UDC 631.53.02:582.736.303]:631.8
DOI https://doi.org/10.32851/2226-0099.2023.129.23

EFFECT OF PRE-SOWING SEED TREATMENT AND FOLIAR FERTILIZATION ON GROWTH PROCESSES OF WINTER PEA VARIETIES

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An important direction of agricultural production and improvement of the technology of increasing the yield of leguminous crops, in particular winter peas, is the use of modern plant growth regulators and bacterial drugs, their complex application and the implementation of foliar fertilizing with microfertilizers. The purpose of the research was to study the effect of pre-sowing seed treatment with plant growth regulator Endophyt-L1 PK, the bacterial drug BTU-p, their complex application and two foliar fertilizers (at the phase of 3–5 leaves of LF-LEGUMES and at the phase of 3–5 of LF-LEGUMES and during budding phase LF-BEAN + Biobor 140) on the height and biomass growth of winter pea plants of NC Moroz and Enduro varieties. Field research was carried out during 2019–2022 on the basis of the trail farm 'Agronomichne' of Vinnytsia National Agrarian University at Agronomichne village, Vinnytsia district, Vinnytsia region. The research program provided for the establishment of a three-factor field experiment in which the varieties were studied (factor A), pre-sowing treatment of seeds of PPP Endophyt-L1 PK, BTU-p inoculants, their complex application (factor B) and foliar fertilizing (factor C) at the 3–5 leaves phase with microfertilizers LF-LEGUMES and at the phase of 3–5 of LF-LEGUMES and budding LF-BEAN + Biobor 140. Winter pea NC Moroz and Enduro varieties were studied. The positive effect on the increase of plant height of winter pea NC Moroz and Enduro varieties was established for applying mineral fertilizers at $N_{45}P_{45}K_{45}$ doses and foliar fertilizing at various rates and phases with microfertilizers LF-LEGUMES and Biobor 140. At the phase of bean formation, over three years of research the average value of plant height was 71–75 cm and 70–74 cm, in winter peas of NC Moroz and Enduro varieties, respectively, which corresponded to their varietal characteristics. Pre-sowing treatment complex Endophyt L1 PK + BTU-p amid main fertilizer $N_{45}P_{45}K_{45}$ and with two foliar top-dressings with microfertilizers at different phases of development ensured an increase in the height of plant of varieties NC Moroz and Enduro by 5–10% and 6–9%, respectively, in comparison to the control. It was investigated that the greatest biomass of winter pea plants of NC Moroz and Enduro varieties was noted in the variants of the complex application of pre-sowing treatment Endophyte L1 PK and BTU-p with $N_{45}P_{45}K_{45}$ fertilizer and two-fold fertilizing (3–5 leaves and budding phases) LF-LEAN and LF – LEGUMESES + Biobor 140. At the budding, flowering, and bean formation, the weight of plants increased by 66%, 24%, 15% and 67%, 29%, and 15%, respectively, compared to the control without pre-sowing treatment. Single-dose fertilizer applying at the phase of 3–5 leaves, the indicators increased by 45%, 14%, 12% and 46%, 17%, and 12%, respectively, according to the above-mentioned phases and varieties

Key words: *plant growth regulators, bacterial preparations, growth, biomass, fertilizing, winter peas.*

Шевчук В.В. Вплив передпосівної обробки насіння та позакореневих підживлень на ростові процеси сортів гороху озимого

Важливим напрямком сільськогосподарського виробництва та удосконалення технології підвищення врожайності зернобобових культур, зокрема гороху озимого, є застосування сучасних вітчизняних регуляторів росту рослин і бактеріального препаратів, їх комплексного застосування та здійснення позакореневих підживлень мікродобривами. Метою проведення досліджень було вивчення дії передпосівної обробки насіння регулятором росту рослин Ендофіт-L1 РК, бактеріальним препаратом БТУ–р, їх комплексного застосування та двох позакореневих підживлень (у фазу 3–5-ти листків LF–БОБОВІ та у фази 3–5-ти лисків LF–БОБОВІ і у бутонізації LF–БОБОВІ + Біобор 140) на висоту та наростання біомаси рослин гороху озимого сортів НС Мороз та Ендуро. Польові дослідження виконували впродовж 2019–2022 років на базі дослідного господарства

«Агрономічне» Вінницького національного аграрного університету в селі Агрономічне Вінницького району Вінницької області. Програмою досліджень передбачалося закладення трифакторного польового досліду, у якому вивчали сорти (фактор А), передпосівна обробка насіння РРР Ендофіт-L1 РК, інокулянтом БТУ–р, їх комплексного застосування (фактор В) та позакореневе підживлення (фактор С) у фазу 3–5-ти листків мікродобривами LF–БОБОВІ та у фази 3–5-ти лисків LF–БОБОВІ і у бутонізації LF–БОБОВІ + Біобор 140. Сорти гороху озимого, що вивчалися, – НС Мороз і Ендуро. Встановлено позитивний вплив на збільшення висоти рослин сортів гороху озимого НС Мороз і Ендуро за внесення мінеральних добрив у дозі $N_{45}P_{45}K_{45}$ та проведення позакореневих підживлень у різних нормах та фазах мікродобривами LF–БОБОВІ та Біобором 140. У фазу формування бобів середнє значення висоти рослин за три роки досліджень у гороху озимого сортів НС Мороз та Ендуро становило 71–75 см та 70–74 см відповідно, що відповідало їх сортовим особливостям. Комплексна передпосівна обробка Ендофіт L1 РК + БТУ–р на фоні основного удобрення $N_{45}P_{45}K_{45}$ та з дворазовими позакореневими підживленнями мікродобривами у різні фази розвитку забезпечувало приріст висоти рослин у сортів НС Мороз та Ендуро на 5–10% та 6–9% відповідно у порівняні з контрольним варіантом. Досліджено, що найбільша біомаса рослин гороху озимого сортів НС Мороз та Ендуро була відмічена у варіантах з комплексним застосуванням передпосівної обробки Ендофіт L1 РК і БТУ–р з удобренням $N_{45}P_{45}K_{45}$ і двофазним підживленням (3–5-ти листків і бутонізації) LF–БОБОВІ і LF–БОБОВІ + Біобор 140, де у фази бутонізації, цвітіння, формування бобів у порівнянні з контролем без передпосівної обробки маса рослин зростала на 66%, 24%, 15% та 67%, 29%, 15% відповідно. При застосуванні одного підживлення у фазу 3–5-ти листків показники зростали на 45%, 14%, 12% та 46%, 17%, 12% відповідно до вище зазначених фаз та сортів.

Ключові слова: *регулятори росту рослин, бактеріальні препарати, ріст, біомаса, підживлення, горох озимий.*

Introduction. Modern agricultural science constantly faces the question of developing and improving technological methods of growing of agricultural crops, which would ensure not only high yields of economically valuable parts but also improve their quality indicators. This problem is also acutely related to leguminous crops, the grain of which has high protein content.

It is known that the main source of plant protein both for animal husbandry as well as for population nutrition is legumes, which occupy an important place in the structure of the plant protein resources of Ukraine. An important leguminous crop in Ukraine is pea, which, compared to other legumes, has a high grain yield, good quality indicators, and a short growing season. Pea grain is a valuable food product for the population and an integral component of livestock feed, as it contains 22–24% crude protein, which is well-balanced in terms of the content of basic amino acids, including critical ones, and is also rich in mineral salts and vitamins [1].

In addition to plant protein resources, peas act as the best precursor for many agricultural crops, in particular for winter wheat. This is a typical nitrogen-fixer.

In Ukraine, the area of spring peas is intensively reduced and amounts to 131,000 ha. However, in recent years, the winter pea of NC Moroz variety has been introduced, having a number of advantages over the spring pea, namely: a steady crop of grain and green mass; soil protection from wind and water erosion; effective use of moderate temperatures or moisture in the late autumn and early spring periods.

The use of fertilizers has a significant effect on the yield of field peas [2, 3].

It is known that the systematic use of fertilizers not only increases the productivity of agricultural plants, furthermore it also affects the properties of the soil.

One of the possible directions of agricultural production and improvement of the technology of increasing the yield of agricultural crops is the use of chemical means of controlling biological processes with the help of plant growth regulators [4] and bacterial preparations [5, 6], which reduce material and financial costs. The use of these substances in our time makes it possible to solve quite a lot of problems in the practice of crop production. A number of agrotechnical methods and technologies for growing certain crops are implemented, on the basis of which costs are sharply reduced, sometimes several times, and labor productivity increases, that is, with the help of drugs of these groups, agriculture can be transformed into a more intensive one [7]. However, there is a need for further studies of the effectiveness of these drugs in their complex interaction, which can lead to synergism, antagonism, and additivity.

Therefore, the search for ways is aimed at researching new varieties of winter peas in the conditions of the right-bank forest-steppe and increasing the yield level of grain crops due to the introduction of new technological methods of its cultivation.

In a number of works, issues of research on the yield of seed peas under the influence of growing technologies with the use of plant growth regulators [8], bacterial preparations [9], their combined application and foliar fertilizing [10]. There are only isolated studies on the features of growth processes, yield and qualitative composition of winter pea grain [11]. However, literary experimental data, which are focused on the use of re-regulating and bacterial preparations, their combined application, and foliar fertilizing in the technology of growing different varieties of winter peas and their influence on the course of the main morphological-physiological and other processes in plants are practically absent, which determined the relevance of the study of this question.

The purpose of the research was to study the effect of pre-sowing seed treatment with the plant growth regulator Endophyt-L1 PK, the bacterial drug BTU-p, their complex application and two-fold foliar fertilizing (at the phase of 3–5 leaves of LF-BEAN and at the phase of 3–5 leaves of LF-LEGUMES and budding LF-LEGUMES + Biobor 140 on the growth processes of NC Moroz and Enduro varieties of winter pea. The objectives of the study were to study the indicators of linear growth and above-ground biomass of winter pea varieties NC Moroz and Enduro with the use of re-regulating and bacterial preparations, their combined application, and the implementation of foliar fertilization.

Literature Review. Research processes of growth and development of agricultural crops are important criteria of cultivation technologies. In the process of plant growth, in its tissues and organs, there is a redistribution of primary assimilates and metabolic products, therefore, indicators of growth processes determine the size of the harvest. Plant development is influenced by various factors: varietal characteristics, soil and climatic conditions [12], cultivation technology [13]. A close relationship between the growth and development of plants and physiological and biochemical processes was noted [14]. Internal changes occur under the influence of various factors, in particular, the use of bacterial and growth-regulatory drugs is reflected in growth processes [15].

Morphological features of species of the genus *Pisum* L. are parameters of plant height and whisker length. However, these parameters largely depend on the varietal characteristics of the culture, weather conditions and technological methods of cultivation.

It was established that the pre-sowing treatment of pea seeds of Glyans variety with the growth regulator AKM (0.3 l/t) led to intensive sprout growth in length, while the use of Rhizobophyte inoculant (0.5 l/t) did not cause significant changes. The greatest effect on the growth and development of pea sprouts was found with the combined use of the growth-regulating drug AKM (0.3 l/t) and Rhizobophyte inoculum (0.5 l/t) at the rate of 20 l of the working solution per 1 ton of seeds [16]. Similar results were found on pea plants of the Oplot spring variety when using the stimulating drug Regoplant (0.01 l/t), the bacterial drug Rizokativ (2 l/t) and their mixture (Regoplant (0.01 l/t) + Rizokativ (2 l/t) at the rate of 20 litres of working solution per 1 ton of seeds [8].

To ensure high productivity, agricultural crops must accumulate the maximum amount of above-ground mass, which largely determines the level of their productivity.

Literary sources [17] indicate that an increase in plant leaf-stem mass leads to an increase in their reserves of plastic substances, which, in turn, are a necessary material for the formation of reproductive organs and crop formation.

Therefore, a weighty indicator of plant productivity is the mass of its aerial part, which depends on weather and climatic conditions, the level of agricultural technology, as well as the use of various technological methods of cultivation, etc [18, 19]. Since all leguminous crops are characterized by a multi-stage and complex process of formation of above-ground mass and harvest, which is caused by weak regulation of the structural indicators of their coenosis and slow differentiation of plant organs, all the above-mentioned factors exert a significant influence on their formation. In order to maximize the productivity potential of winter peas, it is worth investigating the effect of various technological methods on the dynamics of the growth of above-ground mass and culture.

It is known that there is a close positive relationship between the amount of above-ground mass and the grain yield, i.e. the greater the indicators of the vegetative mass of a plant is the higher is its grain yield [20].

It has been proven that by treating the seeds of winter peas of the NC Moroz variety with the microbial drug Optimize Pulse and combining the use of MaxiMox herbicide (0.8–1.1 l/ha) with the growth regulator Agriflex Amino (1.0 kg/ha) by spraying vegetative plants at phase 3–4 leaves of developed whiskers, in comparison with variants of self-application of herbicide, growth processes were stimulated in plants, which in terms of height and above-ground biomass were 7–65% higher than the control [11].

Materials and Methods. The research was carried out during 2019–2022 on the basis of the trial farm 'Agronomichne' of the Vinnytsia National Agrarian University at Agronomichne village, Vinnytsia district, Vinnytsia region. In accordance with the set goal, the research program and the field experiment scheme were developed (Table 1). The experiment studied the effect and interaction of three factors: A – variety, B – pre-sowing treatment of seeds with a plant growth regulator, bacterial drug, their complex application, C – foliar top-dressing with microfertilizers. The ratio of factors is 2:4:3. The area of the registered experimental plot is 50 m^2, the total area is 60 m^2. Factorial formula 2*4*3=24 options*4 repetitions = 96 plots.

Table 1

Formation of elements of the morpho-biological structure of winter peas (field experiment scheme)

Variety (factor A)	Pre-sowing treatment of seeds (factor B)	Foliar top-dressing fertilizing (factor C)
1. HC Moroz 2. Enduro	1. without treatment (control) 2. Endophyt – L1 3. BTU-p 4. Endophyt – L1+BTU-p	1. $N_{45}P_{45}K_{45}$ (media) 2. Media + LF-LEGUMES 1.5 l/ha 3. Media + LF-LEGUMES 1.5 l/ha + LF-LEGUMES 2.5 l/ha + Biobor 140 1.0 l/ha

On the day of sowing, winter pea seeds were treated with the seed poison Teviron (1.8 l per 1 ton of seeds), the bacterial drug BTU-p (3 l per 1 ton of seeds) and the growth stimulator Endophyt L1 PK (10 ml per 1 ton of seeds) using PKS-20 Super. When fertilizing, the complex, granular mineral fertilizer Diamofoska $(NH_4)_2HPO_4$ with an active substance content of 10:26:26 (GOST: 218615) was used. Two-fold fertilizing was carried out at first with LF-LEGUMES fertilizers (1.5 l/ha) at the phase of 3–5 leaves and the second combination was used at the phase of 3–5 leaves with LF-LEAN fertilizers (1.5 l/ha) and at budding phase with LF-LEGUMES fertilizers (2.5 l/ha) + Biobor 140 1.0 l/ha. The variant with pre-sowing treatment of seeds with Teviron poison (1.8 l per 1 ton of seeds) and $N_{45}P_{45}K_{45}$fertilizer media was taken as control.

The growing technology for winter pea plants is generally accepted for the soil and climatic conditions of the Right-bank Forest-steppe of Ukraine in experimental plots [21]. The predecessor is winter wheat. The stubble was peeled after harvesting the precursor. Complex fertilizers in the form of Diamofoska were applied under plowing. The main tillage of the soil is plowing to a depth of 22–25 cm, PLN is 5–35, then pre-sowing cultivation was carried out to a depth of 6–8 cm.

In 3–4 days before sowing, the seeds were treated with a poison regulated by the ‘List of pesticides and agrochemicals permitted for use in Ukraine’ Teviron, t.c.s. (thiabendazole, 45 g/l + flutriafol, 30 g/l) at a rate of 1.8 litres per 1 ton of seeds.

Sowing was carried out in the second decade of October in a continuous method with a row width of 15 cm. The sowing rate is 1.1 million similar seeds per 1 ha. The depth of sowing seeds is 4–5 cm.

During the growing season, as soon as the winter pea plants reach the stage of 1–3 leaves, the herbicide Bazagran 48% was applied to control annual dicotyledonous weeds w. s. (a. s. bentazon 480 g/l) in a dose of 2.0 l/ha, using a knapsack sprayer with a consumption of working fluid 300 l/ha.

Research was carried out on winter pea varieties of NC Moroz and Enduro. The NC Moroz variety was included in the State Register of plant varieties suitable for distribution in Ukraine in 2016. The originator is the Institute of Agriculture and Vegetable Growing, Novi Sad. This is the first winter variety of protein pea intended for grain production. The variety is ultra-early, uniform ripening and high resistance to low temperatures at the same level as winter wheat/ It is resistant to diseases and lodging. The variety is suitable for mechanized harvesting with small yield losses. Recommended growing areas are Steppe, Forest Steppe, Polissia.

The Enduro variety is an upright, ultra-early ripening, high-yield winter variety of yellow-peas with the possibility of autumn sowing. The originator is ‘Celgen a.s.’, Czech Republic. It is not picky about autumn moisture. The variety is medium-early and leafless. It is characterized by high winter hardiness (up to 16 °C), resistant to diseases and lodging. It is recommended for growing in such areas as Steppe, Forest Steppe, Polissia.

Endophyte-L1 PK (a.s. auxins, gibberellins, cytokinins and other biologically active substances complex, 5.0 g/l) is a highly effective drug, a product of biotechnological cultivation of a new strain of ginseng root fungi. Manufacturer is PE ‘VCF ‘Imptorg-service’, Ukraine.

BTU-p bioinoculant (*Bradyrhizobium japonicum* 50±20% + *Rhizobium leguminosarum* 50±20% titer 2×109 – 6×109 CFU/cm^3, macro- and microelements, biologically active products of bacterial life: vitamins, heteroauxins, gibberellins, etc.). Manufacturer is PP ‘BTU-Center’, Ukraine.

‘LF-LEGUMES’ is a concentrated complex of chelated microfertilizer of the third generation, which includes NPK and microelements in chelated form, which is used for foliar fertilizing of leguminous crops. Active substances are Boron (B) – 10%, Manganese (Mr) – 1%, Cobalt (Co) – 1%, etc.

LF Biobor 140 is a concentrated chelated microfertilizer for foliar feeding for Boron (B) deficiency. Active substances: Boron (B) – 140–141 g/l, Nitrogen (N) – 62–65 g/l, Modibden (Mo) – 0.05–0.1 g/l. Preparative forms is solution. Manufacturer is Leaf-Forte microfertilizers, Ukraine.

The height of winter pea plants was determined by measuring on 25 plants fixed with pegs in four folded on two non-adjacent repetitions [22], and the above-ground mass was determined by the weight method [23]. Statistical processing of experimental data was carried out by the method of dispersion and correlation-regression analysis with a comparison of arithmetic values and the significance of the difference between them on PC using Excel and Statistics software packages.

Results and Discussion. It was established that during the years of the study, weather conditions significantly influenced the formation of plant height indicators of both researched winter pea varieties, both in the experimental variants and in the control variant without pre-sowing treatment. In the variant without pre-sowing treatment and with $N_{45}P_{45}K_{45}$ fertilizer, on average, over three years of research, the height of plants at the budding phase of winter peas of NC Moroz variety was 43.4 cm (Fig. 1). Due to fertilization at the phase of 3–5 leaves, plant growth increased by 10% compared to the control, and due to the complex application of two-fold feeding at the 3–5 leaves phase and the budding phase – by 12%.

The height of pea plants at the budding phase increased by 7% after pre-sowing seed treatment with the restorative drug Endophyt L1 amid $N_{45}P_{45}K_{45}$ fertilizer. Two-fold foliar fertilizing at the phase of 3–5 leaves of LF-LEGUMES (the first fertilizing option) and at the phase of 3–5 leaves of LF-LEGUMES + at budding phase of LF-LEGUMES adding Biobor 140 (the second fertilizing option) led to an increase in height plants by 15 and 19%, respectively.

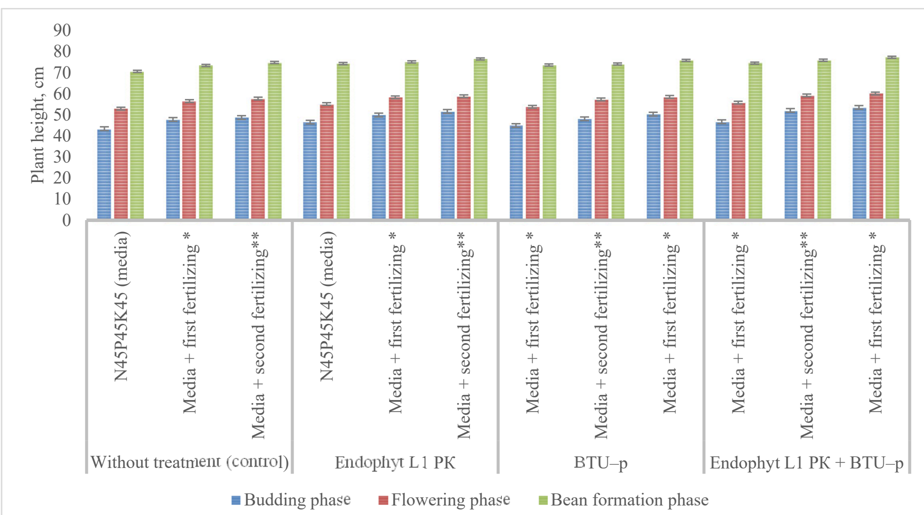

Fig. 1. The height of pea plants of winter pea NC Moroz variety using PPP Endophyt L1 PK, BTU-p, their complex application and foliar fertilizing, cm (average for 2019–2022 years)

Notes: * – at the phase of 3–5 leaves of microfertilizer LF-LEGUMES 1.5 l/ha;

** – at the phase of 3–5 leaves of microfertilizer LF-LEGUMES 1.5 l/ha + LF-LEGUMES 2.5 l/ha + Biobor 140 1.0 l/ha

The inoculation of seeds with $N_{45}P_{45}K_{45}$ fertilizer, the first and second fertilizing options contributed to the improvement of growth processes and ensured an increase in plant height by 4%, 11% and 16%, respectively, compared to the option without pre-sowing treatment.

The best effect was found as a result of the combined use of plant growth regulator and bioinoculant with $N_{45}P_{45}K_{45}$ fertilizer, the first (at the phase of 3–5 leaves) and the second (at the phase of 3–5 leaves and the budding phase) fertilizing options, where the stem growth increased by: 8%, 20% and 23%, respectively.

At the phase of flowering and formation of beans, a similar dependence was observed in winter pea crops of NC Moroz. However, the most significant growth of plants was observed in variants with complex application of pre-sowing seed treatment and fertilizer application using two-fold fertilizing. The excess compared to the control was on average 12–14% at the phase of flowering and 8–10% at the phase of bean formation.

Plant height indicators of winter peas of the Enduro variety were noted to be lower. In the variant without pre-sowing treatment and using $N_{45}P_{45}K_{45}$ fertilizer, the height of plants in the budding phase was 43.1 cm on average over three years of research (Fig. 2). Fertilizing peas at the phase of 3–5 leaves with LF-LEGUMES (1.5 l/ha), plant growth increased by 6% compared to the control. and with the complex application of two-fold top-dressing at the phase of 3–5 leaves of LF-LEGUMES (1.5 l/ha) and the budding phase of LF-LEGUMES (2.5 l/ha) + Biobor 140 (1.0 l/ha) – by 10%.

The height of pea plants in the budding phase increased by 6% under the incrustation of PP Endophyte L1 seeds and on the background of $N_{45}P_{45}K_{45}$ fertilizer. Two-fold foliar feeding in the phase of 3–5 leaves (the first fertilizing option) and in the phase of 3–5 leaves + in the budding phase (the second feeding option) led to an increase in plant height by 14 and 17%, respectively.

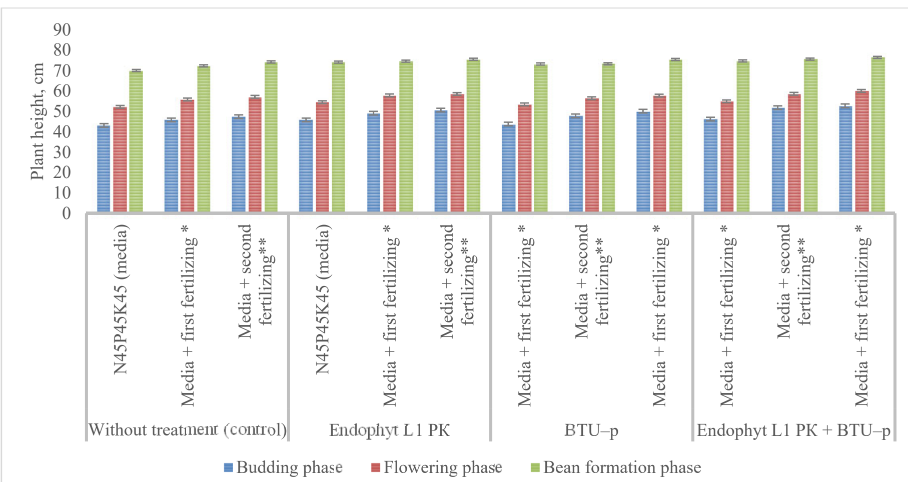

Fig. 2. The height of pea plants of winter pea Enduro variety using PPP Endophyt L1 PK, BTU-p, their complex application and foliar fertilizing, cm (average for 2019–2022 years)

Notes: * – at the phase of 3–5 leaves of microfertilizer LF-LEGUMES 1.5 l/ha;

** – at the phase of 3–5 leaves of microfertilizer LF-LEGUMES 1.5 l/ha + LF-LEGUMES 2.5 l/ha + Biobor 140 1.0 l/ha

Pre-sowing inoculation of BTU-p seeds with $N_{45}P_{45}K_{45}$ fertilizer. as well as the application of two fertilizing options contributed to the growth processes and ensured an increase in plant height by 2%. 11% and 16%, respectively, compared to the option without pre-sowing treatment.

It should be noted that in both Enduro variety, as well as NC Moroz variety, the higher indicators were noted with the complex application by stimulating drug and bioinoculant with $N_{45}P_{45}K_{45}$ fertilizer, during the first and second fertilizing. The growth of the pea stem in the Enduro variety according to the above-mentioned experimental options increased by 7%, 20% and 22%, respectively, compared to the control.

In crops of winter peas of Enduro variety at the phase of flowering and formation of beans, the best result was found in the case of the combined use of stimulating and bacterial drugs and complex fertilizing, where the excess was relative to the control averaged 12–15% at flowering phase and 8–9% at the phase of bean formation.

The results of experimental studies on winter pea plants of NC Moroz and Enduro varieties showed that the growth of above-ground biomass depended on the action of the pre-sowing treatment of PPP Endophyte L1 seeds, bioinoculant of BTU-p, their combined use amid $N_{45}P_{45}K_{45}$ fertilizer and the use of various foliar fertilizers, as well as weather conditions during the years of research (Fig. 3, Fig. 4). Analysis of average values of biomass for three years of the study indicates that the control variant without pre-sowing seed treatment, but with the use of the main fertilizer and various supplements caused an increase in the growth of the biomass of pea plants of the winter NC Moroz variety. The value of the indicator of vegetative mass with the main fertilization during the phase of budding, flowering and formation of beans were 7,89, 18,86 and 22,12, carrying out the first fertilizing at the phase of 3–5 leaves (LF-LEGUMES 1,5 l/ha), the indicators increased by 26%, 7% and 4%, and under the use of two-fold top-dressing at the phase of 3–5 leaves (LF-LEGUM 1,5 l/ha) and in the budding phase LF-LEGUMES (2,5 l/ha) + Biobor 140 (1,0 l/ha) the increase was 39%, 20% and 13% according to the control option with $N_{45}P_{45}K_{45}$ fertilizer (Fig. 3).

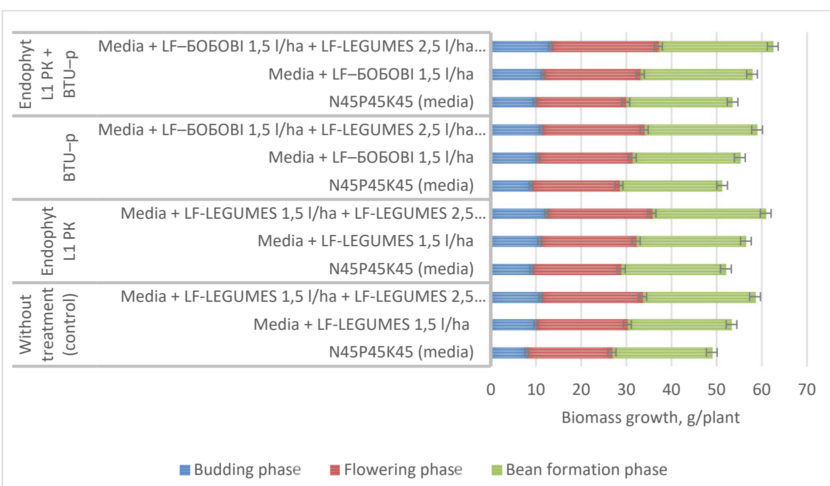

Fig. 3. The effect of PPP Endophyt L1 RK, BTU-p, complex application and foliar fertilizing on the biomass growth of winter pea plants of NC Moroz variety, g/plant (average for 2019–2022 years)

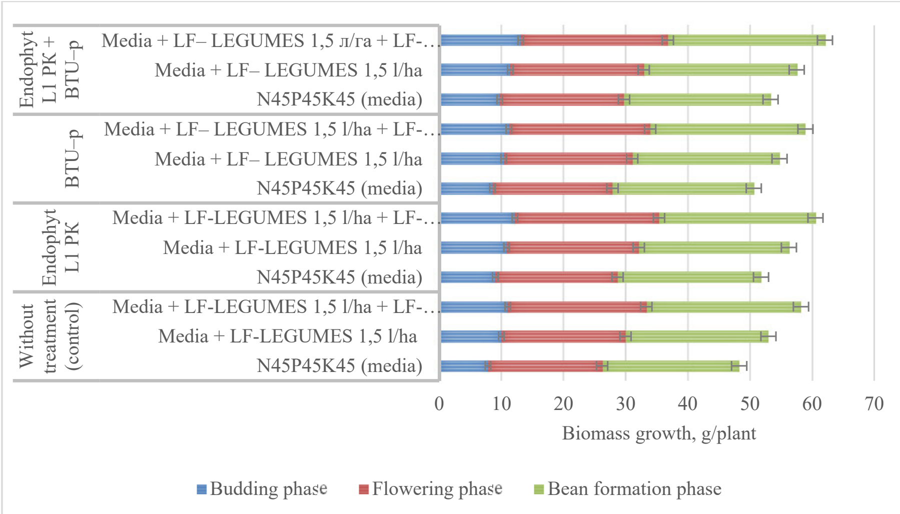

Fig. 4. The effect of PPP Endophyt L1 RK, BTU-p, complex application and foliar fertilizing on the biomass growth of winter pea plants of Enduro variety, g/plant (average for 2019–2022 years)

Ground biomass of winter pea plants of the NC Moroz variety in comparison with the control option without pre-sowing treatment by: 14% at the budding phase, 5% at the flowering phase, 5% at the bean formation phase. During the phase of budding, flowering and formation of beans, with the first top-dressing of LF-LEGUMES (1.5 l/ha) there was an increase in indicators by 36%, 13% and 10%, and with the application of the second top-dressings with LF-LEGUMES (1.5 l/ha) and LF-LEGUMES (2.5 l/ha) + Biobor 140 (1.0 l/ha) the increase was 55%, 24% and 14% in comparison to the variant with $N_{45}P_{45}K_{45}$ fertilizer.

The application of BTU-p bacterizator of seed material before sowing in.

The independent use of the restorative preparation Endophyt L1 in the pre-sowing treatment with $N_{45}P_{45}K_{45}$ fertilization ensured the growth of the above-media with $N_{45}P_{45}K_{45}$ fertilization led to an increase in the vegetative mass of winter pea plants in the above-mentioned phases of development relative to the control without pre-sowing seed treatment by 12%, 3%, and 3%, respectively, carrying out the first fertilization at the phase 3–5-th leaves the values increased by 31%, 11% and 8%, and after the second fertilization at the phase of 3–5 leaves and at the phase of budding, the increase was 41%, 21% and 13%, respectively, in comparison to the option without pre-sowing treatment and with fertilizer $N_{45}P_{45}K_{45}$.

High biomass of winter pea plants was noted in variants with the complex application of growth-regulatory and bacterial preparations with the main fertilizer $N_{45}P_{45}K_{45}$, where at the phase of budding, flowering and formation of beans, compared to the control without pre-sowing treatment, the mass of plants increased by 23%, 6% and 7% in accordance,

The highest biomass of winter pea plants was noted in the variants with complex application of pre-sowing treatment of PPP and inoculants with $N_{45}P_{45}K_{45}$ fertilizer and two-fold fertilization (3–5 leaves and budding) LF-LEGUMES (1.5 l/ha) and LF-LEGUMES (2.5 l/ha) + Biobor 140 (1.0 l/ha), during the phase of budding, flowering and formation of beans compared to the control without pre-sowing treatment, the mass of plants increased by 66%, 24% and 15%, respectively. In this variant, slightly lower indicators were noted when $N_{45}P_{45}K_{45}$ was fertilized with one feeding at the phase of 3–5 leaves of LF-LEGUMES (1.5 l/ha), which increased by 45%, 14% and 12%, respectively,

The analysis of biomass growth of winter pea plants of the Enduro variety by phases of growth and development and by years of research shows that with different pre-sowing treatment of seeds and feeding with microfertilizers, the indicators differed not only by years, but also by options.

After analyzing the average values of the biomass of winter pea plants over three years of research, it can be concluded that this indicator was slightly lower in the Enduro variety compared to the NC Moroz variety.

In the control variant of this variety without pre-sowing seed treatment, but with the use of the main fertilizer $N_{45}P_{45}K_{45}$ and two-fold fertilization, an increase in the growth of plant biomass was noted. The indicator of the ground mass with the main fertilization at the phases of budding, flowering and formation of beans was 7.83, 18.37 and 22,06 g, when carrying out the first fertilizing of LF-LEGUMES (1.5 l/ha), the indicators increased by 27%, 9% and 4%, and when using two-fold fertilization of LF-LEGUMES (1.5 l/ha) and LF-LEGUMES (2.5 l/ha) + Biobor 140 (1.0 l/ha) the increase was respectively 41%, 21% and 13% in the control with the main fertilizer (Fig. 4).

The use of the bacterial preparation BTU-p and the main fertilizer $N_{45}P_{45}K_{45}$ in the pre-sowing treatment led to an increase in the ground mass of winter pea plants in the above-mentioned phases of development relative to the control without pre-sowing seed treatment by 9%, 5%, and 3%, respectively. 5 leaves (LF-LEGUMES 1.5 l/ha) values increased by 32%, 13% and 8%, and when carrying out two-fold fertilizations at the phase of 3–5 leaves (LF-LEGUMES 1.5 l/ha) and in the budding phase (LF-LEGUMES 2.5 l/ha + Biobor 140 1.0 l/ha) the increase was respectively 43%, 24% and 13% for the option without pre-sowing treatment and with the main fertilizer.

Observations showed that the use of the re-regulating drug in pre-sowing treatment with basic fertilizer ensured the growth of the above-ground biomass of winter pea plants in comparison with the control option without pre-sowing treatment in the budding phase by 15%, in the flowering phase by 7%, at the phase of bean formation by 5%. During the first fertilizing at the phase of 3–5 leaves (LF-LEGUMES 1.5 l/ha) in the above-mentioned phases there was an increase in indicators by 38%, 16% and 10%, and when applying two-fold fertilization at the phase of 3–5 leaves (LF-LEGUMES 1.5 l/ha) and in the budding phase (LF-LEGUMES 2.5 l/ha + Biobor 140 1.0 l/ha) the increase was respectively 55%, 26% and 14% with basic fertilizer.

Biomass indicators of winter pea plants were somewhat higher in variants with pre-sowing treatment, where a growth regulator and inoculants with the main fertilizer were used. Thus, at the phase of budding, flowering and formation of beans, compared to the control without pre-sowing treatment, the mass of plants increased by 24%, 9% and 7%, respectively.

The best indicator of the biomass of winter pea plants was found in the variants with the complex application of pre-sowing treatment with re-regulating and bacterial preparations with $N_{45}P_{45}K_{45}$ fertilizer and two-fold fertilization of LF-LEGUMES (1.5 l/ha) and LF-LEGUMES (2.5 l/ha) + Biobor 140 (1.0 l/ha), where at the phase of budding, flowering and formation of beans compared to the control without pre-sowing treatment, the mass of plants increased by 67%, 29% and 15%, respectively. However, in the experimental version where the basic fertilizer $N_{45}P_{45}K_{45}$ with one feeding of LF-LEGUMES

(1.5 l/ha), the biomass indicators were lower and increased respectively by 46%, 17% and 12% according to the above-mentioned phases.

Conclusions. A positive effect on the increase in plant height of winter pea varieties of Moroz and Enduro was established for applying of mineral fertilizers in the dose of N45P45K45 and foliar fertilizing in different rates and phases with microfertilizers LF-LEGUMES and Biobor 140. At the phase of bean formation, the average value of plant height for the studied years in winter peas of NC Moroz and Enduro varieties was 71–75 cm and 70–74 cm, respectively, which corresponded to their varietal characteristics. Complex pre-sowing treatment Endophyt L1 PK + BTU-p amid the main fertilizer $N_{45}P_{45}K_{45}$ and with two-fold foliar top-dressings with microfertilizers during different development phaseы ensured an increase in the height of plants in varieties NC Moroz and Enduro by 5–10% and 6–9%, respectively, compared to the control variant.

It was investigated that the greatest biomass of winter pea plants of NC Moroz and Enduro varieties was noted in the variants with the complex application of pre-sowing treatment Endophyte L1 PK and BTU-p with $N_{45}P_{45}K_{45}$ fertilizer and two-fold fertilizing (3–5 leaves and budding) LF-LEGUMES and LF – LEGUMES + Biobor 140, where at the phase of budding, flowering, formation of beans compared to the control without pre-sowing treatment, the weight of plants increased by 66%, 24%, 15% and 67%, 29%, 15%, respectively. Applying one top dressing in at the phase of 3–5 leaves, the indicators increased by 45%, 14%, 12% and 46%, 17%, 12% according to the above-mentioned phases and varieties.

The use of combinations of biological preparations for pre-sowing seed treatment and foliar fertilization in different rates and phases is promising for their further study as environmentally safe measures to increase the yield of winter peas.

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