FORMATION OF SOLANUM TUBEROSUM YIELD WITH REGULATED NUTRITION LEVEL AND APPLICATION OF GROWTH REGULATORS

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Solanum tuberosum are one of the leading and most valuable food, industrial and feed crops. European cuisine knows more than 200 potato dishes. Processing tubers into food products and semi-finished products opens up great opportunities for their use. They are of particular value for solving the problem of nutrition and it is not for occasional that people call them “the second bread”.

Physiological standards of the Institute of Nutrition of the Academy of Medical Sciences provide for the average annual consumption of 110 kg of potatoes per person. The average per capita consumption of potato tubers in our country is 104 kg per year (Fomicheva L. A. et al., 1989).

Existing potato varieties have a biological yield potential of 400 c/ha or more (Pisarev B. A., 1990). According to N. D. Goncharov et al. (1987), the coefficient of realization of their genetic capabilities ranges from 0.9 to 0.7, but in production conditions it is much lower.

K. A. Timiryazev (1957) notes that the main task of science is to determine optimal conditions, facts that contribute to the best development of plants and to satisfy the needs of plants in these conditions profitably for humanity.

The bulk of the organic matter of a plant - 90-95% or more, is formed during the process of photosynthesis due to carbon dioxide, water and light energy, and only a small part of it is created due to mineral elements (Vecher A. S. et al., 1973; Mokronosov A. T., 1981).

Potato plants use solar energy most effectively when the assimilation surface of the leaves is at least 5-40 thousand m2/ha (Mokronosov A. T., 1990). The energy utilization coefficient of the photosynthetically active part of the solar spectrum is usually 1.0-1.5% (Nichiporovich A. A., 1976) with a theoretically possible range of 4 to 6% (Nichiporovich A. A. et al., 1965). The accumulation of 2-3% of photosynthetically active radiation by cultivated plants on a planetary scale will increase the production of plant products by 4-6 times (Shatilov I. S., 1979).

Many people strive to increase potato yields by applying high rates of fertilizers - especially nitrogen, as well as when cultivating potatoes on soils rich in organic matter, but under conditions of sufficient moisture, rapid growth of above-ground mass is observed, which leads to a delay in tuberization and the accumulation of nitrates in tubers above the maximum permissible concentration (more than 250 mg per 1 kg of raw tubers), and such tubers become unsuitable for food purposes.

The yield level is determined not only by the provision of plants with available forms of macroelements, but also by the content of mobile microelements in the soil (Khachataryan B. S., 1975; Vlasenko N. E., 1987). In conditions of a lack of macroelements, plants produce low and insufficient quality of yields (Stoilov P. P., 1965; Peive Ya. V., 1968).

Although a plant organism is capable of independently synthesizing the biologically active compounds it needs in its tissues, under certain circumstances there is a shortage of these substances and an additional supply of them can have a significant positive effect on the most important physiological and biochemical processes and plant yield (Maksimov N. A., 1946).

In connection with the above facts, there is a special need to study the possibility of controlling the growth and development of potato plants, ensuring a high yield of tubers with good nutritional properties.

Place, methodology and design of research. Experiments to study the characteristics of potato crop formation were carried out in 2005-2007. on the experimental fields of the Department of Plant Growing in the educational and experimental farm of the Timiryazevsk Agricultural Academy (TSHA), Mikhailovskoye, Podolsk district, Moscow region.

The research was carried out in two experiments: in the first one, crop formation was studied at a controlled level of mineral nutrition, and in the second one, crop formation was studied under conditions of the use of physiologically active compounds, copper sulfate and a low-frequency electromagnetic field.

In the first experiment, potatoes were planted after winter wheat in a field crop rotation: fallow (vetch – and - oat mixture), winter wheat, potatoes, barley + perennial grasses, grasses of the first year of use, grasses of the second year of use, oats. Crop rotation is deployed in time and space on poorly, medium and well-cultivated soil.

The soils of the first experimental plot are soddy-podzolic, medium loamy, with a topsoil depth of 20-25 cm. The level of its fertility was characterized by the following indicators (Table 1).

The arrangement of options in the first experiment is as follows: on moderately cultivated soil - 1 - without fertilizers (control); 2 – calculated fertilizer rate for potato yield of 250 c/ha, or absorption of 2% PAR; 3 – calculated fertilizer rates for a yield of 350 c/ha or absorption of 3% PAR; 4 – recommended fertilizer rate for the Moscow region. On well-cultivated soil, the 2nd corresponds to the 3rd, and the 3rd – to the 4th option, on moderately cultivated soil.

The size of the plot on poorly cultivated soil is 360 m^2, repeated 3 times. On medium- and well-cultivated soil, the plot size is 180 and 100 m^2, respectively, and the repetition is 4-fold.

In the second experiment, potatoes were planted outside the crop rotation and its predecessor in 2005 and 2007 was corn for silage, and in 2006 - winter wheat. The soil of the experimental plot is soddy-podzolic, medium loamy, with an arable layer depth of 25 cm. It was characterized by the following agrochemical indicators: pH - 6.0, humus content according to Tyurin - 2.0, easily mobile P_2O_5 and K_2O - 16-18 mg per 100 g of soil.

The scheme of the second experiment included 17 options: 1- control; 2- simarp, 1 mg/l; 3 - krezacin, 40 mg/l; 4 - control (water); 5 - furolan, 30 mg/l: 6 - furolan, 50 mg/l; 7 - furolan, 70 mg/l; 8 - furolan, 10 mg/l; 9 - furolan, 30 mg/l; 10 - furolan, 50 mg/l;

11 - furolan, 60 mg/l; 12 - furolan, 80 mg/l; 13 - furolan, 100 mg/l; 14 – copper sulfate bloom, 500 mg/l; 15 – copper sulfate (budding), 500 mg/l; 16 – copper sulfate (budding), 500 mg/l + (blooming), 500 mg/l; 17– EM. Options 2, 5, 6, 7 and 17 – processing of seed material, and the remaining options – spraying of plants before the budding phase. The size of the survey plot was 75 m^2, the replication was 4 times.

Agrochemical characteristics of experimental plots

Soil	Option	pH			Content								
					humus			mobile P_2O_5			mobile K_2O		
		2005	2006	2007	2005	2006	2007	2005	2006	2007	2005	2006	2007
Well-cultivated	1	6,0	6,0	5,6	2,47	2,44	2,02	13,1	13,0	15,5	16,8	14,8	10,5
	2	6,4	6,0	5,7	2,86	2,78	2,36	25,2	22,6	25,8	25,5	20,4	26,0
	3	6,2	6,0	5,8	2,64	2,76	2,38	22,3	21,6	27,6	20,8	17,3	17,2
Medium cultivated	1	6,0	6,0	5,9	2,19	1,79	1,81	13,4	10,3	11,2	13,9	5,7	5,2
	2	6,6	6,2	6,0	2,45	2,25	2,34	18,5	13,7	18,4	24,0	14,9	16,7
	3	6,6	6,5	5,9	2,40	2,63	2,46	18,0	16,2	21,8	25,5	16,1	23,5
	4	6,4	6,4	6,0	2,28	2,73	2,16	18,1	16,3	21,4	17,5	9,0	13,0
Pour cultivated		4,6	4,7	4,3	1,80	1,84	1,27	2,6	2,4	2,9	6,3	5,6	5,1

Note: humus content according to Tyurin, %;
mobile P_2O_5 and K_2O – mg/100 g of soil.

The object of study was the medium variety Nevsky, released since 1990, which is distinguished by good ecological plasticity and the ability to accumulate high yields on different types of soil and in different soil and climatic conditions, which is very important for the weather conditions of the Moscow region.

Following the harvesting of winter wheat, peeling was carried out in 2 tracks with a disk huller (LDG - 5) to a depth of 6-8 cm, and after corn for silage - with a disc harrow (BDT - 7) in 2 tracks to a depth of 10-12 cm. In September, autumn plowing was made to a depth of 20-25 cm.

In the experiments, organic and phosphorus-potassium fertilizers were applied in fall under the fall plowing, and nitrogen fertilizers were applied during the growing season (½ on days 10-12 after germination and ½ during the flowering phase) with simultaneous incorporation into the soil. The rates of applied mineral fertilizers are shown in Table 2. Organic fertilizers in the first experiment were applied at the rate of 35 t/ha of manure, except for poorly cultivated soil, where organic and mineral fertilizers and protection products have not been applied for 25 years.

2. Norms for applying mineral fertilizers, kg/ha.

Soil	Option	2005	2006	2007
Wellcultivated soil	2	$N_{120}P_{45}K_{247}$	$N_{110}P_{45}K_{234}$	$N_{110}P_{45}K_{177}$
	3	$N_{45}P_{45}K_{45}$	$N_{45}P_{45}K_{45}$	$N_{45}P_{45}K_{45}$
Medium cultivated soil	2	$N_{90}P_{45}K_{155}$	$N_{90}P_{61}K_{165}$	$N_{90}P_{45}K_{148}$
	3	$N_{120}P_{78}K_{74}$	$N_{120}P_{111}K_{178}$	$N_{170}P_{45}K_{209}$
	4	$N_{45}P_{45}K_{45}$	$N_{45}P_{45}K_{45}$	$N_{45}P_{45}K_{45}$

Experiments were carried out according to research methods on a potato culture (Andryushina N.A. et al., 1977), testing regulators of plant growth and development in an open and protected ground (Kazakova V.N. et al., 1990).

The treatment of the planting material with simarp (1 mg/l) and furolan (30-50-70 mg) was carried out the day before planting at the rate of 30 l/t of tubers. The seed material was exposed two days before planting. Before budding, potato plants were sprayed with water, krezacin (40 mg/l), furolan (10-30-50-60-80-100 mg/l) using a backpack sprayer at the rate of 400 l/ha of aqueous solution. Plants were treated with a solution of copper sulfate before budding (500 mg/l) and during flowering, both separately in the indicated phases and together at a consumption of an aqueous solution of 400 l/ha.

During the growing season, the following phenological phases of plants were noted: germination, budding, flowering, harvesting. The beginning of the phase was taken to be the time when this sign was observed in 10% of plants, and the full onset of the phase was taken to be 75% of plants.

The accumulation of raw and absolutely dry mass was studied in dynamics, with the first three determinations coinciding with the phases of germination, budding, flowering, and then after flowering on the 15th, 30th and 45th day. The accumulation of raw matter both in the above-ground part and in the underground part was determined in a sample composed of 10 plants (bushes). The dry matter content in the above-ground mass, roots and tubers was found by drying crushed samples (3-5 times repeated in each sample) in an oven at a temperature of 105°C.

The leaf area was calculated by the “cutting” method during sampling for the accumulation of raw and absolutely dry matter (Nichiporovich A.A., 1955). The photosynthetic potential of the leaf surface of potato plantings was calculated according to the generally accepted method (Nichiporovich A. A., 1955). The net productivity of photosynthesis was determined using the formula proposed by Kidds, West and Briggs (Nichiporovich A. A., 1961).

$$Fnpp = B_2 - B_1 / \frac{1}{2} (L_1 + L_2)\, T, \text{ where}$$

Fnpp – net productivity of photosynthesis;
B_1 and B_2 – dry mass at the beginning and end of the accounting period;
$\frac{1}{2}(L_1+L_2)$ – average working leaf area for this period of time;
T – number of days in the accounting period.

Soil moisture during the growing season was determined monthly by taking soil samples with a drill in the middle of the ridge from a layer of 0-10 cm, every 10 cm with two repetitions, in two repetitions for each soil layer and drying them at the temperature of 105 ° C to constant weight in a dryer closet.

The soil temperature during the period of tuberization of potato plants was determined in the ridge at three depths (5-10-20 cm) from 5 to 14 measurements per day.

The infection of plants by viruses (X, Y, S, M, L) was determined in the leaves of the middle tier at the beginning of the flowering phase in 10-15 fold repetitions using the enzyme immunoassay method (Instructions, 1990).

The content of nitrates in tubers was determined using an ion-selective electrode on a universal ionometer (EV - 74), starch - on a sugarimeter (SU-4), according to the Everes method (Methodology for research on potato culture, 1967); vitamin C content - according to Murri (Peterburgsky A. V., 1968); reducing sugars - according to the Schorl method, total sugars - according to the Felushin method, protein - by the biuret method in the Jennings modification on a photoelectric concentration colorimeter (KFK - 2) (Vinogradova A. A. et al., 1991).

The influence of physiologically active compounds on late blight resistance of potato tubers was assessed by the content of the antifungal substance - rishitin, formed in tubers after infection with an incompatible race of late blight pathogen, as well as after treatment of untreated tubers with growth regulators. The content of rishitin was determined by the colorimetric method (Ozeretskovskaya O. L. et al., 1975).

The content of available phosphorus in the soil was determined according to A. G. Kirsanov, available potassium - according to A. L. Maslova and E. V. Chernisheva (Arinushkina E. V., 1980).

Doses of mineral fertilizers in variants with calculated doses were calculated taking into account affective fertility, removal of the main elements of mineral nutrition with the planned harvest and coefficients of use of nutrients from the soil and applied fertilizers (Zamaraev A. G. et al., 1979).

The yield properties of tubers from the studied variants of the second experiment were studied in a separate experiment, repeated 4 times, where N_{90} P_{60} K_{60} was added. The size of the plots is 30 m^2.

Meteorological conditions during the years of the experiments varied both in the amount of precipitation and air temperature.

The growing season of 2005, in terms of temperature conditions and precipitation distribution, was relatively favorable for the growth and development of potatoes. The average daily air temperature in May was 1.3°C below normal, and the amount of precipitation was approximately at the level of the long-term indicator. During the month of July, the air temperature was 1.1°C below the long-term average, and the amount of precipitation was within the normal range, although in the first ten days it fell almost twice as much as normal. In July, the average daily temperature was slightly below normal. July is characterized by uneven precipitation. In the first ten days of July it was almost absent, but in the third ten days 77.3 mm fell, which is 49.3 mm more than normal. Large amounts of precipitation at the end of the month caused rapid development of late blight. In general, during this month precipitation fell 23.9 mm more than normal. In August, the same pattern of precipitation was observed as in July. In general, during the month precipitation fell 25.5 mm above normal. During the growing season of 2005, the air temperature was 0.7°C below the long-term average, and the amount of precipitation was 43.7 mm more than normal.

The growing season of 2006 was characterized by higher air temperatures and less precipitation compared to 2005. During the month of May, precipitation fell 28.8 mm more than normal and the air temperature was 1.1°C higher. June and July turned out to be drier and warmer compared to the long-term average. During the month of August, the air temperature was at normal levels. As for precipitation, it fell at the end of August by 31.9 mm more than normal.

The growing season of 2007 turned out to be unfavorable for the growth and development of potatoes. It is characterized by: high daytime soil and air temperatures, low precipitation. During the month of May, precipitation fell 19.9 mm less than normal, and its precipitation was characterized by unevenness. During the month, 22.7 mm of precipitation fell, which is 3 times below normal. The average daily air temperature was 1.0°C below the long-term indicator. In July and August, precipitation fell significantly below normal. So, in July it fell 52.8 mm less than normal, and in August by 39.5 mm. The air temperature in August was 2.2°C above normal. In general, during the growing season, precipitation fell 157.5 mm less than the long-term average, and the air temperature was 0.9°C above normal.

Research results.

A number of factors have a significant impact on the growth and development of potato plants: weather conditions, quality of planting material, fertilizer, soil fertility, etc.

The results of phenological observations are presented in table. 3. Potato shoots in 2005 appeared only after 40 days and this was the result of reduced quality of seed material and unfavorable weather conditions (low soil temperature). In 2006, the planting material was of slightly better quality and the soil temperature was more favorable; seedlings appeared 12 days earlier than in 2005.

3. Phenological observations.

	Planting	Shoots	Budding	Blooming	Harvesting	Planting - harvesting
2005						
Date	9.05	18.06	7.07	16.7	10-18.09	
Duration of the interphase period (days)		40	19	9	56-64	124-132
Date	17.05	14.06	1.07	8.07	3-5.09	
Duration of the interphase period (days)		28	17	7	57-59	109-111

The onset of all phenological phases of growth and development of potato plants in 2006 occurred earlier than in 2005 due to more favorable weather conditions during the growing season.

The rains of September 2005 caused a postponement of the harvesting date and, due to significant soil moisture, the harvesting period was extended.

Potatoes, like all green plants, are an autotrophic organism that performs all its vital functions using organic matter created from elements of inanimate nature and the energy of sunlight.

The bulk (85% or more) of organic matter created by a plant is formed during the process of photosynthesis due to carbon dioxide, water and light energy (Vecher A. S. et al., 1973; Makhanko L. A., 1985).

The main organ of photosynthesis is the leaf (Mokronosov A.T., 1981) and the accumulation of organic matter yield is highly dependent on the growth rate and size of the photosynthetic organs. We obtain high productivity of photosynthesis under the condition that the leaf area increases, very quickly reaching the optimal level, and then remains active at this level for a long time and partially or completely dies at the end of the growing season (Nichiporovich A. A. et al., 1958; Mäetadu H. I. et al., 1984).

Most researchers (Stroganova L. E., 1959; Nichiporovich A. A., 1963) believe that in the conditions of the Non-Chernozem Zone, a leaf surface index of 3.5-4.0 m^2/m^2 is optimal. With irrigation and abundant fertilization, an increase in yield can be associated with an increase in leaf area to 50 thousand m^2/ha (Pisarev B. A., 1990).

As A. A. Nichiporovich et al. (1965) point out, at low light intensities, maximum photosynthesis intensity is observed with a relative leaf area of about 4-6 m^2/m^2, and with crop illumination of 100*103 erg/cm^2 sec, the optimal leaf area is about 8-9 m^2/m^2.

The intensity and magnitude of the increase in the assimilation surface depend on soil moisture, the provision of available nutrients and other factors. In our experiments, the size of the leaf surface of potato plantings varied greatly from year to year and depended on the prevailing weather conditions, soil fertility, and rates of application of organic and mineral fertilizers (Table 4, Figure 1-2).

The progress of leaf surface formation is represented by a single-peak curve with a maximum on the 15th day after flowering. Although in 2006, on option 2 in medium- and well-cultivated soil, the maximum leaf area was on the 30th day after flowering.

4. Leaf area, thousands m^2/ha.

Option	Shoots	Budding	Blooming	After flowering on		Harvesting
				day 15	day 30	
Moderately cultivated soil						
1	1,1 2,9	7,1 3,1	12,3 4,2	23,8 5,5	22,0 3,0	- 0,9
2	2,2 3,0	7,2 5,2	19,5 7,5	31,4 16,4	22,2 17,4	- 9,1
3	2,2 3,2	9,0 5,6	27,2 8,7	46,5 19,6	38,6 18,5	- 10,9
4	1,6 3,1	10,1 4,3	21,3 9,0	28,7 15,2	26,3 11,2	- 3,8
Well-cultivated soil						
1	1,7 3.1	6,7 3,7	9,7 4,4	20,9 7,6	8,5 5,0	- 1,6
2	2,5 4,0	9,2 7,7	21,8 12,4	28,4 21,3	20,5 22,7	- 12,8
3	2,3 3,9	10,8 6,0	22,0 10,0	36,3 18,1	22,7 17,8	- 10,1
Poorly cultivated soil						
	1,5 1,2	2,5 1,4	3,7 3,2	4,8 4,8	3,6 3,7	- 0,5

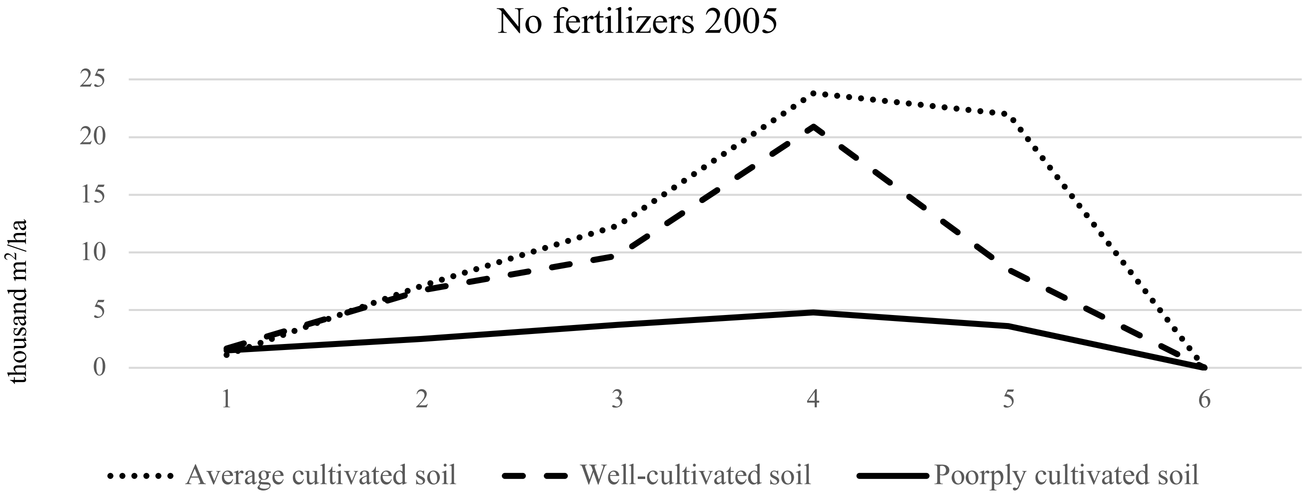
Note: numerator – 2005; denominator – 2006.

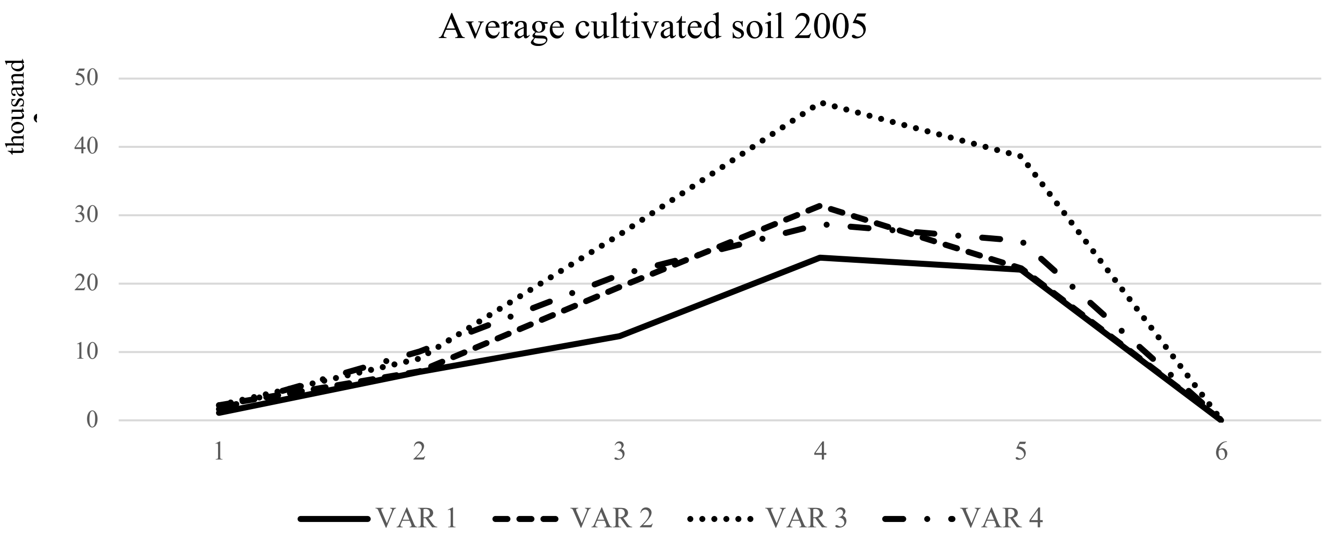
Soil fertility had a positive effect on leaf area. In the variant without fertilizers on well-cultivated soil it was 435 and 158% more, and on moderately cultivated soil it was 496 and 115% more than on poorly cultivated soil in 2005 and 2006 on the 15th day after flowering.

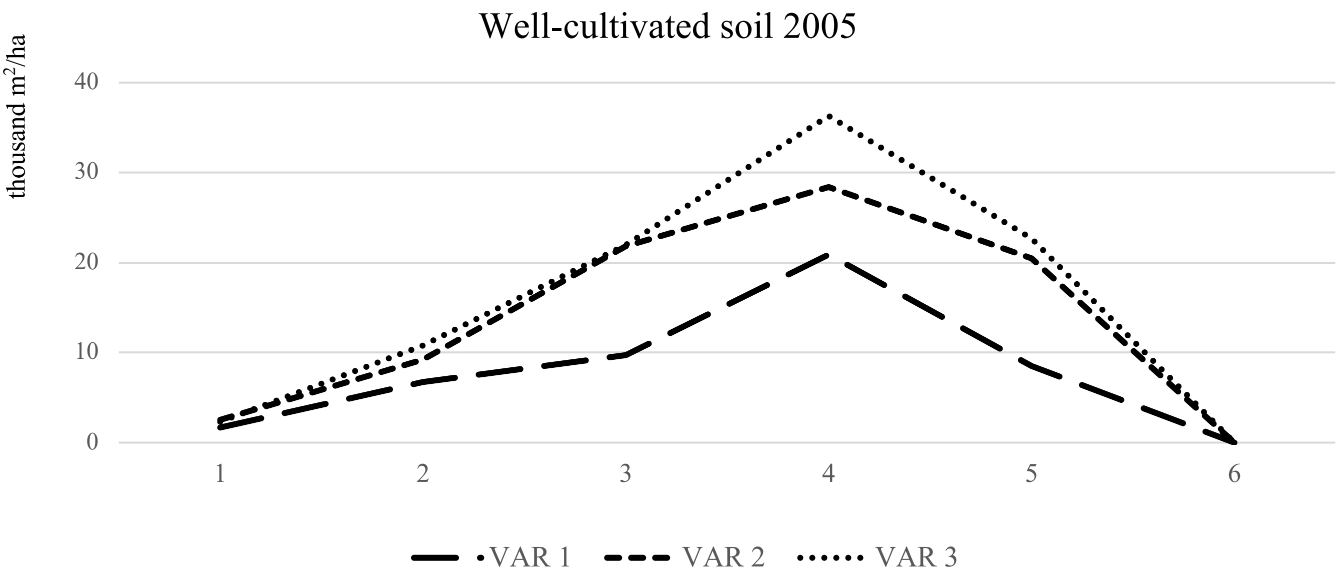
The largest leaf area was observed in 2006 on medium- and well-cultivated soil in the variants where the calculated rates of fertilizers were applied to absorb 3% PAR, and in 2005 on well-cultivated soil the maximum leaf area of 36.3 thousand m^2/ha was observed in the variant with the recommended fertilizer standards, and on a medium-cultivated one - 46.5 thousand m^2/ha in the option for absorbing 3% PAR at 4.8 thousand m^2/ha on a poorly cultivated one.

The maximum increase in leaf surface was in 2005 on medium-cultivated soil of option 3 during the interphase flowering period - day 15 - 19.3 thousand m^2/ha. 20 days after flowering, leaves died off in all variants.

In 2005, this process accelerated due to the development of late blight and by the time of harvesting there were practically no green leaves on all variants, and in 2006 their area was - on poorly cultivated soil from 0.5 thousand m^2/ha to 12.8 thousand m^2/ ha on well-cultivated soil of option 2.

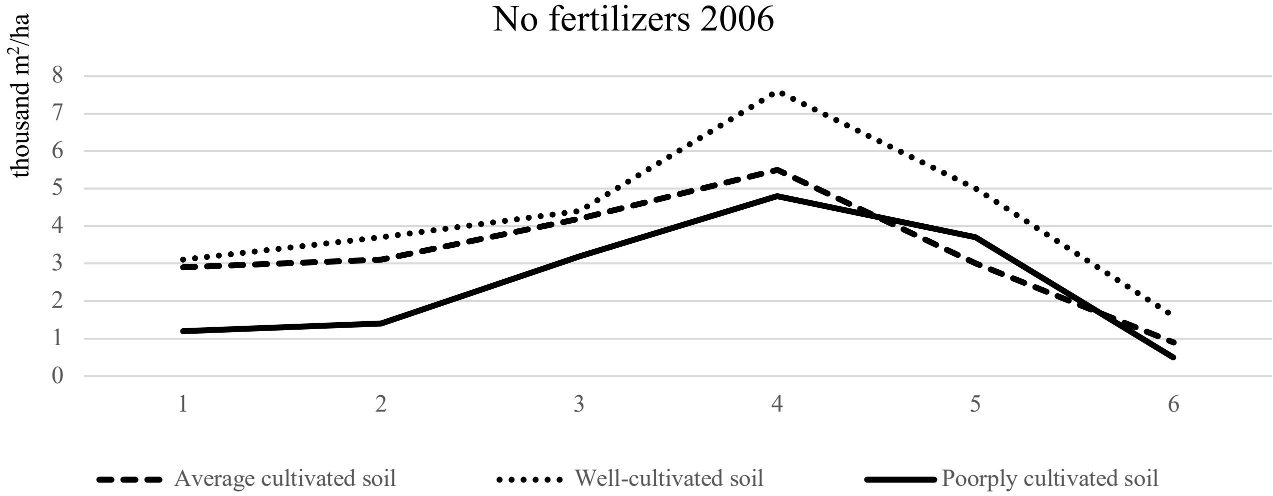




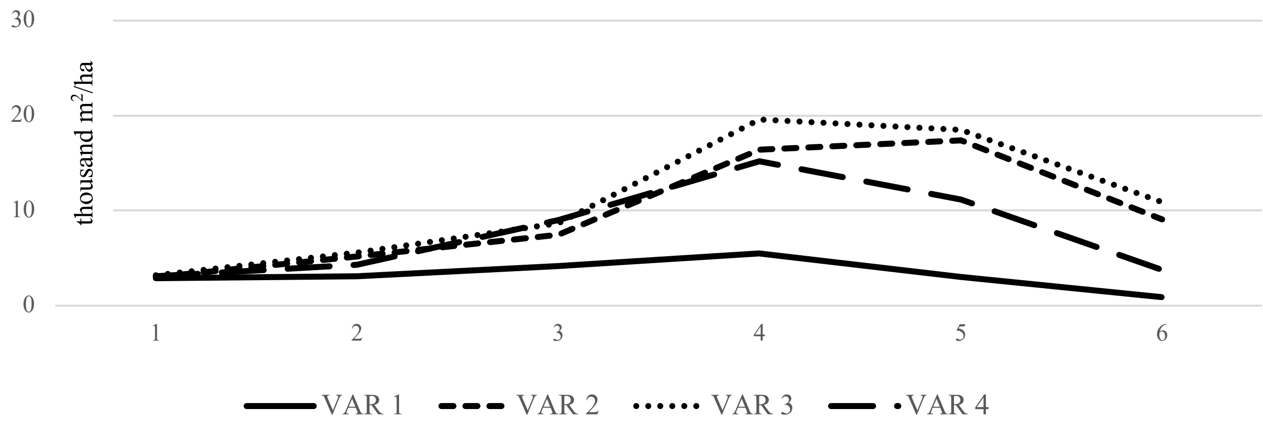


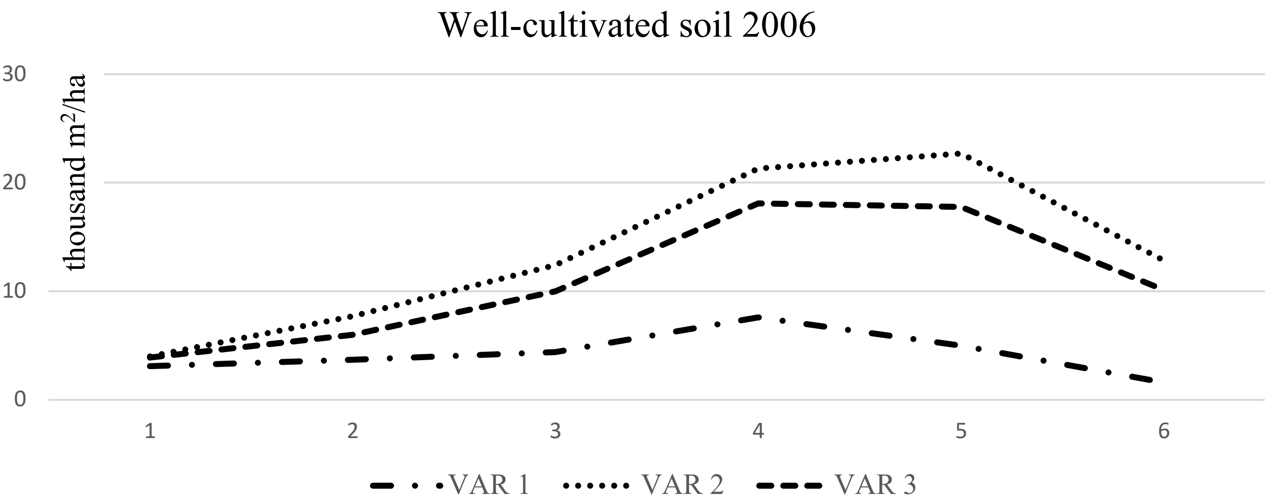
Dynamics of increase in leaf area

Note: I – shoots; II – budding; III – flowering; IV and V – on the 15th and 30th days after flowering; VI –harvesting.



Average cultivated soil 2006





Dynamics of increase in leaf area.

Note: I – shoots; II – budding; III – flowering; IV and V – on the 15th and 30th days after flowering; VI –harvesting.

The highest productivity of a potato plant, 362 c/ha, was formed on medium-cultivated soil of option 3 with the following course of leaf surface growth: shoots – 2.2; budding – 9.0; flowering – 27.2; on the 15th and 30th days after flowering - 46.5 and 38.6 thousand m^2 ha.

In our studies, intensive growth of leaf surface in variants with calculated and recommended doses of fertilizers occurred due to a rapid growth, more intensive development of plants and the formation of larger leaf shares.

In order to truly reflect in our minds the picture of yield formation by potato plants, it is necessary to study the process of tuberization in dynamics. One of the main indicators characterizing this process is a daily growth.

Yield accumulation and a daily increase in raw weight of potato tubers are presented in table. 5-6. Weather conditions had a significant impact on the dynamics of these indicators. For example, planting tubers in a slightly heated soil in 2005 caused the tubers to grow, which subsequently affected the daily growth and accumulation of raw weight by potato tubers.

5. Accumulation of raw weight by potato tubers, c/ha.

Option	Deadlines for determination					
	1	2	3	4	5	6
Moderately cultivated soil						
1	4,5 -	28,8 2,1	44,7 19,8	91,4 47,4	235,5 86,9	220,6 146,0
2	6,7 -	25,0 5,0	75,1 35,0	172,7 97,5	315,5 262,5	375,4 286,7
3	4,4 -	26,2 5,6	96,7 36,0	186,3 106,5	386,0 305,0	448,4 390,1
4	7,5 -	32,8 3,9	57,0 33,6	145,0 102,5	371,2 208,5	390,3 274,7
Well-cultivated soil						
1	8,6 -	21,2 1,5	47,5 25,1	120,0 55,6	186,2 103,1	202,2 161,5
2	7,4 -	34,5 5,8	80,0 42,6	125,5 131,0	283,0 287,5	272,3 379,5
3	4,2 -	28,6 5,2	84,2 40,1	155,0 108,0	270,7 210,0	307,1 267,3
Poorly cultivated soil						
	2,7 -	17,4 1,0	34,8 13,6	67,2 43,0	99,8 77,8	77,3 87,9

The use of recommended and calculated doses of fertilizers increased daily growth. Thus, in option 2 of well-cultivated soil on the 30th day after flowering in 2006, it was 9.2 c/ha, which is 3.3 times more than the control option.

Soil fertility had a significant impact on the accumulation process and daily increase in raw mass. For example, on poorly cultivated soil these indicators were lower than the unfertilized variants of medium- and well-cultivated soil.

The bulk of the potato tuber harvest is formed by plants during the flowering period - the 30th day after it. All efforts when cultivating potatoes should be aimed at creating conditions for the optimal progress of crop formation during this period.

6. Daily increase in raw weight of potato tubers, c/ha.

Option	Phases of growth and development					
	Shoots	Budding	Blooming	After flowering on		
				day 15	day 30	day 45
Moderately cultivated soil						
1	0,5 -	1,9 0,3	2,0 1,8	3,6 2,0	9,0 2,3	-1,1 4,2
2	0,67 -	1,4 0,7	6,3 3,0	7,5 4,5	8,9 9,7	4,3 1,7
3	0,44 -	1,7 0,8	8,8 3,0	6,9 5,0	12,5 11,7	4,5 6,1
4	0,75 -	1,9 0,6	3,0 3,0	6,8 4,9	14,1 6,2	1,4 4,7
Well-cultivated soil						
1	0,86 -	1,0 0,2	3,3 2,4	5,6 2,2	4,2 2,8	1,1 4,2
2	0,74 -	2,1 0,8	5,7 3,7	3,5 6,3	9,8 9,2	-0,8 6,6
3	0,42 -	1,9 0,7	7,0 3,5	5,4 4,9	7,2 6,0	2,6 4,1
Poorly cultivated soil						
	0,27 -	1,1 0,1	2,2 1,3	2,5 2,1	2,0 2,0	-1,6 0,7

The most important indicator of the plant production process is the dynamics of dry matter accumulation.

The progress of dry matter formation by potato plants is presented in Table 7-8 and figure 3-5. From the first phases of plant growth and development until the period of 15-30 days after flowering, depending on the weather conditions of the year, there was an increase in the dry matter of the above-ground part, and then it began to decrease due to the aging of leaves (their fall), the decrease is associated not only with abscission, but also weakening of the arrival of PAR, reducing on this basis the photosynthetic activity of assimilating organs.

The accumulation of dry matter by tubers by the flowering phase in 2005 on well-cultivated soil of options 1 and 2 exceeded its accumulation by the aboveground part, although the maximum accumulation of matter by the tops was observed on the 15th day after flowering, which is very important for obtaining a high potato yield. On poorly cultivated soil this year, the amount of dry matter accumulation by tubers already at the budding phase exceeded the tops by 1.67 times. The above mentioned fact was not observed this year on moderately cultivated soil. In 2006, in the 1st variant of well- and moderately cultivated soil, an early intersection of the curves of dry matter accumulation by tubers and tops was noted.

7. Accumulation of dry mass by potato plants, c/ha. (2005).

Option	Deadlines for determination					
	I	II	III	IV	V	VI
Moderately cultivated soil						
1	1,52 / 0,64	4,84 / 4,32	6,93 / 6,03	12,39 / 11,97	15,11 / 40,51	4,48 / 42,0
2	1,82 / 0,92	4,88 / 3,28	11,88 / 9,84	19,03 / 21,93	11,33 / 53,0	5,45 / 57,81
3	1,53 / 0,62	6,17 / 3,64	16,45 / 12,67	26,16 / 24,22	19,72 / 64,08	5,69 / 63,67
4	1,14 / 0,4	7,24 / 4,36	12,16 / 7,41	16,32 / 18,27	15,68 / 62,36	3,49 / 59,72
Well-cultivated soil						
1	0,97 / 1,29	4,63 / 3,14	4,96 / 7,08	13,53 / 14,64	5,96 / 35,57	2,28 / 36,6
2	1,72 / 1,06	5,72 / 4.73-	9,63 / 9,84	18,87 / 14,68	13,29 / 47,54	3,32 / 45,49
3	1.46 / 0,62	6,57 / 4,0	12,43 / 10,61	23,77 / 17,67	14,31 / 45,75	2,21 / 43,61
Poorly cultivated soil						
	1,3 / 0,4	1,8 / 3,01	2,77 / 6,16	5,63 / 10,82	3,14 / 20,96	0,58 / 20,82

Note: in the numerator – the above-ground part; the denominator is tubers;
I – sprout; II – budding; III – flowering; IV and V – on the 15th and 30th day after flowering;
VI –harvesting.

8. Accumulation of dry mass by potato plants, c/ha. (2006).

Option	Deadlines for determination					
	I	II	III	IV	V	VI
Moderately cultivated soil						
1	1,0 / -	2,0 / 0,2	2,7 / 2,9	3,6 / 7,3	4,3 / 17,5	1,7 / 29,2
2	1,1 / -	3,1 / 0,6	6,5 / 4,8	8,1 / 13,3	15,6 / 51,5	9,0 / 57,6
3	1,3 / -	3,4 / 0,6	6,4 / 4,9	10,7 / 14,5	13,4 / 60,4	11,2 / 78,4
4	1,1 / -	2,6 / 0,4	6,4 / 4,5	8,1 / 14,2	9,5 / 40,7	5,7 / 54,9
Well-cultivated soil						
1	1,1 / -	2,7 / 0,2	3,9 / 3,9	4,1 / 8,9	2,2 / 22,4	1,1 / 35,5
2	1,7 / -	4,4 / 0,6	9,6 / 6,4	10,8 / 17,6	16,2 / 56,1	12,2 / 82,4
3	1,2 / -	3,7 / 0,6	7,4 / 6,1	9,0 / 16,2	10,1 / 41,0	9,2 / 57,5
Poorly cultivated soil						
	0,8 / -	1,1 / 0,1	2,7 / 2,1	3,8 / 7,7	1,7 / 17,3	0,8 / 21,0

Note: in the numerator – the above-ground part; the denominator is tubers;
I – sprout; II – budding; III – flowering; IV and V – on the 15th and 30th day after flowering;
VI –harvesting.

Based on the data on the accumulation of dry matter by plants (Tables 7 and 8), we can conclude that the application of fertilizers causes a later suppression of the dry matter accumulation curves by tubers and tops. The most intensive accumulation of dry matter by tubers occurs from the flowering phase until the 30th day after it, and then the rate of dry matter accumulation decreases somewhat.

The maximum accumulation of dry matter by potato plants in 2005 was on the 30th day after flowering, and in 2006 - during the harvesting period, which is associated with different weather conditions.

The dynamics and magnitude of dry matter accumulation by plants was influenced by soil fertility in both years of research. Thus, on well-cultivated soil in the variant without fertilizers in all phases of plant growth and development, the intensity of accumulation was higher than on poorly cultivated soil and at harvest it amounted to 36.6 and 21.8 c/ha in 2006.

Over the course of two years of research, we noted a certain pattern in the process of accumulation of dry matter mass in potatoes. In the early stages of potato growth until the flowering phase, the increase in dry matter was slow. Starting from the budding phase, the effect of fertilizers on the increase in dry matter began to appear. The highest rate of dry matter accumulation was observed in 2006 on well - and moderately cultivated soil using calculated doses of fertilizers to absorb 3% PAR than using recommended doses. Thus, in 2006, on well-cultivated soil in option 2, the accumulation of dry matter was 94.6 c/ha, and in option 3 – 66.7 c/ha. The application of fertilizers caused more intensive accumulation of dry matter by plants. On medium cultivated soil in option 3 in the flowering phase it was 11.3 c/ha and at harvest - 89.6 c/ha, and in the option without fertilizers it was 5.6 and 30.9 c/ha, respectively.

Photosynthetic potential is one of the decisive factors determining the size of the crop, as it gives an idea of what photosynthetic area and for what time worked to form the crop.

A. Nichiporovich (1965) and A. T. Mokronosov (1990) believe that a good crop should have a photosynthetic potential of 2.0-2.5 million m^2. days/ha, days calculated for every 100 days of actual growing season. However, creating an optimal leaf surface or tops mass per 1 ha and achieving high values of photosynthetic potential by plantings does not guarantee high yields of potato tubers. As can be seen from our studies (Table 9), the photosynthetic area of plantings depended both on the year of research, soil fertility, and the amount of fertilizer applied. The most favorable conditions for the development of photosynthetic potential occurred in 2005. On a medium cultivated soil in the variant with calculated fertilizer rates for the absorption of 3% PAR (photosynthetically active radiation), it amounted to 1658.7 thousand m^2/ha days, while on poorly cultivated soil it reached only 206.0 thousand m^2/ha days.

The highest value of photosynthetic potential, regardless of the weather conditions of the growing season, reached the 5th period of determination (15 days after flowering) and corresponded to the period of formation of the largest leaf surface by plants.

For example, on moderately cultivated soil in 2005, by the 5th period of determining the PP (Photosynthetic potential) in the option of absorbing 3% PAR was 680.8 thousand m^2/ha days, and on poorly cultivated soil - 67.2 thousand m^2/ha days.

9. Photosynthetic potential of potatoes (thousand m^2/ha days), 2005 – 2006.

Option	Deadlines for determination						During the growing season
	1	2	3	4	5	6	
Moderately cultivated soil							
1	5,5	53,3	77,6	234,7	366,4	154,0	891,5
	16,0	21,0	36,5	67,9	72,3	27,3	241,0
2	11,0	61,1	106,8	330,9	428,8	155,4	1094,0
	16,5	28,7	63,5	167,3	287,3	185,5	748,8
3	11,0	72,8	144,8	749,1	680,8	270,2	1658,7
	17,6	30,8	71,5	198,1	323,9	205,8	847,7
4	8,0	76,1	125,6	325,0	440,0	184,1	1158,8
	17,1	25,9	66,5	169,4	224,4	105,0	608,3
Well-cultivated soil							
1	8,5	54,6	65,6	198,9	235,2	59,5	622,3
	17,1	23,8	40,5	84,0	107,1	46,2	318,7
2	12,5	76,1	124,0	326,3	391,2	143,5	1073,6
	22,0	41,0	100,5	235,9	374,0	248,5	1021,9
3	11,5	85,2	131,2	379,2	472,0	158,9	1237,8
	21,5	34,7	80,0	196,7	305,2	195,3	833,4
Poorly cultivated soil							
	7,5	26,0	24,8	55,3	67,2	25,2	206,0
	6,6	9,1	23,0	56,0	72,3	29,4	196,4

Note: numerator – 2005; denominator – 2006.
1 – shoots; 2 – budding; 3 – flowering; 4 and 5 – on the 15th and 30th days after flowering; 6 – harvesting.

The formation of PP by potato plants was greatly influenced by soil fertility, so in 2006 the total photosynthetic potential on well-cultivated soil was 318.7 thousand m^2/ha days, and on poorly cultivated - 196.4 thousand m^2/ha days, although in 2005 on well-cultivated soil it was slightly lower compared to averagely cultivated soil.

For all experimental variants, the amount of applied fertilizer had a significant effect on the value of photosynthetic potential. Thus, in the most favorable year of 2005, the photosynthetic potential in the variant with calculated doses of fertilizers to absorb 3% PAR was 1.43 times higher than in the variant with recommended doses on moderately cultivated soil, and on well-cultivated soil 1.73 times higher than in the variant without fertilizers and slightly lower compared to the variant where the recommended doses were used. It should be especially noted that on poorly cultivated soil, the photosynthetic potential in all years of research was lower than on the control variants of moderately and well-cultivated soil.

Photosynthesis is the main source of the creation of organic matter by plants, and the most important role in this process is played by leaves. But as it was said earlier, creating an optimal leaf surface per 1 hectare does not guarantee high yields of potato tubers. Of great importance in determining the intensity of accumulation of organic mass is the value of net productivity of photosynthesis (the amount of dry matter accumulated per day per 1 m^2 of leaves), which can greatly change under the influence of external factors.

The net productivity of photosynthesis is determined by the gross productivity of photosynthesis minus the cost of organic matter for respiration and all kinds of losses due to root secretions into the soil, dying and falling of leaves.

10. Net productivity of potato photosynthesis (g/m^2 day), 2005 – 2006.

Option	Deadlines for determination						Average for the growing season
	1	2	3	4	5	6	
Moderately cultivated soil							
1	39,3 / 6,3	13,1 / 5,7	4,9 / 9,3	4,9 / 7,8	8,5 / 15,1	-5,9 / 33,3	5,2 / 12,8
2	24,9 / 6,1	8,9 / 9,4	12,7 / 12,0	5,8 / 6,0	5,5 / 15,2	-0,7 / 0,8	5,8 / 8,9
3	19,5 / 7,4	10,5 / 8,8	13,3 / 10,2	4,4 / 7,0	4,9 / 15,0	-5,3 / 7,7	4,2 / 10,6
4	27,3 / 6,4	12,4 / 7,3	6,3 / 11,9	4,6 / 6,7	9,9 / 12,4	-8,1 / 9,9	5,5 / 10,0
Well-cultivated soil							
1	26,6 / 6,4	10,1 / 7,6	6,5 / 12,1	8,1 / 6,2	5,7 / 10,8	-4,3 / 26,0	6,3 / 11,5
2	22,2 / 7,7	10,1 / 8,0	7,3 / 10,9	4,3 / 5,3	7,0 / 11,7	-8,4 / 9,0	4,5 / 9,3
3	18,1 / 5,6	10,0 / 8,9	9,5 / 11,5	4,9 / 5,9	3,9 / 8,5	-9,0 / 8,0	3,7 / 8,0
Poorly cultivated soil							
	22,7 / 12,1	12,0 / 4,4	16,6 / 15,7	13,6 / 12,0	11,4 / 10,4	-10,6 / 9,5	10,4 / 11,1

Note: numerator – 2005; denominator – 2006.
1 – shoots; 2 – budding; 3 – flowering; 4 and 5 – on the 15th and 30th days after flowering; 6 – harvesting.

Our research, presented in Table 10 show that the indicators of net productivity of photosynthesis change throughout the entire growing season depending on the area of the leaf surface, the rate of its formation, the duration of active leaf growth, meteorological factors, and soil fertility. In the first periods of tops formation and growth, the assimilation apparatus is represented by the most efficient young leaves and therefore during this period its productivity is the highest. In our experiments, it fluctuated during this period from 5.5 in 2006 to 39.3 g/m^2 per day in 2005. This is probably due to weather conditions during the period of germination and the beginning of the formation of the leaf surface.

The productivity of photosynthesis is inversely proportional to the growth of leaf area; as a result, the net productivity of photosynthesis on unfertilized variants was higher than on variants with calculated and recommended doses of fertilizers.

The productivity of the potato leaf surface and the economic efficiency coefficient are the most important indicators of the photosynthetic activity of potato plantings.

In our experiments, as well as in the works of I. S. Shatilov (1971, 1975) with colleagues, Yu. I. Pashin (1989) and A. M. Dzeitov (1974), the productivity of leaves depends on weather conditions, soil fertility and doses of fertilizers (Table 11-12). Each thousand units of photosynthetic potential synthesized from 20.8 to 29.7 kg of tubers in 2005, and from 29.6 to 45.5 kg of tubers in 2006.

11. Leaf surface productivity (kg of dry matter and tubers per 1 thousand PP units), 2005.

Option	Shoots	Budding	Blooming	After flowering on		Harvesting	Account for tubers	Khoz
				Day 15	Day 30			
Moderately cultivated soil								
1	39,3	15,6	9,5	6,6	7,5	5,2	23,0	0,90
2	24,9	11,3	12,1	8,0	6,9	5,8	26,2	0,91
3	19,5	11,7	12,7	7,1	6,0	4,2	21,8	0,92
4	27,3	13,8	9,3	6,5	8,0	5,6	29,7	0,94
Well-cultivated soil								
1	26,6	12,3	9,4	8,6	7,4	6,3	24,6	0,94
2	22,2	11,8	9,2	6,2	6,5	4,6	21,1	0,93
3	18,1	10,9	10,1	6,8	5,6	3,7	20,8	0,95
Poorly cultivated soil								
	22,7	14,4	15,3	14,5	13,3	10,4	27,7	0,97

12. Leaf surface productivity (kg of dry matter and tubers per 1 thousand PP units), 2006.

Option	Shoots	Budding	Blooming	After flowering on		Harvesting	Account for tubers	Khoz
				Day 15	Day 30			
Moderately cultivated soil								
1	6,3	5,9	7,6	7,7	10,2	12,8	43,7	0,94
2	6,1	8,2	10,4	7,8	11,6	8,9	34,0	0,87
3	7,4	8,3	9,4	7,9	11,5	10,6	41,9	0,88
4	6,4	7,0	10,0	8,0	10,0	10,0	37,4	0,91
Well-cultivated soil								
1	6,4	7,1	9,6	7,9	9,0	11,5	45,5	0,97
2	7,7	7,9	9,8	7,1	9,3	9,3	34,9	0,87
3	5,6	7,7	9,9	7,6	8,0	8,0	29,6	0,86
Poorly cultivated soil								
	12,1	7,6	12,4	12,1	11,4	11,1	39,5	0,96

The applied fertilizers, regardless of the level of natural soil fertility, reduced the productive work of the leaves. Thus, in 2005, every thousand units of photosynthetic potential in option 1 of well-cultivated soil synthesized 6.3 kg of dry matter, and in options 2 and 3 only 4.6 and 3.7 kg. In 2006, exactly the same picture was observed as in 2005, but there was already more than 1 kg of dry matter for every thousand units of leaf surface. This decrease was due to, but not proportional to, an increase in leaf area. Therefore, fertilizers ultimately contributed to greater dry matter and tuber yields.

Soil fertility levels significantly affected leaf productivity only in 2005. For example, on poorly cultivated soil, for every thousand units of photosynthetic potential there were 10.4 kg of dry matter, and on medium- and well-cultivated soil, 5.2 and 6.3 kg, respectively.

One of the main characteristics of the photosynthetic activity of potato plantings is the indicator of the economic value of the crop (Kkhoz), equal to the ratio of the dry mass of tubers to the total yield of dry matter.

According to A. T. Mokronosov (1971), in potatoes it can vary widely: from 0.87-0.89 under conditions favorable for tuber formation and up to 0.4-0.5 with one-sided nitrogen nutrition and abundant water supply. For the conditions of the Moscow region, this figure is 0.92 (Vecher A. S. et al., 1973).

In our studies (Table 12), fertilizers reduced this indicator only in 2006. Thus, on poorly cultivated soil it was 0.96, and on medium and well-cultivated soil in the variants with the use of fertilizers it changed from 0.86 to 0.88.

The economic efficiency coefficient, as well as the productivity of the assimilation apparatus in our studies, varied depending on weather conditions. In the wettest of the years studied, 2005, according to the options, it ranged from 0.90 to 0.97 on poorly cultivated soil.

Productivity is an integral indicator determined by the complex interaction of external and internal factors (Velyaminova-Zernova L.D., 1982).

Cultivation of potatoes under various conditions of mineral nutrition with favorable moisture had a noticeable effect on its productivity (Table 14). On average, over 2 years on moderately cultivated soil, when applying calculated doses of fertilizers for tuber yields of 250 c/ha, 271 were obtained, and when calculating 350 - 359 c/ha. The increase to the control was 116 and 204 c/ha or 74.8-131.6%. The calculated dose of fertilizers to produce 350 centners had an advantage in yield formation over the recommended doses on average for 2 years.

On well-cultivated soil, the variant with calculated doses of fertilizers received an average of 292 centners over 2 years, which is 143 centners higher than the control. There was a clear predominance of calculated doses over recommended ones in 2006.

Significant impact on potato productivity in 2005-2006 had soil fertility. The yield of potato tubers on well- and moderately cultivated soil without the use of fertilizers on average over 2 years was significantly higher than on poorly cultivated soil by 81-87 c/ha.

The difference in the yield of tubers grown on well- and moderately cultivated soil without the use of fertilizers in 2005-2006 research was significant, but on average over 2 years it was not significant.

The dry summer and high air temperature of 2007 negatively affected the tuberization process. On some days the air temperature rose to almost 32°C.

F. I. Bobryshev (1977) points out that at air temperatures above 22-23°C, the assimilation of carbon dioxide by plants decreases sharply, and at higher temperatures, complete inhibition of the synthesis of organic matter is observed.

According to O. I. Volovik (1990), an increase in air temperature from 15 to 28°C leads to a significant – 27-30% – reduction in the accumulation of organic matter.

Potato productivity for all options in 2007, with the exception of poorly cultivated soil, was significantly lower than in previous years.

The use of calculated and recommended doses ensured an increase in yield on medium and well-cultivated soil. The calculated dose of fertilizers to produce 350 centners of tubers provided an increase in yield over the control of 112 centners/ha on medium cultivated soil.

The yield of potato tubers consists of the yield of individual fractions used for various purposes. The use of calculated and recommended doses of fertilizers on average over 2 years contributed to a significant increase in the proportion of the coarse fraction due to a decrease in the small and seed fractions (Table 13).

Soil fertility had a certain influence on the structure of the crop. On poorly cultivated soil, more seed and small tubers were formed than on control variants of well- and moderately cultivated soil.

13. Structure of the potato harvest (in %, tubers).

Option	2005			2006			Average for 2005-2006			2007		
	<30 g	30-80 g	>80 g	<30 g	30-80 g	>80 g	<30 g	30-80 g	>80 g	<30 g	30-80 g	>80 g
Moderately cultivated soil												
1	20,5	25,7	53,8	11,1	48,1	40,8	15,8	36,9	47,3	17,8	56,8	25,4
2	8,0	14,9	77,1	1,9	14,5	83,6	5,0	14,7	80,3	14,1	29,2	56,7
3	5,3	14,2	80,5	3,1	14,3	82,6	4,2	14,3	81,5	22,4	31,2	46,4
4	9,0	12,2	78,8	1,8	19,3	78,9	5,4	15,8	78,8	11,2	19,1	69,7
Well-cultivated soil												
1	8,9	32,4	58,7	5,6	36,0	58,4	7,	34,2	58,5	14,0	58,0	28,0
2	9,6	13,3	77,1	4,3	12,0	83,7	7,0	12,6	80,4	24,7	29,9	45,4
3	11,6	20,7	67,7	7,1	32,2	60,7	9,4	26,4	64,2	14,0	35,9	50,1
Poorly cultivated soil												
	27,3	50,4	22,3	11,7	42,3	46,0	19,5	46,4	34,1	55,9	44,1	-

In the dry year of 2007, the share of the coarse fraction noticeably decreased due to an increase in the small and seed fraction. On poorly cultivated soil, there were no tubers >80 g. The recommended dose of fertilizers on moderately cultivated soil increased the proportion of large tubers due to a decrease in the seed fraction compared to the calculated doses.

14. Potato yield (by fractions) at different levels of mineral nutrition (2005-2007).

Option	Year	Tuber yield, c/ha	Tubers obtained (per 1 ha)		
			small	seed	coarse
			<30 g, c/ha	30-80 g, c/ha	>80 g, c/ha
1	2	3	4	5	6
Moderately cultivated soil					
1	2005	205	42,0	52,7	110,3
	2006	105	11,7	50,5	42,8
	cp.	155	24,5	57,2	73,3
	2007	78	13,9	44,3	19,8
2	2005	287	23,0	42,8	221,2
	2006	255	4,8	37,0	213,2
	cp.	271	13,6	39,8	217,6
	2007	155	21,9	45,3	87,8
3	2005	361	19,1	51,3	290,6
	2006	356	11,0	50,9	294,1
	cp.	359	15,1	51,3	292,6
	2007	190	42,6	59,3	88,1
4	2005	344	31,0	42,0	271,0
	2006	228	4,1	44,0	179,0
	cp.	286	15,4	45,2	225,4
	2007	161	18,0	30,8	115,2
Well-cultivated soil					
1	2005	153	13,6	49,6	89,8
	2006	145	8,1	52,2	84,7
	cp.	149	10,9	51,0	87,1
	2007	112	15,7	65,0	31,3
2	2005	226	21,7	30,1	174,2
	2006	357	15,4	42,8	298,8
	cp.	292	20,4	36,8	234,8
	2007	190	46,9	56,8	86,3
3	2005	258	29,9	53,4	174,7
	2006	247	17,5	79,5	150,0
	cp.	253	23,8	66,8	162,4
	2007	169	23,7	60,7	84,6
Poorly cultivated soil					
	2005	57	15,6	28,7	12,7
	2006	78	9,1	33,0	35,9
	cp.	68	13,3	31,6	23,1
	2007	57	31,9	25,1	-

Significant increase in yield in 2005-2006 occurred due to greater collection of the large fraction. On poorly cultivated soil, the collection of all fractions was significantly lower than on more fertile soil (Table 14).

Part of the solar energy used by plants for the process of photosynthesis is called a photosynthetically active radiation and it makes up 48% of the total radiation (Klimov A. A. et al., 1971).

The arrival of a photosynthetically active radiation according to the phases of development of potato plants and during the growing season as a whole varies from year to year (Table 15). Thus, in 2006, it was received during the flowering-harvesting period 1.7 times more than in 1990.

15. PAR arrival by phases of development of potato plants, million kcal/ha.

Year	Planting - shoots	Shoots - budding	Budding - flowering	Flowering - harvesting	Посадка - уборка
2005	867,0	444,2	200,1	906,6	2417,9
2006	781,8	491,9	223,0	1545,8	3042,5

Indicators of the efficiency of solar energy absorption is the coefficient of the use of photosynthetically active radiation for the process of photosynthesis and the formation of phytomass. It depends on many factors: meteorological conditions, leaf surface area, level of mineral nutrition, biological and genetic characteristics of the variety, etc.

In our studies, the amount of solar energy absorption (PAR) by potato plants changed over the years (Table 16). Thus, in the wet year of 2005 it was higher than in the less wet year of 1991, except for the variant with calculated doses of fertilizers for a yield of 350 centners of tubers in well-cultivated soil and the variant of poorly cultivated soil.

16. Utilization of solar energy by potato plants, % of incoming PAR.

Option	Aligned from the field	Enters the soil					PAR utilization factor	PAR utilization rate on average over 2 years
	tubers	Total	tubers	tops	litter	roots		
Moderately cultivated soil								
1	0,65/0,31	0,49/0,15	0,05/0,02	0,08/0,02	0,13/0,03	0,23/0,08	1,14/0,46	0,80
2	0,80/0,75	0,86/0,41	0,25/0,02	0,10/0,13	0,22/0,06	0,29/0,20	1,66/1,16	1,41
3	0,93/1,05	0,86/0,45	0,23/0,02	0,10/0,16	0,23/0,03	0,30/0,24	1,79/1,50	1,65
4	0,96/0,67	0,70/0,31	0,14/0,01	0,06/0,08	0,21/0,05	0,29/0,17	1,66/0,98	1,32
Well-cultivated soil								
1	0,50/0,43	0,61/0,18	0,16/0,01	0,04/0,02	0,18/0,04	0,23/0,11	1,11/0,61	0,86
2	0,61/1,05	0,69/0,49	0,13/0,01	0,06/0,18	0,26/0,05	0,24/0,25	1,30/1,54	1,42
3	0,67/0,73	0,61/0,36	0,13/0,01	0,04/0,13	0,20/0,03	0,24/0,18	1,28/1,09	1,19
Poorly cultivated soil								
	0,16/0,23	0,19/0,13	0,03/0,02	0,01/0,01	0,08/0,03	0,07/0,07	0,35/0,36	0,36

Note: the numerator is 2005, the denominator is 2006.

The use of calculated and recommended doses of fertilizers increased the efficiency of using photosynthetically active radiation compared to control options.

In variants with calculated doses of fertilizers for a tuber yield of 350 centners, the coefficient of PAR utilization was higher than in variants with recommended doses. So, on average over 2 years on medium and well-cultivated soil it was 1.65 and 1.42%, and at recommended doses 1.32 and 1.19%.

The coefficient of solar energy use on unfertilized variants of medium- and well-cultivated soil on average over 2 years was 2.2-2.4 times higher compared to poorly cultivated soil.

The size of the phytomass has a significant influence on the consumption of physiologically active radiation by potato plants; the greater the accumulation of phytomass (Table 17), the higher the coefficient of solar energy use (Table 16).

17. Balance of potato phytomass, c/ha.

Option	Phytomass, total	Aligned from the field	Enters the soil					Phytomass average for 2 years
			Total	tubers	tops	litter	roots	
Moderately cultivated soil								
1	63,8 33,2	35,9 21,6	27,9 11,6	2,7 1,3	4,5 1,7	7,9 2,6	12,8 6,0	48,5
2	92,8 81,5	44,1 52,2	48,7 29,3	13,6 1,7	5,5 9,0	13,5 4,6	16,1 14,0	87,2
3	100,4 104,8	51,3 72,9	49,1 31,9	12,4 1,5	5,7 11,2	14,0 2,2	17,0 17,0	102,6
4	92,5 68,5	52,6 46,6	39,9 21,9	7,1 0,4	3,5 5,7	12,8 3,8	16,5 12,0	80,5
Well-cultivated soil								
1	62,5 42,4	27,7 29,7	34,8 12,5	8,9 0,4	2,4 1,1	11,1 3,0	12,4 8,0	52,4
2	73,1 108,0	33,7 73,1	39,4 34,9	6,9 0,7	3,3 12,2	15,6 40,	13,6 18,0	90,6
3	71,4 76,2	36,6 50,6	34,8 25,6	7,0 1,4	2,2 9,2	12,1 2,0	13,5 13,0	73,8
Poorly cultivated soil								
	20,0 25,8	8,8 15,9	11,2 9,9	1,6 1,4	0,6 1,0	5,0 2,5	4,0 5,0	22,9

Note: numerator – 2005; denominator – 2006

In our studies, the energy productivity of plants changed over the years (Table 18). Thus, in 2005, on medium and well-cultivated soil in options without the use of fertilizers, it was 1.9-1.5 times greater compared to 2006.

The use of recommended and calculated doses of fertilizers for a yield of 250 and 350 centners of tubers significantly increased the calorie content of the phytomass. For example, on average cultivated soil in option 2 (calculated doses of fertilizers for a tuber harvest of 350 c), the energy productivity of the agrophytocenosis on average over 2 years amounted to 44.65 million kcal/ha, which is 2.1 times higher than the indicator for the option without fertilizers.

18. Energy productivity of potatoes, million kcal/ha.

Option	Aligned from the field	Enters the soil					Coefficient of PAR utilization for tubers	Coefficient of PAR utilization on average for 2 years
	Tubers	Total	Tubers	Tops	Tubers	Total		
Moderately cultivated soil								
1	15,8 / 9,5	11,83 / 4,89	1,19 / 0,53	1,98 / 0,74	3,16 / 1,04	5,50 / 2,58	27,63 / 14,39	21,01
2	19,45 / 22,96	20,73 / 12,56	5,98 / 0,74	2,42 / 3,96	5,40 / 1,84	6,93 / 6,02	40,18 / 35,52	37,85
3	22,57 / 32,07	20,88 / 13,77	5,46 / 0,66	2,51 / 4,92	5,60 / 0,88	7,31 / 7,31	43,45 / 45,84	44,65
4	23,14 / 20,5	16,88 / 9,35	3,12 / 0,17	1,54 / 2,5	5,12 / 1,52	7,10 / 5,16	40,02 / 29,85	34,94
Well-cultivated soil								
1	12,19 / 13,06	14,74 / 5,29	3,92 / 0,17	1,06 / 0,48	4,44 / 1,20	5,32 / 3,44	26,93 / 18,35	22,64
2	14,83 / 32,16	16,57 / 15,00	3,04 / 0,30	1,45 / 5,36	6,24 / 1,60	5,84 / 7,74	31,40 / 47,16	39,28
3	16,10 / 22,26	14,7 / 11,04	3,08 / 0,61	0,97 / 4,04	4,84 / 0,80	5,81 / 5,59	30,80 / 33,30	32,05
Poorly cultivated soil								
	3,87 / 6,99	4,69 / 4,20	0,70 / 0,61	0,26 / 0,44	2,0 / 1,00	1,73 / 2,15	8,56 / 11,19	9,88

Note: numerator – 2005; denominator – 2006.

The calorie content of the potato harvest on poorly cultivated soil on average over 2 years was 2.1-2.3 times less than the calorie content of the yield of variants without fertilizers in medium- and well-cultivated soil.

As a result of harvesting potatoes, the solar energy accumulated by the agrophytocenosis is divided: part of it is alienated from the field by humans, and part of it enters the soil, replenishing the reserves of organic matter. In the humid year of 2005, from 42.2 to 54.8% of the stored solar energy entered the soil with unharvested tubers (losses), tops, litter and root system of plants, and in the less humid year of 2006 it entered from 30.0 to 37.5 %.

Productivity is the product of photosynthetic activity of green leaves. The formation of the yield of potato plants is significantly influenced by a number of factors: weather conditions, soil fertility, level of agricultural technology, quality of planting material and others.

The research results showed that physiologically active substances and low-frequency electromagnetic fields influence the realization of the potential capabilities of potato plants to varying degrees. The control yield on average over 2 years was 284.5 c/ha (Table 19).

19. Productivity of potato tubers, c/ha.

Option	2005	2006	Average for 2005-2006	Average increase		2007
				c/ha	%	
Control	276,0	293,0	284,5	-	-	206,0
Simarp, 1 mg/l	330,0	290,0	310,0	25,5	9,0	209,0
Krezacin, 40 mg/l	374,0	366,0	370,0	85,5	30,1	218,0
Water	294,0	287,0	290,5	6,0	2,1	-
Furolan, 30 mg/l	316,0	317,0	316,5	32,0	11,2	-
Furolan, 50 mg/l	331,0	324,0	327,5	43,0	15,1	-
Furolan, 70 mg/l	331,0	330,0	330,5	46,0	16,2	216,0
Furolan, 10 mg/l	270,0	304,0	287,0	2,5	0,9	-
Furolan, 30 mg/l	318,0	309,0	313,0	29,0	10,2	-
Furolan, 50 mg/l	315,0	317,0	316,0	31,5	11,1	-
Furolan, 60 mg/l	317,0	345,0	331,0	46,5	16,3	224,0
Furolan, 80 mg/l	323,0	361,0	342,0	57,5	20,2	230,0
Furolan, 100 mg/l	340,0	340,0	340,0	55,5	19,5	221,0
Copper sulfate bloom, 500 mg/l	344,0	332,0	338,0	53,5	18,8	-
Copper sulfate budding, 500 mg/l	317,0	344,0	330,5	46,0	16,2	223,0
Copper sulfate budding, 500 mg/l + flowering, 500 mg/l	326,0	342,0	334,0	49,5	17,4	-
EM	281,0	298,0	289,5	5,0	1,8	-
NSR_{05} c/ha	17,8	23,7				23,0

Krezacin turned out to be the most effective in influencing plant productivity. Spraying plants with the drug caused an increase in yield to 370 c/ha, which is 30.1% higher than the control.

The use of simarp in different years had a different impact on the realization of the genetic capabilities of plants.

A more stable increase in potato productivity compared to simarp was caused by spraying seed material with furolan at a drug concentration of 70 mg/l, where the yield on average over 2 years was 16.2% higher.

The use of furolan during the growing season ensured an increase in productivity. With an increase in the concentration of the drug, there was an increase in yield from 287 c/ha at the minimum (10 mg/l) to 342 at 80 mg/l.

Copper sulfate increased potato yields, but this effect was slightly lower compared to krezacin. The yield over 2 years of research for the three options where the drug was used was approximately the same and varied from 330.5 to 338 c/ha.

The low-frequency electromagnetic field did not have a significant effect on yield. In this option, over 2 years, the average tuber harvest was 289.5 c/ha.

Due to the dry summer of 2007, the differences between the options in terms of yield were insignificant. It varied from 206.0 c/ha in the control to 230.0 c/ha in the variant with the use of furolan (80 mg/l) during the growing season.

A prerequisite for active photosynthetic activity of plants is optimal moisture supply. A decrease in soil moisture primarily affects the formation of tubers (Buzover F. Ya., 1957, 1963).

The soil temperature during the period of tuber formation on some days rose to almost 27˚C at a depth of 5 cm and more than 20˚C at a depth of 20 cm, which negatively affected the process of their formation and accumulation of organic matter.

According to P. I. Alsmik et al. (1979), at soil temperatures above 20°C, tuber formation is sharply inhibited, and at 29°C it stops. Normal tuberization in potatoes occurs at temperatures no higher than 18-19°C.

Physiologically active substances influenced the structure of the crop (Table 20). In 2005, potato tops were attacked by late blight at the end of flowering, and as a result, the proportion of the coarse fraction decreased. In all variants, except for the treatment of tubers with furolan, compared to the control, the proportion of the large fraction (>80 g) was higher due to a decrease in the proportion of the seed fraction (30-80 g).

20. Structure of potato harvest, in%.

Option	2005			2006			Average for 2005-2006			1992		
	<30	30-80	>80	<30	30-80	>80	<30	30-80	>80	<30	30-80	>80
Control	9,1	44,9	46,0	6,5	21,0	72,5	7,8	33,0	59,2	11,5	75,1	13,4
Simarp, 1 mg/l	7,8	27,4	64,8	5,5	29,0	65,5	6,7	28,2	65,1	11,4	84,3	4,3
Krezacin, 40 mg/l	9,3	32,7	58,0	1,5	14,5	84,0	5,4	23,6	71,0	14,8	30,3	54,9
Furolan, 70 mg/l	10,2	44,5	45,3	3,5	20,0	76,5	6,9	32,2	60,9	15,2	71,9	12,9
Furolan, 80 mg/l	12,2	21,5	66,3	2,0	16,0	82,0	7,1	18,8	74,1	10,2	61,1	28,7
Copper sulfate budding, 500 mg/l	7,8	25,0	67,2	2,0	5,0	93,0	4,9	15,0	80,1	11,9	57,9	30,2

The use of krezacin, furolan during the growing season and copper sulfate in 2006 contributed to an increase in the proportion of large fractions by reducing the proportion of small (<30 g) and seed (30-80 g) ones. On average, over two years of research, the proportion of tubers >80 g in the above-mentioned variants was significantly higher than in the control.

21. Potato yield (by fractions) under the influence of growth regulators (2005-2007)

Option	Year	Tuber yield, c/ha	Tubers obtained (per 1 ha)		
			small	seed	coarse
			<30 g, c/ha	30-80 g, c/ha	>80 g, c/ha
Control	2005	276,0	25,1	123,9	127,0
	2006	293,0	19,1	61,5	212,4
	av	284,5	22,2	93,9	168,4
	2007	206,0	23,7	154,7	27,6
Simarp, 1 mg/l	2005	330,0	25,7	90,4	213,9
	2006	290,0	16,0	84,0	190,0
	av	310,0	20,8	87,4	20,8
	2007	209,0	23,8	176,2	9,0
Krezacin, 40 mg/l	2005	374,0	34,8	122,3	216,9
	2006	366,0	5,5	53,1	307,4
	av	370,0	20,0	87,3	262,7
	2007	218,0	32,3	66,1	119,6
Furolan, 70 mg/l	2005	331,0	33,8	147,3	149,9
	2006	330,0	11,6	66,0	252,4
	av	330,5	22,8	106,4	201,3
	2007	216,0	32,8	155,3	27,9
Furolan, 80 mg/l	2005	323,0	39,4	69,5	214,1
	2006	361,0	7,2	57,8	296,0
	av	342,0	24,3	64,3	253,4
	2007	230,0	23,5	140,5	66,0
Copper sulfate budding, 500 mg/l	2005	317,0	24,7	79,3	213,0
	2006	344,0	6,9	17,2	319,9
	av	330,5	16,2	49,6	264,7
	2007	223,0	26,5	129,1	67,4

Yield growth in 2005-2006 occurred due to a greater collection of the large fraction (>80 g) in all options (Table 21). In 2007, which was atypical for weather conditions, there was a difference in the harvest structure among the variants. The use of simarp caused an increase in the proportion of the seed fraction (30-80 g) due to a decrease in the proportion of the coarse fraction (>80 g). Krezacin, copper sulfate and furolan during the growing season influenced the share of the large fraction (>80 g).

Taking into account the dependence of the yield on the quality of the seed material, during 2006 and 2007 we studied the influence of physiologically active substances, copper sulfate and low-frequency electromagnetic field on the yield of tubers in the offspring. Tubers after winter storage were planted on the same agricultural background with the application of $N_{90}P_{60}K_{60}$ and 35 tons of organic fertilizers.

22. Seed properties of tubers under conditions of use of physiologically active substances.

Option	2006	Average increase		2007	Average increase	
		c/ha	%		c/ha	c/ha
Control	361,0	-	-	269,0	-	-
Krezacin, 40 mg/l	366,0	+5,0	+1,4	283,0	+14,0	+5,2
Furolan, 70 mg/l	488,0	+127,0	+35,2	251,0	-18,0	-6,7
Furolan, 80 mg/l	466,0	+105,0	+29,1	291,0	+22,0	+8,2
Copper sulfate budding, 500 mg/l	-	-	-	248,0	-21,0	-7,8
EM	405,0	+44,0	+12,2	249,0	+20,0	-7,4
NSR_{05} c/ha	32,4			29,1		

The experimental results (Table 22) clearly show that some growth regulators affect the seed properties of tubers. Thus, the use of furolan for pre-planting treatment of tubers caused an increase in productivity in the offspring by 35.2%, while the use of krezacin had no effect. In 2007, due to drought, there were no significant differences between the options.

23. Structure of the potato harvest, in%, 2007.

Option	fractions		
	<30 g	30-80 g	>80 g
Control	10,4	28,1	61,5
Krezacin, 40 mg/l	8,5	27,3	64
Furolan, 70 mg/l	13,6	49,0	37,4
Furolan, 80 mg/l	8,6	39,9	51,5
Copper sulfate budding, 500 mg/l	11,8	45,2	43,0
EM	10,1	33,0	56,9

The use of physiologically active substances when growing potatoes caused a change in the structure of the yield in the offspring (Table 23). Furolan and copper sulfate ensure an increase in the proportion of the seed fraction by reducing the coarse fraction.

The area occupied by potatoes, other things being equal, produces almost three times more dry matter than bread (D. P. Pryanishnikov, 1965).

The dry matter of tubers contains a number of compounds that characterize the taste and culinary qualities of potatoes. One of the main nutritional indicators of potato tubers is the starch content. The starch content in tubers depends on many factors: weather conditions, characteristics of the variety, agricultural technology, level of mineral nutrition, etc.

The use of physiologically active substances in the experiments influenced the process of starch accumulation (Table 24). Spraying seed material with furolan only in 2005 ensured an increase in its content by 1.5%. The use of krezacin in 2007 contributed to an increase in its content by 0.9%. On average, over three years there were no significant differences among the options in terms of starch content in the tubers.

In our studies, the process of the starch accumulation was influenced by weather conditions. Thus, in the dry year of 2007, the tubers were characterized by a higher starch content than in the wet year of 2005.

24. Content of starch, nitrates, sugar and protein in potato tubers.

Option	Processing time	Year	Starch, %	Nitrates, mg/kg	Ascorbic acid, mg%	Sugars reducing, %	Sugars total, %	Protein, %
Control		2005 2006 2007 av	17,9 18,6 19,1 18,5	55,0 140,0 - 97,5	0,25	1,79	4,69	1,28
Simarp, 1 mg/l	1	2005 2006 2007 av	17,8 18,4 19,3 18,5	50,0 150,0 - 100,0	0,40	1,78	2,50	1,10
Krezacin , 40 mg/l	2	2005 2006 2007 av.	18,1 18,4 20,0 18,8	61,0 71,7 - 66,4	0,31	1,77	3,93	1,03
Furolan, 70 mg/l	1	2005 2006 2007 av.	19,4 18,6 19,1 19,0	47,0 71,7 - 59,4	0,33	1,47	2,20	1,18
Furolan, 80 mg/l	2	2005 2006 2007 av	18,1 18,7 19,2 18,7	56,0 70,1 - 63,1	0,31	1,62	3,50	1,09
Copper sulfate budding, 500 mg/l	2	2005 2006 2007 av	18,2 18,5 19,2 18,6	40,0 128,0 - 84,0	0,42	2,0	3,95	1,22

Note: 1 – processing of planting material; 2 – spraying plants.

An essential indicator of the quality of tubers is the nitrate content. The process of accumulation of nitrates in tubers is influenced by many factors: meteorological conditions, fertilizer, variety and others.

The use of physiologically active substances in our studies had different effects on the nitrate content in tubers (Table 24). In the humid year of 2005, growth regulators did not have a noticeable effect on the process of nitrate accumulation by tubers, and this year, according to all options, their content was 4-6 times lower than the MPC. In the less humid year of 2006, in the control variant, their content was 140 mg/kg, which is 1.7 times lower than the norm. From the above it follows that weather conditions can have a significant impact on the process of accumulation of nitrates by tubers. The use of physiologically active substances (krezacin and furolan) in 2006 provided a significant reduction in nitrates. For example, spraying potato plants with furolan caused a decrease in nitrates by almost 2 times.

The most important indicators of the quality of potato tubers include: the content of ascorbic acid, protein and sugars. Spraying plants with copper sulfate increased the vitamin C content by 68%, and with simarp - by 60%. Physiologically active substances and copper sulfate did not have a significant effect on the content of reducing sugars and protein in the tubers. In the variants using simarp and furolan before planting tubers, the content of total sugars was lower than the control variant. The low content of ascorbic acid and high content of sugars can probably be explained by the fact that the analyses were carried out 3 months after harvesting.

Growth regulators ensured an increase in starch yield per unit area (Table 25), but this was largely due to a higher yield than to its relative content. Krezacin ensured an increase in starch collection on average for 2005-2007 by 29.8%.

25. Starch collection, c/ha.

Option	Processing method	2005	2006	Average for 2005-2006	Average increase		2007
					c/ha	%	
Control		49,4	54,5	52,0	-	-	39,3
Simarp, 1 mg/l	1	58,7	53,4	56,1	4,1	7,9	40,3
Krezacin, 40 mg/l	2	67,7	67,3	67,5	15,5	29,8	43,6
Water	2	54,1	52,2	53,2	1,2	2,3	-
Furolan, 30 mg/l	1	56,9	58,3	57,6	5,6	10,8	-
Furolan, 50 mg/l	1	59,9	59,9	59,9	7,9	15,2	-
Furolan, 70 mg/l	1	64,2	61,4	62,8	10,8	20,8	41,3
Furolan, 10 mg/l	2	50,0	55,9	53,0	1,0	1,9	-
Furolan, 30 mg/l	2	56,9	55,9	56,4	4,4	8,5	-
Furolan, 50 mg/l	2	58,3	59,0	58,7	6,7	12,9	-
Furolan, 60 mg/l	2	58,0	64,5	61,3	9,3	17,9	43,2
Furolan, 80 mg/l	2	58,5	67,5	63,0	11,0	21,2	44,2
Furolan, 100 mg/l	2	62,6	62,2	62,4	10,4	20,0	42,9
Copper sulfate bloom, 500 mg/l	3	63,0	62,4	62,7	10,7	20,6	-
Copper sulfate budding, 500 mg/l	2	57,7	63,6	60,7	8,7	16,7	42,8
Si. 500 mg/l + 500 mg/l	2-3	58,7	62,9	60,8	8,8	16,9	-
EM	1	51,7	55,7	53,7	1,7	3,3	-

Note: 1 – processing of planting material; 2 – spraying plants.

A viral infection significantly changes almost all plant parameters at all levels - from the state and functional activity of the photosynthetic apparatus, the activity of enzyme systems, the consumption and accumulation of mineral elements, the intensity of transpiration, the area of vascular bundles (Ambrosov A.L. et al., 1979, Leontyeva Yu A. et al., 1974).

Tsoglin L. N. et al. (1990) found out that the total photosynthesis during the entire growing season in healthy plants is almost 40% higher than in infected ones, and they are characterized by faster growth of the leaf surface.

Plants freed from viruses have an increased physiological activity compared to conventional seed material, which determines a higher level of tuber yield (Batsanov N. S. et al., 1974).

N. I. Adamov et al. (1985) indicate that the degree of plant damage by viruses is reflected in the potato yield, but it depends on the potato variety, its resistance to viruses and the growing area.

The most harmful to potato plants is the leaf curl virus (L), which can cause a reduction in yield up to 77%, loss of starch - up to 12.6% and vitamin C - up to 12.1% (Azbukina E. M., 1980).

In the experiments of V. I. Igontov (1990), the overall infection of potatoes with viruses and mycoplasma diseases of the Volzhanin and Volzhsky varieties changed slightly under the influence of growth regulators, but there was a tendency towards an increase in infection. Physiologically active substances (ethrel, alar and camposan) contributed to a decrease in potato infection by certain viruses in the Volzhanin variety, but no clear pattern was identified.

The results of our research show that the use of physiologically active compounds has an impact on the spread of viral infection. In 2005, in variants using the growth stimulants, there were no plants infected with virus Y, and in 2006, their use caused a decrease in the infection of potato plants with virus X.

In response to infection, plant tissues are capable of producing substances that are practically absent in intact tissues and have nonspecific fungitoxic effects. Plants oppose pathogens of infectious diseases, phytoalexins, which are a special class of phytoncides (Metlitsky L. V. et al., 1985; Metlitsky L. V., 1982; Ozeretskovskaya O. L., 1990).

Phytoalexins are formed not only in damaged plant tissue, but also in response to treatment with a number of chemical agents and physical stress, and in this regard they are sometimes called stress metabolites (Stoessl A. et al., 1976).

In cells infected with a race of late blight (*Phytophthora infestans*) incompatible with the potato variety under study, mainly two phytoalexins are formed - rishitin and lyubimin (Metlitsky L.V. et al., 1980).

As indicated by L. V. Metlitsky et al. (1971), fungicides containing copper have the greatest inducing activity against phytoalexins.

26. The influence of physiologically active substances and copper sulfate on the induction of rishitin.

Option	Rishitin content, mcg/5 ml
Control	0,00
Cu O_4*7H_2O (500 mg/l)	7,89
Krezacin, 40 mg/l	0,00
Simarp, 1 mg/l	0,00
Furolan, 70 mg/l	0,0

The results of our studies (Table 26) show that treatment of tubers only with a solution of copper sulfate ($CuSO_4$ * $7H_2O$) caused the biosynthesis of rishitin in the cells and its content was 7.89 µg per 5 ml of extract.

When cells interact incompatibly with an infection, they quickly react to it and become necrotic, resulting in the rapid release of oligosaccharins responsible for phytoalexin formation. Phytoalexins accumulate in necrotic cells where the parasite is localized and have a negative effect on it. In some cases, phytoalexins kill pathogen cells, and in others they inhibit their growth, in other words, they have both biocidal and biostatic effects. Having killed the parasite, they are metabolized by the tissue and disappear from the necrotic zone (Metlitsky L. V. et al., 1971).

Treatment of seed material with BIF-2 (3-benzimidazolidophosphate) in tubers of a new crop causes an increase in the biosynthesis of phytoalexins when they are infected with the virulent late blight mildew (Tyutchev S. L. et al., 1984).

The use of physiologically active substances for processing seed material and during the growing season of plants had an after-effect when tubers were infected with an incompatible race of the late blight fungus (*Phytophthorosa infestans* (Mont.) de Bazy) on the biosynthesis of rishitin (Table 27).

27. Content of rishitin in potato tubers when they are affected by an incompatible race of late blight, mcg/5 ml.

Option	Rishitin content, mcg/5 ml			
	48 hours after infection	% to control	72 hours after infection	% to control
Control	4,68	-	44,60	-
Simarp, 1 mg/l	20,32	434,2	46,53	104,3
Krezacin, 40 mg/l	11,85	253,2	60,24	135,1
Furolan, 70 mg/l	4,92	105,1	44,11	98,9
Furolan, 80 mg/l	4,60	98,3	36,05	80,8
Cu O_4*7H_2O (500 mg/l)	11,45	244,7	37,02	83,0

The tubers where simarp was used had the greatest activity in the formation of rishitin 48 hours after infection, and its content exceeded the control variant by 434.2%. Spraying potato plants with krezacin and copper sulfate also had an effect on the induction of rishitin, where it was 2.53 and 2.45 times higher than the control variant.

The use of furolan (70 mg/l) for processing seed material and furolan (80 mg/l) for spraying plants did not affect the biosynthesis of rishitin.

72 hours after infection of the tubers, the rishitin content increased in all variants compared to the first recording period (48 hours). The maximum amount of rishitin was contained in tubers obtained from plants sprayed with krezacin, where it was 35.1% more than in the control variant. In other variants, the phytoalexin content was at the control level or slightly lower than it. The most intensive process of induction of rishitin occurred in the control variant compared to the first recording period (after 48 hours) and its amount increased by 9.53 times in 24 hours. The rate of rishitin biosynthesis in the cells of other variants was lower.

Krezacin and simarn, not being direct inducers of phytoalexin (rishitin) and not having an antifungal effect in the concentrations we tested, are able to enhance the biosynthesis of rishitin induced by the fungus, and thus increase the stability of tubers during storage. Copper sulfate is the cause of bioinduction of rishitin, has an antifungal effect and is able to enhance its synthesis. The use of furolan for processing seed tubers and during the growing season does not have a significant effect on the content of rishitin.

CONCLUSIONS AND PROPOSAL TO PRODUCTION

1. An increase in the leaf surface area of the Nevsky potato variety is observed until 15 days after flowering, and then due to the natural aging of leaves and the development of late blight, it decreases.

2. Potato plants reach the maximum accumulation of dry matter on the 30th day after flowering or before harvesting, depending on weather conditions. The application of mineral fertilizers, especially nitrogen, causes a later intersection of the dry matter accumulation curves of tops and tubers.

3. Due to the use of physiologically active substances in 1990, there were no plants affected by the virus on potato plantings, and in 1991 they helped to reduce the incidence of the virus on plants.

4. Application of calculated doses of fertilizers taking into account the absorption of 2% and 3% PAR on well- and moderately cultivated soil ensures the production of 271 - 359 c/ha of tubers, and the increase in yield occurs due to a greater collection of the coarse fraction.

5. The accumulation of harvest by potato plants is greatly influenced by: soil fertility, the level of mineral nutrition, the phase of plant development and others. The bulk of the tuber harvest is formed during the flowering period - the 30th day after it, and during this period the daily increase can reach 14.1 c/ha.

6. Spraying seed material and potato plants with physiologically active substances and copper sulfate ensures an increase in yield up to 85.5 c/ha, and the increase in yield occurs due to an increase in the proportion of the coarse fraction (> 80 g).

7. The use of a low-frequency electromagnetic field, furolan for processing planting material and spraying plants improves the yield properties of seed tubers. The productivity of potato plants increases by 12.2 - 35.2% compared to the control (1991).

8. Physiologically active substances and copper sulfate, used for processing seed material and during the growing season of plants, have an aftereffect when tubers are infected by an incompatible race of late blight fungus on the biosynthesis of rishitin. The tubers where simarp was used had the greatest activity in the formation of rishitin 48 hours after infection and its content exceeded the control variant by 434.2%, and after 72 hours the tubers obtained from plants sprayed with krezacin.

9. Calculated doses of fertilizers ensure an increase in the coefficient of PAR use on medium and well-cultivated soil from 1.41 to 1.65%. The higher the accumulated phytomass, the higher is the solar energy utilization rate.

10. Wet and cool weather during harvest formation helps to reduce the nitrate content, while dry and warm weather increases their content. The use of krezacin and furolan in warm and less humid growing seasons reduced the nitrate content by almost 2 times.

11. The starch content is influenced by weather conditions. Hot and dry weather increases its content. The use of furolan before planting provided an increase in the starch content by 1.5% in 1990, and krezacin in 1992 by 0.9%. Physiologically active substances increase starch collection, but this increase occurs largely at the expense of tuber yield.

In the conditions of the Moscow region, when cultivating potatoes for food purposes, it is necessary to use calculated doses of fertilizers that ensure the accumulation of 2-3% of photosynthetically active radiation by plants, as well as to use physiologically active substances and copper sulfate on commercial and seed plantings in order to increase plant productivity and improve seed properties of tubers.

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