Two-yielding potato culture in Moscow region

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Abstract. Double potato harvest is obtained in the southern regions of the country. In recent years, due to warming, this method of growing has become possible in the middle lane, in the Moscow region. Tubers are marketable, have a delicate taste and are in demand among the population. The first crop is sold at a higher price, and the second crop allows the use of young delicious potatoes until late autumn. This contributes to the production of physiologically young tubers, which leads to the maintenance of planting material in a healthy state for a longer time without variety updating, also physiologically young tubers are better stored and need to be stored less time, thereby reducing storage costs. Obtaining two harvests of potato tubers will make the potato industry in Russia more autonomous and economically more profitable.

1. Introduction
In recent years, there has been a climate change on the Earth toward warming, the duration of warm days is getting longer, and the average annual temperature is increasing. In addition, anomalies, sharp jumps in temperature, droughts, heavy rains and hurricanes are more often observed.

In Russia, according to Russian meteorological service, the average annual temperature has increased, the greatest warming is observed in the northern regions of the Russian Federation. According to their forecasts, in the next 10-50 years, the average temperature in winter throughout Russia may increase by 2 - 5 °C, summer temperatures will increase by 1 - 3 °C (Fig. 1)\textsuperscript{[1]}. Warming temperatures for agriculture in the Russian Federation carries not only risks, but also benefits. Under the changing conditions of warming in recent years, it has become possible to cultivate a two-crop potato crop.

A two-yielding potato culture is solved in the more southern regions of our country, in Ukraine, Central Asia, etc. Such plantings are characterized by a decrease in the degeneration of varieties and are considered an effective method of seed production of early ripening varieties. Also, tubers obtained from two-crop crops are in great demand among the population and the restaurant business, having a delicate peel and a delicious taste, since early table varieties are used for growing by the two-crop culture method.

According to some scientists, such potatoes are less prone to sprouting, tubers are more intense coloration and tubers are small and convenient to prepare\textsuperscript{[2]}.

The possibility of cultivating potatoes by the two-crop method in the conditions of the Moscow region was studied.

2. Materials and methods
Studies were carried out in 2018-19 years on the site of the laboratory of vegetable growing RSAU-MTAA (Russian State Agrarian University - Moscow Timiryazev Agricultural Academy).

Soils are soddy-podzolic medium loamy, arable layer thickness of 20 . . . 22 cm, easily hydrolyzable nitrogen content of 9.3 mg per 100 g of soil, phosphorus - 15.0, potassium - 8.3 mg per 100 g of soil, humus 2.6%, pH- 5.8.
The experiments repeated for 3 times. The area of one experimental plot is 25 m². Planting pattern was - 70 x 35 cm. For planting, seeds of the middle fraction (40 ... 80 g), the elite were used. Planting dates - the first planting when warming the soil to 6 ... 8 °C., Usually in early May (May 4..6). The second landing was carried out on July 15 immediately after harvesting the first landing on the vacant seat. The cultivation technology is standard.

3. Research results and discussion

For a two-crop potato crop, you must have a long growing season. Long-term climatic data of vegetation periods were analyzed such as temperature, precipitation, the beginning of the vegetation period and the end.

Air temperature is one of the important climatic characteristics. In winter, an increase in temperatures is observed; there is no obvious summer increase, but the temperature gradient between the cold and warm periods increases, as can be seen from Figure 1.

![Figure 1. Trend of average temperatures in recent years](image)

Also, the climatic characteristic is the amount of precipitation, as the potato makes high demands on soil moisture [3] for the conditions of the Moscow region, the transpiration coefficient is 300 ... 450 [4]. With a lack and excess of moisture in the soil, the transpiration coefficient increases. According to Pisarev B.A. to obtain a yield of 250 ... 300 c / ha, the water consumption according to its data is 1500 ... 3000 t / ha [2].

The potato has a weakly expressed cuticle and low osmotic pressure; in this regard, it is a hygrophilic type plant, i.e. more adapted to humid conditions. Therefore, potatoes are sensitive to sudden changes in temperature and humidity. High moisture demand is observed during the period of “budding-mass flowering” and insufficient rainfall dramatically affects productivity and it decreases to 50 ... 60% [5]. Small droughts during this period also reduce crop yields. Potatoes use 5 ... 6 mm of water per day from the soil moisture reserve [6]. Therefore, the provision of water is the main task to achieve stable and high yields, especially during tuberization. And the indicator of rainfall is one of the main limiting factors in the life of potato plants, which affects the quantity and quality of the crop. In recent years, the amount of precipitation in May has been increasing, in June it has been decreasing, as can be seen from Fig. 2. In the middle and end of the month of June, the period of “budding-mass flowering” is coming.
In 2018, it was favorable for the growth and development of potatoes. In 2019, there was a high air temperature in the month of June and there was practically no rainfall during this period, in July the temperature decreased and the amount of precipitation increased.

**Figure 2.** Change in average rainfall for May (a) and June (b) months compared to years

**Figure 3.** Average daily temperature for the growing periods of 2018-19 (according to www.climate-energy.ru)

**Figure 4.** Precipitation in 2019 (according to www.climate-energy.ru)
Analyzing the data, it is clear that the growing season has increased as a result of warming (Fig. 5), potatoes can be planted in late April or early May. As a result of warming, it is possible to land earlier than the recommended landing dates [7-8].

An important point in obtaining early production is the selection of varieties. As a rule, for a two-yielding potato culture, it is possible to use early and medium early varieties that have a short growing season or those varieties that are capable of rapid germination and tuberization, etc. Interesting scientific works by a number of scientists on the cultivation of varieties that do not have a dormant period and do not need artificial violation of it are found. Hybrid two-yielding potato varieties are obtained by crossing cultivated and wild and semi-wild potato species [2]. At present, single-crop varieties with a shallow dormant period are used for two-crop crops.

Agro-technics with a two-crop culture is slightly different from single-crop culture. A feature is the early planting of potatoes with the use of germination and other techniques that accelerate the growth and development of plants.

Planting was carried out last year's seed material, as young tubers did not pass the rest period during early harvesting. Although according to some scientists it is possible to use freshly harvested tubers for planting, they must be treated with stimulants to disturb the dormant period [9]. They are washed with cold water and treated with thiourea and gibberellins. In our case, we used last year's planting material with white sprouts. This requires additional storage costs at low positive temperatures.

Planting was carried out on July 15 at the place of harvested potatoes (Fig. 6). By July 15, the days begin to shorten, and, as you know, with a short day, the formation of tubers and their ripening is faster.

The shoots were already on the 11th day, the vegetative mass also quickly formed, by the third decade of August, the plants bloomed (August 23 - Fig. 7), flowering lasted until September 10. The formation of tubers began during the budding period. Harvesting was carried out on day 52 from the beginning of seedlings (seedlings July 26) September 17.

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**Figure 5.** Length of the growing season as a result of warming (according to [www.climate-energy.ru](http://www.climate-energy.ru)), linear trend \(-y = 0.5899x + 165.63\)
Interphase periods in this case are faster, since there is enough heat, the soil is warm and there are no night frosts. Nutrients were introduced during planting, and the plants were provided with moisture through rainfall and watering. Plants were distinguished by a small number of stems (1-2 stems).

The yield data are presented in table 1. The yield of the first crop was 710 grams, for July 15 these are good indicators, at this time the price of tubers of young potatoes is quite high, when harvesting at the recommended time (end of July), the yield was 940 g / 1 bush.

**Table 1. Yield of early potatoes, on average for 2018-19**

| Option        | Cleaning 15.07. | Cleaning 30.07. | Cleaning 20.09. |
|---------------|-----------------|-----------------|-----------------|
|               | g / rast.       | g / rast.       | % ± to control  |
| Landing May 4 | 710             | 940             | + 33.0          |
| Landing July 15| -               | -               | -               |

Figure 6. Potato planting July 15

Figure 7. Flowering potatoes on August 23
Productivity is quite high for the second crop. Marketability is high, tubers are mainly medium and large fractions: 70 ... 120 gr. Rounded oval in shape, perfectly suitable for use in food. The tubers have a very delicate peel and a non-darkening flesh, easy to clean. All early varieties are distinguished by good nutritional and gustatory qualities, good digestibility in the preparation of boiled potatoes and mashed potatoes. It should be remembered that in the second half of the summer in our area potatoes are affected by late blight and it is necessary to protect the plants [10-12]

Productivity was 560 gr 1 bush (this year was characterized by an increased amount of rainfall in the July – August month), the plants were provided with all the factors of life in sufficient quantities. During the harvesting period, a lot of medium late potatoes are sold on the market. They are good for storage and use at a later date. Later varieties are also high in starch and can be used for technical purposes.

4. Conclusion
The economic efficiency of growing potatoes using the two-crop method is not in doubt. Thus when harvesting the first crop earlier, there is an advantage from selling young potatoes at a higher price. The second harvest allows eating young delicious potatoes until late autumn. It will also help to maintain healthy planting material for a longer time without varietal renewal, since less degeneration of the variety and smaller tubers are physiologically young and give a higher yield. Physiologically, young tubers are also better stored and need to be stored in less time, thereby reducing storage costs. This will make the potato industry in Russia more autonomous and economically more profitable.

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

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