Assessment of the collection of sweet potato varieties (*IPOMOEA BATATAS L.*) in terms of suitability for cultivation and breeding in CRNZ

Vitaly Bobkov[1], *Viktor* Voronchikhin[3], *Maria* Polyakova[2], *Alexey* Meleshin[2], and *Irina* Voronchikhina[3,*]

[1]Federal State Budgetary Educational Institution of Higher Education "Russian Timiryazev State Agrarian University", 127550, Moscow, Russian Federation
[2]Lorkh All-Russian Research Institute of Potato Farming, 140051 Moscow, Russian Federation
[3]Federal State Budgetary Institution of Sciences the Main Botanical Garden named after N. V. Tsitsin of Russian Academy of Sciences, 127276, Moscow, Russian Federation

Abstract. The article presents the results of a reconnaissance study of the suitability of sweet potato varieties collection for cultivation and breeding process in the conditions of the Central region of the Non-Chernozem zone. Sweet potato cuttings with 4-5 nodes were planted according to the scheme 70 x 40 cm with subsequent watering. During the growing season, sweet potato was watered as necessary. Each variant was tested in 4-fold repetition, 10 plants per plot. The varieties had a high variability of all economically useful traits within the repetitions. For most varieties, the sum of effective temperatures was not enough to accumulate a sufficient amount of plastic substances in the root tubers. As a result of our research, it was found that sweet potato varieties Vinnitskiy rozoviy and Manchzhurskiy are most suitable for cultivation in the CRNZ. They are characterized by a relatively high yield of commercial root tubers. The remaining varieties (Americanskiy begevy, Boregard, Yaponskiy, Germanskiy belyi and O'Henry) are not suitable for cultivation in this zone. Nevertheless, they are characterized by a high potential for the formation of root bulges, which can be used in sweet potato breeding. The possibility of breeding work with sweet potato in the conditions of the CRNZ is shown. Nevertheless, for successful work in this direction, it is necessary to use a greenhouse.

1 Introduction

Plant introduction makes it possible to involve new types of crops in the production, which in turn contributes to the expansion of the range of products included in the diet of modern man, and therefore makes his diet more diverse and healthy. Sweet potato may be one of these plants, due to its unique nutritional properties. The possibility of its introduction in Russia has been theoretically substantiated and practically verified by a number of

* Corresponding author: yarinkapanfilova@gmail.com

researchers in the Udmurt Republic [5, 19], the Voronezh region [11-13], and the Republic of Dagestan [7].

Sweet potato is an evergreen perennial herbaceous plant (annual in crop) with long creeping stems (lianas) reaching a length of 1 to 5 meters. The leaves are simple, heart-shaped or palmately parted. The color of the shoots varies from green to purple. The root system is fibroid when propagated by cuttings, and tap-root when propagated by seed. The flowers are large, located in leaf axils, have a infundibulum consisting of a small calyx and densely fused petals, colored white or pink. The flower has 5 stamens and a lower ovary with 4 chambers. The fruit is a box containing from 2 to 4 small seeds with a dense shell. Root tubers of various varieties differ in shape (from elongated to rounded), the color of the peel and pulp (white, ivory, yellow, orange, pink, red, purple), the content of nutrients. Their mass varies widely – from 0.1 to 1.5 kg, reaching in rare cases 20-25 kg. Sweet potato is a fairly thermophilic plant. It grows perfectly at +30 ^{0}C, good at +20 ^{0}C, stops growing at +10 ^{0}C, dies at 0 ^{0}C. Cultivation of precocious varieties is possible in subtropical and temperate regions, where the average daily temperatures do not fall below +18 ^{0}C and there are no sharp temperature fluctuations during the growing season. According to the moisture requirements, it can be attributed to drought-resistant crops, but it develops well when 25 mm/ha of moisture falls daily, and watering is stopped by the end of the growing season (2-3 weeks before harvesting). In areas with precipitation up to 1000-1200 mm/ha per year, sweet potato is grown without irrigation. To obtain a stable harvest of good quality, it is necessary to grow sweet potato on soils with a light granulometric composition, good water and air permeability, pH 6.0. Removal of fertilizer elements for 12 tons of products: N - 33-37 kg/ha, P_2O_5 - 9-14.5 kg/ha, K_2O - 33-72 kg/ha. Sweet potato responds well to decomposed manure and composts. In terms of nutritional advantages, sweet potato is superior to potato: starch content is 25-32%, sugars - 3-6%, protein is up to 3%, and the calorie content is 1.5 times higher. It also contains trace elements, vitamins A and C, antioxidants, etc. [2-4, 8, 20].

Sweet potato is widely used in cooking (boiled, fried, baked, stewed, etc.), starch, alcohol, molasses, and powder are obtained from it, which can be added to bakery products to increase their nutritional value [14-18].

In the USSR, a very large-scale and time-consuming work was carried out on the introduction of this crop, as evidenced by the studies of Tyutin [19] and Alekseev [2]. About two dozens of varieties have been bred, the fate of which is currently unknown. Currently, the study of this crop, starting from 2012-2013, is being carried out in the Voronezh region [11-13], the Republic of Dagestan [7], the Udmurt Republic [5, 20], as well as in the EurAsEC countries – Belarus and Tadjikistan.

Scientists of the RSAU-MAA named after K. A. Timiryazev also conducts active research to determine the potential of growing sweet potato in the conditions of the CRNZ [10], the effect on its growth and development of growth regulators [9], and microclonal reproduction *in vitro* [1]. A unique database has also been created, the purpose of which is to collect, generalize, process, and preserve existing and newly received data on sweet potatoes [6].

The purpose of our study is to assess the possibility of cultivating and breeding sweet potato in the conditions of the CRNZ on the example of the Moscow region, as well as its verification through field experience.

2 Material and research methods

The object of the study were the following sweet potato varieties: Pobeda 100 (USSR), Manchzhurskiy (Asia), Vinnytskiy rozoviy (Ukraine), American7skiy bezheviy (USA),

Boregard (USA), Yaponskiy (Asia), Germanskiy beliy (Tuapse), and O'Henry (USA), obtained from the Potato FRC named after A. G. Lorkh.

The soil of the experimental field is sod-podzolic, sandy loam. Before planting, the soil was prepared as for potato, a film was laid on the ridges to prevent weed development. The planting of cuttings 20-30 cm long with 4-5 nodes was carried out according to the scheme 70 x 40 cm with subsequent watering. During the growing season, sweet potato was watered as necessary.

In the experiment, each variant was planted on a plot of 10 plants in a ridge with a fourfold repetition. Placement of variants is according to the type of randomized blocks. The harvest was took-out at the end of August, three months after the beginning of the growing season. The yield after harvesting was considered separately by weighing on technical scales. Data analysis was carried out by single-factor analysis of variance.

The most important condition for sweet potato growing is heat supply. The Moscow region is in a zone of risky farming, even for the cultivation of traditional crops. Nevertheless, in recent years, the average daily summer temperatures have begun to exceed the average annual values by several degrees. This can be seen in Figure 1. The average air temperature during the growing season from the beginning of June to the end of August was 21.4 ºC at a norm of 17.5 ºC. Moistening conditions varied greatly in different periods of the sweet potato growing season (Fig. 1). June was excessively humid, July – arid, August – humid. A total of 178.1 mm of precipitation fell during the growing season with a norm of 212.0 mm. Sum of effective temperatures (above 10 ºC) amounted to 1963.8 ºC. The HTC was equal to 1.096 (corresponds to a slightly arid year).

In general, the temperature conditions were satisfactory for sweet potato growth and development, but insufficient in terms of moisture supply and the length of the growing season (90 days instead of 120).

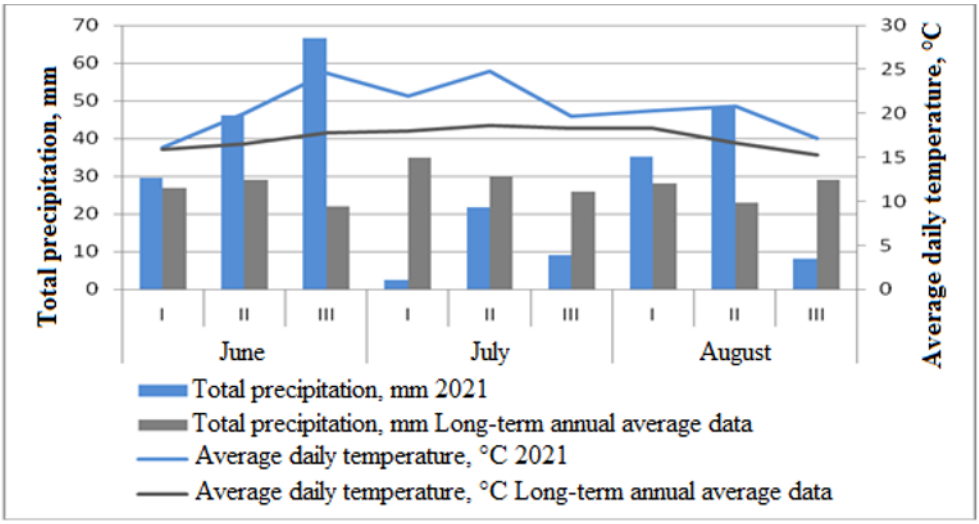

Fig. 1. Meteorological conditions of the research years, 2021 Data provided by the Meteorological Observatory named after V. A. Michelson.

3 Results and Discussion

Sweet potato varieties in the conditions of the Moscow region differed in the yield of root tubers from the plot (Fig. 2, 3). The maximum yield was found in the Pobeda variety 100 –

4.6 kg. At the same time, the trait variation within the repetitions was of an average degree (coefficient of variation of 16%).

The varieties Manchzhurskiy, Vinnytskiy rozoviy, and Americanskiy bezheviy were characterized by an average yield of root tubers in the range of 3.1-3.9 kg, while not statistically significantly differing from the Pobeda 100 variety. Nevertheless, these varieties showed a strong variation in the mass of root tubers within the repetitions (coefficient of variation was 38, 55, and 27%, respectively).

The remaining varieties turned out to be unproductive, unable to form a satisfactory harvest in the conditions of the Moscow region. Particularly regarding the Germanskiy beliy and O'Henry varieties.

Fig. 2. View of sweet potato root tubers obtained under CRNZ conditions, 2021.

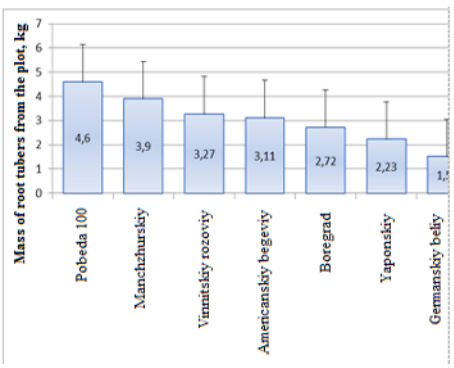

Fig. 3. Yield of root tubers of sweet potato varieties from the plot, kg. The error bars represent LSD_{05}

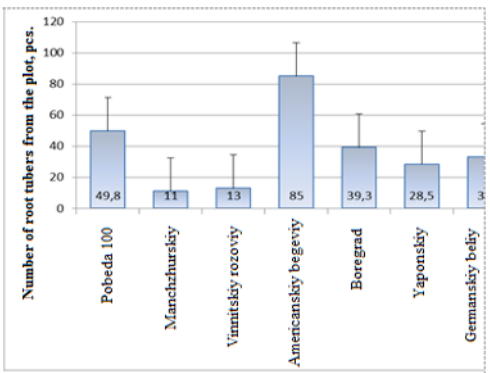

Fig. 4. The average number of root tubers of sweet potato varieties from the plot. The error bars represent LSD_{05}

Analysis of the number of root tubers from the plot showed that the most productive variety Pobeda 100 (50 pcs.) does not differ significantly in this indicator from the most harvestless ones – Boregard, Yapovskiy, and Germanskiy beliy (39, 29, 33 pcs., respectively) (Fig. 4). At the same time, the average weight of one tuber of all these varieties is comparable – within 100 g (Fig. 5). The variation in the number of root tubers from the plot for varieties Pobeda 100 and Germanskiy beliy was very large (coefficient of variation of both varieties was 28%), which indicates a high potential for the formation of root tubers. Whereas in low-yielding varieties Bouregard, Yaponskiy, and O'Henry, this

trait varied to an average degree (13, 15, and 15%, respectively), which indicates a less pronounced tuber-forming ability of these varieties.

The maximum number of root tubers was formed in the medium-yielding Americanskiy begeviy variety (85 pcs.), but their mass was the lowest among the entire set of studied varieties (only 37 g). The variation in the number of root tubers within the repetitions was very high (coefficient of variation was 42%), which indicates a high potential for tuber formation of the variety. Apparently, there was not enough heat for this variety to form a full-fledged crop in the conditions of the CRNZ, since this factor cannot be changed in the field.

The varieties Manchzhurskiy and Vinnytskiy rozoviy were characterized by the smallest number of root tubers from the bush (only 11 and 13, respectively) and a strong variation of the trait within the repetitions (coefficient of variation 36 and 38%, respectively). But their size was the maximum (354 and 252 g, respectively) and met the requirements for commercial root tubers. Such results are impressive and suggest that the meteorological conditions of the Moscow region that developed in 2021 are quite suitable for these varieties.

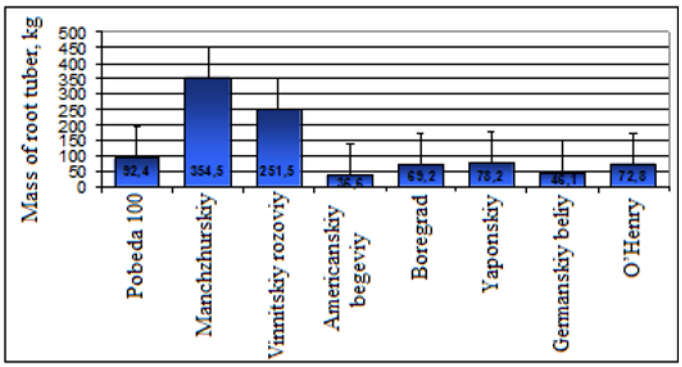

Fig. 5. The average weight of one commercial root tuber of sweet potato varieties. The error bars represent LSD_{05}

Fig. 6. Flowering of sweet potato varieties in the conditions of the CRNZ, 2021

In the breeding of any crop, crosses of specially selected parental forms are used to combine their traits in descendants, and then in the process of studying populations, the best samples are selected. For sweet potato, the possibility of a breeding process in the conditions of the CRNZ is determined by the ability of plants to bloom in conditions different from their usual cultivation conditions. Being a tropical plant, sweet potato is normally a short-day variety. Therefore, in the conditions of a long day in the Moscow region, its flowering is possible in case of photoneutrality. Observations of experimental varieties in the field have shown that most varieties are not able to move to the generative phase of development during the short Russian summer. Weak flowering was noted only in Manchzhurskiy (high-yielding, forms a small number of large root tubers), Americanskiy begeviy (medium-yielding, forms a lot of small root tubers), Bouregard, and Yaponskiy varieties (low-yielding, average number of small root tubers) (Fig. 6). Therefore, for the successful breeding process of this crop, it is necessary to use a greenhouse, where plants that have accumulated the sum of effective temperatures during the field vegetation period should be replanted. In the greenhouse in winter, the plants will continue growing during a short day. This can promote flowering and successful crosses to create their own populations for selection. From these populations, when grown in CRNZ conditions, it is

possible to try to select forms capable of forming a satisfactory yield of root tubers in a region unusual for tropical crop.

4 Conclusions

As a result of the study, it was found that:

1. Sweet potato varieties Vinnytskiy rozoviy and Manchzhurskiy are most suitable for cultivation in the CRNZ. They are characterized by a relatively high yield of commercial root tubers. The remaining varieties (Americanskiy begevy, Boregard, Yaponskiy, Germanskiy belyi and O'Henry) are not suitable for cultivation in this zone. Nevertheless, they have a high potential for the formation of root bulges, which can be used in sweet potato breeding.

2. The possibility of breeding work with sweet potato in the conditions of the CRNZ is shown. Nevertheless, for successful work in this direction, it is necessary to use a greenhouse.

References

1. D.A. Zorin, A.V. Fedorov, Yield of Ipomoea batatas Lam. in the northern agro-climatic region of the Udmurt Republic, **44(5)**, 46-49 (2018)
2. V.A.K. Sagi, E.V. Nevskaya, A.A. Nevsky, Study of sweet potato juice and powder effect on the quality indicators of bakery products from wheat flour, **5**, 33-36 (2017)
3. A.V. Povarnitsyna, A.V. Shitikova, Possibilities of growing sweet potato in agroecological conditions of the Central district of the non-chernozem zone, **73(8)**, 151-155 (2021) DOI:10.18411/lj-05-2021-332.
4. V.B. Podlesny, Cultivation of sweet potato at different planting dates in the Central Chernozem region of Russia, **7**, 19-20 (2013)
5. V.B. Podlesny, Sweet potato culture – a promising direction of Russian vegetable growing, **2**, 46-49 (2014).
6. B.M. Magomedova, Z.M. Asadulaev, Yu.M. Yarovenko, Sweet potato as a valuable food crop for the Republic of Dagestan (First Communication), **4**, 24-33 (2017)
7. A. Diaconu, R. Draghici, M. Croitoru, I. Draghici, M. Dima, A.N. Paraschiv Dynamics of the production process of sweet potato cultivated in the sandy soil conditions in Romania, **51(2)**, 617-622
8. V.E. Ermakova, Tropical and subtropical reclamation agriculture, 63 (1987)
9. P.M. Zhukovsky, Cultivated plants and their congeners, 284-287 (1971)
10. S.T. Gichuki, M. Berenyi, D. Zhang, M. Hermann, J. Schmidt, J. Glössl, K. Burg Genetic diversity in sweetpotato [Ipomoea batat as (L.) Lam.] in relationship to geographic sources as assessed with RAPD markers, **50(4)**, 429-437 (2003)
11. A.V. Fedorov, D.A. Zorin, Cultivation of *Ipomoea batatas* lam. in the Udmurt Republic, **11**, 734-737 (2018)
12. M. Šlosár, I. Mezeyová, A. Hegedusová, M. Golian Sweet potato (Ipomoea Batatas L.) growing in conditions Of Southern Slovak Republic, **10(1)**, 384-392 (2016) DOI:10.5219/626.
13. A.V.K. Sagi, G.G. Yusupova, E.V. Nevskaya, The effect of sweet potato processing products on dough properties and quality of bakery products from wheat flour, **2**, 55-57 (2018)

14. S. Srisuwan, D. Sihachakr, S. Siljak-Yakovlev The origin and evolution of sweet potato (Ipomoea batatas) and its wild relatives through the cytogenetic approaches, **171(3)**, 424-433(2006) DOI:10.1016/j.plantsci.2006.05.007.
15. V.A.K. Sagi, E.V. Nevskaya, A.G. Zueva, Study of the effect of sweet potato processing products on the quality of bakery products, **4**, 40-45 (2020)
16. V.A.K. Sagi, E.V. Nevskaya, A.A. Nevsky, Study of sweet potato juice and powder effect on the quality indicators of bakery products from wheat flour, **5**, 33-36 (2017).
17. A.V. Povarnitsyna, A.V. Shitikova, Possibilities of growing sweet potato in agroecological conditions of the Central district of the non-chernozem zone, **73(8)**, 151-155 (2021) DOI:10.18411/lj-05-2021-332
18. A. Povarnitsyna, The effect of growth regulators on the formation of sweet potato green mass, 192-197 (2021).
19. H.G. Abubakarov, E.A. Kalashnikova, R.N. Kirakosyan, A.V. Shitikova, Reproduction of *Ipomoea batatas* L. (Lam) in in vitro culture, Plant and meadow growing, 468-470 (2020) DOI: 10.26897/978-5-9675-1762-4-2020-104.
20. D. Zhang, J. Cervantes, Z. Huaman, E. Carey, M. Ghislain Assessing genetic diversity of sweet potato (Ipomoea batatas (L.) Lam.) cultivars from tropical America using AFLP, **47(6)**, 659–665 (2000) DOI:10.1023/A:1026520507223.