

DOI: 10.12731/2658-6649-2025-17-5-1255

EDN: HHBFPF

UDC 633.491



Original article

THE INFLUENCE OF PLANT GROWTH REGULATORS ON THE YIELD AND QUALITY CHARACTERISTICS OF POTATO TUBERS IN NON-CHERNOZEM ZONE CONDITIONS

*I.S. Pityurina, A.A. Meleshin,
D.V. Vinogradov*

Abstract

Background. The main advantage of the stimulating effect of growth regulators is the acceleration of potato plant development, improvement of the quality of tubers with a simultaneous increase in yield. At the moment, a fairly large number of plant growth regulators are known that can be used in potato growing. However, the emergence of new plant growth regulators requires their detailed study, in order to investigate the effect of the applied concentrations, the characteristics of the variety of grown potatoes and cultivation conditions.

The **purpose** of the conducted studies was to investigate the effect of plant growth regulators on growth processes, yield and quality of potatoes as a result of pre-planting treatment of tubers and spraying of vegetative plants.

Materials and methods. The research methods were based on generalization of both domestic and foreign scientific sources, as well as on conducting laboratory and field experiments, phenological observations and records in accordance with recommendations and generally accepted methods. Microsoft Office Excel was used to process statistical data.

Results. The results of the conducted studies established a positive effect of growth regulators on germination of eyeholes of Vympel and Krasa Meshchery varieties. The maximum number of germinated eyeholes was observed when tubers were treated with growth regulator Mival-Agro, KRP - 83.5% for Vympel variety, Krasa Meshchery had 80.3%. This value exceeded the control indicator by 17.2% and 16.5%, respectively. The use of Megafol, Zh and Ecopin, TPS also stimulated bud germination, reaching 77.6% and 72.4% for Vympel potatoes, 76.9% and 70.4% for Krasa Meshchery potatoes, respectively. Field germination of the studied pota-

to varieties increased by 3.8–5.6% compared to the control group. The vegetation period for the variant of treated tubers and vegetating plants using Megafol, Zh and Mival-Agro, KRP was six days shorter than in the control group, and three days shorter compared to the use of growth regulator Ecopin, TPS. When treating tubers and plants with Mival-Agro, TPS, an increase in the number of stems by 10.4% and leaves by 6.9% was observed compared to the control, the leaf area increased by 12.03% and plant height by 12.0% on average for two varieties and years of research. In the variants of using growth regulators, an increase in photosynthetic potential of up to 28.2% was observed. The greatest increase in indicators on average for two varieties over three years of research was in the variant with growth regulator Mival-Agro, KRP: tops weight by 42.6%, stems weight by 56.0%, leaves weight by 41.5% tuber weight by 21.4%, and the number of tubers by 18.1% higher than the control.

The use of growth regulator Mival-Agro, KRP led to the maximum yield compared to the control variant: Vympel had 38.7 dt/ha (+ 18.2%) and Krasa Meshchery had 36.3 dt/ha (+ 17.8%). The use of growth regulators Megafol, Zh and Ecopin, TPS also contributed to an increase in the yield of two varieties, but to a lesser extent: Vympel had 30.6 dt/ha (+ 14.4%) and 30.2 dt/ha (+ 14.2%); Krasa Meshchery had 27.8 dt/ha (+ 13.7%) and 26.7 dt/ha (+ 13.1%), respectively.

Conclusion. The study of the efficiency of plant growth regulators (Mival-Agro, KRP; Megafol, Zh; Ecopin, TPS) on Vympel and Krasa Meshchery potato varieties demonstrated their positive effect on plant growth and development, yield and product quality. Treatment of tubers before planting and spraying vegetative plants with growth regulators led to an increase in the efficiency of agricultural technology. The most significant results were obtained when using growth regulator Mival-Agro, KRP on Vympel potato variety. In this variant, the yield was 38.7 dt/ha, which was 18.2% higher than the control variant. The starch content in tubers reached 14.3%, and an increase in the proportion of large potato fraction was also observed. The study confirmed the efficiency of using the studied growth regulators to improve the quality and yield of potatoes grown in the non-chernozem zone of Ryazan region.

Keywords: non-chernozem zone; growth regulator; agrochemical; variety; potato; quality characteristics; efficiency; yield

For citation. Pityurina, I. S., Meleshin, A. A., & Vinogradov, D. V. (2025). The influence of plant growth regulators on the yield and quality characteristics of potato tubers in non-chernozem zone conditions. *Siberian Journal of Life Sciences and Agriculture*, 17(5), 119-134. <https://doi.org/10.12731/2658-6649-2025-17-5-1255>

Научная статья

ИССЛЕДОВАНИЕ ВОЗДЕЙСТВИЯ РЕГУЛЯТОРОВ РОСТА РАСТЕНИЙ НА УРОЖАЙНОСТЬ И КАЧЕСТВЕННЫЕ ХАРАКТЕРИСТИКИ КЛУБНЕЙ КАРТОФЕЛЯ В УСЛОВИЯХ НЕЧЕРНОЗЕМЬЯ

*И.С. Питюрина, А.А. Мелешин,
Д.В. Виноградов*

Аннотация

Обоснование. Основным достоинством стимулирующего действия регуляторов роста является ускорение развития растений картофеля, улучшение качества клубней с одновременным увеличением урожайности. В данный момент известно достаточно большое количество регуляторов роста растений, которые могут быть использованы в картофелеводстве. Однако, появление новых регуляторов роста растений требует их детального изучения, с целью исследования влияния вносимых концентраций, особенностей сорта выращиваемого картофеля и условий возделывания.

Цель исследования – изучение воздействия регуляторов роста растений на процесс вегетации, продуктивность и качество картофеля как следствие предпосадочной обработки клубней и опрыскивания вегетирующих растений.

Материалы и методы. Исследовательские методы основываются на обобщении как отечественных, так и зарубежных научных источников, а также на проведении лабораторных и полевых экспериментов, фенологических наблюдений и учетов в соответствии с рекомендациями и общепринятыми методиками. Для обработки статистических данных использовалась программа Microsoft Office Excel.

Результаты. По результатам проведенных исследований установлено положительное влияние регуляторов роста на прорастание глазков картофеля сорта Вымпел и Краса Мещеры. Максимальное количество проросших глазков наблюдается при обработке клубней регулятором роста Мивал-Агро, КРП – 83,5% по сорту Вымпел, Краса Мещеры – 80,3%. Это значение превышает контрольный показатель на 17,2% и 16,5% соответственно по сортам. Применение Мегафол, Ж и Экопин, ТПС также стимулировало прорастание почек, достигнув 77,6% и 72,4% у картофеля Вымпел, 76,9% и 70,4% у картофеля Краса Мещеры со-

ответственно. Полевая всхожесть исследуемых сортов картофеля увеличилась на 3,8–5,6% по сравнению с контрольной группой. Вегетационный период для варианта обработанных клубней и вегетирующих растений с использованием Мегафол, Ж и Мивал-Агро, КПП оказался на шесть дней короче, чем в контрольной группе, и на три дня короче по сравнению с использованием регулятора роста Экопин, ТПС. При обработке клубней и растений Мивал-Агро, ТПС наблюдалось увеличение числа стеблей на 10,4%, листьев на 6,9% по сравнению с контролем, площадь листьев увеличилась на 12,03%, высота растений на 12,0% в среднем по двум сортам и годам исследований. В вариантах применения регуляторов роста наблюдается увеличение фотосинтетического потенциала до 28,2%. Наибольшая прибавка по показателям в среднем по двум сортам за три года исследований в варианте опыта с регулятором роста Мивал-Агро, КПП: масса ботвы на 42,6%, масса стеблей на 56,0%, масса листьев на 41,5% масса клубней на 21,4%, а количество клубней на 18,1% выше контроля.

Использование регулятора роста Мивал-Агро, КПП привело к получению максимального показателя урожайности по сравнению с контрольным вариантом: Вымпел – 38,7 ц/га (+18,2%), Краса Мещеры – 36,3 ц/га (+17,8%). Использование регуляторов роста Мегафол, Ж и Экопин, ТПС также способствовало увеличению урожайности двух сортов, но в меньшей степени: Вымпел – 30,6 ц/га (+14,4%) и 30,2 ц/га (+14,2%); Краса Мещеры – 27,8 ц/га (+13,7%) и 26,7 ц/га (+13,1%) соответственно.

Заключение. Исследование эффективности регуляторов роста растений (Мивал-Агро, КПП; Мегафол, Ж; Экопин, ТПС) на сортах картофеля Вымпел и Краса Мещеры продемонстрировало их положительное влияние на рост, развитие растений, урожайность и качество продукции. Обработка клубней перед посадкой и опрыскивание вегетирующих растений регуляторами роста привела к повышению эффективности агротехники. Наиболее значимые результаты были получены при применении регулятора роста Мивал-Агро, КПП на картофеле сорта Вымпел. В этом варианте урожайность составила 38,7 ц/га, что на 18,2% превысило контрольный вариант. Содержание крахмала в клубнях достигло 14,3%, а также наблюдалось увеличение доли крупной фракции картофеля. Данное исследование подтверждает эффективность применения изученных регуляторов роста для повышения качества и урожайности картофеля, выращиваемого в нечерноземной зоне Рязанской области.

Ключевые слова: регуляторы роста; новые сорта; картофель; характеристики качества; эффективность; урожайность

Для цитирования. Питюрина, И. С., Мелешин, А. А., & Виноградов, Д. В. (2025). Исследование воздействия регуляторов роста растений на урожайность и качественные характеристики клубней картофеля в условиях Нечер-

НОЗЕМЬЯ. *Siberian Journal of Life Sciences and Agriculture*, 17(5), 119-134. <https://doi.org/10.12731/2658-6649-2025-17-5-1255>

Introduction

Currently, one of the key areas of work of agricultural enterprises is to increase the volume of agricultural production by increasing the yield of cultivated crops. Potatoes are one of the most important agricultural crops in global crop production. In modern conditions of agronomic practice, the use of growth regulators is a promising method for increasing potato productivity. The use of growth regulators in small doses allows to influence the entire cycle of plant development. These substances make it possible to control physiological processes in plants, which is an important factor in modern agricultural technologies. Growth regulators contribute to intensification of plant growth and development. At the same time, they enhance natural resistance of crops to adverse environmental conditions of not only natural but also anthropogenic origin, increasing the yield and quality of finished plant products. The group of natural regulators of non-hormonal origin includes such regulators as: Mival-Agro, KRP, Megafol, Zh, and Ecopin, TPS.

The purpose of the research was to study the influence of natural regulators Mival-Agro, KRP, Megafol, Zh and Ecopin, TPS on growth processes, yield and quality of potatoes of Vympel and Krasa Meshchery varieties during the preparation of planting material and the treatment of plants during their growth and development.

Scientific novelty. For the first time in conditions of the non-chernozem zone, studies were conducted devoted to the analysis of the impact of natural growth regulators on field germination, development, yield and quality indicators of potatoes.

Materials and methods

Scientific research on the influence of natural growth regulators on the development of potato plants and the formation of the potato crop structure was carried out in 2022-2024 in conditions of Research Center “Agrotechnopark” in Ryazan region.

The objects of the research were two mid-season potato varieties Vympel and Krasa Meshchery, and three growth regulators: Mival-Agro, KRP; Megafol, Zh; Ecopin, TPS

The selected potato varieties for research are approved for use in 2020. The Vimpel variety, included in the State Register in 2016, is characterized by high and stable yields and increased resistance to adverse external factors. The Krasa Meshchera variety, registered in 2017, is resistant to adverse environmental conditions and is characterized by good shelf life.

The experimental design included the following options:

1. Control (tubers and plants without treatment);
2. Megafol, Zh (tubers - 4 ml/t, plants - 0.4 ml/ha);
3. Mival-Agro, KRP (tubers - 2 g/t, plants - 20 g/ha);
4. Ecopin, TPS (tubers - 0.1 kg/t, plants - 0.3 kg/ha).

During the growing season, potato plants were treated in the phase of full shoots and in the phase of the beginning of budding.

The forecrop in the experiment was winter wheat. Azofoska (2.1 dt/ha) was added during spring soil cultivation. Potatoes were planted in the first ten days of May, according to the 70 by 25 scheme, the depth of tuber planting was 7-8 cm, the planting rate was 3 t/ha.

When caring for experimental plantings, pesticide treatments and mechanical soil treatments were carried out as needed. Potatoes were harvested in the second ten days of August, with the tops removed five to six days before harvesting.

According to the Ryazan Center for Hydrometeorology and Environmental Monitoring, the meteorological conditions of the growing seasons of 2022-2024 were characterized by significant fluctuations in air temperature and uneven precipitation, both during individual months and throughout the period.

The weather conditions of the growing season over the years of research were characterized by the following indicators: 2022 – hot in some periods with average moisture availability (GTC – 0.95); 2023 – humid, hot in some periods (GTC – 1.30); 2024 – was noted as arid, the air temperature was above the annual average (GTC – 0.78).

The soil of the experimental plots of the Ryazan region of the Ryazan region was characterized by the following indicators: humus (according to Tyurin) 3.39-2.78%, mobile phosphorus (according to Kirsanov) P₂O₅ – 153-155 mg/kg of soil, exchangeable potassium (according to Kirsanov) K₂O – 125-130 mg/kg of soil, pH (according to Korshunov) – 5.44-5.25.

Phenological observations, study of biometric indicators of plants, accounting of the harvest and its structure were carried out according to generally accepted, standard methods. Experimental data were subjected to mathematical processing. The experiment was laid down in fourfold repetition, the placement of plots was randomized.

Research results and discussion

Analysis of the conducted laboratory studies showed that growth regulators stimulated more active awakening of dormant buds on tubers, which in turn contributed to further increase in stems, assimilation surface of leaves and productivity of potato plants.

The results of the effect of treating tubers with the studied growth regulators on the germination of eyeholes of Vympel potato variety and field germination are presented in Figure 1.

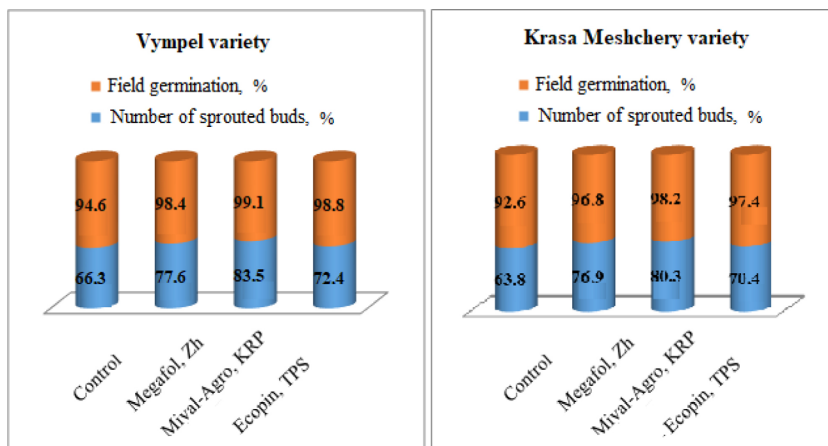


Fig. 1. Effect of tuber treatment with the studied growth regulators on the germination of eyeholes and field germination of potato varieties

The analysis of the data presented in Figure 1 shows that the maximum number of sprouted eyeholes was observed when treating tubers with growth regulator Mival-Agro, KRP - 83.5% for Vympel variety and 80.3% for Krasa Meshchery. This value exceeded the control indicator by 17.2% and 16.5%, respectively, for the varieties. The use of Megafol, Zh and Ecopin, TPS also stimulated the germination of buds, reaching 77.6% and 72.4% for Vympel potatoes, 76.9% and 70.4% for Krasa Meshchery potatoes, respectively.

During the field observations, an acceleration of the germination process of potato plants treated with growth regulators was established. Preliminary treatment of potato tubers with growth regulators led to an increase in field germination by 3.8-5.6% compared to the control group. The maximum increase in germination (by 4.5% for Vympel potato variety and by 5.6 for Krasa Meshchery potato variety) was noted when using Mival-Agro, KRP preparation. Treatment of tubers with Megafol, Zh and Ecopin, TPS preparations contributed to an increase in germination by 3.8% and 4.2% for Vympel variety, by 4.2% and 4.8% for Krasa Meshchery variety, respectively. In addition, the emergence of seedlings in variants with treatment for two varieties was observed 1-3 days earlier than in the control.

The conducted studies of the phenological stages of potato development over three years showed a more intensive dynamics of their onset associated with the use of growth regulators. In general, an acceleration of a number of key stages of plant development was observed compared to the control group. The use of growth regulators led to the fact that the first potato shoots appeared 1-3 days earlier, the budding phase occurred 2-5 days earlier than in the control variant. Potato sprouts treated with growth regulators Mival-Agro, KRP and Megafol, Zh demonstrated more intensive development compared to the control group. This suggests that growth regulators contributed to a more rapid and effective development of the root system and the aboveground part of potato plants. The use of growth regulators Mival-Agro, KRP and Megafol, Zh contributed to the intensive development of potato plants. This was probably due to their complex effect on physiological processes, including stimulation of growth and development, increased resistance to stress factors, improved absorption of nutrients and optimization of photosynthesis. It is important to note that the results of the studies depended on a number of factors, such as: potato variety, climatic conditions, soil type, dosage of growth regulators and the method of their application. Therefore, further studies are needed to study in more detail the effect of growth regulators on potato development and its yield.

When studying the biometric indicators for the experimental variants over three years of research, it was found that a significant increase in the parameters of the studied varieties was observed in the variants with Mival-Agro, KRP and Megafol, Zh (Table 1).

Table 1.

Effect of growth regulators on biometric indicators of potato plants in the flowering phase (average for 2022-2024)

Option	Number of stems, pcs/a bush		Plant height, cm		Number of leaves, pcs/ bush		Leaf area, m ² / plant	
	Vy-mpel	Krasa Mesh-chery	Vy-mpel	Krasa Mesh-chery	Vy-mpel	Krasa Mesh-chery	Vy-mpel	Krasa Mesh-chery
Control	4.8	4.6	48.2	47.5	65.0	63.8	0.44	0.43
Megafol, Zh (4 ml/t + 0.4 ml/ha)	5.2	5.0	53.7	49.3	68.9	65.5	0.48	0.46
Mival-Agro, KRP (2 g/t + 20 g/ha)	5.3	5.1	54.0	52.6	69.5	66.8	0.51	0.47
Ecopin, TPS (0.1 kg/t + 0.3 kg/ha)	5.1	4.9	53.5	48.9	68.4	64.3	0.46	0.45

According to the results of the research, it was revealed that when treating tubers and plants with Mival-Agro, KRP, the number of stems exceeded the control on average for two varieties over 3 years of research by 10.4%, leaves by 6.9%, their area by 12.03%, the plant height indicator exceeded the value of the control option by 12.0%, and the leaf area by 13.0%, which was the highest indicator of all the experimental options.

When treating tubers and plants with Megafol, Zh and Ecopin, TPS, on average for two varieties over three years of research, the number of stems exceeded the control by 8.3% and 6.25%, leaves by 6.0% and 5.2%, their area by 5.2% and 4.5%, plant height by 11.4% and 11.0%, respectively.

Photosynthetic potential characterizes the efficiency of solar radiation assimilation by plants for the implementation of the photosynthesis process during the entire period of active growth. Figure 2 presents the results of the study demonstrating the effect of growth regulators on the photosynthetic potential of potato plants of Vympel and Krasa Meshchery varieties at the flowering stage.

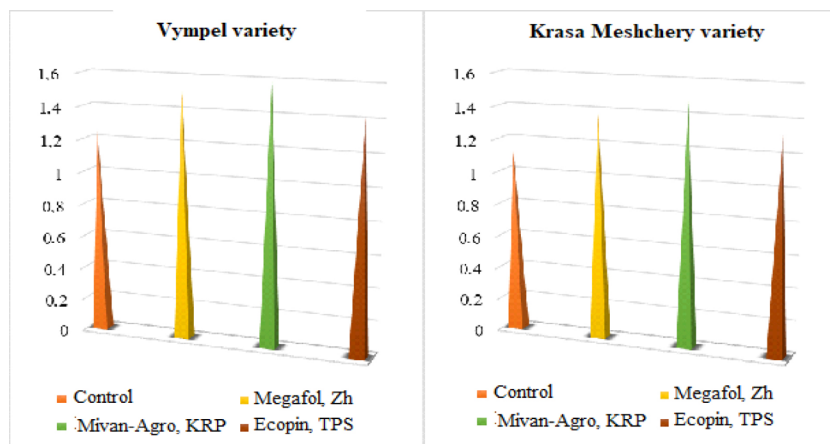


Fig. 2. Effect of growth regulators on the photosynthetic potential (million m^2 day/ha) of potato plants in the flowering phase (average for 2022-2024)

In all variants of growth regulator application, an increase in photosynthetic potential by 14.5-28.2% was observed. Vympel variety showed the following results in experimental studies: in the control sample, the photosynthetic potential value in the flowering phase was 1.24 million m^2 days/ha, in the variant with the use of Mival-Agro, KRP was 1.59 million m^2 days/ha, Megafol, Zh - 1.51 million m^2 days/ha and Ecopin, TPS - 1.42 million m^2 days/ha.

In Krasa Meshchery, the highest value of the photosynthetic potential indicator in the flowering phase was observed with the use of Mival-Agro, KRP - 1.48 million m²day/ha, the lowest value in the control variant was 1.12 million m²day/ha.

Analysis of the effect of growth regulators on the biometric indicators of the studied potato varieties is presented in Table 2.

Table 2.

Effect of preparations on biometric parameters of potato plants in the flowering phase (average for 2022-2024)

Option	Tops weight, g		Stems weight, g		Leaves weight, g		Tubers weight per bush, g		Number of tubers per bush, pcs.	
	Vympel	Krasa Meshchery	Vympel	Krasa Meshchery	Vympel	Krasa Meshchery	Vympel	Krasa Meshchery	Vympel	Krasa Meshchery
Control	284.3	279.4	118.2	117.6	152.3	151.6	738.3	736.2	8.3	7.9
Megafol, Zh (4 ml/t + 0.4 ml/ha)	351.8	347.5	154.6	154.3	191.8	187.6	875.5	863.4	9.2	8.7
Mival-Agro, KRP (2 g/t + 20 g/ha)	405.5	389.6	184.5	179.8	215.5	209.6	896.3	884.2	9.8	8.9
Ecopin, TPS (0.1 kg/t + 0.3 kg/ha)	353.6	349.8	165.5	160.2	186.4	184.3	860.8	859.7	9.6	8.8

Experimental studies showed that the studied growth regulators had a positive effect on the dynamics of growth of biometric indicators of Vympel and Krasa Meshchery potato varieties. The greatest increase in indicators on average for two varieties over three years of research was in the variant of the experiment with growth regulator Mival-Agro, KRP: tops weight was 42.6% higher, stems weight was 56.0% higher, leaves weight was 41.5% higher, tuber weight was 21.4% higher, and the number of tubers was 18.1% higher than the control.

The tops weight on average over three years of research for both varieties increased by 24.4% when using Ecopin, TPS and by 23.7% when using Megafol, Zh. The stems weight increased by 40.0% and 30.8%, respectively. The leaf mass indicators were 22.4% for Ecopin, TPS and 25.9% for Megafol, Zh. The increase in tuber mass reached 16.6% of the control when treated with Ecopin, TPS and 18.6% when using Megafol, Zh. The number of tubers increased by 15.7% and 10.8%, respectively.

The use of growth regulators contributed to an increase in both quantitative and qualitative characteristics of Vympel and Krasa Meshchery potato tubers. The data on potato yield are presented in Figure 3.

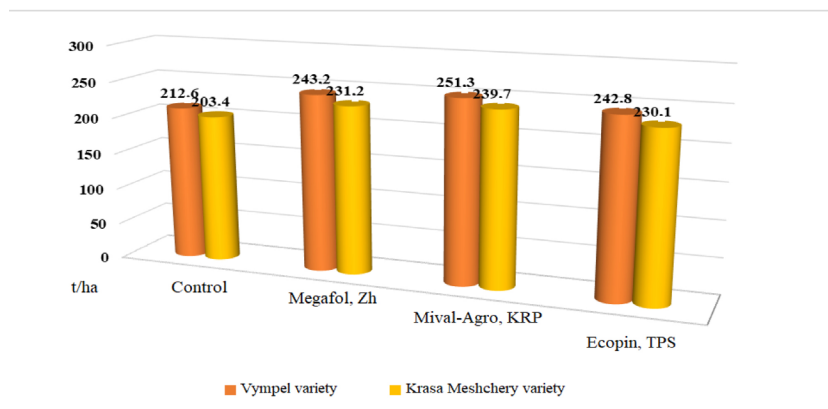


Fig. 3. Effect of preparations on the yield (t/ha) of potato varieties Vympel and Krasa Meshchery (average for 2022-2024)

Experimental studies showed that the use of growth regulator Mival-Agro, KRP during the potato growing season, both on tubers and on plants, led to the maximum increase in yield compared to the control variant: Vympel - 38.7 dt/ha (18.2%), Krasa Meshchery - 36.3 dt/ha (17.8%). The use of growth regulators Megafol, Zh and Ecopin, TPS also contributed to an increase in yield, but to a lesser extent: Vympel - 30.6 dt/ha (14.4%) and 30.2 dt/ha (14.2%); Krasa Meshchery - 27.8 dt/ha (13.7%) and 26.7 dt/ha (13.1%), respectively.

The analysis of the effect of growth regulators on quality characteristics of potatoes of Vympel and Krasa Meshchery varieties is presented in Table 3.

According to the results of studies on the quality indicators of potato tubers of Krasa Meshchery and Vympel varieties when using growth regulators, it could be concluded that Vympel variety was more responsive to the use of preparations.

Based on characteristics of Vympel variety, it had starch content of 10.2-13.2% and marketability of 71-94%. From these studies, it could be concluded that the preparations had a positive increase not only in potato yield, but also contributed to improving the quality indicators of tubers. Thus, in terms of starch content, all treatment options with growth regulators exceeded the control: Megafol, Zh treatment by 12.5%, Mival-Agro, KRP treatment by 14.3%, Ecopin, TPS treatment by 6.3%.

Table 3.

Studying the effect of growth regulators on quality indicators of potato tubers of the studied varieties (average for 2022-2024)

Option	Starch, %		Fraction content to total mass						Marketability, %	
			large (> 80 g)		medium (50-80 g)		small (< 50 g)			
	Vympel	Krasa Meshchery	Vympel	Krasa Meshchery	Vympel	Krasa Meshchery	Vympel	Krasa Meshchery	Vympel	Krasa Meshchery
Control	11.2	10.2	66.8	65.5	24.3	25.3	8.9	9.2	91.1	90.8
Megafol, Zh (4 ml/t + 0.4 ml/ha)	12.6	11.3	69.9	68.6	23.3	24.3	6.8	7.1	93.2	92.9
Mival-Agro, KRP (2 g/t + 20 g/ha)	12.8	11.8	71.4	70.1	22.9	23.9	5.7	6.0	94.3	94.0
Ecopin, TPS (0.1 kg/t + 0.3 kg/ha)	11.9	10.9	68.8	67.5	23.1	24.1	8.1	8.4	91.9	91.6

The use of growth regulators influenced the increase in the proportion of large fraction in the experimental variants on average for two varieties over three years of research: Megafol, Zh by 4.6%, Mival-Agro, KRP by 6.9%, Ecopin, TPS by 3.0%.

Conclusion

Thus, the use of the studied growth regulators (Megafol, Zh, Mival-Agro, KRP, Ecopin, TPS) in conditions of Ryazan region influenced the growth and development processes of potato plants of Vympel and Krasa Meshchery varieties, which entailed a more intensive development of the generative organs of the crop, which contributed to the growth of both quantitative and qualitative indicators of the studied potato varieties.

At the same time, growth regulator Mival-Agro, KRP proved to be more effective in the complex treatment of tubers before planting (2 g/t); and during vegetation in the phases of 2-3 leaves and budding (20 g/ha).

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AUTHOR CONTRIBUTIONS

The authors contributed equally to this article.

ВКЛАД АВТОРОВ

Все авторы сделали эквивалентный вклад в подготовку статьи для публикации.

DATA ABOUT THE AUTHORS

Irina S. Pityurina, Associate Professor of the Department of Logistics of the Penal Enforcement System, Candidate of Agricultural Sciences, Associate Professor

Academy of the Federal Penitentiary Service of Russia

1, Sennaya Str., Ryazan, 390000, Russian Federation

SPIN-code: 7768-4683

piturina@yandex.ru

Alexey A. Meleshin, Deputy General Director of Innovation, Candidate of Agricultural Sciences

JSC Ozery GK Malino

23, Central Estate of the State Farm 'Ozery', Kolomna, Moscow region,

140560, Russian Federation

a-mela@mail.ru

Dmitry V. Vinogradov, Doctor of Biological Sciences, Professor, Department of General Agriculture and Agroecology; Head of the Department of Agronomy, Agrochemistry and Plant Protection

Moscow State University Named after M.V. Lomonosov; Ryazan State

Agrotechnological University Named after P.A. Kostychev

1, building 12, Leninskie Gory, 119234, Russian Federation; 1, Kosty-

chev Str., Ryazan, 390044, Russian Federation

vdv-rz@rambler.ru

SPIN-code: 3264-3460

ORCID: <https://orcid.org/0000-0003-2017-1491>

ResearcherID: X-7792-2018

Scopus Author ID: 57203098120

ДАнные ОБ АВТОРАХ

Питюринa Ирина Сергеевна, доцент кафедры тылового обеспечения уголовно-исполнительной системы, к.с.-х.н., доцент
Академия ФСИН России
ул. Сенная, 1, г. Рязань, 390000, Российская Федерация
piturina@yandex.ru

Мелешин Алексей Алексеевич, заместитель генерального директора по инновациям, к.с.-х.н.
АО Озера ГК Малино
пос. центральной усадьбы совхоза “Озёры”, 23, г. Коломна, Московская обл., 140560, Российская Федерация
a-mela@mail.ru

Виноградов Дмитрий Валериевич, профессор кафедры общего земледелия и агроэкологии МГУ; заведующий кафедрой агрономии, агрохимии и защиты растений РГАТУ, д.б.н., профессор
Московский государственный университет имени М.В. Ломоносова; Рязанский государственный агротехнологический университет им. П.А. Костычева
ул. Ленинские горы, 1, стр. 12, 119234, Российская Федерация; ул. Костычева, 1, г. Рязань, 390044, Российская Федерация
vdv-rz@rambler.ru

Поступила 25.12.2024

После рецензирования 17.04.2025

Принята 25.04.2025

Received 25.12.2024

Revised 17.04.2025

Accepted 25.04.2025