JUSTIFICATION OF POSSIBILITY OF CULTIVATING IN MOSCOW REGION TWO-CROP CULTURE OF EARLY POTATOES

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Abstract. Climate change is one of the world's modern challenges. Climate warming for Russia carries certain risks, but also gives some advantages - the ability to cultivate early potatoes in a two-crop culture in the third light zone, i.e. cultivation of two crops in one growing season. This is confirmed by agroclimatic data presented by the V.A. Meteorological Observatory V.A. Michelson. An increase in the sum of active temperatures above 10 ° C over the past 30 years, an increase in the duration of the growing season due to an earlier start of the growing season and its later end, were noted. Moisture resources are in sufficient quantity. The studies were conducted on the site of the department "Olericulture ", Timiryazev Academy in 2018 ... 19. The first planting was carried out in early May, the harvesting took place on July 15, and on the same day the second planting of last year's tubers, which were harvested on September 20, was carried out. The early varieties were used: Luck, Meteor, Zhukovsky early, Bullfinch, Red Scarlet. As a result of the research, two harvests of ecologically clean standard products of early ripening varieties with good taste and nutritional qualities were obtained. The minimum average weight from 1 bush was obtained from the Bullfinch variety - 388 g, the maximum from the Zhukovsky early variety with germination. Light germination for the first crop allows to accelerate the passage of development phases and subsequently affects the yield (an increase of 1.3-2.0 times). The minimum average weight from 1 bush in the second crop was obtained in the control variant, with the addition of natural concentrate of glauconite sands and watering, the yield increased by 1.4 times. Thus, in changing climatic conditions in the third light zone, two crops can be obtained and this will increase the efficiency of potato production.

Keywords: potatoes, variety, yield, sum of active temperatures, growing season.

Introduction

According to the UN, climate change is one of the modern challenges, as there are various anomalies in weather and climate conditions: droughts, heavy rain showers, hurricanes in places where they never existed, not to mention jumps in temperature and pressure. All of this puts food production at risk.

The UN Intergovernmental Panel on Climate Change notes that the average global temperature has increased by 0.85 ºC by 2013, increased sea volume, etc. [1]. Also, the Federal Service of the Russian Federation Roshydromet emphasizes that the average annual temperature in Russia has increased and the greatest warming occurs in the northern regions [2]. Warming for Russia, as for many other countries, carries certain risks to agriculture, especially in areas of insufficient moisture. In the Moscow region, related to the zone of sufficient moisture, climate warming gives some advantages, namely, the ability to cultivate early potatoes in a two-crop culture.

Potato is an important crop in the world and in our country [3]. Gross production is more than 370 million tons [4]. More than half of the world production is in developing countries for the nutrition of the population. In Russia, it is also a fundamental element of the food security of the country, since the basis of the population's nutrition is bread and potatoes [5]. Its economic value is also increasing due to the use of potato starch for various purposes - from confectionery production to oil drilling [6].

According to FAO, China, India and Russia are the main producers of gross potato. However, gross production is not an indicator of industry development. The main indicator is crop productivity. In terms of productivity, Russia is in one of the last places. According to FAOSTAT, the average world productivity in 2016 was 19.6 $t \cdot ha^{-1}$, in Russia – 14.6. The yield growth of this crop is observed in all countries and continents; the world rating is headed by the USA and New Zealand, where the average yield was 49.0 $t \cdot ha^{-1}$ [7-9].

In some countries, there is a system of "parallel cultivation of potatoes and rice" [4], where both rice and potatoes are cultivated during the growing season (up to 32 tons of potatoes and rice per hectare). In conditions of warming in our region, it is possible to cultivate early potatoes twice on the same field and get a harvest of marketable potatoes. The purpose of our research was the agronomic

justification of the technological processes of cultivating a two-crop culture of early potatoes in the third light zone (Moscow region). For this, climate data were analyzed and two-year experience was set, which will be continued in the future.

Materials and methods

Studies were carried out in 2018-2019 on the site of the laboratory of vegetable growing RGAU-MSHA named after K.A. Timiryazev. Soils are soddy-podzolic medium loamy, the thickness of the arable layer is 20-22 cm, the content of readily hydrolyzable nitrogen is 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 were repeated three times. The area of one experimental plot is 25 m^2. Planting pattern – 70 × 35 cm. Standing density 46.7 thousand plants per hectare. To plant were used tubers of medium fraction (40...80 g), the elite. Planting dates – the first planting, when the soil is warm 6-8 ºC, usually in early May (May 4-6). Varieties: Luck, Zhukovsky early, Bullfinch, Red Scarlet, Meteor. Options with germination and without germination. The second landing was carried out on July 15 immediately after harvesting the first landing on the vacant seat with planting material of the last year of Meteor variety. Planting options for the second crop: 1) concentrate of glauconite sand with drip irrigation; 2) drip irrigation; 3) control - a natural background. The cultivation technology is standard. It included tillage (plowing in the autumn, milling in spring, cutting ridges before planting), as well as plant care, which consisted of inter-row processing and hilling. Planting was carried out by a single-row potato planter for field research. When caring for plantings, treatment was carried out against the Colorado beetle (Leptinotarsa decemlineata) with the drug "Actara" (a.s. thiamethoxam) norm of 60 g ha^{-1}, treatment against Phytophthora (Phytophthora infestans) was not carried out. The generally accepted methods were used in conducting field and laboratory studies on potato culture [10] and statistical processing of data B. Dospekhova [11].

Research results

Potato productivity depends on a combination of factors: nutrition elements, climatic conditions, especially the length of the growing season and its use by plants, the amount of precipitation that falls, a combination of temperature and humidity conditions, etc. All plant life processes (biochemical and physiological) are possible only with a certain heat balance, determined by the amount of heat and the duration of its action. Tubers that have passed the dormant period begin to germinate at a temperature of 3-5 ºC, but very slowly. The normal germination of tubers is observed at a soil temperature of 7-8 ºC [12]. For the full development of plants, a certain sum of active temperatures (more than 10 ºC) is necessary. For potatoes, in connection with different ripening periods, it is 1000-1600 ºC, for early varieties 1000-1100 ºC [6].

The availability of heat during the growing season depends on the beginning of the growing season. F.F. Davita revealed a relationship between the beginning of spring and the total amount of heat in summer [13]. The index of the beginning of spring is conventionally accepted as the date of a steady transition of air temperature through 10 ºC in spring. The sooner this transition occurs, the greater the sum of the active temperatures will accumulate. Late spring will be a harbinger of this year's overall heat shortage [14]. This relationship was established as a result of processing long-term data from meteorological observations of the main weather stations [14], data from the V.A. Meteorological Observatory are presented. Michelson (Table 1).

Table 1

Sum of active air temperatures above 10 ºC, 1990-2019 (according to the V.A. Michelson Meteorological Observatory)

Years	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
$\sum_t$>10 ºC	2082	2466	2480	2055	2073	2558	2301	2186	2472	2450
Years	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
$\sum_t$>10 ºC	2258	2383	2561	2529	2333	2626	2555	2592	2193	2521
Years	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
$\sum_t$>10 ºC	2964	2943	2857	2578	2769	2565	2566	2116	2672	2527

The sum of active temperatures increases over the years, so in 1990 it was 2082 ºC, and in 2018 – 2672 ºC. The minimum sum of active temperatures over the past 30 years was 2055 ºC in 1993, the maximum – 2964 ºC in 2010. The difference between them was 909 ºC, which indicates large jumps in temperature. The average sum of active temperatures in the observed years has changed, so the average sum of active temperatures above 10 ºC for 1881-1980 was 2072 ºC, for 1961-1990 – 2211, and for 1981-2010 already 2399 ºC. The difference is 327 ºC. This testifies to the changing climate conditions, to which it is necessary to adapt in the future and use them correctly.

The temperature increase does not occur linearly, there are also decreases, but there is a trend towards an increase in the duration of the growing season (Table 2).

Table 2

Vegetation periods from 1988 to 2019 (according to the V.A. Michelson Meteorological Observatory)

Year	Temperature, °C	Beginning of the growing season	End of the growing season	Duration of the growing season, days	Trend of duration
1988	15.2	21.04.1988	17.10.1988	179	175.4
1989	15.4	12.04.1989	03.10.1989	174	175.7
1990	12.4	23.03.1990	28.09.1990	189	176.0
1991	13.7	08.04.1991	24.10.1991	199	176.3
1992	14.0	07.04.1992	05.10.1992	181	176.6
1993	13.4	08.04.1993	14.09.1993	159	177.0
1994	13.6	16.04.1994	07.10.1994	174	177.3
1995	15.4	15.04.1995	16.10.1995	184	177.6
1996	15.8	22.04.1996	22.09.1996	153	178.0
1997	13.6	19.04.1997	25.09.1997	159	178.3
1998	15.6	23.04.1998	30.09.1998	160	178.6
1999	14.6	31.03.1999	16.10.1999	199	178.9
2000	14.2	11.04.2000	13.10.2000	185	179.2
2001	15.4	06.04.2001	09.30.2001	177	179.5
2002	15.6	13.04.2002	03.10.2002	173	179.8
2003	14.3	18.04.2003	17.10.2003	182	180.1
2004	14.1	20.04.2004	13.10.2004	176	180.4
2005	14.5	09.04.2005	20.10.2005	194	180.7
2006	14.6	15.04.2006	15.10.2006	183	181.0
2007	14.4	23.03.2007	13.10.2007	204	181.3
2008	13.5	05.04.2008	27.10.2008	205	181.7
2009	15.2	27.04.2009	11.10.2009	167	182.0
2010	17.1	02.04.2010	04.10.2010	185	182.3
2011	16.6	23.04.2011	15.10.2011	175	182.6
2012	16.0	16.04.2012	12.10.2012	179	182.9
2013	16.3	17.04.2013	28.09.2013	164	183.2
2014	14.7	26.03.2014	05.10.2014	193	183.5
2015	15.0	12.04.2015	09.10.2015	180	183.9
2016	15.6	10.04.2016	12.10.2016	185	184.2
2017	13.6	07.04.2017	03.10.2017	179	184.5
2018	15.6	10.04.2018	25.10.2018	198	184.8
2019	16.7	09.04.2019	24.09.2019	168	185.1

According to Table 2, the beginning of the growing season is shifted to an earlier date (second decade of April), in rare cases it is observed even in the third decade of March (1990; 1999; 2007; 2014). The end of the growing season is also shifted to a later date and ends mainly in the second decade of October, there are also later deadlines for the end of the growing season (1991; 2008; 2018). Due to this, the total duration of the growing season increases.

Temperature is one of the most powerful factors affecting the rate of plant development. It is known that with increasing air temperature (up to a certain limit), according to a number of authors, the pace of plant development accelerates [15]. Scientists believe that the rate of plant development is the path that a plant has traveled in its development per unit of time. So, the duration of the interphase periods decreases [6].

While maintaining the current rate of increase in the air temperature, which is observed from a comparison of climatic data and the needs of the culture, it is clear that in the conditions of the Moscow Region, early potatoes can be grown not only once, but twice.

Potato is a ductile crop; it easily adapts to growing conditions and is cultivated almost everywhere in Russia, starting from Kaliningrad to Kamchatka, except for the Far North [16]. This is possible due to varieties that differ in the length of the growing season.

The vegetation period of early varieties is almost three months, but the interphase periods decrease with increasing temperature, even when cultivating the first and second crops. In the period from planting to the emergence of seedlings, according to Pisarev B.A. [15], the growth of plants, to a greater extent than the features of the genotype, is affected by the temperature and air conditions of the soil. Raising the soil temperature to 18-25 ºC reduces the duration of the planting-seedling period to 12-13 days. The growth of young shoots is enhanced, seedlings appear earlier, due to an increase in the intensity of seedling development. Also, the experiments of the Potato Research Institute found that potatoes at a temperature of 10-12 ºC in moderately moist soil sprout on 25-27 days, at 14-16 ºC – on 18-22 days, ot 18-25 ºC - on 12-13 days, at 27-28 ºC – on 16-17 days. At very low and too high temperatures the rate of potato germination slows down [12; 15].

This is especially observed, when cultivating the second crop. In the middle of summer, when the second planting occurs, the seedling development intensity increases significantly, as a result of which seedlings appear earlier [12] and all periods of development pass faster.

Early varieties begin to form tubers 10-15 days after plant emergence, they are characterized by faster growth of haulm and tuber formation. Over the same period of time, according to a number of scientists, they accumulate more tubers [17]. Therefore, the growing season for cultivation of the second crop of early potatoes will be sufficient.

An important factor in the yield of any crop is the availability of moisture, potatoes make high demands for soil moisture [18]. Due to the fact that potato belongs to the plants of the hygrophilic type due to the low osmotic pressure and poorly expressed cuticle, the tubers are sensitive to sharp changes in humidity and temperature. An increased need for moisture is noted during the period of “budding-mass flowering” and, according to some scientists, with a lack of it during this period, a decrease in the yield to 50-60 % is observed [6; 12; 15].

Moisture resources are estimated by the amount of precipitation (Table 3). In the Moscow Region, the amount of precipitation ranges from 488.0 to 880.5 mm per year, the difference is almost two times.

Table 3

Annual precipitation for the last 30 years, mm

Years	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**
∑ precipitation	823.9	861.9	555.1	831.9	695.2	576.5	561.1	586.7	882.1	566.1
Years	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
∑ precipitation	780.4	762.9	540.1	701.2	865.2	681.0	624.5	648.1	871.2	739.6
Years	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
∑ precipitation	601.9	594.2	810.7	890.8	488.0	716.6	880.5	825.8	646.6	735.8

Providing moisture during tuberization is especially important (May-June for the first crop and August for the second crop). According to researchers, in recent years the amount of precipitation in May has been increasing, in June it has been decreasing [12]. It should also be noted that in the second half of summer, in the conditions of the third light zone, an increase in precipitation is noted, which often leads to the defeat of potatoes by Phytophthora infestans. The provision of moisture can be regulated by irrigation, as well as the provision of mineral nutrition. Therefore, under changing conditions, it is necessary to use technologies of cultivation with irrigation.

Two-yielding potato culture is known in the southern regions of the country, in Central Asia, in China, etc. [4]. A big problem with such cultivation is the planting material. It is necessary until the second landing to keep additional planting material in storage or refrigerators, and this requires additional storage costs. Especially for two-crop cultures, early and mid-early varieties, in which the dormancy period is short, are mainly suitable.

To obtain the second crop, it is possible to use young newly harvested tubers; many scientists indicate this [15], using physical and chemical methods of influence on the newly excavated young stolons [12]. However, the use of these methods is not always quite effective; varietal specificity exists. Interesting is the work on the cultivation of two-yielding varieties of potatoes with a short rest period, which will not need artificial violation of the rest period. A number of hybrid two-yielding varieties were created under the direction of S.M. Bukasova (VIR) [12], unfortunately, currently in practice for two-crop crops single-crop varieties are used, characterized by a shallow and easily broken dormancy. Given the current global climate change, such work will be interesting and in demand in the future.

The phases of development of the first crop did not differ from ordinary plantings, seedlings appeared on days 19-27, the flowering phase was observed depending on the variety on days 27-32, depending on the variety.

Table 4

Potato yield on 07/15/2020 (average for 2017-2019)

Experience variant	Average number of tubers from 1 bush, pcs.	Average mass of tubers from 1 bush, g	Yield, $t \cdot ha^{-1}$
Luck with germination	12.3	857	40.02
Luck without germination	10.3	437	20.40
Zhukovsky early with germination	12.0	925	43.19
Zhukovsky early without germination	12.0	595	27.70
Bullfinch with germination	12.9	742	34.65
Bullfinch without germination	9.2	388	18.12
Red scarlet with germination	10.3	731	34.14
Red scarlet without germination	9.4	569	26.75
Meteor with germination	9.3	822	38.38
Meteor without germination	6.9	351	16.36
LSD_{05} private differences			2.20
LSD_{05} for A (germination)			1.26
LSD_{05} for B (varieties)			$F\phi < F_{05}$

The data in the table indicate that in the variants with germination of the planting material on July 15, the crop was formed; this is evidenced by the number of tubers from 1 bush and the average weight of tubers from the bush. Maximum yields were obtained using light germination of planting tubers for all varieties (by 35.0…50.9 %). High yields are associated with earlier germination, for example, in the Zhukovsky early variety, when germinating over an average of years, seedlings appeared already on day 19, without germination on day 24, respectively, tuberization started earlier, and by the time the tubers were harvested, on average, one the same quantity, but the mass increased, and accordingly the yield became higher.

The second planting was carried out with last year's tubers Meteor. The phases of development of the second crop were faster, as the seedlings appeared already on day 11 (July 26), the vegetative mass also quickly formed, by the third decade of August the plants entered the flowering phase, flowering was long. The interphase periods passed faster, since the air and soil temperatures were optimal for germination and further growth, nutrients were introduced during planting, plants were provided with moisture due to rainfall and watering. Tuber formation began at the beginning of the budding phase. Potato plants were distinguished by a small number of stems (1-2 stems). The cleaning was carried out on September 17-September 18, at 52 days from the start of seedlings.

The yield data are presented in Table 5. The yield 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. Such tubers are in great demand among the population and in the restaurant business.

Table 5

Productivity varieties Meteor landed on July 15, 2018…19

Experience variant	Fraction						Total g from 1 bush; pcs	Total g from 1 bush; g
	Shallow		Medium		Large			
	pcs	g	pcs	g	pcs	g		
Glauconite + drip irrigation	1	25	785	170	5.5	590	9	785
Drip irrigation	1	20	613	170	3	423	8	613
Natural background (control)	3	73	560	154	2	336	8	560

Without the use of irrigation and glauconite sand, the yield was 560 g. on 1 bush (this year was characterized by an increased amount of rainfall in July – August months), plants were provided with all factors of life in sufficient quantities. With the addition of irrigation, the productivity increased by 53 g. on 1 bush due to an increase in the mass of large tubers. In the version with glauconite sands, the productivity increased by 225 g. from 1 bush compared to control. The increase was a large fraction, the tubers were more than 100 g., aligned in weight and shape, which is very convenient for processing.

During the second harvest, a lot of medium-late and late potatoes are sold on the market. They are good for storage and use at a later date. Later varieties also have high starch content and can be used for technical purposes and long-term storage. Early potatoes obtained in the second harvest are in great demand among the population, as it has a very delicate peel and non-darkening pulp, easy to clean. All early varieties are distinguished by good nutrition and taste features, good digestibility in the preparation of boiled potatoes and mashed potatoes, as well as among restaurateurs. Thus, in the conditions of the third light region, to which the Moscow Region belongs, it is possible to obtain a second crop of environmentally friendly standard products of varieties of early ripening, which in market conditions will improve production efficiency.

Conclusions

1. Climatic data allow in the conditions of the Moscow region to obtain a second crop of early potatoes.
2. To get the first crop, it is necessary to use pre-planting light germination, which accelerates the growth and development of plants and increases the productivity by 35.0-50.9 %.
3. When planting the second crop, it is necessary to use glauconite sands, which can increase the productivity by 40 %.

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