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THE PHENOLOGY, GROWTH AND DEVELOPMENT OF POTATO PLANTS DEPENDING ON THE TIMING OF MANURE APPLICATION

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The studies were conducted to identify the influence of the timing of litter manure application in conjunction with mineral fertilizers and planting density on the duration of potato development phases and plant height. The experiments were laid by a systematic method with a tiered arrangement of variants in the experiment, the repetition is 3-fold. Research methods: descriptive method and methods of field experiments. Phenological observations in experiments have shown that the doses of mineral fertilizers and the timing of manure application have some effect on the phases of potato plant development and plant growth. The lowest plants were obtained in variants without manure application and its application in winter *on snow. The tallest plants are noted when applying manure under the chill and during spring application. This work is of practical importance for the cultivation of potatoes on dark chestnut soils of the Republic of Kazakhstan under irrigation with the use of optimal doses of mineral fertilizers and manure.*

Key words: phenology; plant height; planting; manure; fertilizer.

КӨҢДІ ЕҢГІЗУ МЕРЗІМДЕРІНЕ БАЙЛАНЫСТЫ КАРТОП ӨСІМДІГІНІҢ ФЕНОЛОГИЯСЫ, ӨСУІ ЖӘНЕ ДАМУЫ

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Картоптың өсу фазаларының ұзақтығына және өсімдіктердің биіктігіне минералды тыңайтқыштармен бірге төсеніш көңді енгізу мерзімдерінің және отырғызу жиілігінің әсерін анықтау бойынша зерттеулер жүргізілді. Тәжірибеде нұсқалары жүйелі тәсілімен орналасты, қайталануы үшеу. Зерттеу әдістері: сипаттамалық әдіс және далалық эксперимент әдістері. Тәжірибелердегі фенологиялық бақылаулар, минералды тыңайтқыштардың қолдану молшірі мен көңді енгізу мерзімдері картоп өсімдіктерінің даму фазаларына және өсімдіктердің биіктігіндегіне әсер ететіндігін көрсетті. Ең төменгі биіктідігі бойынша өсімдіктер көңді енгізбегенде және қыста қардын үстіне шашылған көңді қолданылған нұсқаларда алынды. Ең биік өсімдіктер көңді сүдігерге енгізу мерзімінде және көктемде сүдігерді қайта жырту кезінде көңді енгізде байқалды. Бұл жұмыстың минералды тыңайтқыштар мен көңнің оңтайлы қолдану мөлшерлерін қолдана отырып, суару жағдайында Қазақстан Республикасының қара-қоңыр топырақтарында картоп өсіру үшін практикалық маңызы бар.

Түйінді сөздер: фенология; өсімдіктердің биіктігі; отырғызу тығыздығы; көң; тыңайтқыштар.

ФЕНОЛОГИЯ, РОСТ И РАЗВИТИЕ РАСТЕНИЙ КАРТОФЕЛЯ В ЗАВИСИМОСТИ ОТ СРОКОВ ВНЕСЕНИЯ НАВОЗА

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Исследования проводились для выявления влияния сроков внесения подстилочного навоза в совместно с минеральными удобрениями и густоты посадки на продолжительность фаз развития картофеля и на высоту растений. Опыты закладывались систиматическим методом с ярусным расположением вариантов в опыте, повторность 3-кратная. Методы исследования: описательный метод и методы полевых экспериментов. Фенологические наблюдения в опытах показали, что дозы минеральных удобрений, и сроки внесения навоза оказывают некоторое влияние на фазы развития растений картофеля и на рост растений. Самые низкие растения были получены в вариантах без внесения навоза и внесение его зимой по снегу. Самые высокие растения отмечены при внесении навоза под зябь и при весеннем внесении под перепашку зяби. Данная работа имеет практическое значение для выращивания картофеля на темно-каштановых почвах Республики Казахстан в условиях орошения с применением оптимальных доз минеральных удобрений и навоза.

Ключевые слова: фенология; высота растений; густота посадки; навоз; удобрения.

Introduction. Potatoes are one of the most important agricultural crops in Kazakhstan. It is an indispensable food item, because it is popularly called a second bread for its nutritional value.

Potatoes are cultivated in more than 100 countries around the world, on an area of more than 17 million hectares and about 360 million tons are harvested annually, Kazakhstan occupies the 17th place in terms of harvested area (more than 192 thousand hectares), and the 21st place in potato production (about 4 million tons) [1].

One of the most effective factors affecting the growth, development and productivity of plants is organo-mineral nutrition. By regulating the intensity of nutrient intake into plants by applying fertilizers, it is possible to change the activity, and even the direction of biochemical reactions, which ultimately will significantly increase the efficiency of applied fertilizers and use the potential of a crop or variety [2, 289 p.].

Organic and mineral fertilizers enrich the soil with nitrogen and ash elements and significantly enhance the mineralization processes in it. Organic fertilizers are used to introduce organic substances that stimulate the vital activity of microorganisms, and a variety of microflora that accelerates the decomposition of organic matter in the soil. Mineral fertilizers increase the intensity of biological processes in the soil, as they are a source of nutrition for microbes with nitrogen, phosphorus, potassium, calcium and other elements [3, 107 p.].

Under the influence of fertilizers, the growth and development of not only the aboveground, but also the underground part of plants changes. So, according to T.E. Aitbaev [4, 11 p.], the intensive development of potato plants was observed with optimal nitrogen nutrition, the number of stems per bush, as well as the height and total weight of the plant increased. If, on the control the plant height was 47 cm, then against the phosphorus-potassium background – 58 cm, and on the fertilized nitrogen variants – 75 (N_{90}), 82 (N_{150}) and 85 cm (N_{210}). The number of stems per plant without nitrogen fertilizers was 4.7-4.8 pieces, and increased up to 5.5-6.2 units at application. The total stem mass per plant in the control was 205 g, against the phosphorus-potassium background 263 g, and on nitrogen fertilized variants from 275 to 320 g. Under the influence of fertilizers, the leaf area increased significantly; up to 217, 254, and 303-340 g, respectively.

Studies have shown that improved nutritional conditions had an impact on the development of plants [5, 147 p.]. It should be noted that the timing of the emergence of seedlings practically did not depend on the nutrition conditions [6, 28 p.]. The data of the conducted studies show that mineral available forms of effluent nitrogen introduced in the first stages of the growing season had a positive effect on the growth of the vegetative organs of potatoes. This is confirmed by the benefits of stem growth and the corresponding increase in the number and size of leaves. The height growth of plants increased by 8%-11.7%, respectively, compared to the background during the active vegetation period, as well as during harvesting. This led to a significant increase in newly harvested green mass [7, 116 p.].

However, in the literature [8, 297 pages], there are reports that the treatment of the above-ground mass with biofertilizers in potato phases on dark chestnut soils of Central Kazakhstan improved the conditions of mineral nutrition, enhanced growth processes and ensured a significant accumulation of dry matter. Plants formed powerful stems and leaves – the main photosynthetic apparatus, the formation and development of reproductive organs improved. Depending on the soil and weather conditions of the year, biofertilizers increased the productivity of potatoes up to 14% of the control, the increase ranged from 2.2 to 5.5 t/ha. These data convincingly show that fertilizers affect plant development in different ways depending on specific soil and climatic conditions.

The growth and development of cultivated plants depend on technological and climatic factors. If the plants deviate from the optimum of at least one of the influencing factors, they are oppressed, and the onset of critical conditions often leads to their death. The authors' task was to establish the spatial-temporal regularities of potato yield formation as one of the 56 main agricultural crops of the Brest region and to develop a probabilistic forecast method [9, 59 p.].

The purpose of the scientific experience: to find out how the timing of the application of manure with mineral fertilizers affects the duration of the phases of potato development and plant height in the West Kazakhstan region.

Materials and methods. During the growing season of 2017-2019, phenological observations were carried out on the growth and development of potato plants in the out peasant farm “Tuatay” Chingirlau district of West Kazakhstan region of the Republic of Kazakhstan [10, 50 p.].

Research methods: descriptive method, complex (summation) phenological characteristics, methods of yield indicators and methods of field experiments. Statistical processing of the yield was carried out by a dispersion analysis according to B.A. Dospekhov. The research was carried out using methodological approaches that comply with the norms of the State Standard of Kazakhstan.

The experiment scheme:

1. $N_{60}P_{120}K_{60}$
2. $N_{90}P_{120}K_{60}$
3. 40 t of manure for wintering + $N_{60}P_{120}K_{60}$
4. 40 t of manure for wintering + $N_{90}P_{120}K_{60}$

5. 40 t of manure on frozen plow + $N_{60}P_{120}K_{60}$
6. 40 t of manure on frozen plow + $N_{90}P_{120}K_{60}$
7. 40 t of manure in winter on snow + $N_{60}P_{120}K_{60}$
8. 40 t of manure in winter on snow + $N_{90}P_{120}K_{60}$
9. 40 t of manure for plowing + $N_{60}P_{120}K_{60}$
10. 40 t of manure for plowing + $N_{90}P_{120}K_{60}$

Landing scheme: 70x25 cm and 70x25 cm.

Soil dark chestnut, medium loamy. The humus content in the arable horizon is from 2.6 to 3.4%, the thickness of the humus horizons is 45-55 cm, effervescence from 45-50 cm. In terms of the content of total nitrogen, phosphorus and potassium, as well as in terms of soil pH, experimental crop rotation fields were relatively homogeneous: total nitrogen content – 0.292-0.356%; P_2O_5 – 2,6-3,5 and K_2O – 45,8-52,0% mg per 100 g of soil; pH – 7.2-7.3 aqueous extract.

Manure was applied in autumn on September 10-15 for plowing of the cold, on November 25-30 for frozen cold, on January 5-7 for shallow snow, in spring on April 20-25 for plowing of the cold.The composition of the manure differed little over the years. The following types of mineral fertilizers were used: ammonium nitrate, double superphosphate, potassium chloride [11, 215 p.].

Mineral fertilizers were applied by plowing the winter. The required amount of manure was weighed and scattered over the plots manually. The main nutrients in manure were determined in samples taken before they were introduced into the soil. The manure was plowed in autumn immediately after its introduction.

The accounting of the phenological phases of potato plant development and the determination of plant height in potato plantings was carried out according to the research methodology on potato culture [12, 170 p.]. For the beginning of the phenological phase, a period was taken when 10% of the studied plants by varieties entered this phase, and for the full phase, the germination period of 75% of the studied samples was taken. The height of the plants was measured using a portable snow measuring rail 180 cm long.

Results and discussion. Phenological observations in experiments have shown that the doses of mineral fertilizers and the timing of manure application have some effect on the phases of potato plant development (Table 1).

Table 1 – Plant phenology depending on the timing of manure application, 2017

Landing scheme	***Terms of manure application***	***Phases of development***						
		boar-ding date	***emergence of seedlings***	***bud formatio n***	***the beginning of bloome-ring***	***full bloom***	***end of bloome-ring***	***the begin-ning of the death of the tops***
70x25 cm	$N_{60}P_{120}K_{60}$	25IV	16V	6VI	15VI	22VI	4VII	4VIII
	$N_{90}P_{120}K_{60}$	25IV	16V	8VI	17V1	25VI	6VII	6VIII
	40 tons of manure under the chill + $N_{60}P_{120}K_{60}$	25IV	16V	10VI	18VI	26VI	8VII	9VIII
	40 tons of manure under the chill + $N_{90}P_{120}K_{60}$	25IV	16V	12VI	21VI	28VI	10VII	11VIII
	40 tons of manure on frozen chills + $N_{60}P_{120}K_{60}$	25IV	16V	13VI	21VI	28VI	10 VII	11VIII
	40 tons of manure on frozen chills + $N_{90}P_{120}K_{60}$	25IV	16V	13VI	21VI	28VI	10VII	11VIII
	40 tons of manure in winter on snow + $N_{60}P_{120}K_{60}$	25IV	I6V	11VI	19VI	26VI	8VII	9VIII
	40 tons of manure in winter on snow + $N_{90}P_{120}K_{60}$	25IV	16V	11VI	19VI	26VI	8VII	9 VIII
	40 tons of manure for plowing in the winter + $N_{60}P_{120}K_{60}$	25IV	16V	12VI	21VI	27VI	9VII	10VIII
	40 tons of manure for plowing in the winter + $N_{90}P_{120}K_{60}$	25IV	16V	13VI	23VI	30VI	12VII	13VIII

Table 1, Continued

Landing scheme	***Terms of manure application***	***Phases of development***						
		boar-ding date	***emergence of seedlings***	***bud formation***	***the beginning of bloome-ring***	***full bloom***	***end of bloome-ring***	***the begin-ning of the death of the tops***
70x35 cm	$N_{60}P_{120}K_{60}$	25IV	16V	7VI	16VI	23VI	3VII	4VIII
	$N_{90}P_{120}K_{60}$	25IV	16V	9VI	17VI	23VI	4VII	6VIII
	40 tons of manure under the chill + $N_{60}P_{120}K_{60}$	25IV	16V	11VI	I9VI	26VI	8VII	10VIII
	40 tons of manure under the chill + $N_{90}P_{120}K_{60}$	25IV	16V	13VI	21VI	28VI	10VII	12VIII
	40 tons of manure on frozen chills + $N_{60}P_{120}K_{60}$	25IV	I6V	13VI	21VI	28VI	10VII	12VIII
	40 tons of manure on frozen chills + $N_{90}P_{120}K_{60}$	25IV	16V	13VI	21VI	28VI	10VII	13VIII
	40 tons of manure in winter on snow + $N_{60}P_{120}K_{60}$	25IV	16V	11VI	19VI	26VI	8VII	11VIII
	40 tons of manure in winter on snow + $N_{90}P_{120}K_{60}$	25IV	16V	12VI	20VI	28VI	10VII	14VIII
	40 tons of manure for plowing in the winter + $N_{60}P_{120}K_{60}$	25IV	16V	14VI	21VI	28VI	10VII	15VIII
	40 tons of manure for plowing in the winter + $N_{90}P_{120}K_{60}$	25IV	16V	15VI	23VI	30VI	12VII	18VIII

So, in 2017, when planting on April 25, seedlings in all variants appeared on May 16, i.e. 21 days after planting. However, with an increase in nitrogen on a mineral background from 60 to 90 kg/ha, the budding phase occurred 2 days later.

The introduction of 40 tons of manure under the chill against the background of $N_{60}P_{120}K_{60}$ delayed the budding phase for another 2 days, and against the background of $N_{90}P_{120}K_{60}$ for another 2 days, i.e. the budding phase when applying manure came 4 and 6 days later compared to the control ($N_{60}P_{120}K_{60}$), and the introduction of manure in winter accelerated this phase compared to the spring application manure for 1-2 days.

Approximately the same number of days later, the other phases of development also occurred. This difference was especially noticeable when the tops died off. With the introduction of $N_{60}P_{120}K_{60}$, the death of the tops in 2017 was noted on August 4, with the introduction of $N_{90}P_{120}K_{60}$ – on August 6. In all variants with the introduction of manure, the dying of the tops began 5-9 days later than without manure.

In the field experiments of I.E. Burlakova [13, 107 p.], On variants where higher doses of mineral fertilizers were applied, the plants entered the budding and flowering phase much later. Even after flowering, the plants of these variants continued to form new shoots. Due to the fact that the period of growth of vegetative mass here was longer, the outflow of nutrients into the tubers was inhibited. With a significantly larger vegetative mass, the mass of tubers in these variants turned out to be less than in the variants where 50-60 mg of NPK was introduced.

The effect of planting density on the beginning of the dying of the tops was noted only in three variants. When manure is applied in winter on snow against the background of $N_{90}P_{120}K_{60}$ and when manure is applied in spring for plowing in the cold. When planting according to the 70x25 cm scheme and applying manure in winter on snow on a mineral background of $N_{90}P_{120}K_{60}$, the beginning of dying off of the tops was noted on August 9, with spring application against the background of $N_{60}P_{120}K_{60}$ – on August 10, against the background of $N_{90}P_{120}K_{60}$ – on August 13, and when planting according to the 70x35 cm scheme, respectively, on August 14, 15 and 18, i.e. for 5 days later.

The total duration of the planting period – the beginning of the dying of the tops when applying $N_{60}P_{120}K_{60}$ was 101 days, when applying $N_{90}P_{120}K_{60}$ – 103 days, when applying manure under the chill 106 and 108 days, or 5 days longer, when applying manure on frozen cold – 108 days, in winter on snow – 106 days, under the plowing of the cold – respectively 107 and 110 days when landing according to the 70x25 cm scheme, and when landing according to the 70x35 cm scheme, the duration of this period in the latter version was 115 days.

Such experiments were carried out by I.P. Rykhlivsky and V.S. Stroyanovsky [14, 33 p.], where it was found that four phases are determined in the development of potatoes: germination, budding, flowering and maturation. The duration of each phase depends on the biological characteristics of the variety and growing conditions. For example, shoots of medium-ripened potato varieties appear in 15-20 days, 17-24 days pass from germination to budding, 14-18 days from budding to full flowering and 45-48 days from flowering to dying off of the tops. In early-maturing varieties, each period is shorter, in late-maturing varieties – a few days longer.

Weather conditions also have a great influence on the duration of interphase periods. As already noted, the spring processes of 2018 were lagging behind the average annual norms. The average monthly air temperature in April was below normal by 0.4°C. In the first decade of May, there is an increase in temperature. The average decadal air temperature of the composition is 13.8°C. In the second and third decades, the temperature dropped again, and they amounted to 11.5 and 11.6°C, respectively. The average monthly air temperature was 11.9°C, which is 3.5°C below normal. Under these conditions, all phases of plant development were more stretched (Table 2 and Figure 1).

Table 2 – Plant phenology depending on the timing of manure application, 2018

Landing scheme	***Terms of manure application***	***Phases of development***						
		boar-ding date	***emergence of seedlings***	***bud formation***	***the beginning of bloome-ring***	***full bloom***	***end of bloome-ring***	***the begin-ning of the death of the tops***
70x25 cm	$N_{60}P_{120}K_{60}$	30IV	25V	18VI	27VI	03VII	10VII	14VIII
	$N_{90}P_{120}K_{60}$	30IV	25V	20VI	29V1	06VII	13VII	16VIII
	40 tons of manure under the chill + $N_{60}P_{120}K_{60}$	30IV	25V	22VI	30VI	07VII	14VII	19VIII
	40 tons of manure under the chill + $N_{90}P_{120}K_{60}$	30IV	25V	23VI	01VII	08VII	15VII	19VIII
	40 tons of manure on frozen swell + $N_{60}P_{120}K_{60}$	30IV	25V	23VI	01VII	08VII	15VII	20VIII
	40 tons of manure on frozen swell + $N_{90}P_{120}K_{60}$	30IV	25V	24VI	02VII	10VII	17VII	20VIII
	40 tons of manure in winter on snow + $N_{60}P_{120}K_{60}$	30IV	25V	22VI	29VI	06VII	13VII	19VIII
	40 tons of manure in winter on snow + $N_{90}P_{120}K_{60}$	30IV	25V	22VI	29VI	06VII	13VII	19VIII
	40 tons of manure for plowing in the winter + $N_{60}P_{120}K_{60}$	30IV	25V	24VI	2VII	10VII	17VII	21VIII
	40 tons of manure for plowing in the winter + $N_{90}P_{120}K_{60}$	30IV	25V	26VI	3VII	11VII	18VII	21VIII
70x35 cm	$N_{60}P_{120}K_{60}$	30IV	25V	18VI	27VI	03VII	10VII	14VIII
	$N_{90}P_{120}K_{60}$	30IV	25V	20VI	29VI	06VII	13VII	17VIII
	40 tons of manure under the chill + $N_{60}P_{120}K_{60}$	30IV	25V	22VI	30VI	07VII	14VII	19VIII
	40 tons of manure under the chill + $N_{90}P_{120}K_{60}$	30IV	25V	23VI	01VII	08VII	15VII	20VIII
	40 tons of manure on frozen swell + $N_{60}P_{120}K_{60}$	30IV	25V	23VI	01VII	08VII	15VII	21VIII
	40 tons of manure on frozen swell + $N_{90}P_{120}K_{60}$	30IV	25V	24VI	02VII	10VII	17VII	22VIII
	40 tons of manure in winter on snow + $N_{60}P_{120}K_{60}$	30IV	25V	22VI	29VI	06VII	13VII	19VIII
	40 tons of manure in winter on snow + $N_{60}P_{120}K_{60}$	30IV	25V	22VI	29VI	06VII	13VII	19VIII

Table 2, Continued

Landing scheme	***Terms of manure application***	***Phases of development***						
		boar-ding date	***emergence of seedlings***	***bud formation***	***the beginning of bloome-ring***	***full bloom***	***end of bloome-ring***	***the begin-ning of the death of the tops***
70x35 cm	40 tons of manure in winter on snow + $N_{90}P_{120}K_{60}$	30IV	25V	23VI	30VI	06VII	13VII	19VIII
	40 tons of manure for plowing in the winter + $N_{60}P_{120}K_{60}$	30IV	25V	25VI	2VII	11VII	18VII	23VIII
	40 tons of manure for plowing in the winter + $N_{90}P_{120}K_{60}$	30IV	25V	25VI	4VII	13VII	20VII	25VIII

So, if in 2017 seedlings appeared after 21 days, then in 2018 after 25 days, or 4 days later.

Favorable temperature conditions in June (the average monthly air temperature was 18.3°C, which is 1.6°C below normal) contributed to the rapid growth and reproduction of plants.

July was hot and dry [15, 71 p.]. This caused an acceleration of flowering and in all variants it stopped a week after full flowering. The first decade of August was also hot, and the second and third decades were cool, which contributed to the good condition of the aboveground mass for a long time and the death of the tops was noted in some variants in the middle, in others at the end of August.

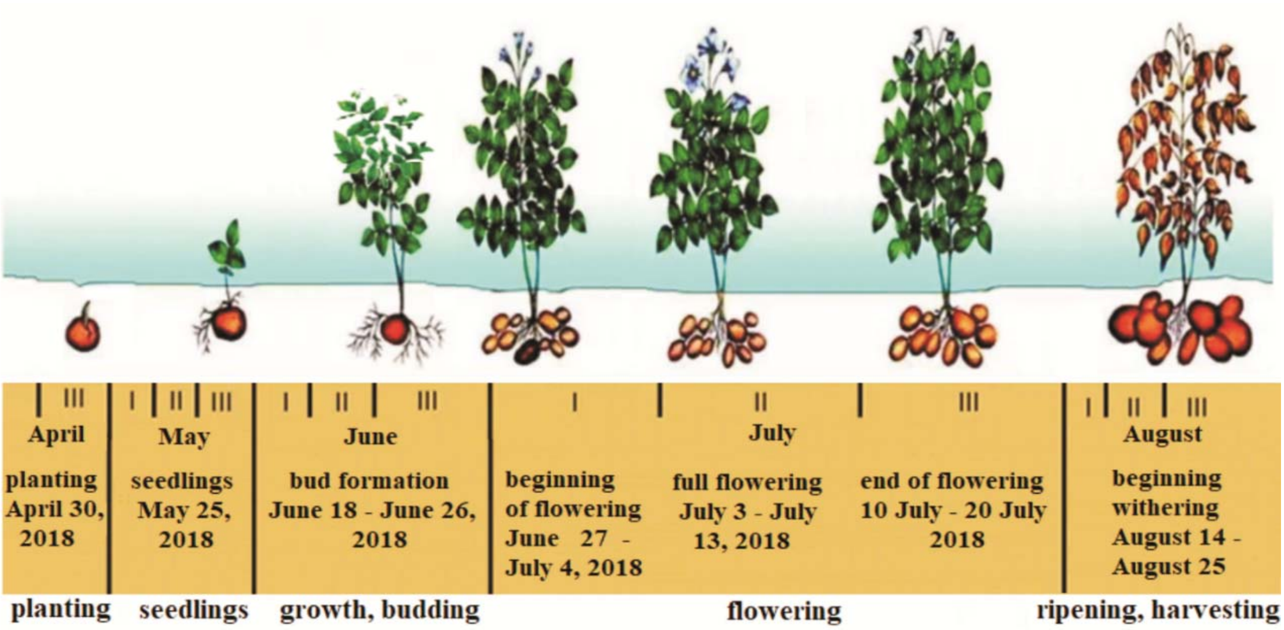

Figure 1 – Phenological phases of potato plant development depending on the timing of manure application (2018) [16]

When applying manure, the dying of the tops was noted 5-11 days later than when applying only mineral fertilizers at a dose of $N_{60}P_{120}K_{60}$.

At the latest, the dying off of the tops was noted during the spring application of manure for plowing the finches. If, when applying $N_{60}P_{120}K_{60}$, the beginning of the dying of the tops was noted on August 14, then when applying the spring plowing of the finch and when planting according to the 70x25 cm scheme – on August 21, i.e. a week later, and when planting according to the 70x35 cm scheme – on August 25, i.e. 11 later than when applying $N_{60}P_{120}K_{60}$ and for 4 days later compared to the thickened planting of 70x25 cm.

The weather conditions in 2019 [17] were very favorable for the growth and development of potato plants (Table 3).

Table 3 – Plant phenology depending on the timing of manure application, 2019

Landing scheme	***Terms of manure application***	***Phases of development***						
		boar-ding date	***emergence of seedlings***	***bud formatio n***	***the beginning of bloome-ring***	***full bloom***	***end of bloome-ring***	***the begin-ning of the death of the tops***
70x25 cm	$N_{60}P_{120}K_{60}$	25IV	13V	30V	08VI	17VI	01VII	31VII
	$N_{90}P_{120}K_{60}$	25IV	13V	30V	09V1	18VI	03VII	01VIII
	40 tons of manure under the chill + $N_{60}P_{120}K_{60}$	25IV	13V	02VI	11VI	20VI	06VII	06VIII
	40 tons of manure under the chill + $N_{90}P_{120}K_{60}$	25IV	13V	03VI	12VI	21VI	08VII	08VIII
	40 tons of manure on frozen chills + $N_{60}P_{120}K_{60}$	25IV	13V	03VI	12VI	21VI	08VII	09VIII
	40 tons of manure on frozen chills + $N_{90}P_{120}K_{60}$	25IV	13V	03VI	13VI	22VI	10VII	11VIII
	40 tons of manure in winter on snow + $N_{60}P_{120}K_{60}$	25IV	13V	02VI	11VI	20VI	8VII	06VIII
	40 tons of manure in winter on snow + $N_{90}P_{120}K_{60}$	25IV	13V	02VI	11VI	20VI	8VII	06VIII
	40 tons of manure for plowing in the winter + $N_{60}P_{120}K_{60}$	25IV	13V	03VI	13VI	22VI	12VII	12VIII
	40 tons of manure for plowing in the winter + $N_{90}P_{120}K_{60}$	25IV	13V	04VI	14VI	24VI	15VII	15VIII
70x35 cm	$N_{60}P_{120}K_{60}$	25IV	13V	03VI	08VI	17VI	01VII	31VII
	$N_{90}P_{120}K_{60}$	25IV	13V	03VI	09VI	18VI	03VII	01VIII
	40 tons of manure under the chill + $N_{60}P_{120}K_{60}$	25IV	13V	03VI	11VI	20VI	05VII	06VIII
	40 tons of manure under the chill + $N_{90}P_{120}K_{60}$	25IV	13V	04VI	12VI	21VI	08VII	08VIII
	40 tons of manure on frozen chills + $N_{60}P_{120}K_{60}$	25IV	13V	03VI	12VI	21VI	08VII	09VIII
	40 tons of manure on frozen chills + $N_{90}P_{120}K_{60}$	25IV	13V	04VI	13VI	22VI	10VII	11VIII
	40 tons of manure in winter on snow + $N_{60}P_{120}K_{60}$	25IV	13V	02VI	11VI	20VI	08VII	08VIII
	40 tons of manure in winter on snow + $N_{90}P_{120}K_{60}$	25IV	13V	04VI	13VI	21VI	08VII	08VIII
	40 tons of manure for plowing in the winter + $N_{60}P_{120}K_{60}$	25IV	13V	04VI	14VI	24VI	12VII	12VIII
	40 tons of manure for plowing in the winter + $N_{90}P_{120}K_{60}$	25IV	13V	05VI	15VI	25VI	15VII	16VIII

The general pattern of growth and development of potato plants was the same as in previous years, but there were also their own peculiarities. In the third decade of April, the average daily air temperature was 9.7° C, in the first decade of May – 13.2° C, in the second 15.3° C in the third – 20.2° C, i.e. there was a constant increase in temperature, accelerated the emergence of seedlings. And if the seedlings in 2017 were obtained 21 days after planting, in 2018 25 days after planting, then in 2019 – 18 days after planting, i.e. 3 days earlier compared to 2017 and 7 days faster than in 2018.

According to T.A. Kapelyukh, observations on the study of the appearance of the potato germination phase of spring planting showed that the studied factors had almost no effect on this process. The further development of plants is also more related to the conditions of the growing season than to the elements set for study in technology [18, 8 p.].

June was cool [17]. The average air temperature in the first decade was the same as in the first decade of May, and in the second and third decades even lower than in May (The air temperature in the first decade of July was 13.5° C, in the second – 14.9° C, in the third – 19.3° C.). Therefore, such important phases of development for the potato plant as budding and flowering were somewhat stretched.

Such data were also shown in experiments at the educational-scientific-practical center of the Nikolaev National Agrarian University (Higher educational institution of Ukraine), where the use of fertilizers, regardless of the application period, slightly restrained the onset of budding and flowering phases – on average, for 1-2 days compared to the control in all varieties [18].

Against the background of only mineral fertilizer $N_{60}P_{120}K_{60}$, the formation of buds was noted on May 30, which is 7 days earlier than in 2017, and against the background of $N_{90}P_{120}K_{60}$ – 9 days earlier. The budding phase for all variants occurred 7-10 days earlier than in 2017, and its duration was, on the contrary, longer by 2-3 days. If full flowering in 2017 was noted 7 days after the beginning of flowering, then in 2019 after 9 days, and in variants with spring manure application – after 10 days. The end of flowering in 2017 was marked in different versions from July 4 to July 12, and in 2019 – 1-15VII, with the same planting date as in 2017.

August, on the contrary, was warmer than usual in 2019 [20, 38 p.]. The average air temperature for the first decade was 23.3° C, in the second 22.0° C, which is higher than in July by 1.2 and 0.6° C. The average air temperature in the third decade was 20.6°C, and the monthly average was 21.9° C, which is 1.1°C higher than normal.

The timing of manure application in combination with mineral fertilizers had a certain effect on plant growth, but differences in plant height were more noticeable from the budding phase and in subsequent phases, so we have given data on plant height in the flowering phase.

The height of plants was influenced by the timing of manure application, the weather conditions of the year, as well as the density of planting (Table 4).

Table 4 – Height of plants depending on the timing of manure application

Landing scheme	***Terms of manure application***	***Height, cm***			
		2017 year	***2018 year***	***2019 year***	***average for 3 years***
70x25 cm	$N_{60}P_{120}K_{60}$	66,6	64,5	69,5	66,8
	$N_{90}P_{120}K_{60}$	72,1	69,0	72,6	71,2
	40 tons of manure under the chill + $N_{60}P_{120}K_{60}$	78,4	75,4	78,9	77,5
	40 tons of manure under the chill + $N_{90}P_{120}K_{60}$	81,2	78,2	84,8	81,4
	40 tons of manure on frozen chills + $N_{60}P_{120}K_{60}$	72,1	72,9	75,2	73,4
	40 tons of manure on frozen chills + $N_{90}P_{120}K_{60}$	75,2	74,2	76,8	75,4
	40 tons of manure in winter on snow + $N_{60}P_{120}K_{60}$	70,3	68,6	73,4	70,7
	40 tons of manure in winter on snow + $N_{90}P_{120}K_{60}$	72,4	69,5	74,8	72,2
	40 tons of manure for plowing in the winter + $N_{60}P_{120}K_{60}$	77,8	73,1	79,9	76,9
	40 tons of manure for plowing in the winter + $N_{90}P_{120}K_{60}$	78,4	77,3	85,6	80,4
70x35 cm	$N_{60}P_{120}K_{60}$	64,1	63,0	64,4	63,8
	$N_{90}P_{120}K_{60}$	65,3	67,4	68,3	67,0
	40 tons of manure under the chill + $N_{60}P_{120}K_{60}$	70,8	68,3	74,4	71,1
	40 tons of manure under the chill + $N_{90}P_{120}K_{60}$	73,7	72,3	76,4	74,1
	40 tons of manure on frozen chills + $N_{60}P_{120}K_{60}$	70,2	69,1	72,2	70,5
	40 tons of manure on frozen chills + $N_{90}P_{120}K_{60}$	71,4	70,1	73,1	71,5
	40 tons of manure in winter on snow + $N_{60}P_{120}K_{60}$	68,1	65,7	68,4	67,4
	40 tons of manure in winter on snow + $N_{90}P_{120}K_{60}$	69,4	68,1	70,4	69,3
	40 tons of manure for plowing the finches+ $N_{60}P_{120}K_{60}$	75,6	72,2	79,6	75,8
	40 tons of manure for plowing the finches+ $N_{90}P_{120}K_{60}$	76,3	74,1	82,5	77,6

So, the lowest plants were obtained in variants without manure and its application in winter on snow. When applying $N_{60}P_{120}K_{60}$ without manure, the height of plants was 66.6 cm, when applying $N_{90}P_{120}K_{60}$, plants were 5.5 cm higher. This pattern has been observed in all years of research. The tallest plants are noted when applying manure under the chill and when applying spring plowing under the chill. When applying manure under the chill in combination with mineral fertilizers at a dose of $N_{60}P_{120}K_{60}$ in 2017, the plants were higher than in the version without manure by 11.8 cm, and against the background of $N_{90}P_{120}K_{60}$ by 9.1 cm.

The lowest plants on the manure background were obtained when it was applied in winter on snow (Diagram 1).

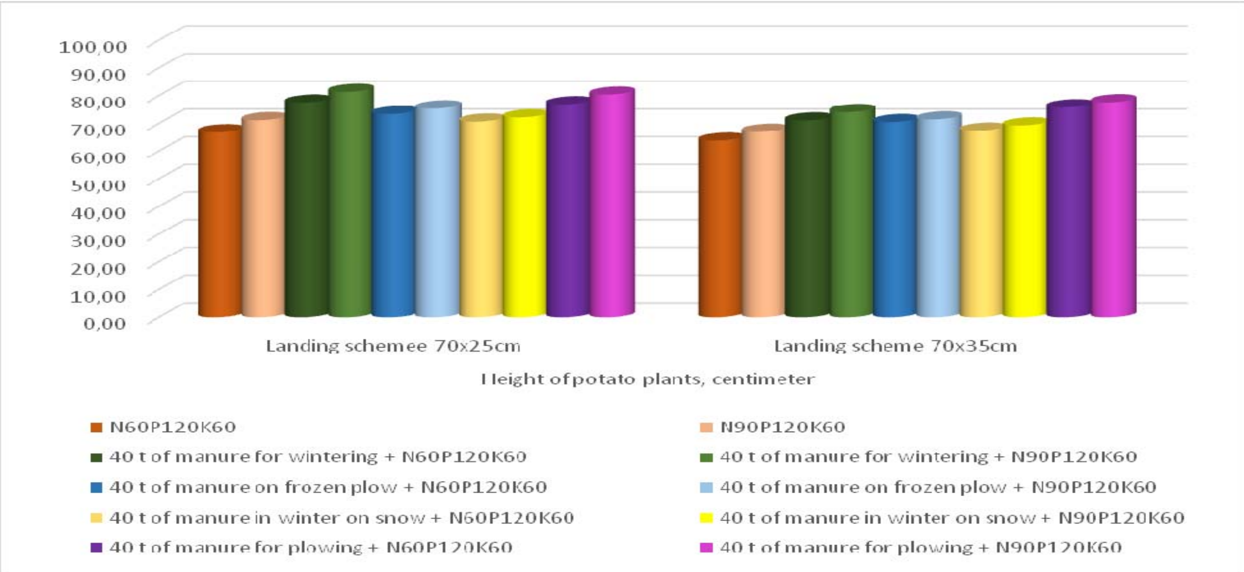

Diagram 1 – Height of potato plants depending on the timing of manure application, average for 3 years

On average, over 3 years, the height of plants in this variant was 70.7 cm against the background of $N_{60}P_{120}K_{60}$ with thickened planting (70x25 cm), and 72.2 cm against the background of $N_{90}P_{120}K_{60}$, or 1.5 cm higher.

In field experiments in the foothills of the Republic of North Ossetia – Alania, it was shown that biotic, abiotic and anthropogenic factors, including agrotechnical factors, have a significant impact on the formation of potato plant height, as well as environmental conditions that depend on the level of nutrition and varietal characteristics [21, 26 p.].].

Such data also showed in the experiments of I.M. Kenyo and N.G.Reznik that in the foothill zone of the Crimea, the potato variety Tiras was distinguished by the highest stems at 64.0 cm, while the control variety Nevsky showed the lowest – up to 49.0 cm, but remaining the lowest, followed by Serafina – 50.0 cm. The Luck variety had a height of 53.5 cm, and Alvara – 56.0 cm [22, 30 p.].

Conclusions. Thus, an analysis of the duration of the phases of potato and plant development by height shows that they are influenced by factors such as the dose of mineral fertilizers, the timing of manure application, planting density and weather conditions:

The total duration of the planting – the beginning of the dying of the tops in 2018 ranged from 106 to 117 days, and was more than 2-5 days than in 2017.

The presence of moisture, optimal temperatures contributed to the active life of the aboveground mass. The dying off of the tops in 2019 in different variants was noted from July 31 to August 16. that is, under the influence of the timing of manure application in combination with mineral fertilizers, the duration of the growing season of potatoes can vary significantly, and this amplitude is up to 16 days.

When planting according to the 70x35 cm scheme on all variants of the experiment, the plants were somewhat (3.0-7.3 cm) lower than when planting 70x25 cm.

The tallest plants were obtained in a very favorable weather conditions in 2019. This year, the planting of plants according to the 70x35 cm scheme was higher than in previous years by 0.3-8.4 cm.

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THE RESULTS OF THE ANALYSIS OF STUDIES OF STRUCTURAL AND OPERATIONAL PARAMETERS OF IMPACT CRUSHERS FOR THE PRODUCTION OF FARM ANIMAL FEED

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The article discusses the issues of improving the design and operating parameters of impact crushers for the production of farm animal feed. Based on the analysis of the grinding process, the calculation of the speed and geometric parameters of the crusher was made. As a result of experiments with an impact crusher, the basic regression equation was obtained, which is necessary to analyze the influence of the factors under consideration on the specific productivity of the crusher. The significance of the coefficients of