3
$LSD_{0,95}$	0.09	0.22		3.55	9.67	
First ten-day period of August						
Potted seedlings	2.05	9.0	5.5	166.0	691.0	428.5
Slips	1.70	8.0	4.9	134.6	633.0	383.8
$LSD_{0,95}$	0.11	0.43		11.5	34.7	

In terms of tuber yield, the methods of obtaining seedlings did not differ significantly (Fig. 1). Over the years of research, there has even been a positive trend towards an increase in the yield of sweet potato tubers when grown through slips; the difference over the years of research ranged from 0.2-1.0 t/ha). There was a positive tendency towards an increase in sweet potato yield (16.9 t/ha) when using slips.

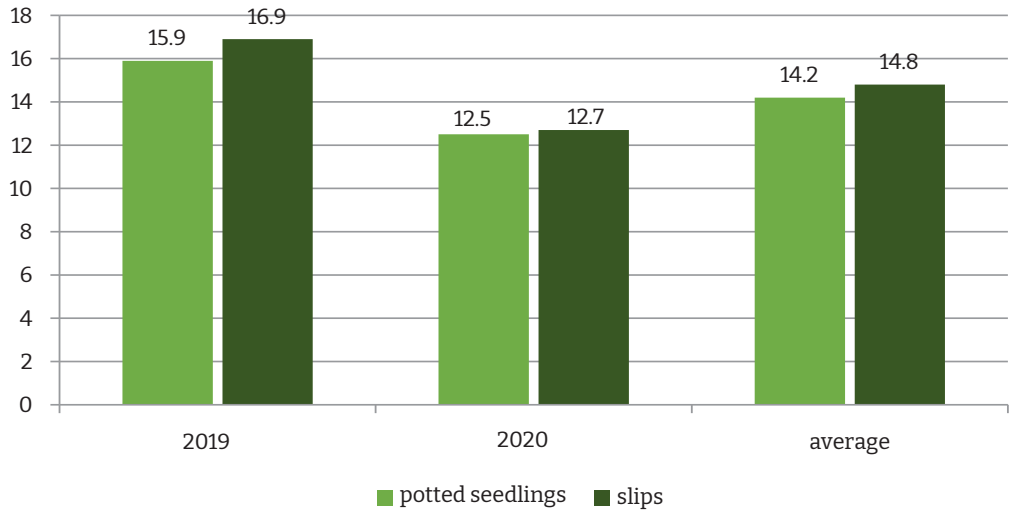

Figure 1. The yield of sweet potato tubers by different methods of seedlings production (2019-2020):
LSD0,95 (2019) = 3.8 t/ha; LSD0,95(2020) = 1.04 t/ha

Furthermore, the use of potted seedlings leads to the formation of sweet potato bushes with deformed tubers (up to 3.5% of the total number of plants), which is associated with a certain bending of the roots at the stage of their growth in a limited space of pots (Fig. 2). It was also found that some plants did not form full tubers at all: 8.3% when using potted seedlings, and 10.0% when using slips. This fact is attributed to the stressful reaction of sweet potato plants to various abiotic factors, primarily to temperature. The temperature minimum for sweet potato plants ranges from 12-15°C. Since during the summer in the Left-Bank Forest-Steppe zone of Ukraine, the air temperature at night can briefly drop below this threshold, some plants cannot withstand the stress load and do not form tubers.

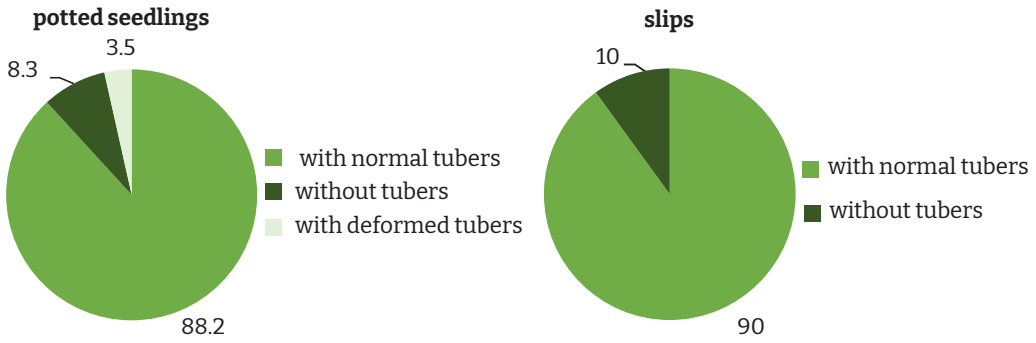

Figure 2. The ratio of plants with different quality of tubers depending on the methods of obtaining seedlings, %

According to the basic parameters of the biochemical composition of tubers, there were no significant differences between different methods of obtaining planting material for sweet potato (Table 2).But there is a positive trend towards an increase in the content of dry matter in tubers (by 0.7%), vitamin C (0.26 mg/100 g) and starch (0.3%) when growing sweet potatoes from slips. A negative factor in the use of slips is a significant increase in nitrate content in sweet potato tubers to 133 mg/kg of fresh weight against 22.4 mg/kg of fresh weight in tubers grown from pot seedlings.

Table 2. The influence of different methods of seedling preparation on the biochemical composition of sweet potato tubers (average for 2019-2020)

Method of obtaining sweet potato seedlings	Content in tubers, %				
	dry matter	total sugar	vitamin C, mg/100 g	starch	nitrates, mg/kg
Potted seedlings	13.1	3.47	5.07	10.4	22.4
Slips	13.8	3.46	5.33	10.7	113.0
$LSD_{0,95}$ (by year)	1,12; 0,98	0,32; 0,29	0,57; 0,62	0,94; 0,88	7,8; 5,7

CONCLUSIONS

The potting method of producing sweet potato planting material provides for the formation of more developed plants (with a greater number of shoots per plant and their total length). However, plants grown from unrooted cuttings (blinds) are characterised by a more intensive growth rate, resulting in a decrease in the difference in the indicated biometric parameters in the second half of the sweet potato growing season.

Slips as a method of obtaining planting material for sweet potatoes provide the formation of tuber yields at the level of 14.8 t/ha with a high content of dry matter (13.8%), starch (10.7%) and vitamin C (5.33 mg/100 g).

When using potted seedlings, some sweet potato bushes are found to have deformed tubers (3.5%), but the proportion of bushes that do not form tubers at all decreases (8.3% compared to 10.0% when using slips).

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Ефективність різних способів вирощування садивного матеріалу батату (*Ipomoea batatas*)

Анотація. Мета дослідження – визначити ефективність різних способів отримання садивного матеріалу батату (через горщечкову розсаду або невкорінені живці) в умовах Лівобережного Лісостепу України. Методи досліджень: польовий, лабораторний, розрахунково-статистичний. Метод горщикування сприяє формуванню більш розвинених рослин (зі збільшеною кількістю пагонів на рослині та їх загальною довжиною). Розсада як спосіб отримання садивного матеріалу батату забезпечує більш інтенсивні темпи росту, формування врожайності бульб на рівні 14,8 т/га з високим вмістом сухої речовини (13,8%), крохмалю (10,7%) та вітаміну С (5,33 мг/100 г). При використанні горщечкової розсади частина кущів батату має деформовані бульби (3,5%), але частка кущів, які взагалі не формують бульб, зменшується (8,3% порівняно з 10,0% при використанні розсади)

Ключові слова: батат, спосіб вирощування садивного матеріалу, урожайність, якість продукції, сліпи, розсада в горщиках