A tropical crop, as Hungarian farmers' potential response to climate change – the sweet potato

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Abstract

The growing interest in sweet potato among Hungarian consumers and producers makes it necessary to improve crop yield and yield stability. Within the framework of an EIP-AGRI project, one of our basic goals was the development of site- and genotype-specific technological solutions. The experiments were carried out in southeastern Hungary, primarily with the registered cultivar 'Ásotthalmi12'. Cultivation without ridges resulted in higher yield on sandy soil. Under the climatic conditions of the region, cultivation of sweet potato in greenhouse resulted extremely poor storage root yields (max. 358 g plant^{-1}). Total lack of irrigation had significant negative effect on root yield, but the beneficial distribution of precipitation in the crop-year could still generate an economic return (1,455 g plant^{-1}). For the same length of growing period (ca. 130 days), early planting (and harvesting) resulted in significantly higher yield (2,355 vs. 1,100 g plant^{-1}). Lifting vines did not have a significant positive effect on yield. Our experimental results and other experiences revealed that sweet potato is a well-adaptable crop with high potential also under the conditions to be expected due to climate change in Hungarian agriculture.

Keywords: *Ipomoea batatas*, yield stability, microbial fertilizer, planting, irrigation

INTRODUCTION

Even though in parallel with the increased consumers' demand, the producers' desire, as well as the area under cultivation increased, the domestic sweet potato (*Ipomoea batatas* (L.) Lam.) crop is currently unable to satisfy the needs of Hungarian consumers. In trade, domestically produced sweet potato is replaced by imports already in springtime. Sweet potato research has a centuries-old history in Hungary, but improving yield and crop safety has made it indispensable nowadays – in addition to solving the issue of virus-free propagating material supply – to elaborate site- and genotype-specific crop management programs based on experiments.

Outdoor planting of sweet potatoes can start after the frosts have passed, when the soil temperature reaches at least 18°C at a depth of 10 cm for 4 consecutive days. Plants that develop from too early planting may be damaged by frost, the roots of the cuttings do not grow properly, the vines turn purple, their vigor decreases, the tuber yield is low, and the roots will be rounded or chunky instead of an elongated shape (North Carolina SweetPotato Commission, without date). According to an earlier technological recommendation based on Hungarian experience, planting is not recommended before the last decade of May due to the risk of frost, and in June due to the shortened growing season (Horváth, 1991). Practical experience, however, showed that planting after the first decade of May and completed one or even two months later could produce acceptable yields (T. Váraljai, pers. commun.).

Sweet potato is a perennial plant grown as annual in temperate zones. Therefore, unlike potatoes, storage roots are not harvested at biological maturity – they can be picked at any time when they reach the marketable size (Brandenberger et al., 2014). Under the conditions of Hungary, with a growing season of 4-6 months, Horváth and Proksza (2005) recommended

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harvesting between October 5 and 10.

Sweet potato is considered to be a moderately drought-tolerant plant that responds very well to irrigation even if water is available in natural ways (DAFF, 2011). If irrigated on demand in the first 40 days from transplanting, sweet potato plants have a good chance to survive later water stress (Monostori and Szarvas, 2015).

Within the framework of an EIP-AGRI project entitled "Development of site- and cultivar-specific cultivation technologies as well as the production of pathogen-free propagating material of sweet potato" running from 2018 to 2024, one of our basic goals was to develop site- and genotype-specific technical solutions, focusing on the most fundamental agronomical factors, such as weather and soil parameters, nutrient supply, planting practices, irrigation coverage, plant care and plant protection among others. The present study summarizes some of our determining experimental results on sweet potato root production in Hungary.

MATERIALS AND METHODS

The field experiments were carried out in southeastern Hungary, the country's hottest region, with the highest number of hours of sunshine. All experiments were performed with the sweet potato cultivar 'Ásotthalmi12' registered in Hungary. Utilization of other accessions is indicated respectively. Experimental conditions are listed below according to the factors examined. For statistical analysis, if relevant, analysis of variance (ANOVA) and LSD as well as Tukey tests were done with the IBM SPSS Statistics software.

Planting practices

In 2020, at Balástya, on sandy loam soil, sweet potato was planted in flat as well as on ridges, keeping a row distance of 75 cm and a plant-to-plant distance of 30 cm. Irrigation by micro sprinkler was applied regularly, the growing season throughout. Four virtual plots of 5 m in length including one row each were determined randomly at the harvest.

In 2020, at Tiszasziget, on loamy soil, the sweet potato cultivars 'Purple' and 'Emmur' were planted into ridges at a row distance of 100 cm and a plant-to-plant distance of 30 cm. Drip irrigation was applied except for one row of 'Purple'. Yields of randomly chosen individual plants as well as the averages of the whole rows were considered for evaluation.

Protected cultivation

In 2020 and 2021 at Szeged, 5 white-fleshed ('Tápiói 96', 'Boribon', 'White', 'Emmur', 'Japan'), 2 orange-fleshed ('Norangel', 'Ásotthalmi12') and one purple-fleshed ('Purple') cultivars were planted in a double-wall plastic greenhouse, into sandy loam soil. The row distance was 100 cm, the plant-to-plant distance 30 cm. The way of data collection did not make the statistical evaluation possible.

Date of planting

In 2018, at Tiszasziget, sweet potato was planted into flat in four periods between May 17 and June 26, while harvesting took place between September 27 and November 7. The growth period was kept as constant ca. 130 days. For evaluation, the storage root weight of 20-20 randomly selected plants, representing the whole area (plot), was measured.

Managing sweet potato vines

Depending on their growth type, sweet potato cultivars can develop long vines. On wet soil, roots – even small, non-marketable storage roots – may grow from the nodes touching the soil. Thus, the water and nutrients supplied to these roots are wasted and the yield of marketable roots is reduced. This loss could be prevented by lifting the vines (Amante and O'Sullivan, n.d.), which consisted of an experimental treatment. In 2019 and 2020, at Sarkad, in farm-size experiments (520 plants per treatment with two repetitions), flat planting was applied with a row distance of 100 cm, and plant-to-plant distance of 30 cm.

RESULTS AND DISCUSSION

Flat or ridge planting

In the comparative experiment conducted at Balástya on sandy loam soil, flat cultivation proved to be preferable compared to cultivation without foil cover on ridges, with micro-spray irrigation (Figure 1). The yield difference (579 vs. 474 g plant^{-1}) was however, not significant. Sweet potato in Hungary can be successfully grown both with and without ridges (Monostori and Szarvas, 2023). Ridges are preferred in most areas to improve drainage (Clark, 2013). Whereas flat planting used to be efficient in Hungary, especially on sandy soils, cultivation in ridges covered with foil became recently more popular (Monostori et al., 2020). In 2020 at Tiszasziget, on loamy soil, ridge planting without foil cover generated yields of up to 2,500-2,700 g plant^{-1}, with different cultivars ('Emmur' and 'Purple', Z. Gombos, pers. commun.).

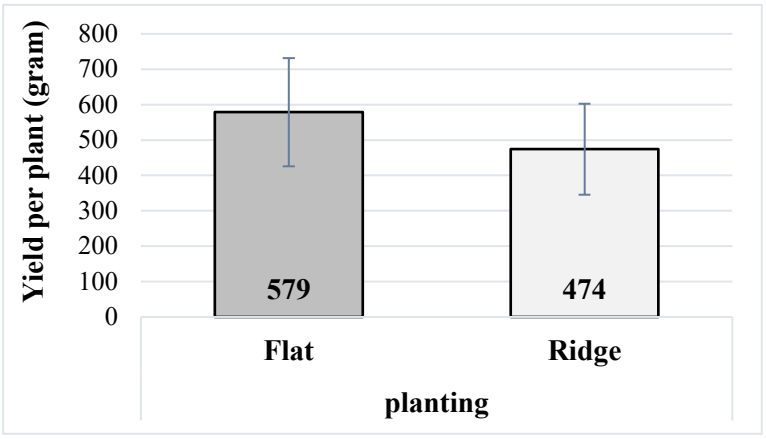

Figure 1. Sweet potato average mass plant^{-1} (± SD, in g) in flat or ridge cultivation at Balástya in 2020.

Restricted irrigation

In 2020 at Tiszasziget, the total absence of irrigation when planting in ridges led to a significant reduction in the yield of 'Purple' (2,690 vs. 1,455 g plant^{-1}). The favourable rainfall distribution during the growing season, however, resulted in an acceptable yield (Figure 2). Saqib et al. (2017) found storage root yield parameters directly linked with the foliage growth. Thus, under water stress conditions, parallel with the decreased vegetative growth, the storage root yield was also reduced. In contrast to the decrease of root yield and nitrogenous compounds on the effect of drought stress, however, root dry matter increased and could serve as the best indicator and selection criterion for drought tolerance (Ekanayake and Collins, 2004). With 'Ásotthalmi12', even above-average yields can be safely achieved by observing a long growing season, under appropriate ecological and technological conditions. Based on these, the usual practice of Hungarian sweet potato growers – postponing planting until the end of June and postponing harvesting until the end of October – may result in lower yields than expected. Therefore, it is recommended to carry out planting at the earliest, when environmental conditions allow, primarily soil temperature.

Protected growing in greenhouse

In a two-year (2020, 2021) greenhouse experiment in Szeged, the plants produced enormous foliage, but the average storage root yields were far below the expectations. Cultivars with white flesh performed the best (195-358 g plant^{-1}) and purple flesh the worst (18 g plant^{-1}). The orange-fleshed cultivars gave intermediate result (96-240 g plant^{-1}) (Figure 3). In the UK, the conditions are ideal for growing sweet potato in greenhouse. Outside, the crop is smaller. Temperature above 30°C can cause heat stress and reduce yield (Agricultural Magazine, 2023). In a greenhouse experiment with sweet potato planted individually into pots, at a mean temperature of 25°C, the increased nitrogen doses resulted in larger foliage

and higher storage root yield. In field grown plants, however, the yield reduced parallel with the excess growth of aboveground parts (Taranet et al., 2017).

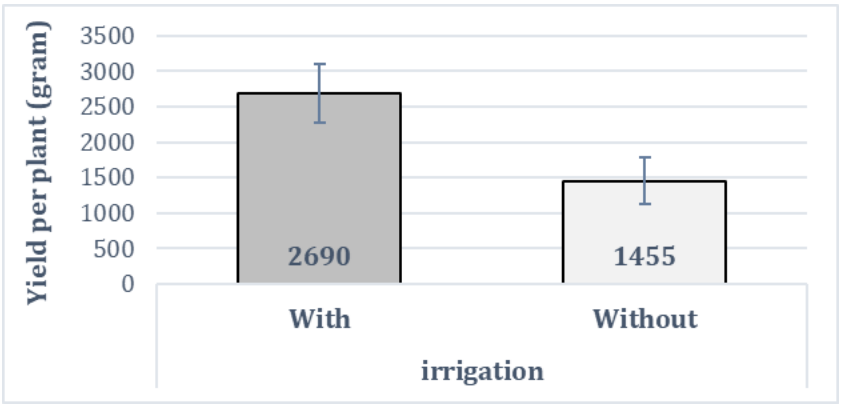

Figure 2. Sweet potato average mass plant^{-1} (± SD, in g) with or without irrigation at Tiszasziget in 2020.

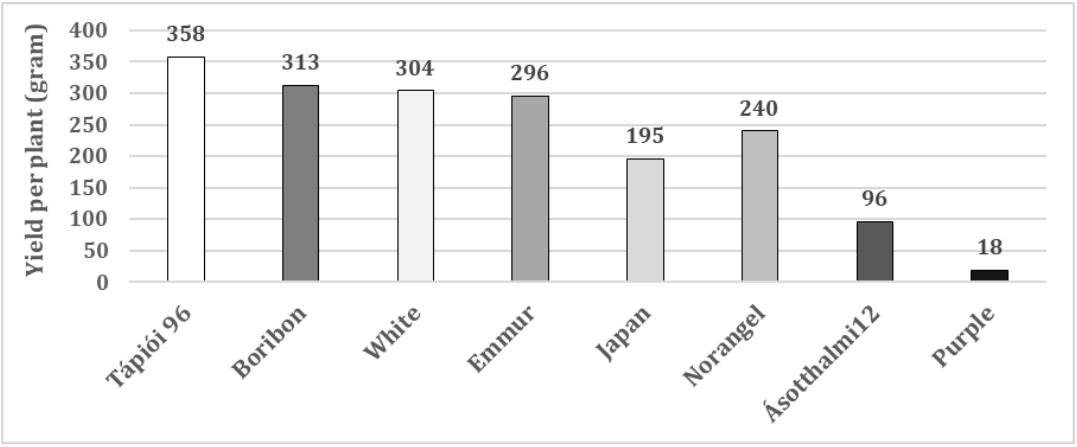

Figure 3. Average mass plant^{-1} (g) of five white-, two orange- and one purple-fleshed sweet potato cultivars in greenhouse at Szeged in 2021.

Date of planting and harvesting

In 2018, in flat tillage at Tiszasziget, early planting and harvesting resulted in definitely higher yields than planting and harvesting several weeks later (Figure 4). Due to high standard deviation values, however, the differences cannot be considered as statistically significant.

Long growing seasons of more than 120 days (planting at the end of May, harvesting at the beginning of October) were similarly reported in experiments with different cultivars in Poland (Krochmal-Marczak et al., 2014). The recommendation of a soil temperature of at least 18°C for 4 days by the North Carolina SweetPotato Commission Inc. can be considered too strict under Hungarian conditions, even according to our current experience (North Carolina SweetPotato Commission, no date). Others recommend waiting at least 4 weeks after the last frosts, or simply planting after the frosts have safely passed (Albert, no date). Based on our experiment, it turned out to be a realistic proposal. However, it is advisable to set the minimum temperature at least 10°C (Bušić, no date). Both too early and too late harvests should be avoided. In the first case, due to lower average yields and lower storage quality, in the second case due to the "woodiness" of the roots, increasing the likelihood of being attacked by weevils and rotting (Horváth and Proksza, 2005; Stathers et al., 2013).

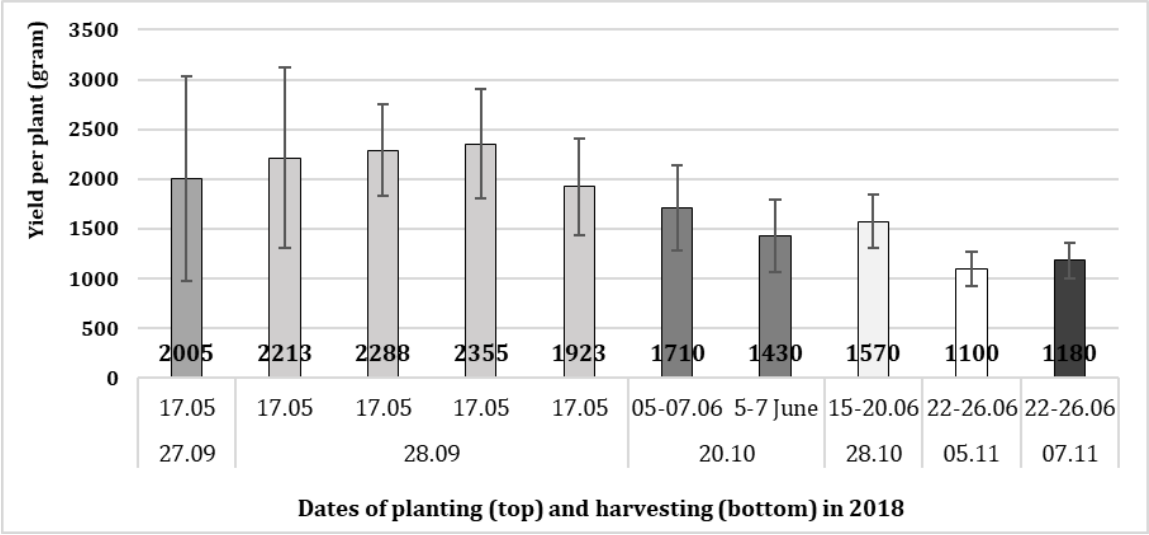

Figure 4. The effect of different planting and harvesting times on the sweet potato mass plant^{-1} (mean ± SD, in g) at Tiszasziget in 2018.

Lifting or not lifting sweet potato vines

In a two-year (2019, 2020) experiment at Sarkad that investigated the effect of lifting sweet potato vines, the results from the two seasons were not consistent (Figure 5). In the first year with vine lifting, in the second year without, produced higher yields, without significant differences. The benefit of vine lifting seemed to depend on the cultivar and the weather conditions. Bushy cultivars generally do not need lifting. Lifting is usually done once or twice during the wet season, and it is often omitted during the dry season. In Indonesia, lifting more than once in the season was beneficial for the yield in very moist conditions only (Amante and O'Sullivan, no date). In Iowa, in a farm-size experiment at two independent locations, no significant differences were found between lifting and no lifting of sweet potato vines on storage root yield or number of tubers (Worley and Ogawa, 2012).

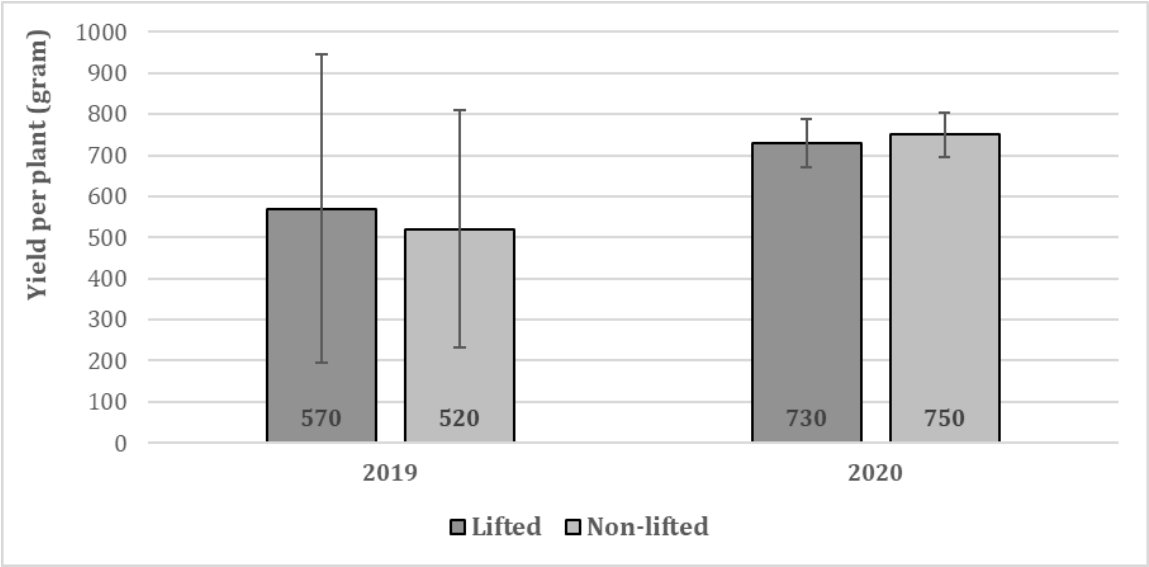

Figure 5. Effect of lifting or not lifting sweet potato vines on storage root yield plant^{-1} (mean ± SD, in g).

CONCLUSIONS

Our experimental data and additional experiences revealed that sweet potato can be efficiently produced under the general climatic conditions of southeastern Hungary. Despite its preferences for light soils, more compact soils can also be good in the case of a thorough tillage. Both flat and ridge planting can result in high yields; on sandy soil, however, cultivation without ridges proved to be more efficient, due to its better water retention capacity compared with ridges without foil cover.

Sweet potato needed adequate irrigation in the first few weeks after planting if they are to be drought tolerant in the later stages of development. Thus, the complete absence of irrigation resulted in a considerable decrease in yield compared with the irrigated plant stands. In the case of a beneficial distribution of precipitation, however, even a reasonable yield can be achieved. The warm climate in the given region during the growth period of sweet potato made no sense to cultivate it in greenhouse during the whole season. However, planting under small polytunnel could promote crop earliness. Based on one-year results that need to be confirmed, it could be recommended to strive for early planting and harvesting of sweet potato.

Supporting the high domestic market demands and the growing interest of the producers, sweet potato appeared to be a well-adaptable crop with high potential in Hungarian agriculture. It tolerated well the current moderate climate (average monthly temperature 15.8-20.8°C, average monthly precipitation 34-80 mm during the growing season). Moreover, its performance under the changing climate – if only the global increase in temperature is considered – is expected to be excellent. Farmers, however, shall be prepared for the supply of water, especially while the probability of summer drought is increasing, and plant breeders in parallel should strive to produce new, drought tolerant cultivars.

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