Radchenko, M., Kabanets, V., Sobko, M., Murach, O., Butenko, A., Pivtoraiko, V., Burko, L., Skydan, M. (2024). Formation of productivity and grain quality of peas depending on plant growth regulator. Agriculture and Forestry, 70 (2): 135-148. https://doi.org/10.17707/AgricultForest.70.2.10

DOI: 10.17707/AgricultForest.70.2.10

Mykola RADCHENKO*[1] Victor KABANETS[1,2], Mykola SOBKO[1,2], Oksana MURACH[2], Andrii BUTENKO[1], Viktor PIVTORAIKO[1], Lesya BURKO[3], Mariia SKYDAN[4]

FORMATION OF PRODUCTIVITY AND GRAIN QUALITY OF PEAS DEPENDING ON PLANT GROWTH REGULATOR

SUMMARY

The formation of high and stable yields is the main value of sowing peas (Pisum sativum L.) as a leguminous crop. The aim of the research was to study the influence of plant growth regulators on the processes of growth and development, formation of productivity, and grain quality of peas. The study of the influence of plant growth regulators on the productivity and quality indicators of peas was conducted according to the following scheme: control (without treatment with preparations), at the budding stage treatment with Humifield VR-18 w.s. (0.4 L ha^{-1}), at the pod formation stage treatment with Fulvigrin Bor (0.5 L ha^{-1}), at the budding stage treatment with Humifield VR-18 w.s. (0.4 L ha^{-1}) + at the pod formation stage treatment with Fulvigrin Bor (0.5 L ha^{-1}). The maximum yield was obtained in the variant with treatment of pea plants at the budding stage with Humifield VR-18 + at the pod formation stage with Fulvigrin Bor, amounting to 3.81 t.ha^{-1}. According to the research results, the highest protein content was obtained from treatment at the budding stage with Humifield VR-18 + at the pod formation stage with Fulvigrin Bor – 23.2%. Based on the research results, it was established that to obtain a pea yield of 3.81 t.ha^{-1} with a protein content of 23.2%, it is proposed to use plant growth regulators at the budding stage with Humifield VR-18 + at the pod formation stage with Fulvigrin Bor.

Keywords: plant growth regulator, plant density, productivity, yield, protein.

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[1]Mykola Radchenko* (Corresponding author: radchenkonikolay@ukr.net), Victor Kabanets, Mykola Sobko, Andrii Butenko, Viktor Pivtoraiko, Sumy National Agrarian University, 160 H. Kondratieva St., UA40021, Sumy, UKRAINE;
[2]Victor Kabanets, Mykola Sobko, Oksana Murach, Institute of Agriculture of Northern East of National Academy of Agrarian Science of Ukraine, 3 Parkova St., UA42343, v. Sad, Sumy region, UKRAINE;
[3]Lesya Burko, National University of Life and Environmental Sciences of Ukraine, 13 Heroyiv Oborony St., UA03041, Kyiv, UKRAINE;
[4]Mariia Skydan, Kharkiv State Biotechnological University, 44 Alchevskikh St., UA61000, Kharkiv, UKRAINE
Notes: The authors declare that they have no conflicts of interest. Authorship Form signed online.
Recieved:12/03/2024 *Accepted:18/06/2024*

INTRODUCTION

The growth and development of agricultural crops are among the most significant agrobiological features that reflect the interaction of the plant's genetic potential with a complex of technological practices and agroclimatic resources of the cultivation zone (Pylypenko *et al.,* 2016; Radchenko *et al.,* 2021). Obtaining high yields of agricultural crops in general, and peas in particular, significantly depends on the timely passage of their development phases, which are determined by both the genetic characteristics of the crop and the weather and climatic conditions of the years. Recent research indicates that the yield of peas depends on many elements of cultivation technology (Rudnichenko, 2019).

Scientific observations have identified that the main problem encountered by farmers in pea cultivation is the failure to adhere to scientifically based cultivation technology, the use of outdated cultivation techniques, and low-productivity, disease- and pest-prone, lodging-prone varieties resulting in grain shedding (Musatov *et al.,* 2010; Zając *et al.,* 2013; Kahlon *et al.,* 2018).

The formation of high and stable yields is the main value of sowing peas as a leguminous crop. Compared to other leguminous crops, peas have good grain quality indicators and a short vegetative period. They are one of the best precursors for winter grain crops. Cultivating legumes is more complex than cultivating grain crops due to the lodging of plants under conditions of excess moisture, their lodging, pod cracking, and seed shedding during ripening (Bushulian and Koblai, 2019). The basis for forming the most important economically valuable quantitative traits such as productivity, yield, and quality is the morphotype of plants. The results of assessing the potential of agricultural plants, including sowing peas, depend on the biometric indicators of the studied varieties (Avramenko *et al.,* 2011; Lemishko *et al.,* 2023).

The indicator of seed productivity of sowing peas is one of the main elements of the crop structure, determined by the interaction of many factors under the influence of soil fertility, resistance to diseases and pests, drought, low temperatures, lodging, etc. To increase the production of high-protein and quality food products with a balanced protein content, essential amino acids, and digestibility, among leguminous crops, each of the listed traits is quite important (Nebaba, 2020; Karpenko *et al.,* 2021).

The implementation of modern technologies aimed at maximizing the utilization of plant biological potential is one of the directions for increasing the quality and yield of cultivated crops (Karpenko *et al.,* 2020; Tanchyk *et al.,* 2021). In the conditions of the need for the development of intensive crop production technologies and the necessity of maintaining the normal state of soils, their microbiological background, and the ecological balance of agricultural production, plant growth regulators become an important element in improving yield (Vasylenko *et al.,* 2018; Khodanitska *et al.,* 2018). Of particular interest in the study of growth regulators in the last 10–15 years is establishing the specificity of their anti-stress effect. To date, significant data has been accumulated on the positive effect of various plant growth regulators on cereals, legumes, vegetables, and other agricultural crops under stress conditions such as drought, low temperatures, waterlogging, salinity, etc (Marchuk *et al.,* 2018; Pervachuk *et al.,* 2018).

Main features of plant growth regulators functioning – high specificity, manifested both in their influence on physiological processes and in the interaction of simultaneous or strictly sequential implementation of stimulators and inhibitors of metabolism in the general system of hormonal regulation, ensuring coordination and functional integrity of the plant organism (Kuryata *et al.,* 2019). As peas are a promising crop in Ukraine, the development of effective cultivation techniques using growth regulators is of practical interest (Musiienko and Kapinos, 2018). The relevance of using growth regulators is also determined by the fact that similar preparations, when applied in low doses, enhance plant resistance and decompose into natural metabolites (Strydhorst *et al.,* 2019; Shepilova *et al.,* 2021). The aim of the research is to study the influence of plant growth regulators on the processes of growth and development, formation of productivity, and grain quality of peas.

MATERIAL AND METHODS

Research on the study of plant growth regulators on pea crops was conducted in the conditions of field stationary experiments at the territory of the Institute of Agriculture of the Northeast, National Academy of Agrarian Sciences of Ukraine. The research field is located in Sad village, Sumy district, Sumy region, Ukraine, with the following geographical coordinates: latitude 50°53'03", longitude 34°42'50", 167.0 m above sea level (Map date ©2023 Google). The research was carried out during 2021–2023. The study of the influence of plant growth regulators on the productivity and quality indicators of peas was conducted according to the following scheme: control (without treatment with preparations), at the budding stage treatment with Humifield VR-18 w.s. (0.4 L ha^{-1}), at the pod formation stage treatment with Fulvigrin Bor (0.5 L ha^{-1}), at the budding stage treatment with Humifield VR-18 w.s. (0.4 L ha^{-1}) + at the pod formation stage treatment with Fulvigrin Bor(0.5 L ha^{-1}). Humifield VR-18 w.s. is a universal anti-stress agent based on potassium humate, which is used for foliar application. It contains the following components: fulvic acid salts 20 g per L; humic acid salts 180 g per L including: amino acids – 25 g per L, potassium – 30 g per L, microelements – 5 g per L. pH 10–11. Formulation: aqueous suspension. Fulvigrin Bor is developed to compensate for boron deficiency in agricultural crops. It contains: fulvic acids – 100 g per L, boron – 100 g per L. pH 7.5–8.5. Formulation: aqueous suspension. The object of the research was the pea variety Oplot. The cultivation technology was generally accepted for the research area. The predecessor was winter wheat. After harvesting the predecessor, primary tillage was carried out, which included discing to a depth of 8–10 cm followed by plowing to a depth of 22–25 cm. In spring, early spring moisture closure and pre-sowing tillage were carried out, which included cultivation to a depth of 6–8 cm with rolling to provide optimal sowing conditions at the specified depth.

Seed sowing for peas was carried out using a solid method with the SS-16 seeder at a seeding rate of 1.4 million sprouted seeds per hectare, at a soil temperature of 6–8°C. Prior to sowing (20 days before), pea seeds were treated with the fungicide Maxim Star 025 FS (1 L t.). On the day of sowing, the seeds were treated with Ryzogumin with a rate of 2 kg t. Experimental treatments were laid out systematically, with repetitions placed in the same strip, each plot area measuring 100 m^2 and the effective area being 70 m^2.

For a significant assessment of field experiments, phenological observations were conducted according to the "Methodology of State Variety Testing of Agricultural Crops" and the "Methods of conducting research in fodder production". Growth stages and plant development phases were noted. The beginning of the phase was determined when it occurred in 10% of the plants, and the full phase was determined when it occurred in 75% of the plants (Yeshenko *et al.,* 2005; Volkodav, 2021). Additionally, plant density was determined at the full emergence stage and before harvest in triplicate. To determine the quantity and mass of rhizobial formations, soil monoliths measuring 25×25×30 cm were sampled. After washing the roots, 5 plants were selected from each repetition, nodules were separated from the roots, their average number per plant was calculated, then they were dried and weighed.

Before harvest, a sample sheaf was taken from each treatment to determine the individual productivity of pea plants. Pea grain was harvested using a Massey Ferguson combine at the full maturity stage, with moisture content of 14–15%, determined by a Wile 55 moisture meter with yield metering and sample selection for further analysis.

The weight of 1000 seeds was determined according to DSTU (State Standards of Ukraine) – 2949. The quality indicator of the yield, protein content, was determined by the Kjeldahl method.

The mathematical and statistical processing of experimental data and the establishment of the reliability of the obtained results were carried out according to Dospekhov (1985) using Microsoft Excel.

The soils of the research plots are typical chernozem, low-humus, weakly leached, coarse-loamy to medium-loamy on forest, with the following main indicators in the plowed layer: humus content – 4.6%, salt pH – 5.5, sum of absorbed bases – 35.6 mg-equiv., content of mobile forms of phosphorus – 19.3 mg per 100 g of soil, exchangeable potassium – 8.1 mg per 100 g of soil, content of easily hydrolyzable nitrogen according to the Kornfield method – 14.2 mg per 100 g of soil.

The average daily annual air temperature in 2021 was 9.4°C, which was 2.0°C higher than the long-term average of 7.4°C. The absolute maximum of 35.0°C was recorded in June in the third decade, and the minimum was -24.0°C in the second decade of January. The total precipitation for the reporting agricultural year 2020–2021 was 453 mm, which was 140 mm less than the long-term average (593 mm).

The average annual air temperature in 2022 was 8.7°C, which was 1.3°C higher than the long-term average of 7.4°C. The absolute maximum of 36.0°C was recorded in June in the third decade, and the minimum was -18.0°C in January in the second decade. The total precipitation for the reporting agricultural year 2021–2022 was 604 mm, which was 11 mm more than the long-term average (593 mm).

The average annual air temperature in 2023 was 9.0°C, which was 1.6°C higher than the long-term average of 7.4°C. The absolute maximum of 36.0°C was recorded in August in the first decade, and the minimum was -19.0°C in January in the first decade. The total precipitation for the reporting agricultural year 2022–2023 was 634 mm, which was 41 mm more than the long-term average (593 mm).

Overall, the most favorable years for crop yield formation were 2022 and 2023. Drought conditions occurred in 2021, characterized by low precipitation and extreme deviations in air temperature throughout the growing season.

RESULTS AND DISCUSSION

Important characteristics of seedling quality and uniformity are seed similarity and germination energy since the potential harvest depends on how successfully mass, full, and uniform seedlings are obtained while adhering to sowing norms and avoiding crop crowding (Khodanitska *et al.,* 2021; Radchenko *et al.,* 2022). In particular, research by many authors has shown that a decrease in seed similarity indicators in field conditions by each percentage point reduces the harvest by 1.5–2%. According to reference data, normal legume seeds should have minimum field similarity indicators of at least 70–80% (Maksimović *et al.,* 2020). In the studies conducted by the Institute of Agriculture of the Northeast, the field similarity of peas ranged from 89.3% to 91.4%, and the number of similar plants ranged from 1.25 to 1.28 million plants ha^{-1} (Table 1). It is worth noting that foliar fertilization did not affect seed similarity, as growth regulators were applied during vegetation.

The yield of agricultural crops depends on the productivity of each plant and their density per unit area. Therefore, determining the number of plants or the density of their stand has direct practical significance in assessing the quality of the crop (Trotsenko *et al.,* 2023). Many scientists in Ukraine in their works argue that the plant density of peas per unit area is a very important factor that significantly affects both the growth and development of the crop (Hamaiunova and Tuz, 2016; Andrushko, 2019). According to the research results of the Institute of Agriculture of the Northeast, the plant survival rate of peas during the vegetation period ranged from 73.6% to 76.4% (LSD_{05} (Least Significant Difference) = 0.7). The maximum number of surviving plants was obtained in the variant with the application of growth regulators in the budding phase, Humifield VR-18 + in the pod formation phase Fulvigrin Bor – 76.4% (1.07 million plants

ha^{-1}), while the minimum was observed in the control (without treatment with preparations) – 73.6% (1.03 million plants ha^{-1}) and for treatments in the pod formation phase Fulvigrin Bor – 73.6% (1.03 million plants ha^{-1}). For treatments in the budding phase Humifield VR-18, the plant survival rate was 74.3% (1.04 million plants ha^{-1}) (Table 1).

Table 1. Plant density and survival rate of pea plants under the influence of a growth regulator (average for 2021–2023)

Treatment during vegetation	Plant growth phase			
	full emergence		full ripeness	
	plant count, million plants ha^{-1}	field germination, %	plant count, million plants ha^{-1}	preservation of plants during the vegetation period, %
Control (no treatment)	1.25	89.3	1.03	73.6
In the budding phase, Humifield VR-18 w.s. (0.5 L ha^{-1})	1.27	90.7	1.04	74.3
In the pod formation phase, Fulvigrin Bor w.s. (0.5 L ha^{-1})	1.26	90.0	1.03	73.6
In the budding phase, Humifield VR-18 w.s. (0.5 L ha^{-1}) + In the pod formation phase, Fulvigrin Bor w.s. (0.5 L ha^{-1})	1.28	91.4	1.07	76.4
LSD_{05}	0.02	0.6	0.02	0.7

One of the measures to increase plant resistance and enhance the efficiency of legume-rhizobial symbiosis and increase yield is the application of plant growth regulators (Petrychenko and Kots, 2014; Backer *et al.*, 2018). When using inoculant and plant growth regulator in combination, the number of active nodules on plant roots increased by 44.2% (5–6 leaf formation stage), 74.8% (flowering stage), and 35.2% (flowering phase) compared to the control (Didur and Shevchuk, 2020). Dynamics of the number of nodules on pea roots in the conditions of the Institute of Agriculture of the Northeast varied from 17.4 to 19.3 units per plant during the budding phase (LSD_{05} = 0.6). Thus, the maximum number of nodules was noted for the treatment of pea plants during budding with Humifield VR-18 + during pod formation with Fulvigrin Bor, amounting to 19.3 units per plant, while the minimum was observed in the control group at 17.4

units per plant. With the application of the growth regulator during budding with Humifield VR-18, the number of nodules was 18.8 units per plant, and with application during pod formation with Fulvigrin Bor, it was 17.6 units per plant. During the flowering phase, the number of nodules on pea roots increased compared to the budding phase and ranged from 27.4 to 30.8 units per plant (LSD_{05} = 0.4). Maximum values were observed for the treatment with Humifield VR-18 during budding + Fulvigrin Bor during pod formation, reaching 30.8 units per plant. The lowest number of nodules was observed in the control group, at 27.4 units per plant. With the application of the growth regulator during budding with Humifield VR-18, the number of nodules was 29.6 units per plant, and with application during pod formation with Fulvigrin Bor, it was 27.7 units per plant. The highest number of nodules on pea roots was observed during pod formation and ranged from 35.7 to 44.4 units per plant (LSD_{05} = 0.6). Thus, the maximum number of nodules was noted for the treatment during budding with Humifield VR-18 + during pod formation with Fulvigrin Bor, amounting to 44.4 units per plant, while the minimum was observed in the control group at 35.7 units per plant (table 2).

Table 2. Dynamics of the number (units per plant) of nodules on pea roots under the application of plant growth regulator (average for 2021–2023)

Treatment during vegetation	Nodule count, units per plant		
	Budding phase	Flowering phase	Pod formation phase
Control (no treatment)	17.4	27.4	35.7
In the budding phase, Humifield VR-18 w.s. (0.5 L ha^{-1})	18.8	29.6	40.1
In the pod formation phase, Fulvigrin Bor w.s. (0.5 L ha^{-1})	17.6	27.7	36.0
In the budding phase, Humifield VR-18 w.s. (0.5 L ha^{-1}) + In the pod formation phase, Fulvigrin Bor w.s. (0.5 L ha^{-1})	19.3	30.8	44.4
LSD_{05}	0.6	0.4	0.6

It is known that the weight of nodules depends on the stage of plant development and growing conditions. The formation and activity of the symbiotic apparatus are directly related to various environmental factors, including soil moisture (Kots *et al.,* 2010). In the conditions of the Institute of Agriculture of the Northeast, during the budding phase, the weight of nodules varied depending on the growth regulator from 0.087 to 0.097 g per plant (LSD_{05} = 0.005). The maximum weight of nodules on pea roots was observed in the treatment with Humifield VR-18 during budding phase combined with Fulvigrin Bor during pod formation phase, reaching 0.097 g per plant, while slightly lower weights were recorded for treatments with Humifield VR-18 during budding phase (0.094 g per plant), Fulvigrin Bor during pod formation phase (0.088 g per plant), and in the control group (0.087 g per plant). During the flowering phase, an increase in nodule weight on pea roots was observed, ranging from 0.137 to 0.154 g per plant across different treatments (LSD_{05} = 0.004). The maximum weight of nodules was recorded in the treatment with Humifield VR-18 during budding phase combined with Fulvigrin Bor during pod formation phase, reaching 0.154 g per plant, while slightly lower weights were observed for treatments with Humifield VR-18 during budding phase (0.148 g per plant), Fulvigrin Bor during pod formation phase (0.139 g per plant), and in the control group (0.137 g per plant). The highest nodule weight on pea roots was observed during pod formation phase, ranging from 0.179 to 0.222 g per plant (LSD_{05} = 0.005). The maximum weight of nodules was recorded in the treatment with Humifield VR-18 during budding phase combined with Fulvigrin Bor during pod formation phase, reaching 0.222 g per plant, while the lowest weight was observed in the control group, with 0.179 g per plant (see Table 3).

Table 3. Dynamics of nodule weight (g per plant) on pea roots under the influence of plant growth regulator (average for 2021–2023)

Treatment during vegetation	Nodule weight, g per plant		
	Budding phase	Flowering phase	Pod formation phase
Control (no treatment)	0.087	0.137	0.179
In the budding phase, Humifield VR-18 w.s. (0.5 L ha^{-1})	0.094	0.148	0.201
In the pod formation phase, Fulvigrin Bor w.s. (0.5 L ha^{-1})	0.088	0.139	0.180
In the budding phase, Humifield VR-18 w.s. (0.5 L ha^{-1}) + In the pod formation phase, Fulvigrin Bor w.s. (0.5 L ha^{-1})	0.097	0.154	0.222
LSD_{05}	0.005	0.004	0.005

Increasing the number of pods per plant and preserving the maximum number of seeds in them is the most effective way to increase the seed productivity of leguminous crops. In the research by Yeremenko and Kapinos (2020), the highest number of pods was formed with the application of growth regulators – 3.43 pods per plant, which exceeded the control indicator by 1.7 to 8.5%. According to the results of research, the number of pods per plant varied from 3.24 to 3.44 pods (LSD_{05} = 0.07). The highest number of pods was observed with treatment in the budding phase with Humifield VR-18 + in the pod formation phase with Fulvigrin Bor – 3.44 pods per plant, while the lowest number of pods was observed in the control – 3.24 pods per plant. With the application of growth regulators in the budding phase with Humifield VR-18, the number of pods was 3.40 pods per plant, and with application in the pod formation phase with Fulvigrin Bor – 3.32 pods per plant (Table 4).

It has been established that the use of growth regulators contributed to an increase in the number of seeds per plant regardless of the pea variety under study. In the research by Yeremenko and Kapinos (2020), for pea cultivation, treatment with growth regulators contributed to the formation of 12.58 seeds per plant, which was higher than the control indicators by 1.1–3.5%. In studies conducted at the Institute of Agriculture of the Northeast, the number of seeds per pea plant varied from 12.8 to 13.4 seeds (LSD_{05} = 0.3). The maximum number of seeds was recorded with treatment in the budding phase with Humifield VR-18 + in the pod formation phase with Fulvigrin Bor – 13.4 seeds per plant, while the lowest seed indicators per plant were obtained in the variant without treatment with growth regulators (control) – 12.8 seeds per plant (Table 4).

One of the main indicators of plant productivity is grain weight per plant. Over the years of research, the weight of seeding peas per plant (g) depending on the growth regulators ranged from 2.43 to 2.65 g. An increase in grain weight per plant from 3.3 to 9.1% compared to the control was observed (Kapinos, 2019). The maximum grain weight per plant in the studies conducted by the Institute of Agriculture of the Northeast was noted in the variant treated in the budding phase with Humifield VR-18 + in the pod formation phase with Fulvigrin Bor – 3.57 g, slightly lower grain weight per plant was obtained with treatment in the budding phase with Humifield VR-18 – 3.48 g, in the pod formation phase with Fulvigrin Bor – 3.40 g, and in the control – 3.36 g (LSD_{05} = 0.11) (Table 4).

Table 4. Elements of pea crop structure depending on the influence of plant growth regulator (average for 2021–2023)

Treatment during vegetation	Number per plant, pcs.		Grain weight per plant, g	Weight of 1000 grains, g
	Pods	Seeds		
Control (no treatment)	3.24	12.8	3.36	262.5
In the budding phase, Humifield VR-18 w.s. (0.5 L ha^{-1})	3.40	13.1	3.48	265.6
In the pod formation phase, Fulvigrin Bor w.s. (0.5 L ha^{-1})	3.32	12.9	3.40	263.6
In the budding phase, Humifield VR-18 w.s. (0.5 L ha^{-1}) + In the pod formation phase, Fulvigrin Bor w.s. (0.5 L ha^{-1})	3.44	13.4	3.57	266.4
LSD_{05}	0.07	0.3	0.11	1.1

Researchers have concluded that the most realistic approach is to create new pea varieties with 7–8 pods, 3–5 productive nodes per plant, and 5–6 seeds per pod, which would allow increasing the yield to 250–280 g per 1000 seeds. At the same time, the weight of 1000 seeds should be maintained at 250–280 g, as varieties with larger seeds have a greater need for moisture during germination, and the sowing rate also increases (Popov *et al.*, 2018). According to the research results of the Institute of Agriculture of the Northeast, the weight of 1000 seeds varies depending on the growth regulator within the range of 262.5–266.4 g (LSD_{05} = 1.1). The highest weight of 1000 seeds was recorded in the variant treated in the budding phase with Humifield VR-18 + in the pod formation phase with Fulvigrin Bor – 266.4 g, which is higher by 0.3% (265.6 g) compared to treatment in the budding phase with Humifield VR-18, by 1.06% (263.6 g) compared to treatment in the pod formation phase with Fulvigrin Bor, and by 1.47% (262.5 g) compared to the control (Table 4).

Pea yield depends largely on the photosynthetic activity of crops, therefore, to achieve optimal yields, it is necessary to create the most favorable conditions. One of the elements of technology for improving photosynthetic activity is the use of growth regulators. With the use of growth regulators, yield increases on average from 0.15 to 0.24 $t.ha^{-1}$ (Vuiko, 2023). In the conditions of the Institute of Agriculture of the Northeast, pea yield ranged from 3.46 to 3.81 $t.ha^{-1}$ (LSD_{05} = 0.12). The maximum yield was obtained with treatment during the budding phase with Humifield VR-18 + during the pod formation phase with Fulvigrin Bor, reaching 3.81 $t.ha^{-1}$. Slightly lower yields were obtained with treatment during the budding phase with Humifield VR-18 – 3.61 $t.ha^{-1}$, during the pod formation phase with Fulvigrin Bor – 3.50 $t.ha^{-1}$, and in the control – 3.46 $t.ha^{-1}$ (Table 5).

Table 5. Grain yield and protein content in pea grain depending on the effect of plant growth regulator (average for 2021–2023)

Treatment during vegetation	Yield, $t.ha^{-1}$	Protein content, %
Control (no treatment)	3.46	22.2
In the budding phase, Humifield VR-18 w.s. (0.5 L ha^{-1})	3.61	22.8
In the pod formation phase, Fulvigrin Bor w.s. (0.5 L ha^{-1})	3.50	22.5
In the budding phase, Humifield VR-18 w.s. (0.5 L ha^{-1}) + In the pod formation phase, Fulvigrin Bor w.s. (0.5 L ha^{-1})	3.81	23.2
LSD_{05}	0.12	0.4

Quality of the harvest is a complex indicator formed during the cultivation of the crop. It depends on the variety, soil type, agronomy practices, meteorological conditions, and the nature of their interaction. The developers of new intensive varieties of field peas are particularly interested in obtaining grain with a high protein content. Pea seeds may contain 2.0–2.5 times more protein than grains of cereal crops (Lykhochvor and Andrushko, 2020). Depending on the application of growth regulators, the protein content in pea grain varies within the range of 22.2–22.8% (Tsyliuryk and Izhboldin, 2022). In the experiments of the Institute of Agriculture of the Northeast, the maximum protein content was observed for treatment during the budding phase with Humifield VR-18 + during pod formation with Fulvigrin Bor, reaching 23.2%. Treatment during the budding phase with Humifield VR-18 showed a lower value of 22.8%, while treatment during pod formation with Fulvigrin Bor resulted in 22.5%. The lowest protein content in pea grain was recorded for the variant without the application of growth regulators (control) – 22.2% (Table 5).

CONCLUSIONS

According to the results of the conducted research, it was found that the maximum plant survival during the vegetation period was achieved for the treatment with growth regulators during the budding phase with Humifield VR-18 + during pod formation with Fulvigrin Bor, reaching 76.4% (1.07 million plants per ha^{-1}). The highest number of nodules on pea plant roots during pod formation was observed with the maximum number of nodules for the treatment during the budding phase with Humifield VR-18 + during pod formation with Fulvigrin Bor, reaching 44.4 nodules per plant, while the lowest number was observed in the control group with 35.7 nodules per plant. The maximum grain yield per plant was noted for the treatment during the budding phase with Humifield VR-18 + during pod formation with Fulvigrin Bor, at 3.57 g, followed by slightly lower values for the treatment during the budding phase with Humifield VR-18 at 3.48 g, during pod formation with Fulvigrin Bor at 3.40 g, and in the control at 3.36 g. The highest weight of 1000 grains was recorded for the treatment during the budding phase with Humifield VR-18 + during pod formation with Fulvigrin Bor, at 266.4 g. The maximum yield was obtained for the treatment during the budding phase with Humifield VR-18 + during pod formation with Fulvigrin Bor, reaching 3.81 $t.ha^{-1}$, followed by slightly lower yields for the treatment during the budding phase with Humifield VR-18 at 3.61 $t.ha^{-1}$, during pod formation with Fulvigrin Bor at 3.50 $t.ha^{-1}$, and in the control at 3.46 $t.ha^{-1}$. According to the research results, the highest protein content was achieved for the treatment during the budding phase with Humifield VR-18 + during pod formation with Fulvigrin Bor, reaching 23.2%.

In the natural-climatic conditions of the Sumy region (northeastern Forest-Steppe of Ukraine), for obtaining a pea yield at the level of 3.81 $t.ha^{-1}$ with a protein content of 23.2%, it is recommended to apply growth regulators during the budding phase with Humifield VR-18 + during pod formation with Fulvigrin Bor.

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