

Thesis of doctoral dissertation

**DEVELOPMENT OF SWEET POTATO (*IPOMOEA BATATAS* (L.)
LAM.) CULTIVATION TECHNOLOGIES AND EXAMINATION
OF ITS POSSIBLE USES**

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1. ANTECEDENTS OF WORK, AIMS TARGETED

During recent years, in our country due to the internet, the gastronomic television shows and the apace development of commerce and infrastructure, sweet potato became more and more popular. Despite the increasing number of producers, we face the problem of low capacity which is not enough to fill up the expanding demand of sweet potato. There are several reasons for this. On the one hand, we still have little crop land. On the other hand, there are regularly occurring crop security problems. Even though sweet potato cultivation technology sheets and experiences are available, these problems cause less than expected yields in quantity and quality. And this discourages growers.

In Hungary, the history of sweet potato naturalization is more than 100 years old. The first experiments were conducted in 1913 and 1914 on the lands of National Royal Hungarian Plant Production Experimental Station. One purpose of these experiments was to evaluate how successful can be the field growing of sweet potato in Hungary. The other purpose was to determine which cultivating method (hotbed or greenhouse planting) is more secure for the growing of this tuberous root plant. Experiments were conducted in the experimental garden in Magyaróvár in 1913 and in the experimental garden of Kassa in 1914. These experiments proved that the cultivation with hotbed planting of batata is successful in our country. Based on the results, field growing of sweet potato can be successful on the southern, warm fields of the country, especially when soil and climatic conditions are prosperous. These experiments with sweet potato were interrupted by the war (SURÁNYI, 1916).

In 1949 and 1950 further experiments began with sweet potato in Experimental Farm of Fertőd. Based on three-year experiment results, batata can be successfully grown in the ecological and agrotechnical conditions of our country. Other conclusions of these experiments were that the yields are largely affected by weather, and with correctly applied agrotechnical methods bigger yields can be reached than in the case of potato (PORPÁCZY, 1952; MATYASOVSKY et al., 2015).

In 1986, Lajos Horváth started nowadays attempts to naturalize sweet potato in Hungary at the predecessor of the Centre of Plant Diversity (NÖDIK), in Tápiószele. His results also confirmed, that sweet potato can be successfully cultivated in Hungary. Beside the development of cropping technology, the other important result of his work is the

yellowish-white-fleshed sweet potato variety Tápíó 96, which got a state certification in 2003.

In the early 1990s, Dénes Váraljai began cultivation and naturalization experiments with sweet potato, in Ásotthalom. These experiments are now being conducted by Bivalyos Tanya Kft. Their orange-fleshed sweet potato variety Ásotthalmi-12, owned by the Local Government of Ásotthalom, got a state certification in 2015.

Currently, cultivation in a larger area and commercial distribution of batata roots and slips is known from Ásotthalom, Berzence and Nyírségi Édesburgonya Zrt. But the number of producers is constantly expanding, sometimes with significant areas (for example Kiskunfélegyháza, Kiskunmajsa, Kecel, Csongrád-Bokros). For the expanding circle of domestic producers, sweet potato cultivation technology guides created by NÖDIK, Bivalyos Tanya Kft., Ko-Ko Kft. and Nyírségi Édesburgonya Zrt. are available. In addition to this information is available on internet forums and the transmission of local and individual practice helps the work of growers too. Despite the several, sometimes decades of experience, the domestic cultivation technology of batata has not been standardized until today. This is because of the lack of growing site- and variety-specific experiments, which would determine the ecological parameters and the optimal agrotechnical elements for batata cultivation. Compared to another important crops, like rice, wheat and maize cultivation, there are less available information and experiments about sweet potato cultivation (CLARK és MOYER, 1988; JANSSON és RAMAN, 1991; WOOLFE, 1992; CAREY et al., 1999; ANDRADE et al., 2009).

Following rice, wheat, potato, maize and cassava, sweet potato is the sixth most important food crop in the world. In the order of countries China is the first one giving 67% of the world's sweet potato yield. With significantly smaller amount, China is followed by Malawi with 3,7%, United Republic of Tanzania with 3,6%, Nigeria with 2,2%, Ethiopia with 2% of the world's sweet potato yield. And they followed by Uganda, Republic of India, Madagascar, Ruanda and the Independent State of Papua New Guinea. Despite published cultivation data from several European countries, FAO records the cultivation of sweet potato only in Portuguese Republic, Kingdom of Spain, Italian Republic and Hellenic Republic.

Sweet potato is also important as animal feed. China, which produces nearly 70% of the world's batata crop, utilizes approximately 40% of the crop in this way. Produced directly

for this purpose, or in the form of by-products of food processing, both the sweet potato's storage roots (primarily for pigs) and its foliage (primarily for ruminants) can be used for feeding. In China, storage roots of batata are used for feed, in the form of pellet, flour and chips, among others. Nowadays, the industrial utilization of batata is still less significant, but it can be used in several fields. For example, in Japan, a part of sweet potato production is used for starch extraction, however in the United States this utilization form is considered uneconomical. Sweet potato can be an important raw material for ethanol production: 100 kg fresh roots yielding 14,5 l ethanol compared to 11,4 l for potato, 11,9 l for sugar beet, 17,6 l for wheat, barely, and oat, and 44,9 l for maize (VILLORDON, 2013). However, in our days it can be sold as food, at an even better price.

1.1. AIMS TARGETED

We conducted the experiments that form the basis of my dissertation in the Southern Great Plain region, in Deszk, Domaszék and Ásotthalom. The overall goals of the searching program were the development of domestic sweet potato (*Ipomoea batatas* (L.) Lam.) production technology and the examination and expansion of the possibilities of its use.

One of the biggest problems of domestic crop production is that the sowing structure is limited to a few large crops. However, under certain field conditions it is possible to grow special plants, such as sweet potato (*Ipomoea batatas* (L.) Lam.). Using the root as foodstuff may appear on the domestic market as an assortment-expanding plant product. Despite several, sometimes decades of experience, the domestic cultivation technology of batata has not been standardized until today. This is because of the lack of growing site-specific experiments, which would determine the ecological parameters and the optimal agrotechnical elements for batata cultivation.

During field experiments we sought answers to questions that may help the work of batata growers in the future. The basis for planning the experiments was to confirm the correctness of the technological solutions developed over decades and to work out the best practice. During three growing seasons, we conducted small plot experiments with the sweet potato variety Ásotthalmi-12. On sandy soil we searched for the optimal row spacing and plant-to-plant distance. On compact soil we had the opportunity to study the effect of different nutrient doses, to compare planting with or without ridges, and to examine the yields achieved with cuttings obtained from tubers or from shoots. Our

results contribute to the successful cultivation of sweet potato in the Southern Great Plain region. In the future, my doctoral dissertation can help Hungarian growers and researchers to apply cultivation factors more accurately, which lead to a larger and more secure yield.

During my experiments our objectives were the following:

- to compare yields achieved with cuttings obtained from tubers or from shoots,
- to compare the effect of different nutrient doses,
- to compare the efficiency of planting with or without ridges,
- to determine the effect of planting density on sweet potato yield per hectare, and
- to determine the nutrient content of batata storage root and foliage.

2. MATERIAL AND METHOD

We set up experiments in three areas: in 2016 in Deszk, Domaszék and Ásotthalom, in 2017 in Deszk and Domaszék and in 2018 in Deszk and Ásotthalom. All three areas are located in Csongrád county.

In **Deszk**, we set up experiments in an area of 300 square meters. The land was set aside for 5 years before 2016, and then we plant sweet potatoes in the area for three years. We used the same territory each year so sweet potatoes were grown here in monoculture.

In **Domaszék**, we set up a small-plot experiment in an area of 150 square meters. Here, we used crop rotation, the forecrops were vegetables and potato.

In **Ásotthalom**, we set up experiments in an area of 500 square meters. In previous years, the experimental area was a fallow.

Deszk (2016, 2017, 2018):

Comparison of planting with and without ridges: Internationally, ridge planting is the prevalent technology (HORVÁTH, 1991a). In our experimental area we formed plots with and without ridges to examine the impact of different planting methods on the yield of sweet potato, and to find out which planting method is more suitable on compact soil.

Comparison of cultivation from primary and secondary cuttings: In this experiment we studied whether the planting of cuttings obtained directly from the tuber (primary cuttings) or from their subdivision, namely from the shoot (secondary cuttings) results in a higher yield.

Comparison of the effect of different nutrient doses on sweet potato yield: Compared to the untreated control plot, we analysed the effect of two nutrient doses applied in practice on yield.

Analysis of the nutrient content of batata storage roots and foliage: In addition to the data in the literature, it is important to determine the value of the content of sweet potato grown in Hungary, and that why it is advantageous to use for human consumption. For animal feed sweet potato sprouts are dried or utilized as silage. In our experiments we determined the parameters of sweet potato foliage from different nutrient treatments that are important for animal feeding.

Domaszék (2016, 2017):

Determination of optimal row and plant-to-plant distance: In this experiment we applied four different row and plant-to-plant distance: 80 cm x 20 cm (row distance x plant-to-plant distance), 80 cm x 30 cm, 100 cm x 20 cm, and 100 cm x 30 cm. The latter is the most common in domestic practice. In 2016 and 2017 we examined which row spacing and plant-to-plant distance combination is worth to use in flat cultivation on sandy soil to achieve the highest yield in the given area.

Ásotthalom (2016, 2018):

Comparison of different nutrient doses: In 2016, compared to the untreated control, we examined the effect of different nutrient doses used in practice on yield. As there was no significant difference between the results, these examinations will not be discussed later in this document.

Determination of optimal row and plant-to-plant distance: In this experiment we applied four different row and plant-to-plant distance: 80 cm x 20 cm (row distance x plant-to-plant distance), 80 cm x 30 cm, 100 cm x 20 cm, and 100 cm x 30 cm. In 2018, we relocated here the Domaszék experiment (see above), also to sandy soil, due to the unsolved white grub infection on the former production site.

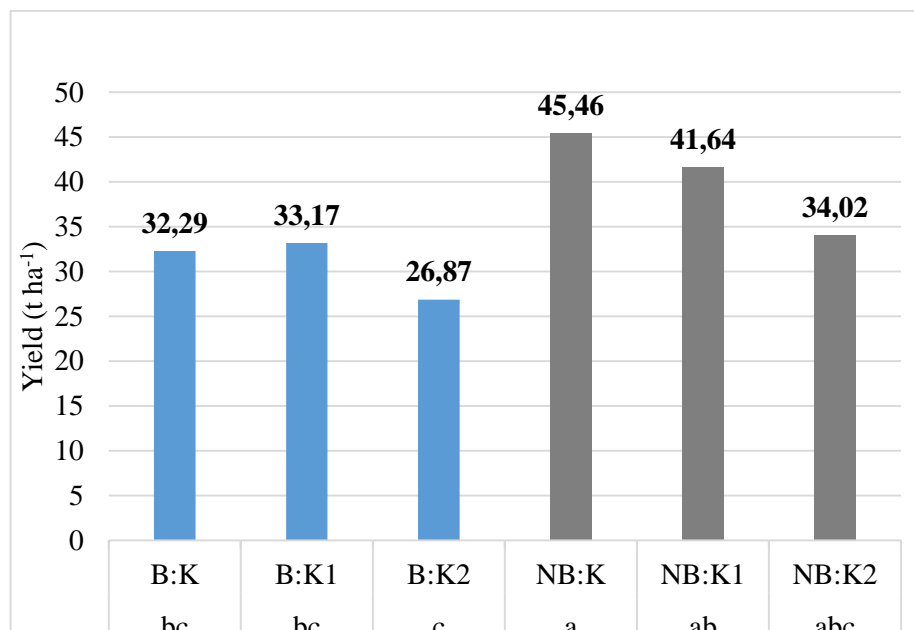
3. RESULTS

The effect of cultivation method, different nutrient doses, and the origin of planting material on sweet potato yield

In the area of Deszk, we conducted the following experiments: comparison of cultivation with and without ridges, comparison of cultivation from cuttings obtained from tubers or shoots, comparison of the effect of different nutrient doses on batata yield, and analyzation of nutritional value of sweet potato storage root and foliage.

Evaluation of the total yield of sweet potato experiments in Deszk using a repeated measurement model

Examining the data of three years, it is clear, that the cultivation method has a significant effect ($p=0,007$; $F=8,152$) on the yield. At the same time, the effect of nutrient supply on yield is not significant ($p=0,104$; $F=2,39$). No significant relation was found between cultivation and nutrient supply interaction and yield ($p=0,746$; $F=0,295$). Moreover, the combined effect of cultivation method and nutrient supply on yield is neither significant.

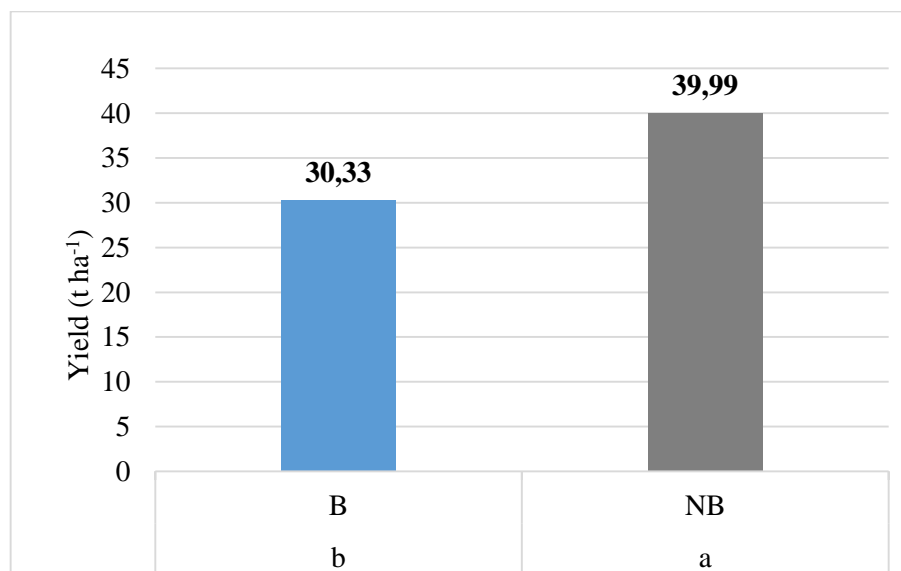


Note: "abcd" statistical analysis by ANOVA Duncan test (significance: $p<0,05$)

B: with ridges, **NB:** without ridges, flat, **K:** control plot, **K1:** 1st treatment, **K2:** 2nd treatment

Figure 1: Combined effect of cultivation method and nutrient doses on sweet potato yield (Deszk, 2016-2018)

Based on the examination of combined effect of cultivation method and nutrient doses, we found a significant difference between the yields of different cultivation and the plots treated with different nutrient doses ($p < 0,05$). Examining the combined data of the three years, the flat-cultivated control (untreated) plot (NB:K) gave the highest yield (45,46 tons per hectare), followed by the flat-cultivated with the 1st treatment (NB:K1) (41,64 t ha⁻¹) and the flat-cultivated with the 2nd treatment (NB:K2) (34,02 t ha⁻¹) plots. The yield of the ridge-planted and first-treated (B:K1) plot is 33,17 t ha⁻¹, that of the ridge-planted control (B:K) plot is 32,29 t ha⁻¹, and that of the ridge-planted second-treated (B:K2) plot is 26,87 t ha⁻¹. The yield of ridge-planted plots is typically lower than that of flat cultivated plots. The yield of the flat cultivated control plot differs significantly from the combination of all three ridge-planted and treated plots (Figure 1).



Note: “abcd” statistical analysis by ANOVA Duncan test (significance: $p < 0,05$)

B: with ridges, **NB:** without ridges, flat

Figure 2: The effect of cultivation method on sweet potato yield
(Deszk, 2016-2018)

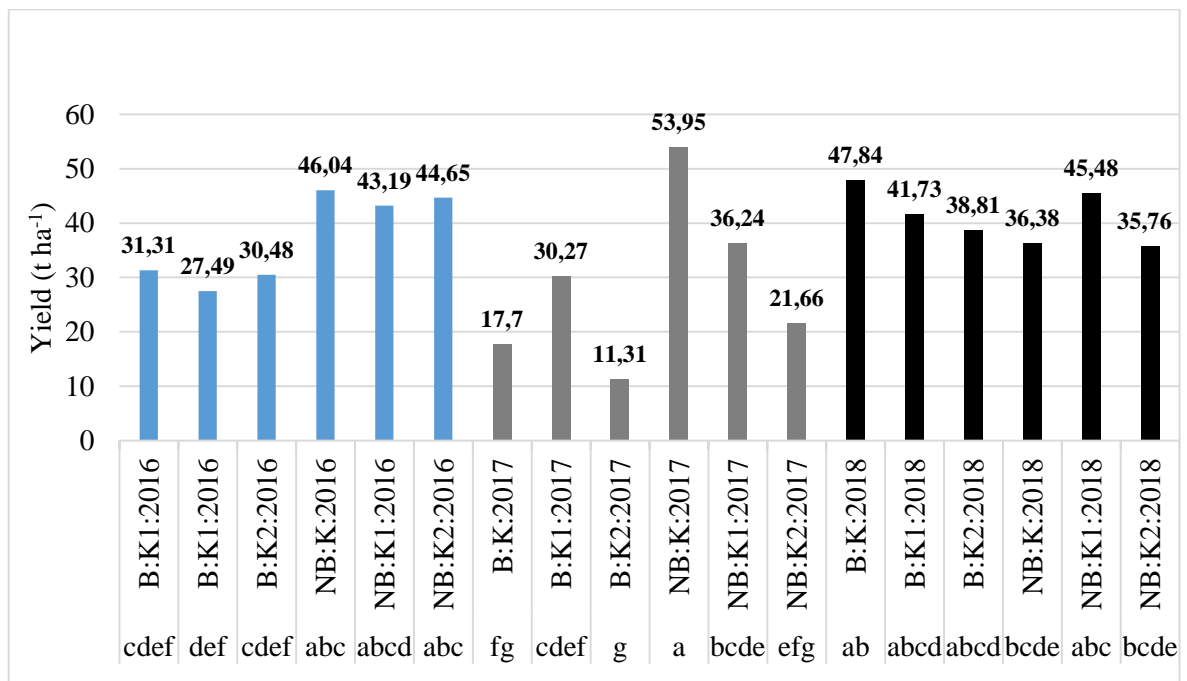
Evaluating the three years data together, the yield of sweet potato grown in flat cultivation (NB) is 39,99 tons per hectare, and that of sweet potato grown in ridge cultivation (B) is 30,33 tons per hectare (Figure 2). The yields of the two cultivation methods differ significantly at the 10% probability level in favour of the “NB a” cultivation method. In contrast to the international experiences, according to which definitely the ridge cultivation is recommended on compact soil, during our experiments set up in the field of

Deszk, the flat cultivation method proved to be better. The shaping up of ridges is labour-intensive, so with flat cultivation we can save time and money.

Evaluation of the effect of growing year in the aggregated measurement model

Based on the data of three years, the growing year has a significant effect on sweet potato yield ($p=0,000$; $F=7,68$). Furthermore, the growing year and the cultivation method together also have a significant effect on the yield ($p=0,003$; $F=6,205$). However, the combined effect of nutrient supply and growing year ($p=0,105$; $F=1,982$), as well as cultivation method and nutrient supply and growing year ($p=0,063$; $F=2,319$) on yield was not significant.

Method, we found a significant difference between the yields of each group ($p<0,05$). Evaluating the three year data together, the highest yield was measured in the flat cultivated, control plot in 2017 (NB:K:2017) ($53,95 \text{ t ha}^{-1}$), followed by the ridge-planted second-treated plot in 2018 (B:K2:2018) ($47,84 \text{ t ha}^{-1}$). The lowest yield was observed in the ridge-planted second-treated plot in 2017 (B:K2:2017) ($11,31 \text{ t ha}^{-1}$). We found significant difference between the yields of several plots (Figure 3).



Note: "abcd" statistical analysis by ANOVA Duncan test (significance: $p<0,05$)

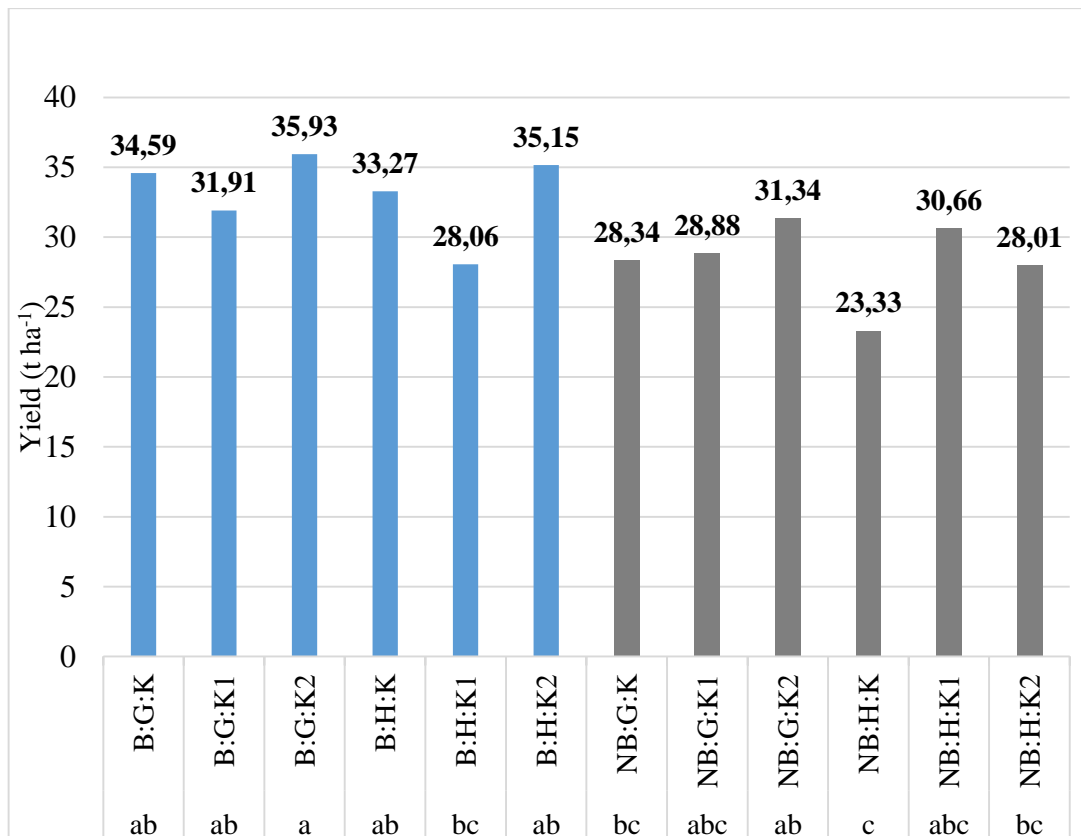
B: with ridges, NB: without ridges, flat, K: control plot, KI: 1st treatment, K2: 2nd treatment

Figure 3: Combined effect of cultivation method, nutrient doses, and growing year on sweet potato yield (Deszk, 2016-2018)

Effect of planting material on sweet potato yield under different agrotechnical conditions

Based on data from three years, cultivation methods have a significant effect on sweet potato yield ($p=0,003$; $F=9,718$). However, the effect of planting material type ($p=0,176$; $F=1,902$), and nutrient supply ($p=0,250$; $F=1,44$) on yield was not significant. Cultivation method and planting material type interaction ($p=0,947$; $F=0,005$), cultivation method and nutrient supply interaction (cultivation:nutrient) ($p=0,106$; $F=2,392$), and nutrient supply and planting material type ($p=0,848$; $F=0,166$) also had no significant effect on yield. The combined effect of planting material type, cultivation method and nutrient supply on yield was not either significant ($p=0,402$; $F=0,934$).

Examining the combined effect of the cultivation method, the planting material and the nutrient supply, it can be stated that there is a significant difference between the yields of plots grown in different cultivation, treated with different nutrient doses and from different planting material sources ($p<0,05$). The highest yield was produced on the ridge-cultivated (B), planted with tuber-derived cuttings (G), and treated with the higher nutrient dose (K2) plot, with a yield of 35,93 tons per hectare. The lowest yield was observed on the flat-cultivated (NB), planted with shoot-derived cuttings (H) untreated control (K) plot (23,33 t ha⁻¹). The results of both the highest and lowest yielding combinations are significantly different from most other combinations (Figure 4).



Note: "abcd" statistical analysis by ANOVA Duncan test (significance: $p < 0,05$)

B: with ridges, **NB:** without ridges, flat, **G:** cuttings from tuber, **H:** cuttings from shoot, **K:** control plot,
K1: 1st treatment, **K2:** 2nd treatment

Figure 4: Effect of cultivation method, planting material and nutrient supply on sweet potato yield
 (Deszk, 2016-2018)

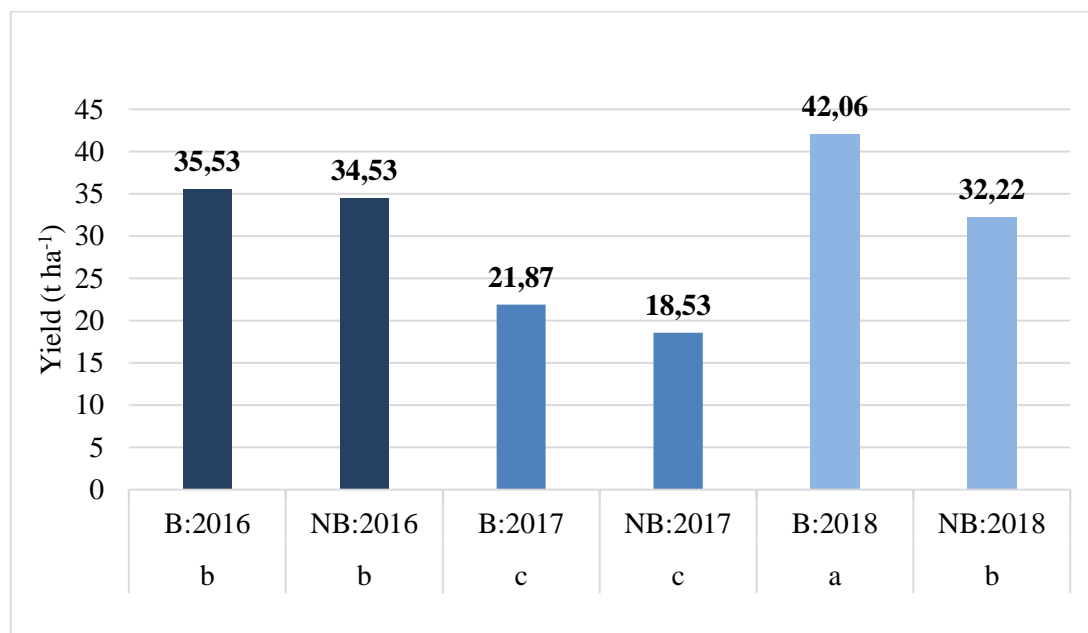
Effect of planting material on sweet potato yield under different agrotechnical and growing year conditions

During the setting up of the planting material experiments, we indicated the origin of the cuttings (cuttings obtained from tubers or shoots, also known as primary or secondary cuttings) at the plots.

Analysing the data of three years together, it is clear that the effect of growing year on sweet potato yield is significant ($p=0,000$; $F=43,585$). However, the factors examined together, such as growing year and cultivation method ($p=0,075$; $F=2,68$), growing year and planting material type ($p=0,226$; $F=1,518$), nutrient supply and growing year ($p=0,692$; $F=0,56$), cultivation method, planting material type and growing year ($p=0,105$; $F=2,322$), cultivation method, nutrient supply and growing year ($p=0,605$;

F=0,684), and cultivation method, planting material type, nutrient supply and growing year (p=0,993, F=0,059) has no significant effect on yield.

Based on the results of the planting material experiments the yields of the plots with different growing year and different cultivation method differ significantly from each other (p<0,05). The highest yield is shown in ridge cultivation (B), in 2018 (42,06 tons per hectare), this is followed by the yield of ridge cultivation (B) in 2016 (35,53 t ha⁻¹), and then follows the yield of flat cultivation (NB) in 2016 (34,53 t ha⁻¹). We observed the lowest yield in flat cultivation in 2017 (18,53 t ha⁻¹). As it can see on Figure 5, the significant difference between different combinations shows a various picture. It should be highlighted that only the yield of 2018, ridge-cultivated plot (that gave the best performance) differs significantly from the results of all other plots.



Note: "abcd" statistical analysis by ANOVA Duncan test (significance: p<0,05)

B: with ridges, **NB:** without ridges, flat

Figure 5: Combined effect of growing year and cultivation method on sweet potato yield (Deszk, 2016-2018)

The effect of different factors on the yield of sweet potato in the complex experiment in Deszk

Analysis of cumulative yields of three years

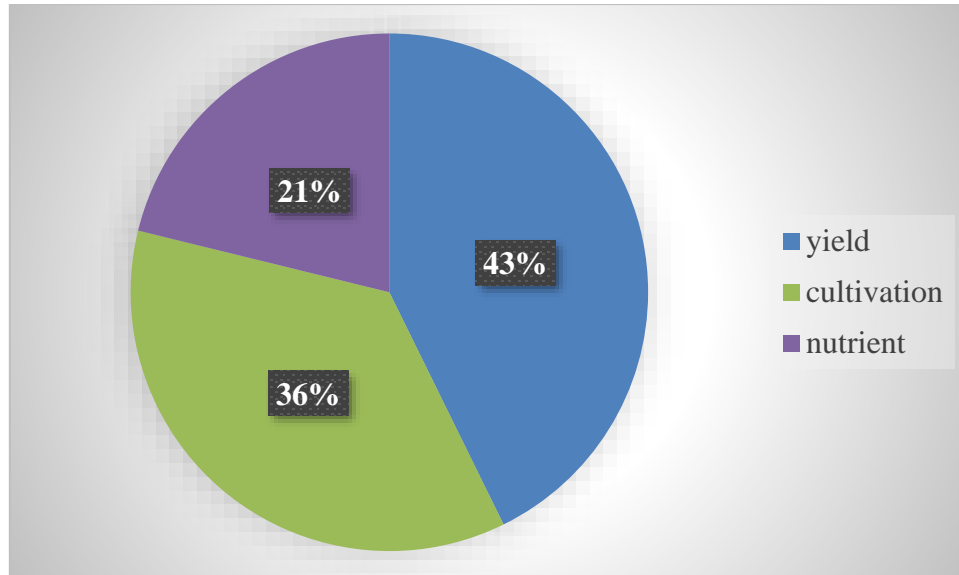


Figure 6: The distribution of the three factors examined

Figure 6 shows, that the variance of the outcome variable is determined by 43% by the growing year, 36% by the cultivation method, and 21% by the nutrient dose. Of the known factors, the growing year has the greatest effect, followed by the cultivation method, while the weakest effect shown by the nutrient dose.

The effect of plant density on the yield of sweet potato

We evaluated the yields given by the experiments set up in Domaszék and Ásotthalom using one-way analysis of variance. These experiments studied the effect of different plant density determined by the different row and plant-to-plant distance. During the analysis of variance, we compared the average yields achieved with different row and plant-to-plant distances within one year, and we performed the analysis between years too.

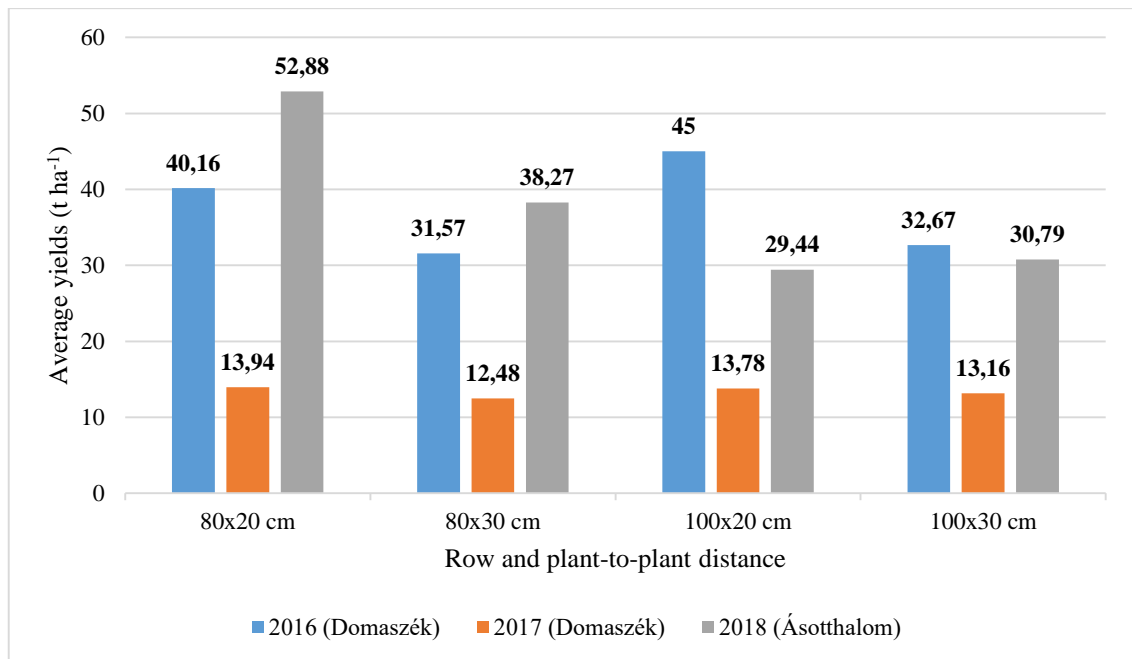


Figure 8: Average yields in the function of row and plant-to-plant distance (2016-2018)

Among the annual average yields of sweet potato slips planted with 80 x 20 cm arrangement, the highest yield was observed in 2018 (52,88 tons per hectare), followed by the average yield of 2016 (40,16 t ha⁻¹), while the lowest average yield in the examined arrangement was in 2017 (13,94 t ha⁻¹). With the 80 x 20 cm set-up, the average yield in 2017 was substantially lower than in the other two years. A significant difference ($p < 0,05$) was observed between annual average yields with the 80 x 20 cm arrangement ($p = 0,000$; $F = 24,480$). According to the post hoc test, the average yield of 2017 is significantly lower than the yield of 2016 ($SE = 5,676$ $p_{LSD} = 0,001$), and the yield of 2018 ($SE = 5,676$ $p_{LSD} = 0,000$). At the same time, there is no significant difference between the average yields of 2016 and 2018 ($SE = 5,676$ $p_{LSD} = 0,052$).

Among the annual average yields of sweet potato transplants planted with 80 x 30 cm set-up, the highest yield was observed in 2018 (38,27 t ha⁻¹). This is followed by the average yield of 2016 (31,57 t ha⁻¹), while the lowest average yield in the examined set-up showed in 2017 (12,48 t ha⁻¹). In this set-up, the average yield in 2017 was substantially lower than in the two other years. With the 80 x 30 cm set-up, a significant difference ($p < 0,05$) was observed between annual average yields ($p = 0,003$; $F = 11,428$). According to the post hoc test, there is a significant difference between 2017 and 2016 ($SE = 5,596$ $p_{LSD} = 0,008$), and between 2017 and 2018 ($SE = 5,596$ $p_{LSD} = 0,001$). However, there is no significant difference between the average yields of 2016 and 2018 ($SE = 5,596$ $p_{LSD} = 0,262$). So, the

year 2017 resulted in a significantly lower yield than the two other years, in the case of 80 x 30 cm set-up.

In the case of sweet potato transplants planted with a 100 x 20 cm spacing set-up, the highest average yield was observed in 2016 (45,00 tons per hectare), followed by the average yield in 2018 (29,44 t ha⁻¹). The lowest average yield in this set-up appeared in 2017 (13,79 t ha⁻¹). The average yields of all three studied years differed substantially from each other. In the case of 100 x 20 cm set-up, we found significant difference ($p < 0,05$) between the annual average yields ($p = 0,001$; $F = 15,729$). According to the post hoc test, 2017 is significantly different from 2016 ($SE = 5,565$ $p_{LSD} = 0,000$), 2017 different from 2018 ($SE = 5,565$ $p_{LSD} = 0,020$), and 2016 different from 2018 ($SE = 5,565$ $p_{LSD} = 0,021$). Therefore, in the 100 x 20 cm set-up, the average yield of all three studied years significantly differ from the average yields of the two other year.

In the case of sweet potato transplants planted with a 100 x 30 cm set-up, the highest average yield was observed in 2016 (32,67 t ha⁻¹), followed by the average yield in 2018 (30,79 t ha⁻¹). However, we observed the lowest average yield in the examined set-up in 2017 (13,17 t ha⁻¹). In the 100 x 30 cm set-up, the average yield in 2017 was substantially lower than in the two other years. In the case of 100 x 30 cm row and plant-to-plant distance, we found a significant difference ($p < 0,05$) between the annual average yields ($p = 0,000$; $F = 26,197$). According to the post hoc test, there is a significant difference between 2017 and 2016 ($SE = 2,972$ $p_{LSD} = 0,000$), and between 2017 and 2018 ($SE = 2,972$ $p_{LSD} = 0,000$). But there is no significant difference between the average yields of 2016 and 2018 ($SE = 2,972$ $p_{LSD} = 0,543$). Thus, 2017 resulted in a significantly lower average yield than the two other years for the 100 x 30 cm set-up (Figure 8).

Overall, it can be stated, that in 2017 significantly less sweet potato were produced in all four examined set-ups, than in the other two years. This was due to the drier and poorer precipitation weather conditions in 2017. Between the average yields of 2016 and 2018, we found a significant difference only with the 100 x 20 cm set-up, in the case of the other set-ups, the difference was not significant.

Examination of the nutritional value of sweet potato foliage in 2016 and in 2018

Based on literature sources, sweet potato foliage can be fed to cattle, sheep, goats, pigs and rabbits. The foliage is used as fodder in fresh, dried form, or it can also be made into silage which has a pleasant, sweet taste.

In laboratory, we analysed the nutritional value of sweet potato foliage samples taken from all three treatments (K, K1, K2) of the experiments conducted in 2016 and 2018 on the field of Deszk. No significant difference was observed between the values of the control (K) and the other two treatments (K1, K2). At the same time, we aimed to compare the nutritional values of sweet potato foliage with the nutritional values reported in literature of alfalfa harvested in the green bud stage. We found that the crude fat and crude ash content of sweet potato foliage is higher than the values of alfalfa. The highest measured carotene content in sweet potato foliage was 312 milligram per kilogram. This is a very good value, as the carotene content of alfalfa varies between 250 and 500 milligram per kilogram, on the average. Therefore, based on the parameters, it is worth using sweet potato foliage as animal feed. However further studies needed to develop the feed production technology.

Examination of the nutritional value of sweet potato storage root in 2017 and 2018

We performed the measurements of the nutritional value of sweet potato roots on tubers lifted in Deszk. We examined the effect of heat treatment on the nutritional value of batata.

Carrying out the measurements, we concluded that the heat treatment reduces the nutritional values of batata. In contrast, the sugar content (degree Brix, in percentage) increased with heat treatment. The sugar content of sweet potato harvested in the autumn of 2018 was 15,30 % before heat treatment, and 21,20 % after heat treatment. From this change we concluded that the heat treatment converts the starch into sugar in the sweet potato, and that is why it becomes sweeter.

4. NEW SCIENTIFIC RESULTS OF THE DISSERTATION

Up to the present, no small plot experiments on sweet potato cultivation has been published in the literature such as the ones conducted by us. We simultaneously performed experiments on three different production sites (Deszk, Domaszék and Ásotthalom) and on different soils. During these, we put through comparative studies on yields related to the nutrient content of the soil, the length of vines, and the row and plant-to-plant distance.

In connection with the cultivation of sweet potato, our new scientific findings related to increasing the yields are the following.

- 1. The role of different planting material.** The transplants derived from tubers gives significantly higher yield than that resulting from cuttings obtained from shoots. When the three years of data are considered together, the yield of sweetpotato grown under flat cultivation is 39.99 t/ha and the ridges is 30.33 t/ha. Time and cost savings can be achieved by producing in flat cultivation. There was significant differences between the cultivation methods (9,66 t/ha).
- 2. The role of different propagation material.** Treatment from tubers gives significantly higher yields than cuttings from shoots. The highest yield was obtained in 2018 from tuber treatment (39.99 t/ha).
- 3. The role of row and plant-to-plant distance.** Ee found that plant-to-plant distance plays much larger role in ensuring yield than row spacing. Accordingly, it is strongly recommended to use a plant-to-plant distance of 20 cm compared to 30 cm. Yields were significantly higher in the 80x20 cm arrangement than in the 80x30 cm arrangement (8.22 t/ha).
- 4. The smaller plant-to-plant distance** is a stronger predictor of the yield compared to the smaller row spacing. For the year 2018, a significant negative directional relationship was found, indicating that the yield average was higher when using the smaller plant to plant and row spacing (22.09 t/ha).
- 5. By dividing the variance components,** we found that the increase in the yield of sweet potato is determined by 43% by growing year, by 36% by cultivation and by 21% by nutrient dose.

5. PRACTICAL USEFULNESS OF THE RESULTS

The results, that can be used in practice, of our experiments related to increasing the yield of sweet potato are the following.

- 1. Cultivation method.** Since the flat cultivation method produces significantly higher yields than the ridge planting, choose flat cultivation to save time and money. The highest yield was given in 2016 with flat cultivation (44,62 tons per hectare) while the lowest yield was achieved in 2017 with ridge cultivation (19,76 tons per hectare).
- 2. Propagating material.** Production should be from tubers, as treatment from tubers gives significantly higher yields than cuttings from shoots!
The highest yields were obtained from tuber treatment in 2018 (39.99 t/ha).
- 3. Row and plant-to-plant distance.** As plant-to-plant spacing plays a much bigger role in ensuring yield, it is strongly recommended to use 20 cm plant-to-plant distance instead of 30 cm. As second in order of importance, it is recommended to use a row spacing 80 cm compared to 100 cm. At the same time, it should be noted that smaller plant-to-plant distance is a more important forecaster of the yield compared to the smaller row distance. This means, that using a smaller plant-to-plant distance is more important to achieve a higher yield than using a smaller row spacing. Among the annual average yields of sweet potato cuttings planted with 80 x 20 cm arrangement, the highest yield was observed in 2018 (52,88 tons per hectare), followed by the average yield of 2016 (40,16 t ha⁻¹), while the lowest average yield in the examined arrangement appeared in 2017 (13,94 t ha⁻¹).

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7. PUBLICATIONS OF THE CANDIDATE ON THE TOPIC OF THE DISSERTATION



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A PhD értekezés alapjául szolgáló közlemények

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