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THE INFLUENCE OF FERTILIZERS ON THE DYNAMICS OF THE DEVELOPMENT OF POTATO VARIETIES OF DIFFERENT MATURITY GROUPS

Theoretical substantiation and new solutions to an important scientific problem are given. The research on the issue of improving certain elements of technology for growing potato varieties of different maturity groups in relation to soil and climatic conditions of the Western Forest-Steppe of Ukraine is analyzed and generalized.

The expediency and topicality of using (both individually and in combination) agro-technological methods that increase crop yields were clarified. Namely: basic nutrition, foliar fertilization with microfertilizers and new growth regulators of biological origin containing L-a-amino acids, and different nutrition areas.

The growth of the vegetative mass of plants with the maximum formation of the daily increase in the yield of tubers is of great importance for increasing the productivity of potatoes. The number of stems in a bush is of significant importance for the accumulation of potato yield, where in the future, each stem in the process of growth and development becomes an independent plant with its own root system that forms stolons and forms tubers.

The plant uses carbon dioxide from the air with the help of chlorophyll, which gives plants its characteristic green colour. Chlorophyll is housed in cellular structures called chloroplasts. Solar energy is captured by chlorophyll grains and the plant synthesizes more or less complex substances, which in turn form real reserves of nutrients. The listed factors generally affect the growth of productivity.

It's done because of the possibility of increasing gross potato production, and yield, improving economically valuable indicators of potatoes: the content of dry matter and starch, vitamins, taste improvement, the possibility of better processing into potato products. It is also a solution to the problem of environmental protection - reducing the application of mineral fertilizers and, accordingly, reducing soil contamination with pesticides. This contributes to environmentally friendly production. Solving these problems is a difficult task, as it requires a unified approach with certain priority areas. The greatest effect can be achieved if you implement integrated elements of technology, complementing and enhancing each other's actions

Keywords: potatoes, planting scheme, fertilizer doses, vegetative mass, chlorophyll grain, productivity.

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Вплив добрив на динаміку розвитку сортів картоплі різних груп стиглості

Наведено теоретичне обґрунтування і нове вирішення важливого наукового завдання, проаналізовано та узагальнено дослідження щодо питання вдосконалення окремих елементів технології вирощування сортів картоплі різних груп стиглості в ґрунтово-кліматичних умовах Західного Лісостепу України.

Висвітлено доцільність і актуальність використання агротехнологічних прийомів, які збільшують урожайність культури, а саме: основного живлення та позакореневого підживлення мікродобривами та новими регуляторами росту біологічного походження з вмістом *L-a*-амінокислот, різних площ живлення як окремо, так і в комплексному поєднанні.

Важливе значення для підвищення продуктивності картоплі має наростання вегетативної маси рослин з максимальним формуванням добового приросту врожайності бульб. Для накопичення врожайності картоплі суттєве значення має кількість стебел у кущі, де в подальшому кожне стебло в процесі росту та розвитку стає самостійною рослиною з власною кореневою системою, що утворює столони та формує бульби.

Рослина використовує вуглекислий газ з повітря за допомогою хлорофілу, який надає їй характерний зелений колір. Хлорофіл розміщується в клітинних структурах, які називаються хлоропластами. Сонячна енергія уловлюється зернами хлорофілу та здійснює синтез рослиною більш або менш складних речовин, які в свою чергу формують справжні запаси поживних речовин. Перераховані чинники в загальному впливають на зростання врожайності.

Насамперед це пов’язано з можливістю збільшення валового виробництва картоплі, підвищення її врожайності, поліпшення господарсько цінних показників: збільшення відсотка вмісту сухої речовини та крохмалю, вітамінів, смакових якостей та можливості застосування виробленої продукції в переробці на картоплепродукти, а також вирішення завдання охорони навколишнього середовища шляхом зменшення доз внесення мінеральних добрив і відповідно зниження забруднення ґрунтів пестицидами, що сприяє суттєвому поліпшенню навколишнього середовища й отриманню екологічно безпечної продукції. Вирішення поставлених проблем є складним завданням, оскільки потребує єдиного підходу з відповідними пріоритетними напрямами, де найбільшого ефекту можна досягти, якщо впроваджувати комплексно елементи технології, взаємодоповнюючи та посилюючи дію один одного.

Ключові слова: картопля, схема садіння, дози добрив, позакореневе підживлення, вегетативна маса, хлорофілове зерно, врожайність.

Introduction. Potatoes are the main source of energy for the population. Potatoes yield per area unit is higher in a shorter time than any

other crop. In addition to carbohydrates, potato tubers contain more protein than other crops, it is rich in vitamin C and contains only 1% fat [3, 17, 18].

Potatoes are a nutrient-demanding crop. Regardless of soil and climatic conditions as well as area of cultivation, fertilization of this crop is a necessary condition for obtaining a high yield of good quality. The effect of fertilizers on plant growth and development depends on the variety and nutrition background; the latter affects the seed, food and quality indices of tubers [1, 2, 4, 5, 8].

Potatoes need a significant amount of nutrients to form a crop. This need depends on the variety, meteorological conditions, nutrient area and availability of nutrients in the soil [9, 10, 11, 12].

Due to the sharp decline in the use of fertilizers, as well as their high cost, potato varieties and seeds are now the main means for obtaining a consistently high yield. Growing high-yielding intensive varieties capable of maximizing the use of fertilizers and high agro-background conditions, dramatically increases the economic efficiency of mineral fertilizers, thereby accelerating cost recovery and will be an affordable and cheap way to increase crop production in general and potatoes in particular [19, 20, 21, 22, 23].

In recent years has become a more relevant issue of using precision farming elements in potato production technology, namely the reduction of pesticides and mineral fertilizers. Its solution is the use of new modern organic and mineral fertilizers, which contain not only the basic nutrients, but also a whole arsenal of trace elements (copper, molybdenum, manganese, zinc, boron, selenium, silicon, etc.) [12, 13, 23, 24, 30].

Microfertilizers are also important for increasing potato yields and improving their quality. They provide the best effect on sandy and loamy sod-podzolic soils. Different groups have the same need for certain micronutrients. It is believed that most soils of the Ukrainian Polissia zone are well supplied with manganese and satisfactorily with copper, but they have little boron, molybdenum and zinc. In some fields, and homesteads, depending on how often and in what quantities apply organic and mineral fertilizers, the content of a trace element in the soil may vary [22, 27, 28].

The application of microfertilizers is an integral part of measures to increase the yield and productivity of potatoes. Trace elements are able to increase germination and enhance plant development [29, 30**]**.

For better growth and development of potato plants, trace elements must be in active form. The most promising and biologically active compounds are metal complexes (chelates). The originality of their action is that they activate enzymes and affect the biochemical processes in cells, stimulate growth and development of potato plants. The composition of

this fertilizer includes water-soluble forms of macro- and microelements in the chelated state, the formula of which has been developed taking into account the biological characteristics of certain crops. Such fertilizers are used to feed plants after determining the optimal phase of growth and development of agricultural plants. Scientists have proven that foliar feeding of plants works better in critical periods of plant growth and development. At this time, plants are undergoing changes in metabolism, ratio and the rate of supply of nutrients. That is why fertilization carried out during this period increases the growth potential of plants and improves the conditions for the formation of generative organs [26, 31].

The Aim was to study the impact of basic nutrition and additional foliar feeding with microfertilizers containing L-a-amino acids using different technological elements to improve biological and morphological characteristics and yield of potato varieties of different maturity groups in relation to soil and climatic conditions of Ukrainian Western Forest-Steppe [32].

Material and Methods. The experiments were conducted on the 4-field crop rotation of the Department of Agricultural Breeding of the Institute of Agriculture of the Carpathian Region of NAAS. The predecessors of potatoes were winter cereals with post-harvest sowing of green manure crops.

Mineral fertilizers were applied in the form of nitroammophoska ($N_{16}P_{16}K_{16}$), and potassium deficiency was balanced by potassium magnesium ($K_{28}Mg_8S_{15}$).

Based on the conducted agrochemical analyses, it was found that experimental soils are poor in humus (1.58–1.67%), have an acid reaction of the soil solution (pH 4.80–5.17), the number of absorbed bases 6.20–7, 22, hydrolytic acidity 2.87–3.29 mg-eq. per 100 g of soil.

The research was carried out according to generally accepted methods in potato growing [11, 15, 16] experimental data were processed on a computer using Microsoft Excel and the following methods [14].

Results and discussion. Plant growth and development is a continuous process that is divided into separate phases of plant development, which gradually pass into each other. The main phases of development for potatoes are germination, budding, flowering, tops' dying.

During the evaluation of potato plants, we analyzed the following interphase periods of potato growth: planting – full germination, full germination – budding, budding – flowering, flowering – complete tops' dying, where we observed the development of potato plants and the impact of fertilizers and micronutrients.

Analyzing the duration of interphase periods, we found that in the soil and climatic conditions of the Western Forest-Steppe, periods of potato plant development, namely: phases of germination, full germination, budding, flowering and complete extinction of tops correspond to their maturity groups to which they belong. That is, the duration of interphase periods of the middle-early variety Aria and the medium-ripe variety Gurman correspond to their morpho-biological characteristics.

The duration from planting to the full germination phase in the Aria variety was 33 days and in the Gurman variety 38 days.

The interphase period from full germination to budding lasted 15 days in the Aria variety and 16 days in the Gurman variety. From the budding phase to the flowering phase, the duration was 14 days in the Aria variety and 20 days in the Gurman variety.

From the flowering phase to the phase of complete tops' extinction, duration was 36 days in the Aria variety and 47 days in the Gurman variety respectively (Figure 1).

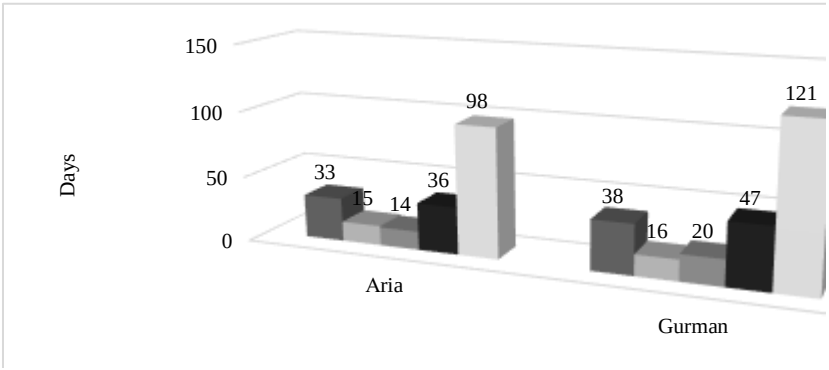

Figure 1. Duration of inter-phase periods by maturity groups of potato varieties (2018-2020)

On average, over the years of study, the growing season of middle-early variety Aria lasted 98 days, and in the medium-ripe variety Gurman 121 days.

One of the important values for increasing the productivity of potatoes is the increase of the vegetative mass of plants with the maximum formation of the daily increase in tuber yield. The number of stems in the bush is essential for the accumulation of potato yield, where in the future each stem in the process of growth and development becomes an

independent plant with its own root system that forms stolons and forms tubers.

There is a direct relationship between the number of stems and the number of tubers, and therefore an increase in the number of stems in the bush leads to an increase in the number of tubers under the bush.

The data of our studies indicate that the stem density of potato plants was influenced by factors such as feeding area, the recommended dose of fertilizers and micronutrient treatment (Table 1).

1. Biological and morphological parameters of potato plants on the 60th day after planting, 2018-2020

Experiment options	Years of research	Number of stems, pcs	Bush height, cm	Number of stems, pcs	Bush height, cm
		v. Aria		v. Gurman	
Control without fertilizers (70x30 cm)	2018	3	74	5	57,5
	2019	2,5	50	5	72,5
	2020	2,8	62	5	65
	Average	2,8	62	5	65
Recommended fertilizer dose $N_{90}P_{90}K_{120}$ (70x30 cm)	2018	2	60	3	70
	2019	3,5	55	5	73,5
	2020	2,8	58	4	71,8
	Average	2,8	58	4	71,8
R.F.D. $N_{90}P_{90}K_{120}$+ microfertilizers (70x20 cm)	2018	3,5	85	3	85
	2019	2,5	63,7	6	67,5
	2020	3	74,4	4,5	76,2
	Average	3	74,4	4,5	76,2
R.F.D. $N_{90}P_{90}K_{120}$+ microfertilizers (70x25 cm)	2018	3	57,5	4,5	72,5
	2019	3	62,5	3	75
	2020	3	60	3,8	73,8
	Average	3	60	3.8	73,8
R.F.D. $N_{90}P_{90}K_{120}$+ microfertilizers (70x30 cm)	2018	3	82,5	5	70,5
	2019	3,5	65	3,5	72,5
	2020	3,3	73,8	4,3	71,5
	Average	3,3	73,8	4,3	71,5

Thus, we see that in the control options without fertilizers and with the introduction of the recommended dose of fertilizer $N_{90}P_{90}K_{120}$, the average number of stems over the years of research was 2.8 pieces.

The largest number of stems in the bush, in relation to the middle-early variety Aria, was on the area of 70x30 cm – 3.3 pieces. In the medium-ripe variety Gurman on the area of 70x20 cm – 4.5 pieces. The density of stems of the Aria variety on other feeding areas, namely 70x20 cm and 70x30 cm was 3 pcs. In the Gurman variety, these indicators were observed on the feeding areas of 70x25 cm – 3.8 pieces and 70x30 cm, respectively 4.3 pieces.

According to the research results, it can be stated that the formation of stem density is influenced by both the feeding area, application of recommended dose $N_{90}P_{90}K_{120}$ fertilizers and additional treatment with microfertilizers.

The largest increase in height of potato plants was observed in both Aria and Gurman varieties in the option with recommended dose of fertilizers and microorganic fertilizer Ecoorganic with a feeding area of 70x20 cm and was respectively 74.4 and 76.2 cm.

In all other variants, the height of Aria variety plants was 60 cm on the feeding area of 70x25 cm, and 73.8 cm on the 70x30 cm area respectively. In the Gurman variety, the height of plants on a feeding area of 70x25 cm was 73.8 cm, on a feeding area of 70x30 cm – 71.5 cm.

The analysis of the obtained data gives grounds to assert that the area of feeding and application of the recommended dose of fertilizers with additional treatment with microfertilizers has a positive effect on both the number of stems formed and height of potato plants.

Scientists believe that in potato crops it is important to form such a leaf surface, and such a leaf index, so that the illumination of the whole plant leaves was sufficient for high intensity and productivity of photosynthesis. They confirm that the optimal average leaf surface size of one plant is 1.15 m^2, which is equivalent to 35,600 plants per 1 hectare of crops, which is 40 - 41 thousand m^2 per hectare of crops. This leaf area is achieved mostly before flowering plants, and therefore the leaf surface area was determined on the 60th day after planting for all variants of the experiment (Table 2).

According to the study results, the average potato leaf surface area in the control variant (without fertilizers) was 13.6 thousand m^2/ha in the middle-early Aria variety and 21.6 thousand m^2/ha in the Gurman variety. In the variant with the application of recommended dose $N_{90}P_{90}K_{120}$ fertilizers, the leaf surface area was 23.8 thousand m^2/ha in the Aria variety and 25.8 thousand m^2/ha in the Gurman variety.

2. Leaf surface area on the 60th day after planting, 2018 - 2020

Experiment variants	Years of research	Assimilation surface, thousand m^2/ha	
		v. Aria	v. Gurman
Control without fertilizers (70x30 cm)	2018	16,0	11,5
	2019	11,1	31,6
	2020	13,6	21,6
	Average	13,6	21,6
Recommended fertilizer dose $N_{90}P_{90}K_{120}$ (70x30 cm)	2018	18.0	15,5
	2019	29,6	36,0
	2020	23,8	25,8
	Average	23,8	25,8
R.F.D. $N_{90}P_{90}K_{120}$+ microfertilizers (70x20 cm)	2018	21,5	38,0
	2019	47,1	45,3
	2020	34,3	41,7
	Average	34,3	41,7
R.F.D. $N_{90}P_{90}K_{120}$+ microfertilizers (70x25 cm)	2018	18,5	21,0
	2019	35,9	38,4
	2020	27,2	29,7
	Average	27,2	29,7
R.F.D. $N_{90}P_{90}K_{120}$+ microfertilizers (70x30 cm)	2018	22,0	26,5
	2019	55,1	33,1
	2020	38,6	29,8
	Average	38,6	29,8

The highest leaf surface area of potato plants was observed in the variant with the recommended dose of $N_{90}P_{90}K_{120}$ fertilizers and micronutrient treatment. It was 38.6 thousand m2/ha for the middle-early Aria variety at a feeding area of 70x20 cm. The highest leaf area (41.7 thousand m2/ha) for the medium-ripe Gurman variety was observed on a feeding area of 70x20 cm with the application of the recommended dose of fertilizer $N_{90}P_{90}K_{120}$ and treatment of microfertilizers.

In all other variants, the leaf surface area of Aria variety potato plants was on feeding area 70x20 cm – 34.3 thousand m^2/ha; 70x25 cm – 27.2 thousand m^2/ha. For the Gurman variety on feeding area 70x25 cm it was 29.7 thousand m^2/ha; 70x30 cm – 29.8 thousand m^2/ha.

During the research period, on the 60th day after planting, the analysis of the potato bush weight was performed. The average weight of the bush in the control variant (without fertilizer) in the variety Aria was 380 g and in the variety Gurman, respectively, 280 g (Figure 2).

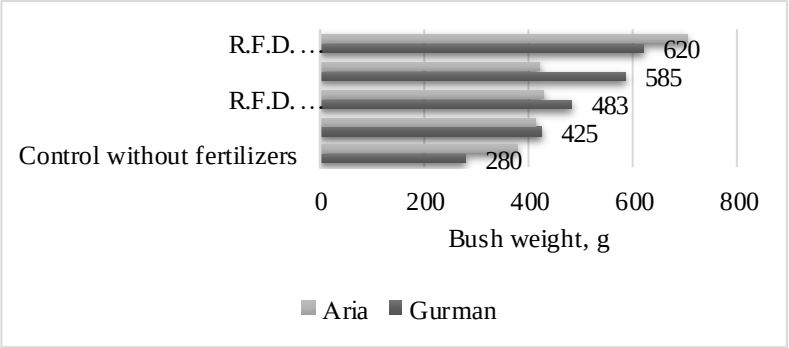

Figure 2. The weight of the potato bush depends on the feeding area and dose of fertilizers

In the variant with a recommended dose of $N_{90}P_{90}K_{120}$ fertilizers, this figure was 413 g in the Aria variety and 425 g in the Gurman variety respectively. The highest weight of potato bush, both in the variety Aria and in the variety Gourmet was observed in the variant with the recommended dose of fertilizer $N_{90}P_{90}K_{120}$ and treatment with microfertilizers on the area of 70x30 cm and was 705 g and 620 g respectively.

In all other variants of research, these indicators were in the variety Aria on a feeding area of 70x20 cm – 430 g; 70x25 cm – 423 g. Accordingly, in the Gurman variety these indicators were on the feeding area of 70x20 cm – 483 g; 70x25 cm – 585 g.

On the 70th day after planting potatoes, the largest number of stems of the Aria variety was 5.8 in the variant with a feeding area of 70x30 cm, application of recommended dose $N_{90}P_{90}K_{120}$ fertilizers and micronutrient treatment. In the Gurman variety this indicator was 8.5 pieces on a feeding area of 70x20 cm. In other versions of the experiment these indicators had the following values in the Aria variety on a feeding area of 70x20 cm – 3.3 pieces; 70x30 cm – 5.5 pcs. In the Gurman variety on the feeding area 70x25 – 5.8 pieces; 70x30 cm – 7.3 pcs.

An increase in the growth of potato plants in height, over the years of research, was observed in both medium-early variety Aria and medium-ripe variety Gurman at a feeding area of 70x30 cm with the recommended dose of fertilizer $N_{90}P_{90}K_{120}$ and micronutrient treatment and was 82.5 cm and 97.5 cm.

In all other variants of Aria variety, these indicators were by the feeding area 70x20 cm – 77 cm; 70x25 cm – 69.8 cm. In Gurman variety on the feeding area 70x20 cm it was 96.3 cm, on 70x25 cm – 82.5 cm.

The dynamics of increasing the height of potato plants on the 70th day after planting in varieties Aria and Gurman are shown in Figure 3.

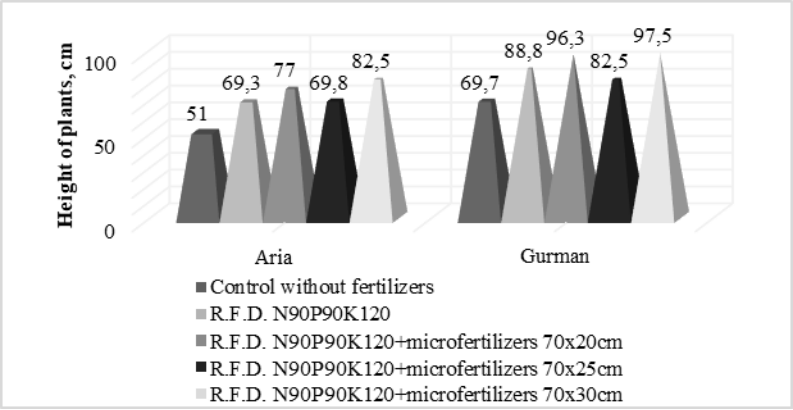

Figure 3. Height of plants depdepends on the feeding area and fertilizers' dose

Under normal growing conditions to obtain high yields of potatoes leaf surface during the period of maximum development of the photosynthetic apparatus should be at least 35-40 thousand m^2/ha. This area of leaves in potato crops is absorbed 80-90 FAR.

The average leaf area of potatoes is shown in table 3.

The leaf surface area of potato plants on the 70th day after planting on the control variant (without fertilizers) was 31.9 thousand m^2/ha for the Aria variety. In the Gurman variety this figure was 36.4 thousand m^2/ha.

In the variant with application of the recommended dose $N_{90}P_{90}K_{120}$ fertilizers, these indicators were in the Aria variety – 50.2 thousand m^2/ha, in the Gurman variety – 55.8 thousand m^2/ha.

The highest indicators of leaf surface area over the years of research were in the variety Aria on the variant with a feeding area of 70x30 cm with introduction of recommended dose of fertilizer $N_{90}P_{90}K_{120}$ and treatment with microfertilizers – 71.4 thousand m^2/ha. Accordingly, in the Gurman variety this indicator was 72.3 thousand m^2/ha on a feeding area of 70x25 cm with the application of the recommended dose of $N_{90}P_{90}K_{120}$ fertilizers and additional treatment with microfertilizers.

3. Leaf area on 70th day after planting, 2018 – 2020

Experiment variants	Years of research	Assimilation surface, thousand m^2/ha	
		v. Aria	v. Gurman
Control without fertilizers (70x30 cm)	2018	23,8	24,1
	2019	39,9	48,6
	2020	31,9	36,4
	Average	31,9	36,4
Recommended fertilizer dose $N_{90}P_{90}K_{120}$ (70x30 cm)	2018	38,9	49,6
	2019	61,4	62,0
	2020	50,2	55,8
	Average	50,2	55,8
R.F.D. $N_{90}P_{90}K_{120}$+ microfertilizers (70x20 cm)	2018	39,9	59,6
	2019	56,9	78,9
	2020	48,4	69,3
	Average	48,4	69,3
R.F.D. $N_{90}P_{90}K_{120}$+ microfertilizers (70x25 cm)	2018	48,9	72,2
	2019	49,9	72,4
	2020	49,4	72,3
	Average	49.4	72,3
R.F.D. $N_{90}P_{90}K_{120}$+ microfertilizers (70x30 cm)	2018	49,8	68,9
	2019	93,0	62,2
	2020	71,4	65,6
	Average	71,4	65,6

In all other variants in Aria variety these indicators were: 70x20 cm – 48.4 thousand m^2/ha; 70x25 cm – 49.4 thousand m^2/ha. Accordingly, in the Gurman variety, these indicators were by 70x25 cm – 69.3 thousand m^2/ha; 70x30 cm – 65.6 thousand m^2/ha.

On 60th and 70th day, leaf surface area in the control without fertilizers increased 2.3 times in the middle-early variety Aria, in the medium-ripe variety Gurman the increase was 1.7 times.

In the variant with the application of the recommended dose of $N_{90}P_{90}K_{120}$ fertilizers, the increase in the medium-early Aria variety was 2.1 times and in the medium-ripe Gurman variety 2.2 times.

In the variants with application of the recommended dose of $N_{90}P_{90}K_{120}$ fertilizers, treatment with microfertilizers and different feeding areas, an increase was observed in the middle-early variety Aria at a feeding area of 70x20 cm – 1.4 times, 70x25 cm – 1.8 times and by 70x30 cm – 1.8 times. In the medium-ripe Gurman variety the increase in the area

of 70x20 cm was 1.7 times, 70x25 cm – 2.4 times and by 70x30 – 2.2 times.

The productivity of agrophytocenosis is determined by the development of stems and assimilation apparatus of plants, which together form the aboveground vegetative plants' mass.

The dynamics of weight gain of one potato bush on the 70th day after planting is shown in Figure 4.

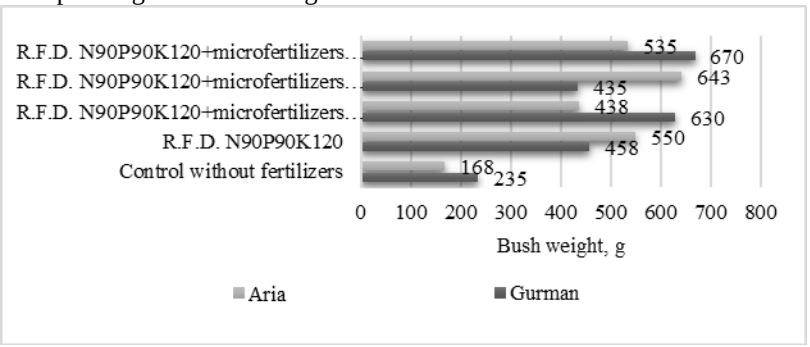

Figure 4. Weight of one potato bush depending on the feeding area and dose of fertilizers on the 70th day after planting

The weight of the bush in the control variant (without fertilizers) for the Aria variety was 168 g, and for the Gurman variety – 235 g. In the variant with the recommended dose of $N_{90}P_{90}K_{120}$ fertilizer this figure was 550 g, respectively in the Gurman variety 458 g.

The highest weight of a potato plant bush in the Aria variety with a feeding area of 70x25 cm and with the recommended dose of $N_{90}P_{90}K_{120}$ fertilizers was 643 g. In the Gurman variety, this figure was 670 g at a feeding area of 70x30 cm with the recommended dose of $N_{90}P_{90}K_{120}$ and microfertilizers' treatment.

For all others, the weight of the potato bush was: in the variety Aria on a feeding area of 70x20 cm – 438 g; 70x30 cm – 535 g. In the Gurman variety these figures were on the feeding area of 70x20 cm – 630 g; 70x25 cm – 485 g.

The plant uses carbon dioxide from the air. Chlorophyll gives plants their characteristic green color and is located in cellular structures called chloroplasts. Solar energy is captured by chlorophyll grains and carries out the plant's synthesis of more or less complex substances, which in turn form real reserves of nutrients.

Studies have shown the content of chlorophyll in all variants of the experiment, which is shown in Figure 5.

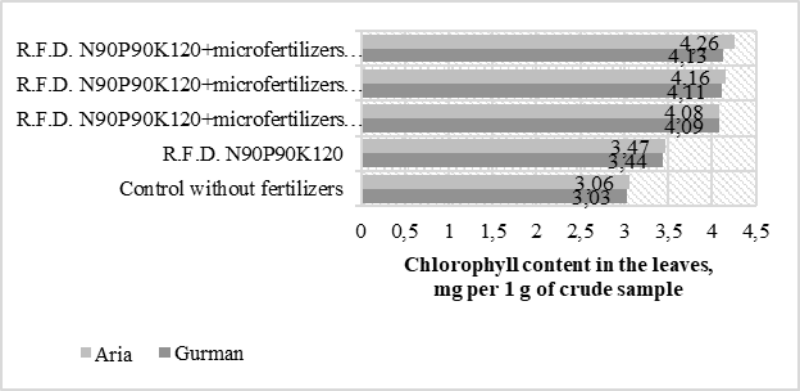

Figure 5. Chlorophyll content depends on the feeding area and dose of fertilizers.

The content of chlorophyll in the leaves of potato plants in the control variant (without fertilizers) were in the variety Aria 3.06 mg, in the Gurman variety – 3.03.

In the variant with application of recommended dose of $N_{90}P_{90}K_{120}$ fertilizers, chlorophyll content in the leaves of potato plants in the variety Aria was 3.47 mg, and in the variety Gurman – 3.44 mg.

The optimal level of nutrition for the greatest formation of chlorophyll grains in the leaves of potato plants was in the option with recommended dose of fertilizer $N_{90}P_{90}K_{120}$ and micronutrients treatment on the area of 70x30 cm in Aria variety – 4.26 mg. In Gurman variety it was 4.13 mg.

In all other variants, these figures were for the variety Aria on the area of 70x20 cm – 4.08 mg; 70x25 cm – 4.16 mg. Accordingly, in the Gurman variety this figure on feeding area 70x20 cm was 4.09 mg; 70x25 cm – 4.11 mg.

Our research has shown that there is an inverse correlation between the area of plant nutrition and content of chlorophyll grains in potato leaves, namely: with a decrease in nutrition area, the content of chlorophyll decreases, but to a certain extent.

The net productivity of photosynthesis of potato plants is determined by the total assimilative surface of the leaves and the intensity of photosynthetic processes per area unit of the leaf.

The dynamics of the net productivity of photosynthesis per day are shown in Figure 6.

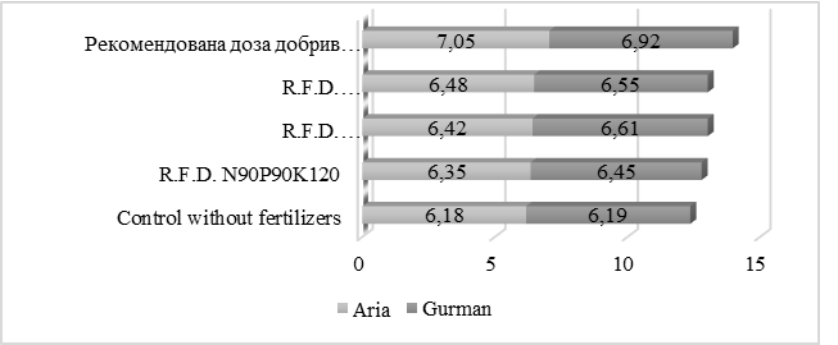

Figure 6. Net productivity of photosynthesis per day

Thus, on average over the years of research, the net productivity of photosynthesis of medium-early potato variety Aria and medium-ripe variety Gurman with the recommended dose of $N_{90}P_{90}K_{120}$ fertilizer + micronutrient treatment and different feeding areas changed as follows.

In the flowering-budding phase, the net productivity of photosynthesis in the Aria variety was 6.18 g/m^2 per day in the control variant (without fertilizers). In the Gurman variety this figure was 6.19 g/m^2 per day.

In the variant with the application of the recommended dose of $N_{90}P_{90}K_{120}$ fertilizers in the flowering-budding phases the net productivity of photosynthesis was 6.35 g/m^2 per day in the Aria variety and 6.35 g/m^2 per day in the Gurman variety.

When to the recommended dose of $N_{90}P_{90}K_{120}$, microfertilizers were added on different areas of nutrition, the net productivity of photosynthesis was in the variety Aria 70x20 cm – 6.42 g/m^2 per day; 70x25 cm – 6.48 g/m^2 per day and 70x30 cm – 6.92 g/m^2 per day.

Accordingly, in the Gurman variety, these figures were on the 70x20 cm feeding area – 6.60 g/m^2 per day; 70x25 cm – 6.55 and 70x30 cm – 6.92 g/m^2 per day.

In our opinion, the increase in net productivity of photosynthesis during the budding-flowering phase is associated with more intensive photosynthesis of young leaves in potato plants.

Obtaining high yields of potatoes is ensured by the high-yielding varieties, high-quality seed material and cultivation technology, which allows realizing the potential of the first two components.

The correct ratio of technological methods helps to establish the optimal effect of individual factors and is the basis for developing the most

effective technology for growing potatoes. Therefore, when developing the technology for growing relatively new varieties of potatoes, it is necessary to study the effect of all agro-technological measures in the complex.

The scheme of the experiment and the method of its implementation provided digging up potatoes on the 60th – 70th day after planting in order to obtain a dynamic accumulation of the crop, as well as for accounting the number of tubers to determine the fractional composition and percentage of marketability.

According to the three-year results of the study, it was established on the control variant (without fertilizers) in the variety Aria with an average tuber weight of 0.29 kg, the yield was 12.3 t/ha. In the Gurman variety the average weight of tubers was 0.34 kg. Respectively, the yield was 14.6 t/ha.

In the variant with the application of the recommended dose of $N_{90}P_{90}K_{120}$ fertilizers, weight of tubers was 0.35 kg in the Aria variety, 0.49 kg in Gurman variety. The yield was 15.0 t/ha for the Aria variety and 21.0 t/ha for the Gurman variety (Table 4).

The highest yields on the 60th day after planting on the variants with the recommended dose of fertilizer $N_{90}P_{90}K_{120}$ and treatment with microfertilizers of the Aria variety were observed in the feeding area of 70x20 cm, where the weight of tubers was 0.37 kg, yield was 26.2 t/ha. In the Gurman variety this indicator was observed on a feeding area of 70x25 cm with a tuber weight of 0.59 kg and a yield of 33.6 t/ha.

In the variants with other feeding areas and application of the recommended dose of $N_{90}P_{90}K_{120}$ fertilizers + microfertilization treatment in Aria variety on the feeding area 70x25 cm the weight of tubers was 0.35 kg, the yield was 20.5 t/ha, on the feeding area 70x30 cm the tubers' weight was 0.42 kg, yield – 18.1 t/ha.

Yield of potatoes on the 70th day after planting on the control variant (without fertilizers) in the Aria variety at an average weight of tubers of 0.31 kg yield was 13.3 t/ha. In the Gurman variety at a tuber weight of 0.36 kg yield was 15.4 t/ha.

4. Potato yield on the 60th day after planting, depending on the area of nutrition and the dose of fertilizers

Variants of the experiment	Years	Aria		Gurman	
		Weight of tubers, kg	Yield, t/ha	Weight of tubers, kg	Yield, t/ha
Control without fertilizers (70x30 cm)	2018	0,54	23,2	0,53	22,7
	2019	0,02	1,1	0,16	6,9
	2020	0,3	12,9	0,34	14,6
	Average	0,29	12,4	0,34	14,6
Recommended fertilizer dose $N_{90}P_{90}K_{120}$ (70x30 cm)	2018	0,59	25,3	0,78	33,5
	2019	0,09	4,3	0,18	7,7
	2020	0,35	15,0	0,49	21,0
	Average	0,35	15,0	0,49	21,0
R.F.D. $N_{90}P_{90}K_{120}$+ microfertilizers (70x20 cm)	2018	0,65	46,1	0,60	42,6
	2019	0,07	5,3	0,15	10,6
	2020	0,37	26,2	0,38	26,9
	Average	0,37	26,2	0,38	29,9
R.F.D. $N_{90}P_{90}K_{120}$+ microfertilizers (70x25 cm)	2018	0,63	35,9	1,02	58,1
	2019	0,08	4,8	0,15	8,5
	2020	0,36	20,5	0,59	33,6
	Average	0,35	20,5	0,59	33,6
R.F.D. $N_{90}P_{90}K_{120}$+ microfertilizers (70x30 cm)	2018	0,69	29,6	0,57	24,5
	2019	0,14	6,0	0,18	7,7
	2020	0,42	18,1	0,38	16,3
	Average	0,42	18,1	0,38	16,3

LSD_{05} fertilizers 2.1
feeding area 1.2
foliar feeding 0.3

In the variant with the application of the recommended dose of $N_{90}P_{90}K_{120}$ fertilizers in the Aria variety, tuber weight and yield were 0.44 kg and 18.9 t/ha. In the Gurman variety the weight of tubers was 0.45 kg, and the yield was 19.4 t/ha (Table 5).

5. Potato yield on the 70th day after planting, depending on the area of nutrition and the dose of fertilizers

Variants of the experiment	Years	Aria		Gurman	
		Weight of tubers, kg	Yield, t/ha	Weight of tubers, kg	Yield, t/ha
Control without fertilizers (70x30 cm)	2018	0,52	22,3	0,54	23,2
	2019	0,09	3,8	0,16	7,3
	2020	0,31	13,3	0,36	15,4
	Average	0,31	13,3	0,36	15,4
Recommended fertilizer dose $N_{90}P_{90}K_{120}$ (70x30 cm)	2018	0,61	26,3	0,69	29,6
	2019	0,27	11,6	0,19	8.1
	2020	0,44	18,9	0,45	19.4
	Average	0,44	18.9	0.45	19.4
R.F.D. $N_{90}P_{90}K_{120}$+ microfertilizers (70x20 cm)	2018	0,64	45,4	0,68	48,2
	2019	0,29	26.2	0,6	42,6
	2020	0,47	33.4	0,65	46,1
	Average	0,47	33,4	0,65	46,1
R.F.D. $N_{90}P_{90}K_{120}$+ microfertilizers (70x25 cm)	2018	0,80	45,6	1,01	57,5
	2019	0,19	10,8	0,41	23.3
	2020	0,50	28,5	0,71	40,4
	Average	0,50	28,5	0.71	40,4
R.F.D. $N_{90}P_{90}K_{120}$+ microfertilizers (70x30 cm)	2018	0,85	36,5	0,86	36,9
	2019	0,45	19,3	0,19	8,1
	2020	0,67	28,8	0,53	22,8
	Average	0,67	28,8	0,53	22,8

LSD_{05} fertilizers 4,1
feeding area 1,9
foliar feeding 0,7

The highest yield on the 70th day after planting, both in the Aria and Gurman variety was observed on a feeding area of 70x20 cm with the introduction of the recommended dose of fertilizer $N_{90}P_{90}K_{120}$ + micronutrient treatment. In the variety Aria by the weight of tubers 0.47 kg the yield was 33.4 t/ha. In the variety Gurman by the weight of tubers 0.65 kg the yield was 46.1 t/ha.

In all other variants by the Aria variety at a feeding area of 70x25 cm with the recommended dose of fertilizer $N_{90}P_{90}K_{120}$ + microfertilizer treatment the weight of tubers was 0.50 kg, yield – 28.5 t/ha. At a feeding area of 70x30 cm the weight of tubers was 0.67 kg, yielding 28.8 t/ha. The Gurman variety weight of tubers was 0.71 kg, yielding 40.4 t/ha. On the

feeding area 70x30 cm the weight of tubers was 0.53 kg and the yield was 22.8 t/ha.

Conclusions

The effect of recommended dose of fertilizers and additional foliar fertilization has a positive effect on the growth and development of potato plants depending on the biological characteristics of the varieties studied. Analyzing the duration of interphase periods, it can be seen that in the soil and climatic conditions of the Western Forest-Steppe the periods of growth and development of potato plants, namely medium-early Aria and medium-ripe Gurman varieties correspond to morpho-biological data of these varieties. The density and height of the stems were affected by the feeding area's recommended dose of fertilizers as well as micronutrient treatment. On the 60th day after planting, the density of potato stalks was the highest in the Aria variety by the feeding area of 70x30 cm – 3 pieces. In the Gurman variety on the feeding area of 70x30 cm – 4.5 pieces. The stem height of potato bushes was the highest in the feeding area of 70x20 cm with the application of the recommended dose of fertilizers and treatment with Ecoorganic micro fertilizers in the variety Aria it was 74.4 cm, and in the variety Gurman – 76.2 cm. On the 70th day, the highest density of potato stalks in the Aria variety was on the feeding area of 70x25 cm – 5.8 pieces, and in the Gurman variety – 8.5 pieces on the area of nutrition 70x20 cm. The height of the stem on the feeding area of 70x30 cm was in the variety Aria – 82.5 cm, in the Gurman variety – 97.5 cm. The leaf surface of plants which provided the maximum photosynthetic effectiveness on the 60th day was in the Aria variety on the feeding area of 70x30 cm – 38,6 thousand m^2/ha, in the Gurman variety – 41,7 thousand m^2/ha. On the 70th day the highest indicator of the leaf surface area in the Aria variety was on the area of feeding 70x30 cm – 71,4 thousand m^2/ha, in the Gurman variety – 72.3 thousand m^2/ha. Our research has shown that there is an inverse correlation between the area of plant nutrition and the content of chlorophyll grains in potato leaves, namely: with a decrease in the nutrition area, the content of chlorophyll decreases, but to a certain extent. The highest yield on the 60th day after planting in the Aria variety was on the background of the recommended dose of fertilizer $N_{90}P_{90}K_{120}$ with micronutrient treatment and feeding area 70x20 cm – 26.7 t/ha and in the Gurman variety – on the feeding area 70x25 cm – 33.6 t/ha. The highest yield on the 70th day after planting was in both the Aria variety and the Gurman variety on the background of the recommended dose of fertilizer $N_{90}P_{90}K_{120}$ with micronutrient treatment on a feeding area of 70x20 cm – 33.4 t/ha and 46.1 t/ha respectively.

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