SWEET POTATO PRODUCTION ON ALLUVIAL SOIL WITH HIGH CLAY CONTENT

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Abstract. *The comprehensive goals of our research program are to develop the domestic production technology and to examine the possibilities of the utilization of sweet potato. In 2016 we set up a production technology experiment of four repetitions in randomized block design on clay loam soil in Deszk, Hungary. The storage root yields of plants developing from cuttings derived directly from sprouting storage roots (primary cuttings) and from the sprouting of primary cuttings (secondary cuttings) did not show significant differences. On hectare level, however, the differences can reach even as much as 10 tons. The evaluation of the effects of different nutrient doses on the storage root yields did not show significant differences. The reason can be the good nutrient supply of the soil of the experimental fields. Despite the heavy soil where usually ridge planting is preferred, the comparison of planting on ridges and flat proved the production technology without ridges being more effective here.*

Keywords: *Ipomoea batatas*, sweet potato, production technology

1. Introduction

The sweet potato also called batata [*Ipomoea batatas* (L.) Lam.] is a tropical-subtropical plant by the origin, however it has also been grown in temperate climate for centuries. The sweet potato belongs to the Morning glory (*Convolvulaceae*) family and the Ipomoea genus [1].

Sweet potato is grown for its storage roots, which are formed by the special thickening of the 2-3 cm roots initiated from the underground part of the stems [2]. The root skin color can be whitish, cream, yellow, orange, brown-orange, pink, red-purple, and very dark purple. The color of the root flesh can be white, cream, yellow, orange or purple. Sweet potato belongs to the traditional cultures in the Southern states of the US (North Carolina, Mississippi, Louisiana, California, Oklahoma, Arkansas, etc.). It is one of the main food crops in Africa and other tropical-subtropical regions, but it can be found anywhere in the world where the climate is suitable [3]. An increasing farmers' and consumers' demand can be observed in the last decades in several European countries. Sweet potato

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production in Spain, Portugal, Italy and Greece is registered in FAO databases [4], however its production is also known from Hungary, Croatia [5, 6, 7], Slovenia [8, 9], Romania [10], Poland [11] and England [12], among others.

Sweet potato is cultivated in Hungary for thirty years [13, 14] but it became well-known and popular in the last years only – thanks to media appearances and its growing commercial availability. It has recently become so popular here that the farmers cannot produce enough sweet potatoes to fill up the market from domestic harvest. Besides the growing area of still unsatisfactory size, other reasons of the problem can be local anomalies in yield stability still occurring frequently, despite the available practical guides and experiences in cultivation technology. The practical experiences can serve as starting point that can be verified or open to be modified according to experiments. It is essential to set up experiments from the production of planting material up to the storage.

The comprehensive goal of our research work is to develop the regional technology of sweet potato production, establishing site- and cultivar-specific practical guides based on experiments that comprise both the local and the international experiences.

Our main objectives in the current work:

Comparison of the effect of planting primary or secondary cuttings on yield. To produce high quality planting material it can be an important information whether slips directly cut from sprouting storage roots (primary cuttings) or those derived by sprouting of the primary cuttings (secondary cuttings) result in higher yield.
Comparison of ridge and flat cultivation. Internationally, sweet potato is usually planted on ridges, regardless of the soil conditions [15]. It is important to determine whether among the local conditions planting on ridges or flat (without ridges) results in higher yields of storage roots.
Comparison of fertilizer doses. Fertilizer doses applied in practice compared to untreated control mean the first step in the optimization of sweet potato nutrient supply.

2. Materials and methods

The experiment was performed in Deszk, Hungary on clay loam soil of medium to very good nutrient content (Table 1). The experimental setup was four repetitions in randomized block design. The planting material derived from the Bivalyos Tanya Family Farm. In our experiment, we used the Ásotthalmi-12 orange-fleshed sweet potato variety. Spring tillage was followed by soil disinfection two times (Bora).

Table 1) Results of soil analysis

pH-KCl	Total salt	Soil plasticity	$CaCO_3$	Humus	P_2O_5	K_2O	Na	Mg
	m/m %	K_A	m/m %	m/m %	mg/kg			
7.10	0.04	46	1.77	3.46	1310	770	36.3	177

The cuttings were planted on 31st May 2016, altogether ca. 1,000 pieces on the whole experimental area of 300 m². The cuttings were planted manually with a dibble. The bottom 2/3 part of the slips was placed into the soil, followed by thorough irrigation. The plot size is 6 m x 2 m containing 40 transplants in two rows (1.0 m row distance, 0.3 m plant-to-plant distance). On sandy soils, flat cultivation (without ridges) is preferred, although world-wide in general, especially on heavy soils, ridge cultivation is common [16, 17]. Ridges were formed on one half of our experimental area, on the other half rows were formed flat.

The experiments with the planting material were started early April. Ten plastic trays were chosen where the sprouting of sweet potato storage roots had already been started. The primary cuttings were cut directly from the storage roots, watered, the lower leaves removed, and the slips were planted into the experimental trays. Secondary cuttings were derived from the sprouting of the primary ones. Both primary and secondary cuttings were used in the field experiments to get information that the primary or the secondary cuttings will give us more yield.

Fertilizers were applied on 22nd June in the forms of calcium ammonium nitrate (CAN), superphosphate and potassium sulphate, respectively. The control plots did not get any fertilizer. In active substances, the first fertilizer treatment is nitrogen 45 kg ha^{-1}, phosphorus 90 kg ha^{-1}, potassium 135 kg ha^{-1}, the second fertilizer treatment is nitrogen 67.5 kg ha^{-1}, phosphorus 90 kg ha^{-1}, potassium 180 kg ha^{-1}. Boron was also applied as foliar fertilizer in split-plot system, however, without any significant result thus we do not report these data in details.

3. Results

The experimental plots were harvested on 15th October 2016. The first five plants from each row were harvested and weighed separately. These plants had grown from primary or secondary cuttings, respectively.

On the experimental plots with ridges, plants grown from primary cuttings gave higher yields. Figure 1 shows that the control and the second fertilizer treatment produced nearly the same results, while the first fertilizer treatment gave the poorest result. Extrapolating the yields per plant to one hectare (33,000 plants), in the case of the control treatment, the difference is below 1 ton (36.795 vs. 37.686 t ha^{-1}) while in the first treatment it is more than 3 tons (29.535 vs. 32.835 t ha^{-1}) between the yields of plants originating from primary and secondary cuttings, respectively.

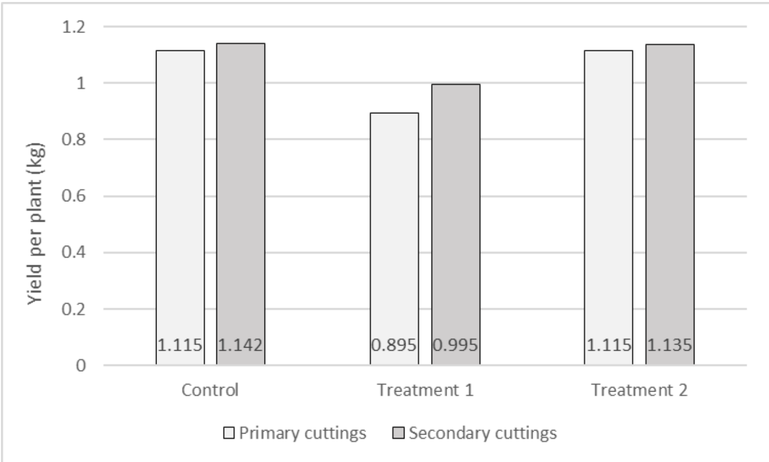

Fig. 1. Effects of slip origin on sweet potato yield in ridge planting
Control: no fertilizer applied
Treatment 1: N 45 kg ha^{-1}, P 90 kg ha^{-1}, K 135 kg ha^{-1}
Treatment 2: N 67.5 kg ha^{-1}, P 90 kg ha^{-1}, K 180 kg ha^{-1}
Standard deviation (s) values (from left to right): 0.257; 0.195; 0.120; 0.207; 0.100; 0.236

Figure 2 shows that in flat planting without ridges, in the first fertilizer treatment the usage of secondary cuttings while in the second fertilizer treatment and in the control the usage of primary cuttings resulted in higher yield of storage roots. Extrapolating the yields per plant to one hectare, in the control treatment, the difference between the yields of plants originating from primary and secondary cuttings (38.445 vs. 28.215 t ha^{-1}) can be even 10 tons.

The total sweet potato yield harvested on the experimental plots with ridges was 433 kg while from the plots without ridges we harvested a total of 537 kg. Regarding the total number of plants being 960, it means 1.01 kg sweet potato yield per plant that is a good result according to bibliographical data.

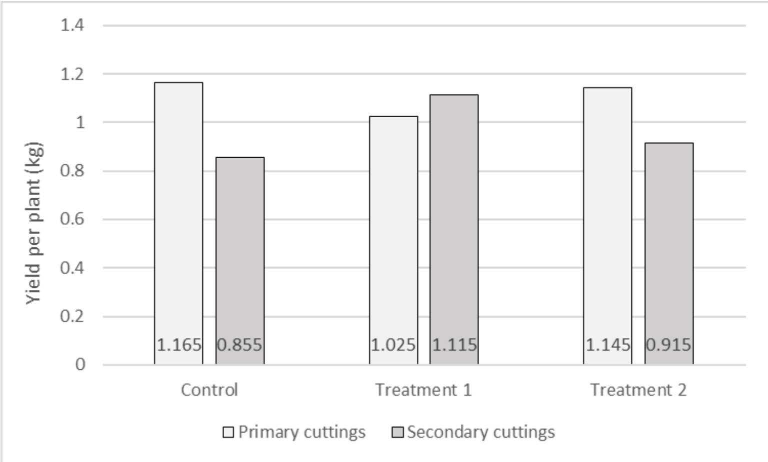

Fig. 2. Effects of slip origin on sweet potato yield in flat (without ridges) planting
Control: no fertilizer applied
Treatment 1: N 45 kg ha^{-1}, P 90 kg ha^{-1}, K 135 kg ha^{-1}
Treatment 2: N 67.5 kg ha^{-1}, P 90 kg ha^{-1}, K 180 kg ha^{-1}
Standard deviation (s) values (from left to right): 0.359; 0.106; 0.159; 0.327; 0.210; 0.218

Figure 3 and 4 show that the sweet potato yield per plant was higher in the flat experimental plots (1.08-1.15 kg plant^{-1}) compared to the plots with ridges (0.87-0.91 kg plant^{-1}). On the level of the total area it means ca. 100 kg more sweet potatoes. This is an unexpected result because on heavier soils the ridge planting is recommended and preferred worldwide.

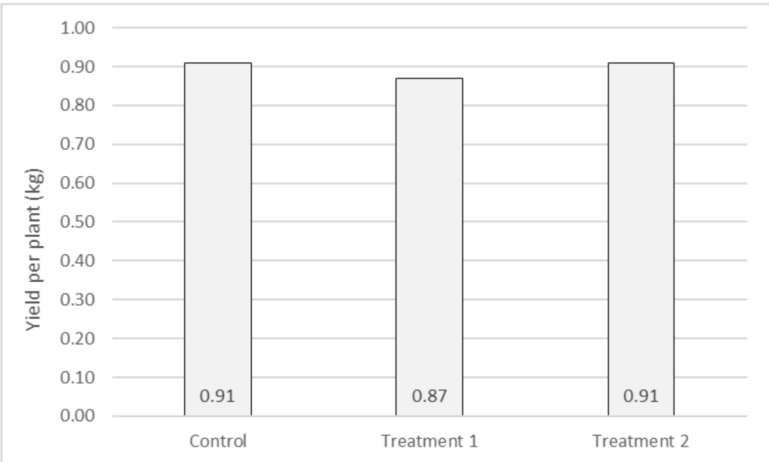

Fig. 3. Average yield of sweet potato plants in ridge planting
Control: no fertilizer applied
Treatment 1: N 45 kg ha^{-1}, P 90 kg ha^{-1}, K 135 kg ha^{-1}
Treatment 2: N 67.5 kg ha^{-1}, P 90 kg ha^{-1}, K 180 kg ha^{-1}
Standard deviation (s) values (from left to right): 0.068; 0.079; 0.109

Neither with nor without ridges, fertilizer treatments did not have a significant effect on sweet potato yield. In both cases, the fertilizer treatment 1 even decreased the yield by ca. 40 g at the single plant level compared to the control (Figures 3 and 4). The enhanced N and K doses in treatment 2 resulted in the same or nearly the same yield as the control.

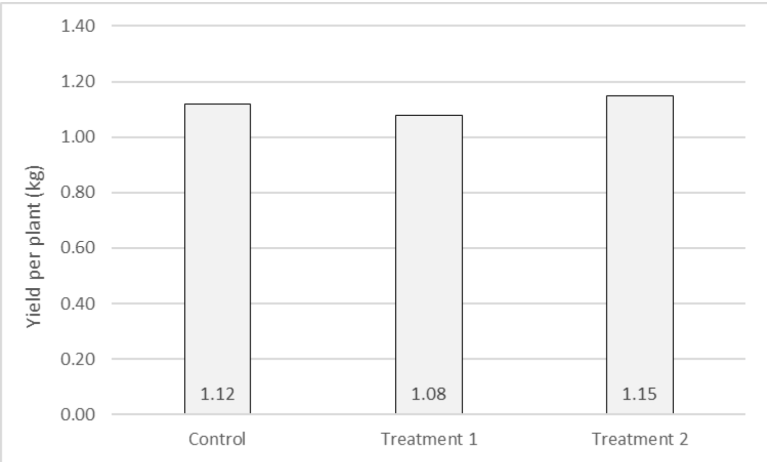

Fig. 4. Average yield of sweet potato plants in flat (without ridges) planting
Control: no fertilizer applied
Treatment 1: N 45 kg ha^{-1}, P 90 kg ha^{-1}, K 135 kg ha^{-1}
Treatment 2: N 67.5 kg ha^{-1}, P 90 kg ha^{-1}, K 180 kg ha^{-1}
Standard deviation (s) values (from left to right): 0.136; 0.151; 0.276

We can conclude that under the given soil (Table 1) and agronomical conditions, fertilizer application could not increase sweet potato yield.

4. Conclusions

In our field experiment with sweet potato we got novel results about the utility of cuttings of different origin, as well as about the effects of planting method and various fertilizer doses on storage root yield.

To determine whether plants derived from primary cuttings or those originating from secondary cuttings give better yield, further experiments are needed. It is clearly shown, however, that under given conditions, the proper choosing of planting material can result even an extra sweet potato yield of 10 tons. To our knowledge, under temperate climate where planting material is grown from storage roots, both primary and secondary cuttings are commercially available and used for transplanting [14, 18].

The different fertilizer doses applied in our experiments, did not have a significant positive effect on sweet potato yield. Moreover, the first treatment resulted in a slight decrease in yield although it meets the required N:P:K proportion of 1:2:3 [19]. The presumed explanation for the lack of yield increasing effect of fertilizers can be the relatively good nutrient supply of the soil at the experimental site. As the drop in yield can hardly be explained, this experiment needs a repetition.

All over the world, especially on clayey soils, sweet potato growing on ridges or beds is common. This offers well-aerated and well-drained conditions for storage root development, furthermore facilitates harvesting [20, 21]. Regarding the heavy structure of our soil, the better performance of sweet potatoes in flat planting was unexpected. Even the foliage developed more intensively (data not shown). The possible explanation can be found in the beneficial conditions of flat areas compared to ridges (e.g. better conservation of water), however, it requires further examination also focusing on the agrotechnical characteristics of the soil.

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