Research results of Jerusalem artichoke varieties and hybrids in the forest-steppe of the Omsk region

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Abstract. The article presents the five-year results of the studying the adaptation of varieties, and hybrids of Jerusalem artichoke in the forest-steppe of the Omsk region. The analysis of biometric indicators and crop yield structure is presented. The dynamics of the accumulation of herbage, as well as the periods of the passage of phenological phases are shown. The chemical composition of plants is determined. The studies show that many hybrids and varieties in Western Siberia do not go through the flowering phase, but at the same time form a full-fledged tuber crop. At the same time, the high yield of the aerial mass of Jerusalem artichoke does not always ensure a high yield of tubers. On average, for five years of research, the French D-5 hybrid, Canadian sample and variety samples’ No. 1 and No. 9 we distinguished in terms of herbage productivity. This indicator was 49.4-58.9 t / ha. In terms of tuber productivity, the best varieties were No. 9 and No. 12, as well as the Sireniki-1 variety (29.1-30.2 t / ha). The distinguished varieties and hybrids of Jerusalem artichoke are recommended for the introduction into production in order to improve the forage base of agricultural enterprises. The research on the selection of varieties and hybrids in order to obtain high-tech tubers (large and aligned) for processing in the food industry will be continued.

1. Introduction

As practice shows, the solution to the problem of productivity increase of animals and in particular cattle, is in 70% determined by the level and availability of food supply and only in 30% by the breed of animals. Thus, one of the fundamental conditions for the further growth of animal productivity is a well-organized system of feed production. In this regard, it is necessary to introduce new, high-yielding and nutritionally balanced plants in production in order to solve the problem of fodder provision. One of these crops is Jerusalem artichoke [1–3].

According to the variety of uses, Jerusalem artichoke is one of the most promising universal crops. This plant can be used for both food and feed purposes. Salads, jams, chips are made from Jerusalem artichoke tubers [4]. Especially useful products from this plant are for patients with sugar disease due to the high content of inulin [5]. The herbage is used for animal feed both in fresh form and in the form of silage.

At the moment, the wide range of varieties and hybrids of Jerusalem artichoke, both in the world and in our country, allows rational selection and development of new varieties for various purposes.
In Russia, Jerusalem artichoke is considered a more promising raw material compared to other plants similar in biological characteristics due to the simplicity of agricultural technology, the possibility of wintering and processing in the spring, high yield of tubers, as well as herbage, which has the same nutritional value as corn and sunflower traditionally cultivated in the region [6].

Jerusalem artichoke has not yet received wide distribution in Western Siberia, although there are some studies on the methods to cultivate this crop. First of all, in order to spread Jerusalem artichoke plantations in the region, it is necessary to select varieties and hybrids adapted to specific conditions.

Therefore, the purpose of our research was to identify more promising varieties for introduction into production in order to obtain the maximum yield of herbage and tubers in the forest-steppe of the Omsk region.

2. Object, conditions and methods of the research

We used 18 varieties and hybrids of Russian and foreign breeding as the object of the research.

The studies were conducted on the small experimental field of Omsk State Agrarian University named after P.A. Stolypin, located in the southern forest-steppe zone of the Omsk Region in 2015-2019. The soil of the land was meadow-chornezem, medium-power, low-humus, medium-loamy. Weather conditions during the years of research were different, but in general, the discrepancies with long-term average climate data of the southern forest-steppe of the Omsk region were insignificant. The biological characteristics of the variety or hybrid, as well as the weather conditions of the growing season during the years of research had the most significant impact on yield.

The studies were carried out in collaboration with the Agro-Technological Research Center on the approved methods for field experiments with fodder crops and methods of state variety testing of agricultural crops [7].

3. Research results

The phase processing of Jerusalem artichoke development and the duration of interphase periods to a greater extent depends on the course of average daily temperatures and soil moisture and the year of plant life [8]. Under the same conditions, in plants of the second year of life, the formation of stolons begins at 6-10 days, tubers are formed at 15-17 days, flowering 6-16 days earlier than in plants of the first year of life and the duration of the flowering-ripening period increases 9-14 days, which contributes to the accumulation of a higher yield of herbage (Table 1).

| Variety, variety sample, hybrid | Average dates of phenological phases |
|---------------------------------|-------------------------------------|
|                                 | Growing | Shooting | Flowering | Tuberization |
| Variety sample № 7             | 12.05   | 22.05    | 24.07     | 06.09        |
| French D-5                     | 10.05   | 20.05    | -         | 06.09        |
| North Caucasian                | 05.05   | 15.05    | -         | 01.09        |
| Omsk red                       | 10.05   | 20.05    | 29.07     | 06.09        |
| Nakhodka                       | 10.05   | 20.05    | 28.07     | 29.09        |
| Hybrid 85/K                    | 12.05   | 22.05    | -         | 06.09        |
| Sakhalin red                   | 12.05   | 22.05    | 30.07     | 01.09        |
| Variety sample №12             | 12.05   | 22.05    | 26.07     | 06.09        |
| Hybrid 7-22                    | 06.05   | 16.05    | 28.07     | 16.09        |
| Dagnytral                      | 12.05   | 22.05    | 30.07     | 06.09        |
| Kiev white                     | 16.05   | 26.05    | 30.07     | 31.09        |
| Sireniki-1                     | 12.05   | 22.05    | 20.07     | 01.09        |
| Variety sample № 3             | 10.05   | 20.05    | 25.07     | 01.09        |
| Variety sample № 11            | 10.05   | 20.05    | 20.07     | 02.09        |
| Canadian variety               | 05.05   | 15.05    | -         | 06.09        |
| Vylgotsky                      | 13.05   | 23.05    | 25.07     | 01.09        |
| Variety sample № 9             | 12.05   | 22.09    | 27.07     | 01.09        |
| Variety sample № 1             | 16.05   | 26.05    | 25.07     | 06.09        |
In this research, the growth of Jerusalem artichoke depended on the variety. The North-Caucasian variety and Canadian sample started the vegetation earlier (May 5 on average), the Kiev White variety and Variety No. 1 grew on May 16 on average. The growth of the aerial mass of Jerusalem artichoke varieties during the growing season was uneven, but on average plant growth ceased by September 7. Not all the varieties in the southern forest-steppe of the Omsk region reached the flowering phase. Thus, the North-Caucasian variety, Hybrids 85 / K and French D-5, the Canadian variety sample completed the vegetation in the stem phase, but this did not affect tuberization. The period of tuber formation of different varieties began from August 15–20 and lasted until September 31.

The main indicator of the adaptability of plants to specific soil and climate conditions is their active growth and development during the growing season. The analysis of biometric indicators showed a trend of different intensities of growth and development of varieties, hybrids and varieties of Jerusalem artichoke. The results are presented in Table 2.

Table 2. Biometric indicators of varieties, sample varieties and hybrids of Jerusalem artichoke (in average for 2015-2019)

| Variety, variety sample, hybrid | Plant height, cm | The number of shoots per plant, pcs |
|---------------------------------|------------------|-----------------------------------|
| Variety sample № 7             | 201              | 4                                 |
| French D-5                     | 280              | 6                                 |
| North Caucasian                | 262              | 4                                 |
| Omsk red                       | 202              | 4                                 |
| Nakhodka                       | 233              | 4                                 |
| Hybrid 85/K                    | 240              | 3                                 |
| Sakhalin red                   | 177              | 4                                 |
| Variety sample №12             | 202              | 4                                 |
| Hybrid 7-22                    | 234              | 6                                 |
| Dagngytral                     | 155              | 4                                 |
| Kiev white                     | 173              | 4                                 |
| Sireniki-1                     | 171              | 8                                 |
| Variety sample № 3             | 199              | 4                                 |
| Variety sample №11             | 154              | 4                                 |
| Canadian variety               | 307              | 2                                 |
| Vylgortsky                     | 142              | 5                                 |
| Variety sample № 9             | 185              | 4                                 |
| Variety sample №1              | 193              | 5                                 |

The height of plants of these varieties and hybrids was different. Thus, at the end of the growing season, the maximum height was observed in the Canadian sample varieties (307 cm) and the French D-5 hybrid (280 cm). The smallest plant height was in Vylgortsky, Dagngytral varieties and Variety sample 11 (142-155 cm). In other versions, this indicator varied from 171 to 262 cm.

As a rule, in the first year of life, the number of shoots on the Jerusalem artichoke plant is from 1 to 3 pcs. By the third year of life, this value can reach 21-22 pcs. per plant (Sirenniki-1, Hybrid 7-22). In average, over five years, the largest number of shoots per plant was in the Sirenniki-1 variety (8 pcs.) and Hybrids 7-22 and French D-5 (6 pcs.). In other plants, this indicator ranged from 2 to 5 pcs.

The productivity of Jerusalem artichoke plants consists of many factors. First of all, the impact on this indicator is provided by weather conditions during the growing season and nutrient mode of the soil. Varietal characteristics of plants play an important role. The integral part of productivity is the crop yield structure (table 3).
Table 3. Yield structure of varieties, variety samples and hybrids of Jerusalem artichoke (in average for 2015-2019)

| Variety, variety sample, hybrid | Mass of 1 shoot, g | The number of tubers per plant, pcs | The mass of tubers of plant, g |
|--------------------------------|-------------------|-----------------------------------|-----------------------------|
| Variety sample № 7            | 177               | 19                                | 497                         |
| French D-5                    | 380               | 25                                | 876                         |
| North Caucasian               | 297               | 23                                | 514                         |
| Omsk red                      | 207               | 17                                | 819                         |
| Nakhodka                      | 416               | 22                                | 882                         |
| Hybrid 85/K                   | 364               | 15                                | 685                         |
| Sakhalin red                  | 187               | 19                                | 738                         |
| Variety sample № 12           | 227               | 23                                | 1087                        |
| Hybrid 7-22                   | 244               | 28                                | 591                         |
| Dagngytral                    | 154               | 35                                | 958                         |
| Kiev white                    | 184               | 21                                | 560                         |
| Sireniki-1                    | 154               | 28                                | 1005                        |
| Variety sample № 3            | 277               | 15                                | 484                         |
| Variety sample № 11           | 174               | 25                                | 847                         |
| Canadian variety              | 474               | 14                                | 455                         |
| Vylgortsky                    | 121               | 32                                | 779                         |
| Variety sample № 9            | 242               | 32                                | 1290                        |
| Variety sample № 1            | 269               | 17                                | 535                         |

The analysis of the table shows that the maximum mass value of one shoot was in Nakhodka variety (416 g) and the Canadian sample (474 g), which was 24-291% more than in other variants. A relatively high level of mass of one shoot was also noted in the 85 / K and French D-5 hybrids - 364 and 380 g, respectively. The minimum value of this indicator was in the varieties Vylgortsky, Dagngytral and Sireniki-1 - 121-154 g.

The important indicator of the productivity of tubers is their number per plant. In our studies, the largest number of tubers was in Vylgortsky, Dagngytral varieties and variety sample No. 9 - 32-35 pcs per plant. The increase compared to other options was 25-105%. The smallest number of tubers was formed by Omsk Red variety and Canadian Sample, 85 / K hybrid, variety samples No 1 and No 3 - 14-17 pcs.

The mass of tubers of one plant determines the crop yield. The studies showed that the maximum mass of tubers is formed by Sireniki-1 variety and variety samples No. 9 and No. 12 - 1005-1290 g. A significant increase compared to other varieties and hybrids was 46-183%. The minimum mass of tubers from one plant was in Canadian sample and Variety sample No. 7 - 455-497.

The above mentioned indicators were decisive in the formation of the yield of herbage and Jerusalem artichoke tubers (table 4).

In average, the maximum yield of herbage over five years was provided by variety samples No. 1 and No. 9 (49.6-50.6 t / ha), as well as French D-5 hybrid (58.9 t / ha). The increase compared to other varieties was 26-126%. The lowest yield of herbage was in Dagngytral variety and variety No. 7 - 26.1-26.8 t / ha.

The largest yield of tubers per hectare was in the Sireniki-1 variety and variety samples No. 9 and No. 12 - 29.1-30.2 t / ha. The minimum value of this indicator was in North Caucasian variety and Canadian samples - 12.7-12.9 t / ha. In other varieties and hybrids of Jerusalem artichoke, the tuber yield varied in the range 13.7-24.5 t / ha.

In feed production and animal husbandry, one of the criteria for the assessment of a variety and a hybrid for its further introduction into production is the determination of its productivity, that is, the concentration of nutrients (feed units, protein, etc.) from a unit area (table 5).
Table 4. Yield of Jerusalem artichoke varieties, sample varieties and hybrids (in average for 2015-2019)

| Varieties, sample variety and hybrid | Herbage, t/ha | Tubers, t/ha |
|-------------------------------------|---------------|--------------|
| Variety sample № 7                 | 26.8          | 13.7         |
| French D-5                         | 58.9          | 19.4         |
| North Caucasian                    | 46.8          | 12.7         |
| Omsk red                           | 37.1          | 17.2         |
| Nakhodka                           | 39.7          | 19.7         |
| Hybrid 85/K                        | 41.8          | 16.5         |
| Sakhalin red                       | 33.4          | 17.0         |
| Variety sample №12                 | 43.6          | 29.4         |
| Hybrid 7-22                        | 46.7          | 22.0         |
| Dagngytral                         | 26.1          | 24.5         |
| Kiev white                         | 31.1          | 24.5         |
| Sireniki-1                         | 32.5          | 29.1         |
| Variety sample №3                  | 46.3          | 13.9         |
| Variety sample №11                 | 32.6          | 18.6         |
| Canadian variety                   | 49.4          | 12.9         |
| Vylygortsky                        | 32.7          | 17.3         |
| Variety sample №9                  | 49.6          | 30.2         |
| Variety sample №1                  | 50.6          | 14.1         |

Analyzing the research results, it is necessary to state that the concentration of nutrients directly correlates with the crop yield. Thus the maximum productivity of herbage was ensured by the Canadian sample variety, variety samples No. 1, No. 9 and French D-5 hybrid - the yield of fodder units reached 11.4-13.5 t / ha. In the same cases, the increased yield of digestible protein was also noted - 939-1119 kg / ha.

Table 5. Productivity of Jerusalem artichoke varieties, sample varieties and hybrids

| Varieties, sample variety and hybrid | Herbage | Tubers | Digestible protein, kg/ha | Digestible protein, kg/ha |
|-------------------------------------|---------|--------|---------------------------|---------------------------|
| Variety sample № 7                 | 6.2     | 509    | 3.7                       | 206                       |
| French D-5                         | 13.5    | 1119   | 5.2                       | 291                       |
| North Caucasian                    | 10.8    | 889    | 3.4                       | 191                       |
| Omsk red                           | 8.5     | 705    | 4.6                       | 258                       |
| Nakhodka                           | 9.1     | 754    | 5.3                       | 296                       |
| Hybrid 85/K                        | 9.6     | 794    | 4.5                       | 248                       |
| Sakhalin red                       | 7.7     | 635    | 4.6                       | 255                       |
| Variety sample №12                 | 10.0    | 828    | 7.9                       | 441                       |
| Hybrid 7-22                        | 10.7    | 887    | 5.9                       | 330                       |
| Dagngytral                         | 6.0     | 496    | 6.6                       | 368                       |
| Kiev white                         | 7.2     | 591    | 6.6                       | 368                       |
| Sireniki-1                         | 7.5     | 618    | 7.9                       | 437                       |
| Variety sample №3                  | 10.6    | 880    | 3.8                       | 209                       |
| Variety sample №11                 | 7.5     | 619    | 5.0                       | 279                       |
| Canadian variety                   | 11.4    | 939    | 3.5                       | 194                       |
| Vylygortsky                        | 7.5     | 621    | 4.7                       | 260                       |
| Variety sample №9                  | 11.4    | 942    | 8.2                       | 453                       |
| Variety sample №1                  | 11.6    | 961    | 3.8                       | 212                       |
The largest concentration of nutrients from tubers was in Sireniki-1 variety and variety samples 9 and 12: feed units - 7.9-8.2 t / ha and digestible protein - 437-453 kg / ha.

4. Conclusion
For the formation of a sustainable fodder supply in the region, it is necessary not only to improve modern technologies for the cultivation of traditional crops, but also introduce promising new plants. Jerusalem artichoke is practically not used in the West Siberian region, while the technology of its cultivation in the Omsk region was developed in the 80s of the 20th century. It is necessary to use varieties adapted to local soil and climatic conditions for quick and high-quality introduction of Jerusalem artichoke into production.

As a result of five years of research, it was found that for the production of green fodder or silage in the forest-steppe of the Omsk region, it is advisable to use the Canadian sample, variety No. 1, No. 9 and the French D-5 hybrid, which ensured the maximum yield of herbage (49.4-58.9 t / ha), the yield of feed units (11.4-13.5 t / ha) and digestible protein (939-1119 kg / ha). For the production of tubers, it is better to use the Sireniki-1 variety and variety samples No. 9 and No. 12 with a yield of 29.1-30.2 t / ha.

In addition, variety samples No. 1, No. 9 and No. 12 are recommended for further selection of Jerusalem artichoke in the Omsk region.

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