The Cultivation of Early Potatoes in the Conditions of Climate Change

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Abstract. Climate change is becoming increasingly dangerous for agricultural regions. Nevertheless, it gives some advantages for cultivating early potatoes. Potato is a ductile crop ubiquitously grown in Russia. In the Moscow region, it is possible to obtain two early potato crops due to various technological methods, e.g., light germination and large fractions of tubers for the first sowing. The first planting was carried out by the germination of tubers Red Scarlet, Meteor, and Lady Claire. The second planting was carried out with the middle fraction of the same array. The obtained crops of early potatoes show the possibility to get two crops in the Moscow region. It is better to carry out the first planting with a large fraction, which is physiologically older since it is more resistant to various growing conditions and has more nutrients in early planting. Thus, the tubers germinate faster, and the development phases pass faster, which allows one to get the crop by July 15. Such products are sold at higher prices and are economically feasible for any farm. The second landing was carried out on July 15. The received products are in demand among the population and restaurateurs in the fall, indicating the appropriateness of this cultivation technology. Therefore, climate change allows obtaining two early potato crops in the conditions of the Moscow Region.

Keywords: Potato · Productivity · Climate change · Variety · Light germination

1. Introduction

Climate is one of the most important factors in agricultural production. Climate change has recently been spoken about by climatologists and humanity, who observe sharp jumps in temperature, atmospheric pressure, frequent hurricanes in unforeseen places, etc.

Russia is a northern country. The Intergovernmental Panel on Climate Change claims that the mid-latitudes of the Northern Hemisphere are significantly affected. In these areas, during the 20th century, the global temperature increased by 0.6±0.2 °C [3, 8], and the minimum temperatures – by about 0.2 °C [1-2]. The snow cover decreased by about 10%. The duration of ice cover on rivers and lakes decreased by two weeks. Thus, climatologists call the last hundred years a period of climate warming, to which agriculture needs to adapt.

Two-thirds of Russia’s agriculture is concentrated in the European part of the country [4]. Climate change can be dangerous in many agricultural regions of Russia. However, it can be useful for other regions. An increase in temperature can affect the production structure since high temperatures affect plant growth and development, especially with a lack of water. On the other hand, fewer frosts can favorably affect more thermophilic plants, which can be acclimatized to southern regions. The spread of diseases, pests, and weeds will also change.
Climate warming is projected to increase carbon dioxide (CO₂), leading to higher yields [12]. High levels of carbon dioxide stimulate photosynthesis, especially in the so-called C-3 plants, including potatoes. According to some scholars, the increased CO₂ content can increase the average yields by 15%. This positive effect can be offset by changes in temperature, rainfall, or the spread of pests and diseases [9].

Potato is a ductile crop; it easily adapts to the growing conditions, as evidenced by the wide distribution in various agroclimatic regions of the country. Potato is a crop of temperate climate. High yields of this valuable crop in the mid-latitudes of the Northern Hemisphere are essential and relevant. Climate change can be limited by changing agricultural technologies to cultivate crops, improve technological methods, choose the right varieties, etc. It is possible to obtain two early potato crops in the Moscow region due to various specialized processes. The study presents the features of the cultivation of early ripening potatoes in the Moscow region.

2. Materials and Methods
Studies were carried out in 2018–2019 in the Educational, Research, and Production center “Vegetable Experimental Station named after V. I. Edelstein” of the RSAU-MTAA named after K. A. Timiryazev. Soils are sod-podzolic, medium loamy. The thickness of the arable layer is 22 cm. Its easily hydrolyzable nitrogen content is 9.3 mg per 100 g of soil, phosphorus – 15 mg, potassium – 8.3 mg, humus content – 2.6%, pH – 5.8.

The experiment was conducted three times. The experimental plot area is 25 m². The density of standing is 46,7 thousand plants per hectare. We used tubers of medium and large fractions of the elite varieties Zhukovsky early, Red Scarlet, and Meteor for planting. The option without germination (middle fraction) was used as a control. The first planting was carried out in early May with sprouted planting material; the second planting was performed on July 15 with the tubers of the last year. The cultivation technology is standard, including autumn plowing, milling, cutting ridges, planting, interrow cultivation, and hilling.

3. Results
Crop productivity directly depends on weather and climate conditions and their changes. Based on the results of 130 years of continuous observations of the Meteorological Observatory under V. A. Michelson RSAU-MTAA [13], we note that the duration of the growing season, as well as the sum of active temperatures, has increased. According to our data, these parameters allowed us to obtain two crops during the growing season without additional technological methods [6, 9] using early varieties. Early varieties have early tuberization; they begin to form tubers already 10–15 days after germination. There is also the rapid growth of tops. According to some scientists, early varieties include more tubers in the same period of growth and development. In this connection, the choice is made in favor of early varieties to obtain two crops.

The first planting was carried out at an earlier date. The nutrition of potato plants in the first period of growth and development is carried out at the expense of its mother tuber. In the conditions of the Moscow Region, returning cold is possible up to the first decade of June. Moreover, there are sharp jumps in temperature and humidity. Therefore, it is interesting to trace the features of growth and development of potatoes during the first planting, depending on the size of the planting tubers (figure 1). The figure shows that the apical eyes develop during germination, regardless of the various features. Nevertheless, the most developed are the lateral eyes, which subsequently affect the number of shoots. The middle fraction has small seedlings, and the large fraction has sprouts that are thicker in dark green color. However, the projections do not exceed 1.5 cm, which subsequently allows one to use a mechanized planting.
In the transition of tubers from dormancy to germination and seedling growth, they physiologically age, which is associated with an increase in the average daily temperature and the length of the germination period. According to scholars, the high physiological age of planting tubers affects the crop [11]. Firstly, it shortens the period from planting to the emergence of seedlings. Plants fall into more favorable development conditions while the potato growing season shifts. Secondly, it inhibits the growth of tops, a decrease in the mass of which during tuberization reduces the evolution of tubers [9]. Depending on the meteorological conditions, the effect of physiological age on tuberization is enhanced or weakened. Higher temperatures favorably affect the development of the top; low temperatures, on the contrary, strengthen it. In many varieties, the physiological age is associated with apical dominance, with few tuberous stems and tubers forming [11]. Additionally, physiologically old tubers are prone to mechanical black spotting of the pulp and, under the influence of phytopathogenic bacteria, to blackleg damage [5]. In this regard, the experience was set to optimize and clarify the physiological age due to the fraction and obtain a higher yield at an early date.

Seedlings appeared 15–21 days earlier, depending on the variety. The reason for this was that the sprouted tubers accelerated plant development. The first were Zhukovsky early and Meteor, followed by Red Scarlet, and Lady Claire. The variants with large tubers grew one day earlier than variants planted in the middle fraction. Spring cooling, registered in early May, did not affect the plants. Some scholars also noted this fact in their works [12].

Plants obtained from sprouted tubers make better use of tubers’ nutrients and develop a more powerful root system and vegetative mass. When harvesting the first crop on July 15, it is evident that the tuberization in the variants began earlier. In this connection, the number of tubers from one bush and the average weight of tubers from one bush are higher.

**Table 1.** The yield of the potato harvested on July 15 (average for 2018–2019).

| Variant     | The average number of tubers from 1 bush, pcs | The average weight of tubers from 1 bush, g | Yield, t/ha |
|-------------|--------------------------------------------|-------------------------------------------|-------------|
| Red Scarlet | 9.4                                        | 569                                       | 26.8        |
| 1)          | 10.3                                       | 731                                       | 34.1        |
| 2)          | 10.6                                       | 805                                       | 37.6        |
| Meteor      | 6.9                                        | 351                                       | 16.4        |
Thus, potatoes are sold at higher prices. Therefore, potatoes are planted with a short daylight period, which is optimal, so the development phases of the second crop were faster; seedlings appeared already on the 11th day. The vegetative mass was also formed faster but less potent than during the first landing, since potatoes are short-day plants, i.e., with a short daylight hour, plant development accelerates [10]. It was also promoted by a higher temperature [7] than during the first landing. Tuberization began during the budding period. Flowering occurred in August and was longer.

Table 2 shows that even without any technological methods, the tubers planted in the middle of summer (July 15) manage to form a good crop. Marketability is high. Tubers obtained in the second crop were heavier than 80–140 grams. This is evidenced by our research and by summer planting, recommended back in Soviet times.

Such plantings will reduce the chemical load, since Phytophthora infestans start to develop in the second half of the summer when the rains begin. Recently, precipitation was more marked in August, and our plants are even younger and more resistant to various diseases. Phytophthora infestans in our zone develops in the second half of summer. Plants quickly get infected due to abundant moisture and damage in old leaves than in young leaves.

It should be noted that only foreign potatoes or potatoes brought from the southern regions are on sale when harvesting the first harvest. Potatoes are sold at higher prices. Therefore, potatoes produced in the Moscow region will be competitive. Farms can also sell at high prices, although yields are not very high compared to later varieties.

By harvesting the second crop, there are many potatoes of late varieties on the market. Still, later types have a high starch content and taste worse than table varieties of early ripening. The first varieties differ with excellent taste, delicate peel, its flesh does not darken, it is easy to clean, and it is in demand among the population and restaurateurs. Therefore, using the two crops is economically feasible and occurs to increase the overall productivity of the potato industry. It will also reduce the dependence on summer deliveries from foreign countries.

4. Conclusion

Thus, it is possible to get a second crop in the Moscow region in climate change. The use of conventional technological methods, allowing us to accelerate plant growth and development, will allow getting a stable crop of quality tubers. It is necessary to use a large fraction (100 g) for the first planting of

| Variant      | The average number of tubers from 1 bush, pcs | The average weight of tubers from 1 bush, g | Yield, t/ha |
|--------------|---------------------------------------------|---------------------------------------------|-------------|
| Red Scarlet  | 9.7                                         | 776                                         | 36.2        |
| Meteor       | 8.0                                         | 560                                         | 26.1        |
| Lady Claire  | 10.2                                        | 810                                         | 37.8        |
| LSD 95       |                                             |                                             | 1.5         |

Source: Compiled by the authors.

Table 2. The yield of the potato planted on July 15 (average for 2018–2019).
The second planting can use the middle fraction. This will reduce the need for foreign supplies in the summer. Moreover, it will allow us to use table potatoes with excellent taste and quality for the restaurants and population.

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7. Conflict of Interest
The authors have no conflict of interest to declare.

References
[1] Alexandrov V A, and Hoogenboom G 2000 The impact of climate variability and change on crop yield in Bulgaria Agric. For. Meteorol. 104 pp 315-327
[2] Belolubtsev A 2010 Agri-environmental effectiveness of techniques to protect soil from erosion in the context of global climate change Bulletin of the Timiryazev Agricultural Academy 4 pp 31-40
[3] Climate-Energy n.d. Official Website Available at: www.climate-energy.ru
[4] Dyikanova M E et al. 2019 The cultivation of early potatoes – a training manual (Moscow, Russia: Publishing House of the Russian State Autonomy and Agricultural Academy named after K. A. Timiryazev)
[5] Elansky S, Smirnov A, Dyakov Y, Dolgova A, Filippov A, Kozlovsky B, … Fry W 2001 Genotypic analysis of Russian isolates of Phytophthora infestans from the Moscow region, Siberia and the Far East Journal of Phytopathology John Willy & Sons 149(10) pp 605-611
[6] Gasparyan I N, Levshin A G, Ivashova O N, Butuzov A Ye, and Dyikanova M Ye 2019 Organic technology of cultivation of ecologically pure potatoes of early variety Bulletin of the Moscow Goryachkin Agroengineering University 6(94) pp 14-18 DOI: 10.34677/1728-7936-2019-6-14-18
[7] Hou X and Li R 2019 Interactive effects of autumn tillage with mulching on soil temperature, productivity, and water use efficiency of rainfed potatoes in the loess plateau of China Agricultural Water Management 224
[8] Intergovernmental Panel on Climate Change [IPCC-2007] 2007 Climate change 2007: The physical science basis (Geneva, Switzerland: Summary for Policymakers)
[9] Ivashova O, Sychev V, Dyikanova M, Levshin, A, and Gasparyan 2020 Two-yielding potato culture in Moscow region IOP Conference Series: Earth and Environmental Science Voronezh State Agrarian University, named after Emperor Peter the Great (pp. 012067). DOI: 10.1088/1755-1315/422/1/012067
[10] Karmanov S N, and Serebrennikov V S 1991 Potatoes (Moscow, Russia: Rosagropromizdat)
[11] Levshin A, Gasparyan I, Bitoev B, and Shchigolev S 2019 Constructive features of the device remove the apical shoots of potatoes. In 18th International Scientific Conference: “Engineering for Rural Development” (pp 532-537) (Jelgava, Latvia: Engineering for Rural Development) Available at: www.tf.ltu.lv/conference/proceedings 2019/Papers/N163.pdf DOI: 10.22616/ERDev2019.18N163
[12] Pisarev B A 1986 Production of early potatoes (Moscow, USSR: Rosselkhoznadzor)
[13] Sennikov V A, Larin L G, Rossinsky T M, Beloliptsev A I, and Korovina L N 2005 Fluctuations in climate change in Petrovsko-Razumovsky over a 125-year observation period TSAHA News 1 pp 141-146