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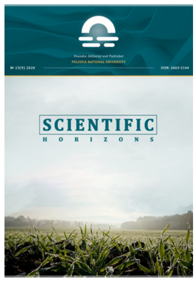

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Formation of seed potato yield depending on the elements of cultivation technology

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Abstract. It is possible to realise the maximum genetic potential of modern potato varieties by improving the elements of agricultural technology, in particular, optimising plant nutrition, which determines the relevance of this study. The purpose of the study was to substantiate the specific features of potato productivity formation depending on the elements of growing technology in Forest-Steppe conditions. Field studies were conducted during 2019-2021 on chernozem soils. The features of growth and development of potato varieties of various ripeness groups Laperla, Granada, and Memphis in Forest-Steppe conditions are examined. It is established that the yield of potato seed tubers of the varieties under study varies depending on the dose and method of fertilisation, the fraction of planting tubers, and varietal characteristics. The highest indicators of

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individual productivity of potato plants of the Laperla, Granada, and Memphis varieties were formed when locally applied in rows $N_{45}R_{45}K_{45}$ against the background of semi-rotted manure, phosphorus-potassium fertiliser, and the use of seed tubers with a fraction of >60 mm. As a result of the action of the factors under study, the number of stems in the bush and under it increased. A strong direct correlation was established between the number of stems in the bush and the number of tubers (r=0.78), with a coefficient of determination of 61.0%. The maximum yield of potato tubers of the examined potato varieties (29.7-41.1 t/ha) was obtained by local application of $N_{45}R_{45}K_{45}$ against the background of semi-rotted manure and phosphorus-potassium fertiliser, depending on the size of seed tubers by the largest transverse diameter. It was identified that the use of tubers with a fraction of >60 mm for planting the potato varieties under study is irrational since the consumption of seed material exceeds the yield growth indicators. It was determined that Laperla, Granada, and Memphis tubers with a fraction of 28-60 mm are optimal for planting potato varieties of different ripeness groups. The research results can be used to adjust the elements of agricultural technology of seed potatoes, obtain high-quality planting material, and conduct profitable agribusiness

Keywords: fertiliser; yield structure; individual plant productivity; variety; tuber size; tuber fraction

INTRODUCTION

Potatoes are one of the most widespread agricultural crops in the world, which ranks fourth after rice, wheat, and corn in terms of value and importance for the world's population and ensuring food security. Potato cultivation in many countries is conducted not only by large agricultural enterprises but also by small farms. This popularity of potato commercialisation is explained by its balance as a human food product, animal feed, and raw materials for the processing industry. Modern potato varieties and hybrids have a high potential for adaptability and productivity, which is the basis for obtaining stable high yields with valuable consumer, technical, and economic properties. Currently, many potato varieties have been imported to Ukraine from other countries, which are not yet fully adapted to the new growing conditions. Therefore, studies of the response of modern varieties to fertiliser optimisation depending on the fraction of seed tubers are relevant and of practical interest.

Balanced use of nitrogen, phosphorus and potash fertilisers is an important factor for maximising crop yields and achieving the desired quality. The study by researchers (Kyryliuk *et al.*, 2020; Biliavska *et al.*, 2021; Kotelnytska *et al.*, 2021) confirmed the improvement of the nutrient regime of the arable soil layer, optimisation of its agrophysical and water-physical indicators by applying organic and mineral fertilisers, which are mineralised by soil microorganisms and provide plants with available nutrients. The positive effect of optimising potato fertiliser on the yield and quality of tubers was noted in the works of many researchers. According to O. Iskakova and V. Gamajunova (2021), application of mineral fertilisers in autumn ($N_{32}P_{32}K_{32}$), before planting ($N_{48}P_{48}K_{48}$) and three-time foliar top dressing (Plantafol, 6 kg/ha) at the beginning of budding in 8-10 days ensures the formation of tuber yield at the level of 37-39 t/ha. The authors also investigated the effect of optimising potato nutrition on reducing the content of dry substances and starch in tubers and increasing the content of ascorbic acid. According to M. Polishchuk (2021a) application of organic and mineral fertilisers (manure 40 t/ha+$N_{90}P_{90}K_{90}$ and manure 40 t/ha+ +$N_{120}P_{120}K_{120}$) and potato planting rates of 50 thousand tubers/ha ensures the formation of the highest yield – 29.3 and 30.5 t/ha, respectively.

Now there is a discrepancy between the norms of planting potatoes and the yield of tubers. Thus, the consumption rates of planting material range from 3.0 to 5 t/ha, and the yield is only 11.0-16.0 t/ha, depending on the year of cultivation (Polishchuk, 2021b). Thus, the ratio between the yield and the planting rate (reproduction rate) is only 2.5-3.0, which makes the cultivation of this crop economically impractical. The correct choice of the size of planted potato tubers and compliance with scientifically based planting density are the crucial factors in solving this problem (Kumar & Aulakh, 2022).

A study by M.J. Sadawarti *et al.* (2021) established the effect of seed tuber size on the overall yield and output of commercial tubers. In the paper of S. Ebrahim *et al.* (2018), a research on the effect of seed tuber size (fractions 25-54, 35-45, and 46-55 mm) on the productivity of three potato varieties Gudenie, Jalene, and Kellacho in Ethiopia is presented. It is established that planting potatoes with large seed tubers ensures the formation of a maximum yield of 42.9 t/ha.

Studies conducted in the northwestern part of India are devoted to the examination of the influence of seed tuber size (25-55 mm, 35-45 mm, 45-55 mm) on potato tuber contamination and yield (Kumar *et al.*, 2021). Researchers identified that planting potatoes with medium (35-45 mm) and large (45-55 mm) seed tubers reduces the number and biomass of weeds, improves seed productivity and increases potato yield to 42.6 and 42.9 t/ha, respectively. However, they identified that it is more reasonable to plant tubers of medium size (35-45 mm).

The fraction of seed tubers affects the stem-forming ability of potato varieties (Ilchuk & Ilchuk, 2021). The maximum potato stalk was formed by varieties Kimmeriia (330 and 342 thousand stems/ha, respectively) and Shchedryk (268 and 375 thousand stems/ha, respectively) when planted with tubers with a fraction of ≥45 mm and ≥60 mm.

Consequently, the production of high-quality potato seed tubers is an important issue in traditional potato growing regions and should be improved by optimising agricultural technologies. Considering the above, the solution to the problem of growing potato seed material becomes relevant and requires the optimisation of elements of cultivation technology. The purpose of the study was to establish the dependence of the formation of the number of stems, the number of tubers under the bush, the mass of tubers from one bush on fertiliser, the fraction of seed material, and the varietal characteristics of potatoes.

MATERIALS AND METHODS

Research on the study of technology elements for potato productivity was conducted during 2019-2021 in the conditions of the farm "Olvia-S" (Sopyn village, Vinnytsia district, Vinnytsia region). The territory of the farm is located in the Forest-Steppe zone. The soil cover of the territory where the study was conducted is represented by deep low-humus medium-loamy chernozems. The arable layer (0-30 cm) of the soil of the experimental site has the following agrochemical indicators: humus content (according to Tyurin) 4.42%, easily hydrolysed nitrogen (according to Kornfield) – 12.0 mg/100 g, mobile phosphorus (according to Chirikov) – 17.1 mg/kg of soil, exchange potassium (according to Chirikov) – 17.8 mg/kg of dry soil, pH of salt extract – 6.5, hydrolytic acidity – 1.44 mg-eq/100 g, the sum of exchange bases is 35.2 mg-eq/100 g. The hydrothermal regime over the years of research was contrasting. According to the Vinnytsia meteorological station, during the growing season of 2019, 317.0 mm fell, which is 28.0 mm less than the annual average and 23.0 mm more than the amount of precipitation in 2020. The highest amount of precipitation (323 mm) was recorded in 2021. The air temperature during all the years of research (2019, 2020, and 2021) was higher by 0.8, 0.1, and 0.2°C, respectively, compared to the perennial average.

The three-factor field experiment was conducted according to the following scheme:

Factor A – varieties: Laperla – early, Granada – medium-early, Memphis – mid-season.

Factor B – fertiliser: 1. Control (without fertilisers); 2. 40 t/ha of semi-rotted manure under the predecessor +$K_{56}Mg_{16}S_{300}$+P_{30} (background); 3. Background +$N_{30}R_{30}K_{30}$ (local application); 4. Background +$N_{45}P_{45}K_{45}$ (local application); background +$N_{60}P_{60}K_{60}$ (scattering application).

Factor C – tuber fraction (size according to the largest transverse diameter, mm and weight, g): 1. size <28 mm, weight 25-50 g; 2. size 28-60 mm, weight 51-80 g; 3. size 60 mm, weight 81-100 g.

Potatoes were grown according to the generally accepted technology for the Forest-Steppe zone. The potato planting rate was: for the fraction of <28 mm – 2-2.15 t/ha, 28-60 mm – 3.6-3.75 t/ha, 60 mm – 5.4-5.55 t/ha. Basic seed material of potato varieties was used for the study. The predecessor was winter wheat. Semi-rotted manure was applied under the predecessor – 40 t/ha. Potassium magnesium ($K_{28}Mg_8S_{15}$) and superphosphate (P_{30}) were applied for the main potato cultivation. During planting, Azofoska ($N_{15}R_{15}K_{15}$) was applied either in a scattering technique for pre-sowing cultivation. During the growing season of potatoes, phenological observations of plant growth and development were conducted and the following phases were visually noted: germination, budding, flowering, and tops dying off (Kutsenko *et al.*, 2002). Individual potato productivity was determined according to generally accepted methods (Bondarchuk & Koltunov, 2019). The fractional composition of seed potato tubers was determined by selection from all variants of the experimental sites in the first and third repetition. The mass of one sample was 10 kg. Potato tubers in the selected samples were divided into three fractions according to the largest transverse diameter: less than 28 mm, 28-60 mm, and over 60 mm. The number of tubers of each fraction was counted, weighed, and determined as a percentage of the total number. Accounting of tuber yield and determination of potato seed productivity was conducted in accordance with generally accepted methods (Kucenko *et al.*, 2002). The obtained results were processed according to modern statistical methods using computer programmes Excel and Statisaca 6.0.

RESULTS AND DISCUSSION

It is possible to ensure the full realisation of the genetic potential of potato varieties by creating optimal conditions for the growth and development of plants in accordance with their needs during the growing season. Individual potato productivity depending on fertiliser, the fraction of planting tubers, and varietal characteristics is shown in Table 1.

With an increase in the fraction of planting tubers, the number of stems in the Laperla variety increased from 3.1 to 3.6 pcs./bush, the number of tubers – from 6.1 to 6.5 pcs./bush, and the mass of tubers – from 358.1 to 391.3 g/bush on the version without fertiliser. Application of 40 t/ha of semi-rotted manure under the precursor, potassium magnesia $K_{56}Mg_{16}S_{30}$, and superphosphate (P_{30}), basic potato cultivation, and an increase in the fraction of planting tubers contributes to an increase in the number of stems from 3.3 to 3.9 pcs./bush, the number of tubers – from 6.9 to 7.3 pcs./bush, and the mass of tubers – from 438.2 to 484 g/bush. An increase in individual potato productivity was observed against the background of phosphorus-potassium fertiliser and the aftereffect of semi-rotted manure and the local application of Azofoska ($N_{30}R_{30}K_{30}$). In this variant, the number of stems increases from 3.5 to 4.0 pcs./bush, the number of tubers – from 7.1 to 7.6 pcs./bush, and the mass of tubers from one bush – from 499.8 to 548.7 g.

***Table 1**. Individual potato productivity depending on fertiliser, seed tuber fraction, and variety, average for 2019-2021*

Fertiliser (factor C)	Tuber fraction, mm (Factor B)	Quantity, pcs./bush		Mass of tubers, g/bush
		stems	tubers	
Laperla variety – factor A				
Control (without fertilisers)	1	3.1	6.1	358.1
	2	3.4	6.3	374.2
	3	3.6	6.5	391.3
40 t/ha+$K_{56}Mg_{16}S_{30}$+P_{30} (background)	1	3.3	6.9	438.2
	2	3.6	7.1	460.1
	3	3.9	7.3	484
Background +$N_{30}R_{30}K_{30}$ (local application)	1	3.5	7.1	499.8
	2	3.8	7.3	520.5
	3	4.0	7.6	548.7
Background +$N_{45}P_{45}K_{45}$ (local application)	1	3.7	7.5	545.3
	2	4.0	7.8	570.2
	3	4.3	8.1	595.4
Background +$N_{60}P_{60}K_{60}$ (scattering application)	1	3.6	7.2	515.5
	2	3.9	7.5	543.0
	3	4.2	7.8	571.0
Variety Granada – factor A				
Control (without fertilisers)	1	3.5	6.5	464.8
	2	3.7	6.7	483.1
	3	3.9	7.0	510.3
40 t/ha of manure +$K_{56}Mg_{16}S_{30}$+P_{30} (background)	1	3.7	7.8	581.9
	2	3.9	8.0	600.8
	3	4.1	8.3	629.1
Background +$N_{30}R_{30}K_{30}$ (local application)	1	3.9	8.6	665.6
	2	4.2	8.8	688.2
	3	4.5	9.1	718.9
Background +$N_{45}P_{45}K_{45}$ (local application)	1	4.2	9.0	702.9
	2	4.5	9.2	725.9
	3	4.8	9.5	755.3
Background + $N_{60}P_{60}K_{60}$ (scattering application)	1	4.1	8.8	864.6
	2	4.3	9.0	707.4
	3	4.4	9.3	735.6
Memphis – factor a variety				
Control (without fertilisers)	1	3.2	6.2	390
	2	3.4	6.4	405.1
	3	3.6	6.7	428.8
40 t/ha of manure +$K_{56}Mg_{16}S_{30}$+P_{30} (background)	1	3.3	8.1	552.4
	2	3.6	8.2	569.1
	3	3.9	8.5	596.7
Background + $N_{30}R_{30}K_{30}$ (local application)	1	3.5	8.2	577.3
	2	3.8	8.5	606.1
	3	4.1	8.8	632.7
Background +$N_{45}P_{45}K_{45}$ (local application)	1	3.7	8.5	609.5
	2	4.0	8.9	645.3
	3	4.3	9.2	675.3
Background + $N_{60}P_{60}K_{60}$ (scattering application)	1	3.6	8.5	605.2
	2	3.8	8.7	625.5
	3	4.2	9.0	653.4

***Source:** compiled by the authors*

The highest indicators of individual productivity of potato plants are formed with an increase in the fraction of planting tubers against the background of phosphorus-potassium fertiliser and the aftereffect of semi-rotted manure and the local application of Azofoska ($N_{45}R_{45}K_{45}$). For these options, the number of stems per bush increases from 3.7 to 4.3 pcs., the number of tubers per bush – from 7.5 to 8.1 pcs., and the weight of tubers per bush – from 545.3 to 595.4 g. Application of Azofoska by scattering under pre-sowing cultivation ($N_{60}R_{60}K_{60}$) against the background of phosphorus-potassium fertiliser and the aftereffect of semi-rotted manure does not provide an increase in individual productivity indicators compared to the previous version. Therefore, it is more effective for plants to use nutrients when applying fertilisers locally compared to applying them in a scattering technique.

The highest indicators of individual productivity among the varieties under study were observed in the Granada Variety at all variants of the experiment. Thus, in the control (without fertilisation), the number of stems was 3.5-5.9 pcs., the number of tubers under the bush – 6.5-7.0 pcs., and the mass of tubers from one bush – 464.8-510.3 g. Against the background of the aftereffect of semi-rotted manure and phosphorus-potassium fertiliser for the main cultivation of Granada potatoes, an increase in the number of stems from 3.7 to 4.1 pcs., the number of tubers from one bush and from 7.8 to 8.3 pcs., and the mass of tubers from the bush from 581.9 to 629.1 g was observed, depending on the fraction of planting tubers. Local application of Azofoska in rows ($N_{30}R_{30}K_{30}$) against the background of the aftereffect of semi-rotted manure and phosphorus-potassium fertiliser provided an improvement in the indicators of individual productivity of the Granada variety. Thus, in this variant, the number of stems is 3.9-4.5 pcs./bush, the number of tubers is 8.6-9.1 pcs./bush, and the weight of tubers is 665.6-718.9 g/bush, depending on the fraction of planting tubers. The highest indicators of individual productivity of the Granada variety were identified in the local application of Azofoska ($N_{45}R_{45}K_{45}$) against the background of the aftereffect of manure and phosphorus-potassium fertiliser. Thus, the number of stems increases from 4.2 to 4.8 pcs./bush, the number of tubers – from 9.0 to 9.5 pcs./bush, and the weight of tubers – from 702.9 to 755.3 g/bush, depending on the fraction of planting tubers.

Application of Azofoska by scattering under pre-sowing cultivation ($N_{60}R_{60}K_{60}$) against the background of the aftereffect of semi-rotted manure and phosphorus-potassium fertiliser does not provide an increase in the number of stems and tubers in the bush, the mass of tubers from one Granada potato bush compared to the previous version. This indicates a smaller efficiency of applying fertilisers in a scattering technique compared to the local one. When applied locally, fertilisers are placed at a certain depth of the soil with a better moisture regime, where a zone with an increased concentration of nutrients is created. This contributes to the full use of nutrients by plants during the growing season.

The number of stems in the bush also has a substantial impact on the potato yield In the process of potato growth and development, each stem becomes an independent plant that has its own root system, forms stolons and tubers. A strong direct correlation was established between the number of stems and the number of tubers in the bush (r=0.78), with a coefficient of determination of 61.0 %. Thus, an increase in the first indicator leads to an increase in the second (Figure 1). The yield of potato tubers depends on the productivity of each main stem, the number of stems in the bush, and the number of plants per area unit.

During three years of research, the structure of the potato yield was determined depending on the fertiliser, the fraction of planting tubers and varietal characteristics (Fig 2-4). As a result of the research, it was identified that with an increase in the fraction of planting tubers (from <28 to 60 mm) in the structure of the potato yield, the share of the tubers with the largest transverse diameter of 28-60 mm increases. Thus, in the Laperla Variety, the proportion of tubers in control (without fertilisers) with the largest transverse diameter of 28-60 mm is 42-51.1%, depending on the increase in the fraction of planting tubers (Fig. 2).

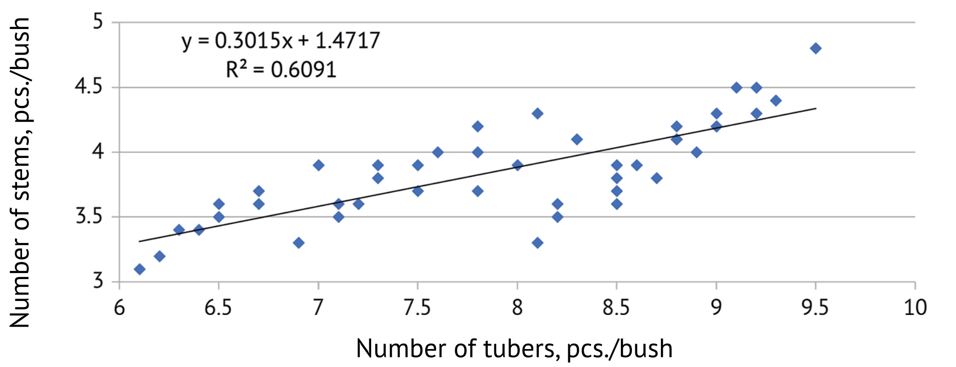

***Figure 1**. Correlation between the number of stems and the number of tubers in the bush*
***Source:** compiled by the authors*

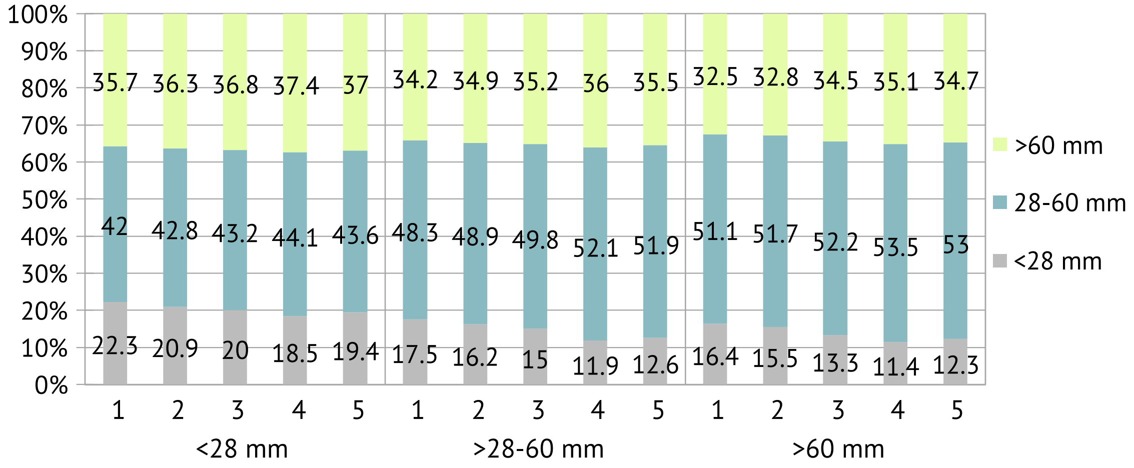

***Figure 2**. Structure of the Laperla potato yield depending on the fraction of seed tubers and fertiliser (2019-2021), %*
***Note:** 1. Control (without fertilisers); 2. 40 t/ha semi-rotted manure under the predecessor +$K_{56}Mg_{16}S_{30}$+P_{30} (background); 3. Background +$N_{30}R_{30}K_{30}$ (local application); 4. Background +$N_{45}P_{45}K_{45}$ (local application); 5. Background +$N_{60}P_{60}K_{60}$ (scattering application).*
***Source:** compiled by the authors*

An increase in the fraction of planting tubers in the control caused a decrease in the proportion of tubers with the largest transverse diameter of >60 mm from 35.7 to 32.5%. This indicates that small planting tubers usually form one or two main stems with a small number of stolons and tubers. However, during the harvesting period, such potato plants usually form larger tubers. Notably, when planted with large seed tubers, more stems and tubers are formed, but smaller. Local application of Azofoska ($N_{45}R_{45}K_{45}$) against the background of the aftereffect of semi-rotted manure and phosphorus-potassium fertiliser provides the highest indicators (44.1-53.5%) of the yield of potato tubers of the Laperla variety with the size of the largest transverse diameter of 28-60 mm. This indicator exceeds that on the control by 2.1-2.4 %. The yield of tubers of the Laperla variety with the largest transverse diameter of >60 mm in this variant is 35.1-37.4%, which is 1.7-2.6% more compared to the control.

The highest rates of tuber yield (44.9-54.6%) for the largest transverse diameter of 28-60 mm were provided by the medium-early Granada variety with local application of Azofoska ($N_{45}R_{45}K_{45}$) against the background of the aftereffect of semi-rotted manure and phosphorus-potassium fertiliser (Fig. 3).

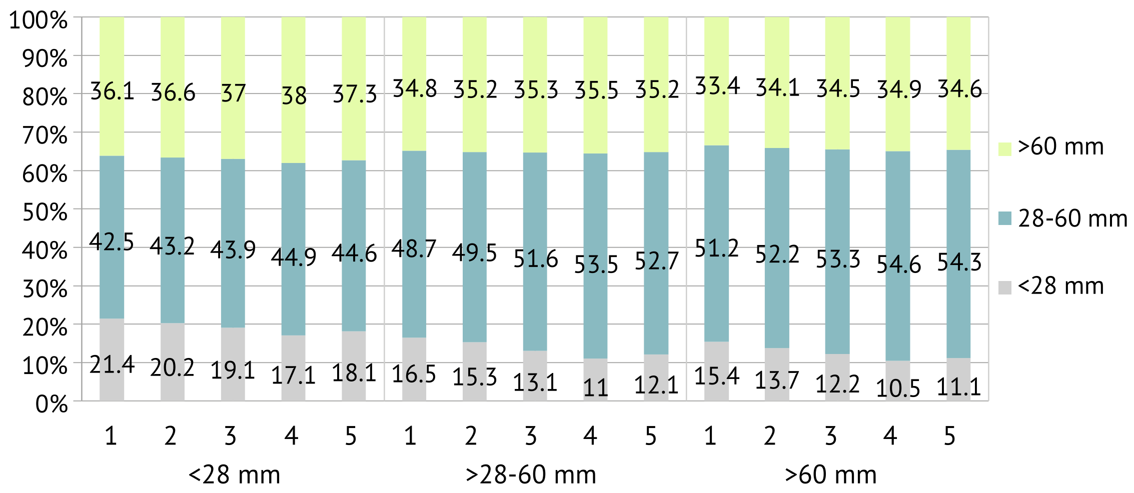

***Figure 3**. Structure of the Granada potato yield depending on the seed tuber fraction and fertiliser (2019-2021), %*
***Note:** 1. Control (without fertilisers); 2. 40 t/ha of semi-rotted manure under the predecessor +$K_{56}Mg_{16}S_{30}$+P_{30} (background); 3. Background +$N_{30}R_{30}K_{30}$ (local application); 4. Background +$N_{45}P_{45}K_{45}$ (local application); 5. Background +$N_{60}P_{60}K_{60}$ (scattering application)*
***Source:** compiled by the authors*

Notably, the proportion of tubers of this fraction varied depending on the size of the tubers of the planting material. Thus, the yield share of tubers of the Granada variety with the largest transverse diameter of >60 mm in this variant is 34.9-38.0%. The lowest yield rates of tubers (10.5-17.1%) for the largest transverse diameter of <28 mm were formed by the Granada variety depending on the fraction of planting material, which is 4.3-4.9% less compared to the control. The best developed were plants from seed tubers of a >60 mm fraction. However, the yield structure (excluding seed material) was maximal in the case of planting slightly smaller tubers (fraction of 28-60 mm), so along with the average seed fraction of tubers, it is advisable to plant healthy small tubers (<28 mm).

The highest rates of tuber yield (44.9-54.3%) for the largest transverse diameter of 28-60 mm were provided by the mid-season Memphis variety with local application of Azofoska ($N_{45}R_{45}K_{45}$) against the background of the aftereffect of semi-rotted manure and phosphorus-potassium fertiliser (Fig. 4).

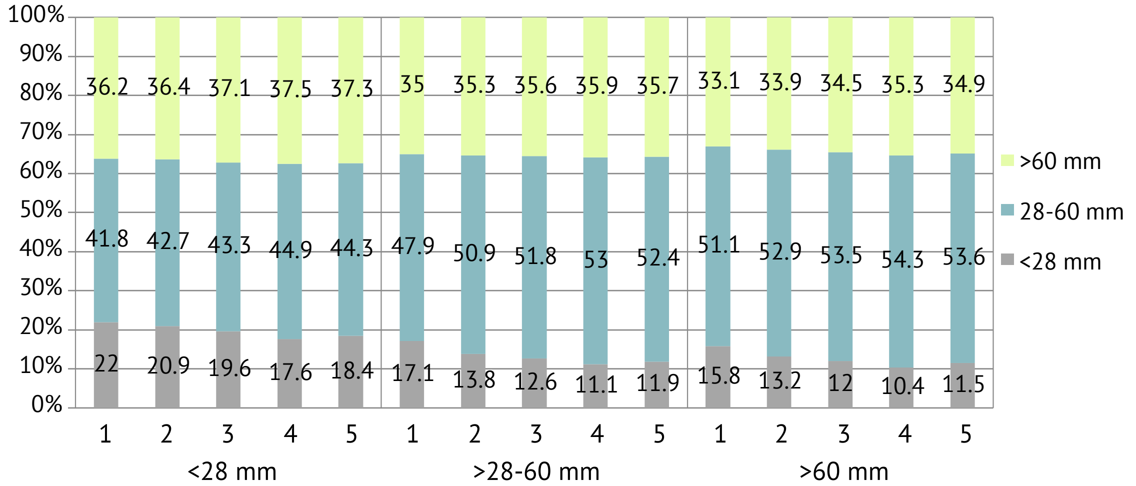

***Figure 4**. Structure of the Memphis potato yield depending on the fraction of seed tubers and fertiliser (2019-2021), %*
***Note:** 1. Control (without fertilisers); 2. 40 t/ha semi-rotted manure under the predecessor $+K_{56}Mg_{16}S_{30}+P_{30}$ (background); 3. Background $+N_{30}R_{30}K_{30}$ (local application); 4. Background $+N_{45}P_{45}K_{45}$ (local application); 5. Background $+N_{60}P_{60}K_{60}$ (scattering application)*
***Source:** compiled by the authors*

The yield share of Memphis tubers with the largest transverse diameter of >60 mm in this variant is 35.3-37.5%, which is 1.3-2.2% more compared to the control. It is known that the yield of potatoes depends on the fraction of planting tubers. The features of the formation of yields of three potato varieties of different ripeness groups depending on fertiliser and seed tuber fraction were examined (Fig. 5)

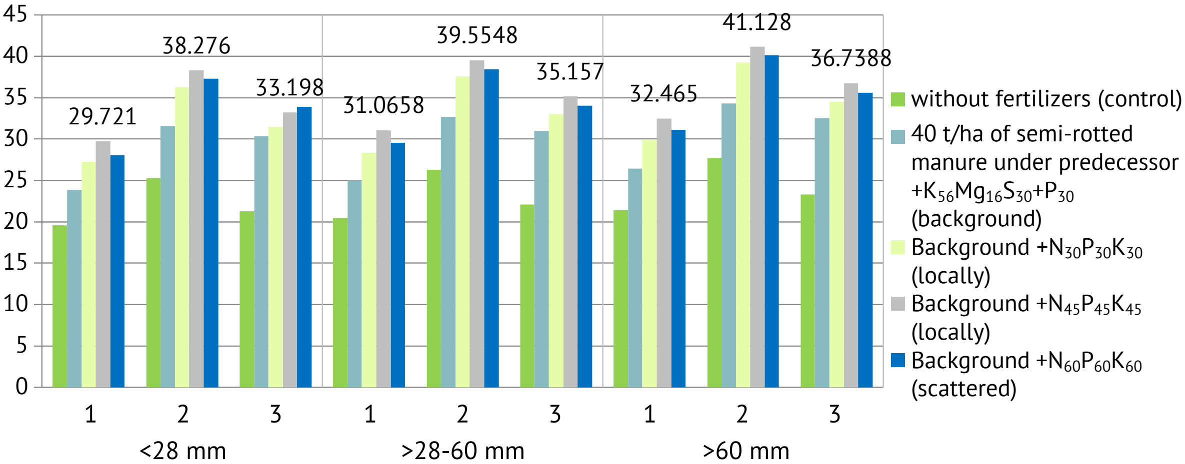

***Figure 5**. Yield of potato varieties of different ripeness groups depending on fertiliser and factions seed tubers (2019-2021), t/ha*
***Note:** 1. Laperla Variety; 2. Granada Variety; 3. Memphis Variety*
***Source:** compiled by the authors*

On average, over three years, the highest yield of tubers (41.13 t/ha) was provided by the medium-early potato variety Granada in experimental plots where Azofoska ($N_{45}R_{45}K_{45}$) was locally applied against the background of the aftereffect semi-rotted manure and phosphorus-potassium fertiliser, planted with tubers with a fraction of >60 mm. The increase in tuber yield was 32.6% compared to the control (without fertilisers). The use of seed tubers with a fraction of >60 mm for planting Granada potatoes increases the yield by 1.5 t/ha compared to the fraction of planting tubers of 28-60 mm with the same method and background of fertilisation. Therefore, when noting yield gains from planting large tubers, it is necessary to mention the consumption of planting material. That is, the difference in the consumption of planting material between the best two variants of the Granada potato variety in the experiment was 1.85 t/ha. Consequently, the increase in consumption of planting material was higher than the resulting increase in the yield of tubers.

A similar pattern was obtained in the early-maturing Laperla potato variety and the medium-maturing Memphis variety, where the yield was 32.5 and 36.7 t/ha, respectively, which is 34.2 and 36.5% more compared to the control (without fertilisers). The yield increase for planting these varieties with large tubers was 1.4 and 1.6 t/ha, respectively, and the difference in seed material consumption was 1.8 t/ha. That is, the seed material consumption on the variants for planting potatoes of Laperla and Memphis varieties with tubers with a fraction of >60 mm was also larger compared to the yield increases of these two varieties. Yield of seed potato varieties of different ripeness groups depending on fertiliser and the fraction of planting tubers (Fig. 6).

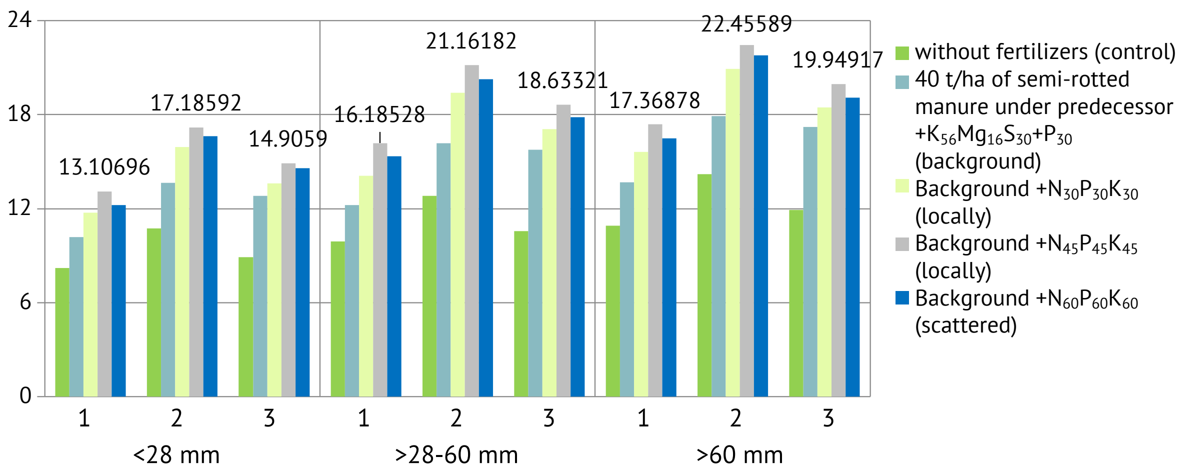

Figure 6*. Yield of seed potato varieties of different ripeness groups depending on fertiliser and seed tuber fraction (2019-2021), t/ha*

Note: *1. Laperla Variety; 2. Granada Variety; 3. Memphis Variety*
Source: *compiled by the authors*

The highest yield (22.45 t/ha) of seed potatoes (fraction of 28-60 mm) was provided by the Granada variety in experimental plots where Azofoska ($N_{45}R_{45}K_{45}$) was locally applied against the background of the aftereffect of semi-rotted manure and phosphorus-potassium fertiliser, planted with tubers with a fraction of >60 mm. For local application of Azofoska ($N_{45}R_{45}K_{45}$) against the background of the aftereffect of semi-rotted manure and phosphorus-potassium fertiliser, planting tubers with a fraction of 28-60 mm, the yield was 21.2 t/ha. However, given the previously justified inexpediency of planting potatoes with tubers of the maximum size (>60 mm), due to the substantial consumption of planting material that was not overpowered by yield increases, it is advisable to use seed tubers with a fraction of 28-60 mm.

It is possible to ensure the formation of high tuber yields and increase resistance to adverse environmental conditions by providing potato plants with mineral nutrients adapted to their needs (Petropoulos *et al.*, 2020; Salikhov *et al.*, 2021; Naumann & Pawelzik, 2023). A study established that the application of mineral fertilisers affects the formation of the number of tubers and their mass (Mhango *et al.*, 2021). In the paper of P. Meise *et al.* (2019), the role of nitrogen in potato yield formation is highlighted. Sicilian researchers S. Lombardo *et al.* (2020) substantiated the application of nitrogen fertilisers (N_{140}) on typical soils of the region under study to obtain maximum yields of potato tubers with high consumer properties and increase the profits of producers. The dependence of the formation of individual potato productivity indicators on the application of organic and mineral fertilisers is confirmed by the obtained experimental data.

Similar studies by A. Podhaietskyi *et al.* (2019) confirm that the development of a large number of tubers in potato plants depends on the genetic characteristics of the variety or hybrid. The results are consistent with studies conducted in Ethiopia. It was identified that planting potatoes with large seed tubers (46-55 mm) increases the number of stems and tubers per plant (Ebrahim *et al.*, 2018). S. Nasir and B. Akassa (2018) also reported an increase in the number of stems and tubers per plant when planted with large seed tubers. An increase in the number of stems in one potato bush under the influence of mineral fertilisers was also noted in the study by Y. Ilchuk & R. Ilchuk (2021). Thus, applying mineral fertilisers ($N_{60}P_{60}K_{90}$) increased the number of stems in the Shchedryk bush by 9.1 and 13.2% compared to the control, depending on the size of the planting tubers.

According to researchers (Podhaietsky *et al.*, 2019), one of the main factors in the productivity of potato varieties is the number of tubers formed in one plant. The dependence of potato yield on the number of stems and tubers in the bush is confirmed by the conducted research.

The results of this study are also consistent with those of D. AL-Taey *et al.*, (2008) on the positive impact of the use of organic and mineral fertilisers on improving the agrophysical condition of the soil, enhancing plant growth and development, and crop yield. According to U. Demirel (2023), to maximise the genetic potential of potato varieties during the growing season, it is necessary to create optimal conditions in accordance with the needs of plants. V. Gamajunova *et al.* (2021) confirmed that the selection of varieties and optimisation of plants with nutrients provides an increase in the yield of potato tubers by 64.7% compared to the control. M. Kravchuk *et al.* (2019) identified that using the organic-mineral fertiliser system (manure, 50 t/ha +straw, 3 t/ha +30 kg/ha +green manure, 22.5 t/ha +$N_{45}P_{50}K_{60}$) increases the yield of potato tubers by 28.3-30.6% compared to the control. The data obtained is also consistent with the studies by Polishchuk (2021a, 2021b), which report the formation of the highest indicators of tuber yield in the Serpanok variety at different planting rates (50-60 thousand units/ha) on variants with the application of organic and mineral fertilisers. Optimisation of elements of crop cultivation technology should ensure not only an increase in their yield but also the profitability of production (Kotelnytska, 2020). Therefore, when noting yield gains from planting large tubers, it is necessary to mention the consumption of planting material.

According to researchers (Singh *et al.*, 2003), small seed tubers lead to reduced productivity, while large tubers become uneconomical due to their increased cost. The findings of this stidy are also consistent with the data from obtained by V. Kumar *et al.* (2021). Thus, they received the highest net profit from planting potatoes with medium-sized seed tubers compared with small and large ones. Therefore, they also recommend using medium-sized tubers (35-45 mm) to obtain high yields of high-quality seed material and increase profitability in Northwestern India.

It was identified that planting potatoes with medium (35-45 mm) and large (45-55 mm) seed tubers provided the formation of yields of small tubers (<35 mm) up to 7.4 and 8.3 t/ha, respectively, and medium-sized tubers (35-45 mm) up to 16.6 and 17.3 t/ha, respectively. The highest yield of tubers (20.2 t/ha) of large size (>45 mm) was obtained by planting small seed tubers (25-55 mm).

CONCLUSIONS

The formation of individual productivity indicators of potato varieties (the number of stems and tubers per bush, the mass of tubers per bush) depends on the method and background of fertilisation, varietal characteristics, and the fraction of seed tubers. Local application of Azofoska ($N_{45}R_{45}K_{45}$) against the background of the aftereffect of semi-rotted manure and phosphorus-potassium fertiliser provides an increase in the number of stems and tubers in the bush, the mass of tubers per bush, and the yield of potato varieties of different ripeness groups Laperla, Granada, and Memphis in Forest-Steppe conditions. The maximum indicators of the yield structure and the number of stems of Laperla, Granada, and Memphis varieties were observed in the experiment, where with an increase in the fraction of planting tubers against the background of phosphorus-potassium fertiliser and the action of semi-rotted manure, local application of Azofoska was conducted ($N_{45}R_{45}K_{45}$).

The highest yield rates of tubers of the Laperla, Granada, and Memphis varieties, the size of which with the largest transverse diameter of 28-60 mm, were obtained in the experiment, where locally applied Azofoska ($N_{45}R_{45}K_{45}$) against the background of the aftereffect of semi-rotted manure and phosphorus-potassium fertiliser for increasing the fraction of planting material. The yield of tubers in the varieties Laperla, Granada, and Memphis was 44.1-53.5%, 44.9-54.6%, 44.9-54.3% accordingly, the proportion of tubers with the largest transverse diameter of >60 mm varied from 37.4 to 35.1%, from 38.0 to 34.9%, and from 37.5 to 35.3%, respectively.

For rational use of seed material, potato varieties of different ripeness groups Laperla, Granada, and Memphis should be planted with tubers with a fraction of 28-60 mm. The inexpediency of using seed tubers with a fraction of >60 mm is explained by an increase in the consumption of planting material compared to the obtained yield increases. In addition, the yield structure (excluding seed material) was maximal when used for planting seed tubers with a fraction of 28-60 mm. Further research should focus on identifying the features of the formation of seed productivity of potatoes depending on the fertiliser and fraction of planting tubers due to the emergence of new varieties, subject to a change in the climate of the growing area.

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CONFLICT OF INTEREST

None.

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Формування урожайності насіннєвої картоплі залежно від елементів технології вирощування

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Анотація. Реалізувати максимальний генетичний потенціал сучасних сортів картоплі можна за рахунок удосконалення елементів агротехнології, зокрема оптимізації живлення рослин, що зумовлює актуальність цього дослідження. Метою роботи було обґрунтувати особливості формування продуктивності картоплі залежно від елементів технології вирощування в умовах Лісостепу. Польові дослідження проводили впродовж 2019-2021 рр. на чорноземних ґрунтах. Досліджено особливості росту і розвитку сортів картоплі різних груп стиглості Лаперла, Гранада і Мемфіс в умовах Лісостепу. Встановлено, що урожайність та вихід насіннєвих бульб картоплі досліджуваних сортів змінюється залежно від дози і способу внесення добрив, фракції садивних бульб та сортових особливостей. Найвищі показники індивідуальної продуктивності рослин картоплі сортів Лаперла, Гранада і Мемфіс сформовано за локального внесення в рядки $N_{45}P_{45}K_{45}$ на фоні дії напівперепрілого гною і фосфорно-калійного удобрення та використання насіннєвих бульб з фракцією >60 мм. У результаті дії досліджуваних факторів збільшується кількість стебел у кущі, кількість та маса бульб під одним кущем. Встановлено високої сили прямий кореляційний зв'язок між кількістю стебел у кущі і кількістю бульб (r=0,78), з коефіцієнтом детермінації 61,0%. Максимальну урожайність бульб картоплі досліджуваних сортів картоплі (29,7-41,1 т/га) отримали за локального внесення $N_{45}P_{45}K_{45}$ на фоні дії напівперепрілого гною і фосфорно-калійного удобрення залежно від розміру насіннєвих бульб за найбільшим поперечним діаметром. З'ясовано, що використання бульб фракцією >60 мм для садіння досліджуваних сортів картоплі є не раціональним, оскільки витрати насіннєвого матеріалу перевищують показники приросту урожайності. Визначено, що оптимальним для садіння сортів картоплі різних груп стиглості Лаперла, Гранада і Мемфіс бульб з фракцією 28-60 мм. Результати досліджень можуть бути використані для корегування елементів агротехнології насіннєвої картоплі, отримання якісного садивного матеріалу і введення прибутного агробізнесу

Ключові слова: удобрення; структура врожаю; індивідуальна продуктивність рослин; сорт; розмір бульб; фракція бульб