Chapter 10

BIOLOGICAL TECHNOLOGY OF GROWING CHICK-PEA

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INTRODUCTION

The modern concept of balanced development of agricultural ecosystems in Ukraine provides for the maximum realization of the potential of natural resources. In this aspect, the biological factors of increasing plant productivity and maintaining soil fertility are becoming more and more relevant, including increasing the share of leguminous and legume crops, as an important factor in improving the nitrogen balance of soils, due to the nitrogen-fixing activity of the leguminous ryzobialnyiapparatus. The introduction of crops that are resistant to droughts and insufficient moisture into agricultural production is especially urgent, and chick-pea is such a crop.

It is leguminous crops, along with providing valuable food products and fodder, that play an exceptional role in phytoamelioration, remediation and phytosanitary cleaning of soils, reducing energy consumption in crop production. Distinctive features of leguminous crops are a nondeterministic growth type and the ability to fix nitrogen in symbiosis with nodule bacteria. However, along with obvious advantages, legumes also have disadvantages. Their yielding capacity is lower than that of grain crops. Also, they are more sensitive to diseases, pests and weeds, which significantly reduce their yield. These disadvantages are overcome by using pesticides. However, it is the introduction of biological agriculture elements that is economically and ecologically beneficial, because due to the use of natural components of agricultural ecosystems, it is possible to increase the productivity of agricultural crops and obtain products that are safe for consumption.

At the same time, many questions regarding the complex effect of biological preparations on plants, the passage of physiological and microbial processes in the plant and soil, are currently insufficiently clarified. In particular, the question of the directionality of the action of microbial preparations'mixtures and plant growth regulators under their complex use with herbicides in the direction of the formation of high productivity of chick-pea crops remains unexplored. That is why the development of individual elements of the complex use of biological preparations in chick-pea cultivation technologies, based on a comprehensive study of changes in physiological and biochemical processes in plants and soil, is relevant and necessary for the formation of ecologically clean and stable harvests of this crop [1,2,3,4,5,6,7,8].

In this edition, the authors focus on a comprehensive approach to the implementation of ecological aspects of the formation of natural and economic balance in agrocoenosis. The possibility of introducing biologization elements into chick-pea growing technology, in particular, the use of microbial preparations and plant growth regulators, has been comprehensively systematized, summarized and supplemented by own research.

A special place in the edition is reserved for materials grouped according to the principle of peculiarities of biological processes in plants and soil (physiological, biochemical, anatomy-morphological, microbial, etc.). The purpose of this publication is to acquaint scientists, agricultural specialists, and readers with systematized modern scientific data and the results of the author's research on the biologization of chick-pea cultivation technology, which can form the basis for the development of rational and environmentally safe agrotechnologies for other agricultural crops.

1. Physiological and biochemical changes in plants during separate and integrated use of herbicides, plant growth regulators and microbial preparations

Many years of research and practice convincingly show that it is impossible to protect leguminous crops from weeds with agrotechnical measures alone. However, the effect of preparations of chemical and

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biological origin has a significant impact on physiological and biochemical processes in plants [9].It is reflected in changes in the level of such indicators as enzyme activity, chlorophyll content, intensity of accumulation of organic matter, yielding capacity, etc.

Recently, numerous data have been cumulated that the general integral indicator characterizing the negative effect of stressors of various nature, including herbicides, is the increase in the generation of reactive oxygen species (ROS) in the plant organism [10, 11].

Currently, a lot of data has been cumulated on the effect of herbicides on the functional showings of plants, including enzyme synthesis, changes in chlorophyll accumulation, photosynthesis activity, growth, and yield formation [12].

As noted by I. V. Kosakivska [13], the common response of all living organisms to stress is the expression of stress-dependent genes and proteins, the activity of which is aimed at protecting cells and maintaining homeostasis. According to the author`sinformation, such reaction is observed under the influence of extreme temperatures, ultraviolet and radioactive radiation, toxic substances, changes in the water regime, mutagens, etc. However, xenobiotics, which are used in the plant protection system, have the largest share of the impact on agricultural plants [14,15]. Their action is manifested in a change in the passage of physiological and biochemical reactions in plants.

The effect of herbicides, at optimal rates of application, has a negligible effect on the physiological and biochemical state of plants, while the improvement of plant nutrition due to the reduction of competition with weedy vegetation is observed. According to V. P. Karpenko and co-authors [16], the herbicide Kalibr 75 at rates of 40, 50, and 60 g/ha, acting independently, had

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[16] Карпенко В. П., Притуляк Р. М., Чернега А. О. Активність окремих антиоксидантних ферментів класу оксидоредуктаз за дії гербіциду Калібр 75 і регулятора росту рослин Біолан. Збірник наукових праць Уманського НУС. 2013. №83. С. 19–25.

a positive effect on the passage of metabolic reactions, which was manifested in the activation of certain enzymes of the oxidoredutase class (catalase, peroxidase) and may indicate an increase in the level of detoxicational processes in the plant organism.

As noted by V. Ya. Bilonozhko with co-authors [17], with increased use rates of the herbicide Granstar 75 and its tank mixtures with the herbicides 2,4-DA 500 and Dikopur F 600, a decrease in the content of chlorophylls *a* and *b* and their sum (2–21%) was observed in the leaves of spring barley, which is as a result of inhibition of chlorophyll synthesis under the action of herbicides. A similar reaction of plants was noted in his experiments by O. I. Zabolotniy with co-authors [18], who noted a lower content of the sum of chlorophylls (*a+b*), chlorophyll *a*, chlorophyll *b*, and carotenoids in corn plants, as well as the neat photosynthetic productivity (NPP), when 2.5 l/ha of Trofi 90 were applied. S. I. Sorokina[19] established a decrease in the content of chlorophylls *a* and *b* and their sum in soybean plants under the independent action of the herbicides metribuzin 0.5 kg/ha, trifluralin 2.4 kg/ha, metolachlor 1.5 kg/ha, imazethapir 80 g /ha, imazamox 30 g/ha, thifensulfuron-methyl 2.25 g/ha.

I. B. Leontyuk [20] observed an increase in the neat productivity of photosynthesis in winter wheat crops under the action of the herbicides Grodil (15–25 g/ha) and Trezor (1.0–1.4 kg/ha), where the excess compared to the control was 3 and 10% respectively.

In the researches of V.P. Karpenko with co-authors[16], the positive effect of the herbicide in combination with biological preparations on the activity of antioxidant enzymes is shown. Thus, the combination of application of different rates (30–60 g/ha) of Caliber 75 herbicide with PGR Biolan caused an increase in the activity of antioxidant enzymes in winter barley plants. An increase in the activity of enzymes was also observed with the combined use of Caliber 75 with PGR Biolan against the background of Biolan treatment of seeds, which indicates an increase in the antioxidant status of plants due to the

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active participation of these enzymes in the adaptation of plants to herbicide stress.

A number of studies [21,22,23] proved the positive effect of the combined use of plant growth regulators and herbicides on the content of chlorophyll in plant leaves. Thus, according to Z. M. Hrytsaienko and V. P. Karpenko, the introduction of the plant growth regulator Emistim C with the herbicide Granstar at 10–25 g/ha had a positive effect on the passage of the main physiological processes in spring barley plants: the content of chlorophyll increased and dry matter in leaves by 5–8%, the neat productivity of photosynthesis increased by 20%,and under the action of the herbicide Titus 50 g/ha in combination with the biological preparation Zeastimulin at the rate of 10 ml/ha – an increase in the content of chlorophylls by 1.34 mg/g of raw material in terms of chlorophyll a and by 0.20 mg/g of raw material in terms of chlorophyll b in corn plants[24].

V. O. Vakulenko with co-authors [25] noted the positive effect of Emistim C and Agrostimulin on photosynthetic processes in white lupine and yellow lupine plants. The treatment of PGR Emistim C seeds contributed to a more intensive accumulation of chlorophyll in the leaves of lupine plants of the Makarivsky white variety.

According to R. M. Prytuliak [26], in the crops of winter triticale, the highest level of indicators of the neat productivity of winter triticale photosynthesis was formed under the action of the herbicide Prim at the rate of 0.8 l/ha and Puma super at the rate of 1.2 l/ha, introduced compatible with Biolan plant growth regulator at a rate of 10 ml/ha.

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In the researches of O. V. Holodryga with co-authors[27], pre-sowing sprinkling of seeds with plant growth regulators Biolan and Rhizobophyte ensured optimization of germination and growth of soybean plants, stimulated the accumulation of mass by above-ground and underground plant organs and contributed to the formation of the photoassimilating leaf surface.

According to O.M. Hryhorieva [28], pre-sowing reparation of soybean seeds with the biological preparation Rhyzogumin (200 g per hectare of seed rate) with the post-emergence application of the plant growth regulator Biolan (20 ml/ha) made it possible to obtain an increase in grain yield at the level of 0,29 t/ha or 13.1%.

It was established [29] that for the use of spring barley in crops Agatu-25 K in combination with Lintur improved the physical parameters of the grain, namely: coarseness increased to 89%, weight of 1000 seeds – from 44.8 g to 48.9 g, nature – up to 658.1 g/l at 635.2 g /l in control.

Summarizing the research of scientists, it can be stated that the use of plant growth regulators is compatible with herbicides[12] and against the background of the use of microbial preparations[30], provides an increase in the resistance of cultivated plants to stress factors and promotes the activation of growth and production processes. However, despite the importance of studying the problem of the combined use of herbicides with biological preparations, there are only a few works in the scientific literature, the purpose

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[27] Голодрига О. В., Леонтюк І. Б., Розборська Л. В., Заболотний О. І. Продуктивність сої за застосування гербіциду Дєсілєт на фоні обробки насіння регулятором росту рослин Біолан і бактеріальним препаратом Ризобофіт. Зб. Наук. Пр. Уманського НУС. 2016. №89. С. 143–151.

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of which was to find out the complex effect of a herbicide, a plant growth regulator and a microbial preparation on chick-pea plants [31,32,33].

Considering this, the problem of complex application of herbicides with biological preparations and their effect on metabolic and productive changes in chick-pea plants requires further active study.

2. The effectiveness of the use of herbicides, plant growth regulators and microbial preparations in the sowing of leguminous crops, including chick-peas

In the technology of growing chick-peas, one of the essential problems is the fight against weeds. In the initial growing season, the plants of this culture first of all develop their root system, and then the above-ground mass, so they compete poorly with weeds. The size of crop losses depends on the phase of culture development and the density of weeding. In years with favorable weather conditions, weeds reduce the yield of chick-peas much more than in dry years. To combat weediness, along with agrotechnical measures, chemical control acquires great importance. And although in recent years, many new preparations with low toxicity, a wide spectrum of action on weeds, and low consumption rates have appeared on the world market, the range of herbicides for this crop is limited. Preparations with which you can work on the steps of culture in case of severe weeding in the spring period also require considerable attention.

According to R. Hutianskyi with co-authors [34], the independent effect of the herbicide Pulsar 40 (0.8 l/ha) caused a decrease in the height of chick-pea plants by 20 cm, a decrease in the weight of 1000 grains by 47 g/per 1000 grains, and a yield of chick-pea by 0.78 t/ha.

According to R. A. Hutianskyi with co-authors [35], the graminicide Miura (0.8 l/ha) best controlled the number and mass of annual grass weeds in chick-pea crops. Another graminicide, Lemur (1.5 l/ha), slightly less than the preparation Miura, but more than the preparation Fusilade Forte 150 EC (1.0 l/ha), controlled cereal annual weeds. Fusilad Forte 150 ES, Lemur and Miura

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anti-fouling herbicides reduced the number of gray mice in chick-pea crops by 91, 99 and 98%, respectively, and common flatworm – by 78, 89 and 98%.Soil herbicide Advocaat (1.0 l/ha), in the background of which the graminicides Fusilade Forte 150 EC, Lemur and Miura were used, controlled the number of white quinoa (Chenopodium album), common sedum (Amaranthus retroflexus), annual sedge (Stachys annua) and ladybug white (Melandrium album) in chick-pea crops by 83, 69, 93 and 95%, respectively. Black nightshade (Solanum nigrum) turned out to be resistant to the herbicide. Perceptible suppression of cereal species by graminicides created prerequisites for the mass growth of other types of dicot annual and perennial weeds. In this regard, the optimal combination of herbicides to ensure the highest level of chick-pea productivity was not found.

According to V. S. Zadorozhnyi with co-authors [36], measures to protect chick-pea crops from weeds should be carried out already in the presence of 10 pcs./m2 of annual weeds and completed within 20 days from the emergence of crop seedlings. Soil preparations showed high selectivity and herbicidal activity in chick-pea crops: Stomp, 33% k.e. (4.0 l/ha); Harness, 90% c.e. (1.5–3.0 l/ha), Frontier Optima (0.8–1.0 l/ha). On average, the reduction of weeds was 85–90%, and the yield increase was 0.72–0.84 t/ha. Of the post-emergence herbicides in chick-pea crops under conditions of mixed type of weediness, it was advisable to use Pulsar (0.9 l/ha), Pivotu (0.8 l/ha). Weed death averaged 80–81%, and yield growth was 0.73–0.74 t/ha. The use of herbicide Harmonyk WG (8 g/ha) was effective against dicotyledonous weeds.

As research of scientists shows, reducing the phytotoxic effect of herbicides on cultivated plants can be achieved as a result of their integrated use with plant growth regulators[37] and microbial preparations [38] that show anti-stress activity.

Various aspects of the formation of stress resistance were considered by the authors from the standpoint of resistance to adverse weather conditions[39], to the effect of herbicides, and resistance of individual varieties.

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According to M. M. Lisovyi with co-authors[40], against the background of the use of the preparation for pre-sowing treatment of chick-pea seeds with *B. thuringiensis* strain 0376 during the growing season of chick-pea varieties Pamyat, Triumf, Antey, Bujak, Rosanna, plant damage by the phytophagous *Liriomiza cicerina* Rd. decreased, which increased the yield on average by 25, 38, 53, 30, 98% compared to the control.

V. S. Pashtetskyi with co-authors [41] proves that the reparation of chick-pea seeds with highly effective strains of *Mesorhizobium repar* and biopreparations of phosphate-mobilizing and bioprotective action improves the structure of the crop, increases productivity up to 22% compared to the control without inoculation, up to 13% compared to monotreatment with rhizobia. It was also noted that the weather conditions of the year affect the effectiveness of reparation. According to O. L. Shchyhortseva with co-authors[42], under the action of the fungicide Biopolycid together with the microbial preparation *M. repar* 065 in the conditions of the south of Ukraine, the yield of chick-peas of the Triumf variety increased by an average of 20% over two years, and of the Rozanna variety – by 23%, compared to variants with the independent action of Vitavax 200 FF (3.0 l/t). When using Rizoplan with strain *M. repar* 065, the yield of chick-peas of the Rozanna variety increased by 2.1 t/ha (15%), Alexandrite – by 3.0 t/ha (21%) compared to variants of independent action of Vitavax (3.0 l/t).

O. L. Turina and co-authors[43] also noted that, along with an increase in chickpea yield by 0.1–0.6 t/ha (5–16%), pre-sowing treatment of seeds with multifunctional biological preparations – *Rhizobophyte I*, *Phosphoenterin (Ph)*, and *Albobacterin (A)* – resulted in a 1–3 percentage point increase in crude protein content in the grain and contributed to the formation of highly productive plant-microbial systems in legume agrocenoses of the Steppe zone of Ukraine.

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As noted by a number of authors [44,45,46], the combined action of plant growth regulators and microbial preparations makes it possible to better reveal the productivity of chick-pea crops and increase the ability of plants to compete with weeds [47,48,49], and as a result, to increase their yield [50,51, 52].

Taking into account the above literary data, which confirm the effectiveness of pre-sowing seed treatment measures with plant growth regulators and microbial preparations, the study of the effectiveness of their action on chick-pea plants and the microbiological state of crops against the background of the use of herbicides is of great importance.

Taking into account the above literature review, it can be stated that the aspects of the combined effect of herbicides, plant growth regulators and microbial preparations on changes in the activity of antioxidant enzymes in chick-pea plants, the content of chlorophylls in them, the formation of the neat productivity of photosynthesis, grain yield and quality, economic efficiency of cultivation remain poorly studied cultures. Therefore, in view of the cited literary material and the lack of individual data in the literature, it can be stated that the study of the issues of the combined effect of herbicides, plant growth regulators and microbial preparations on physiological, biochemical and microbiological changes in chick-pea plants and soil will provide an

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opportunity to reveal the essence of this problem. The study of these issues determined the main directions of research.

3. The effect of herbicide, plant growth regulator and microbial preparation on chlorophyll accumulation

The fundamental basis of plant life is photosynthesis, around which all metabolic processes are grouped. Photosynthesis provides an energy-substrate formation of the crop, combined with the assimilation processes of nitrogen and mineral nutrition elements and is under control in a complex hierarchy of genetic development programs that determine the entire sequence of ontogenesis processes. Studies have shown that the photosynthetic function is controlled by the processes of ontogenesis and the formation of the crop is determined, first of all, by the epigenetic load from the organs consuming assimilates[53, 54, 55]. However, the photosynthetic activity of plants is largely determined by growing conditions. It should be noted that the most vulnerable links of the photosynthetic apparatus, which are primarily damaged during the action of such stress factors as increased and decreased temperature, high intensity of visible light, ultraviolet radiation, heavy metals, pesticides, are, in particular, photosystem II and the system of photosynthetic oxidation of water. The inhibitory effect of more than 50% of herbicides is based on their ability to inhibit the flow of electrons in photosystem II, which leads to the stoppage of the entire process of photosynthesis. Currently available information on the influence of xenobiotics on certain morphophysiological and biochemical parameters of plants mainly concerns wild species. At the same time, it is known that under stress, which includes herbicide treatment, the photosynthetic apparatus and its chlorophyll content are the main vulnerable links in the formation of biomass of cultivated plants.

A number of scientists [56] consider the positive effect of plant growth regulators on the pigment complex of plants in two ways: in particular, as a stimulating component in the synthesis of pigments and the formation of a light-absorbing complex, and as a protective one that prevents premature, or complete, destruction of chloroplasts. However, despite this, the behavior of

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the pigment complex of a number of agricultural crops under the complex action of herbicides, PGR and NPP is poorly studied.

On average for 2015–2017 research (Fig. 2.4) in the phase of five leaves under the independent action of the herbicide Panda in rates of 3.0; 4.0; 5.0 and 6.0, the content of chlorophyll *a* and *b* in chick-pea plants decreased by 2 compared to control I; 5; 10; 13% and 12; 9; 22; 17% respectively.

With the combined effect of PGR Stimpo (0.025 l/t) with Panda herbicide 3.0 l/ha, the content of chlorophylls *a* and *b* increased by 5 and 6%. Under the influence of higher rates of herbicide Panda (4.0-6.0 l/ha), a moderate decrease in the content of pigments was observed. Under the action of Panda herbicide at rates of 5.0 and 6.0 l/ha against the background of NPP Rhizobophyte (1.0 l/t), the content of chlorophyll *a* compared to control I increased by 3% (for the rate of 5.0 l/ha) and decreased by 4% for the norm of 6.0 l/ha, at the same time, the content of chlorophyll *b* decreased to control I by 23 and 20%, respectively.

For the complex use of the plant growth regulator Stimpo (0.025 l/t) and the microbial preparation Rhizobofit (1.0 l/t) for the treatment of chick-pea seeds and the application of the herbicide Panda at the rate of 3.0 against this background; 4.0; 5.0 and 6.0 l/ha, the content of chlorophyll a in the leaves increased by 16 compared to the variant without the use of preparations (control I); 14; 7 and 2%. Under the action of Panda herbicide at rates of 3.0 and 4.0 l/ha, chlorophyll *b* increased by 6 and 9%, while at rates of 5.0−6.0 l/ha, the content of chlorophyll *b* decreased by 9 and 23%, respectively.

With regard to the amount of chlorophylls *a* and *b*, it was the highest in chick-pea leaves on average over three years in the variants of the experiment using Panda herbicide at rates of 3.0; 4.0; 5.0 l/ha against the background of complex treatment of NPP Rhizobofit and PGR Stimpo seeds, where the excess to control I was 14, 13, 4% for the ratio of chlorophyll *a* to *b* 3.8; 3.6; 4.0 respectively.

Analyzing the content of chlorophylls, their sum and ratio in the flowering phase of chick-peas in variants without biological preparations (control I) and with manual weeding (control II), it should be noted that over the years of research, the content of chlorophyll *a* was within 15.3–15.5 mg /100 g of raw material, chlorophyll *b* – 4.6–4.9, the sum of chlorophylls *a+b* 20.1–20.2 mg/100 g of raw material. The ratio of chlorophyll *a/b* was 3.1–3.4. Significant changes in the pigment complex of chick-pea plants were not observed on *a* herbicide-free background and in variants with NPP Rhizobophyt, PGR Stimpo, and with their combined use.

When using Panda herbicide at rates of 3.0–5.0 l/ha, the content of chlorophylls relative to control I did not change significantly, and only at rates of 6.0 l/ha there was *a* decrease in the level of chlorophyll *a* by 7%, chlorophyll *b* by 14%, their ratio – by 8% (Fig. 1). Such a trend is obviously related to the negative impact of the herbicide on metabolic processes in chick-pea plants, including the processes of synthesis and accumulation of chlorophyll.

In the leaves of the experimental chickpea plants, with the simultaneous use of NPP Rhizobophyt 1.0 l/t and PGR Stimpo 0.025 l/t, the content of chlorophylls *a* and *b* and their sum decreased with the increase in the application rate of Panda herbicide, but the excess relative to the control I ranged from 4 to 16% – for chlorophyll *a*; 2–6% – for chlorophyll *b* (corresponding only at herbicide rates of 3.0–4.0 l/ha) and 3–13% – for the sum of chlorophylls *a*+*b* (at herbicide rates of 3.0–5.0 l/ha Ha).

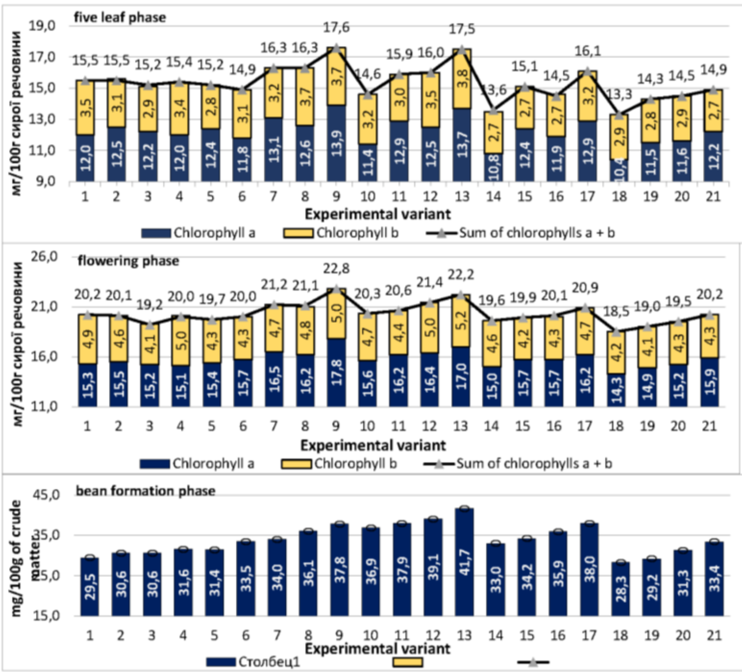

Fig. 1. The content of chlorophylls in the leaves of chick-pea variety Memory for the use of different rates of the herbicide Panda, PGR Stimpo and NPP Rhizobophyt (average for 2015–2017):

1. Without the use of biological preparations and herbicide (control I); 2. Without the use of biological preparations and herbicide + manual weeding during the growing season (control II); 3. NPP Rhizobofit 1.0 l/t; 4. PGR Stimpo 0.025 l/t; 5. NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t; 6. Panda

3.0 l/ha; 7. Panda 3.0 l/ha, NPP Rhizobophyte 1.0 l/t; 8. Panda 3.0 l/ha, PGR Stimpo 0.025 l/t; 9. Panda 3.0 l/ha, NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t; 10. Panda 4.0 l/ha; 11. Panda 4.0 l/ha, NPP Rhizobophyte 1.0 l/t; 12. Panda 4.0 l/ha, PGR Stimpo 0.025 l/t; 13. Panda 4.0 l/ha, NPP Rhizobofit 1.0 l/t+ PGR Stimpo 0.025 l/t; 14. Panda 5.0 l/ha; 15.Panda 5.0 l/ha, NPP Rhizobophyte 1.0 l/t; 16. Panda 5.0 l/ha, PGR Stimpo 0.025 l/t; 17. Panda 5.0 l/ha, NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t; 18. Panda 6.0 l/ha; 19. Panda 6.0 l/ha, NPP Rhizobophyte 1.0 l/t; 20. Panda 6.0 l/ha, PGR Stimpo 0.025 l/t; 21. Panda 6.0 l/ha, NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t.

On average, during the 2015–2017 studies in the phase of bean formation under the independent action of Panda herbicide at rates of 3.0 and 4.0 l/ha, the content of chlorophyll *a* in chick-pea plants increased by 3 compared to control I; 2%, under the influence of norms of 5.0 and 6.0 l/ha, the content of chlorophyll *a* decreased by 2; 5% The content of chlorophyll *b* under the action of the herbicide is 3.0; 4.0; 5.0 and 6.0 decreased by 14; 5; 7 and 17%, respectively.

With the complex use of PGR Stimpo (0.025 l/t) and NPP Rhizobophyt (1.0 l/t) and application of the Panda herbicide in rates of 3.0 against this background; 4.0; 5.0 and 6.0 l/ha, the content of chlorophyll *a* in the leaves increased by 16 compared to the variant without the use of preparations (control I); 11; 6 and 4%. Under the action of Panda herbicide at rates of 3.0 and 4.0 l/ha, chlorophyll *b* increased by 2 and 7%, while at rates of 5.0-6.0 l/ha, the content of chlorophyll *b* decreased by 6 and 14%, respectively.

Summarizing the obtained data on the content of chlorophyll in chick-pea leaves, it can be stated that the accumulation of chlorophyll *a* during the growing season increased on average from the five-leaf phase to the flowering phase by 30%, and from the flowering phase to the bean formation phase by 25%. The decrease in the content of chlorophyll *a* before the phase of bean formation in all variants of the experiment is obviously associated with *a* decrease in the intensity of metabolic processes in plants and an increase in the area of the photosynthetic surface, and the most active decrease of this indicator was observed in the variants on the herbicide background without the use of biological preparations.

The intensity of accumulation of chlorophyll *b* in chick-pea leaves during the growing season was evidenced by its growth in variants where the combination of NPP Rhizobophyt and PGR Stimpo was used. At the same time, from the phase of flowering to the phase of bean formation, *a* decrease in the content of chlorophyll *b* was observed compared to the rates of formation of chlorophyll *a*.This feature of the distribution of the content of chlorophylls *a* and *b* in chick-pea plants can be considered as an adaptive feature, which ensures the functioning of the photosynthetic apparatus by increasing the mutual shading of the leaves, especially in the lower tiers, which prevents the penetration of the long-wave part of the spectrum, but has less effect on its short-wave component, which mostly absorbed by chlorophyll *b*. In addition, in the spring period, there are fewer ultraviolet rays in the light spectrum than in the summer, which also has its effect on the ratio of pigments in chick-pea plants[57].

The combined use of NPP Rhizobophyt (1.0 l/t) and PGR Stimpo (0.025 l/t) against the background of application of Panda herbicide at rates of 3.0–4.0 l/ha ensures a significant increase in the pigment content in the pigment complex of chickpea leaves, which may indicate the creation of more favorable conditions for the passage of physiological and biochemical processes in plants, including photosynthetic ones, due to the direct stimulating effect of biological preparations on the functioning of the pigment complex of the calvarial apparatus of this culture. With the use of Rhizobophyt NPP (1.0 l/t) without herbicide and in variants with the application of Panda herbicide at rates of 3.0–6.0 l/ha, the value of the chlorophyll index (chlorophyll *a*/chlorophyll *b*) was the maximum – 3.7. The ratio of chlorophylls *a/b* usually varies in the range of 2.2–4.0 and is used as a marker of the physiological state of the plant organism. Changes in the ratio of chlorophylls *a/b* may indicate a violation of stoichiometry between complexes of reaction centers of photosystems and light-harvesting complexes, and a certain ratio of chlorophylls *a* and *b* is a characteristic of the normal functioning of the photosynthetic apparatus[58].

Based on the results of dispersion analysis, it was established that the chlorophyll content in chick-pea leaves depended on factor A (Panda herbicide) by 23% and factor B (biological preparations) by 19%, as well as by 24% on the interaction of the studied factors. Calculating the correlation coefficient according to the paired correlation-regression analysis of the data, a moderate relationship (correlation coefficient 0.39) was noted between the indicators of the chlorophyll content and the yield of chick-pea crops.

Thus, it is possible to draw conclusions from the above experimental material:

– the accumulation of chlorophylls *a* and *b* in chick-pea leaves varied depending on the phase of crop development, weather conditions, application rates of Panda herbicide separately and the background of seed treatment before sowing PGR Stimpo and NPP Rhizobophyt.

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[58] Ibid.

– the combined use of NPP Rhizobophyt (1.0 l/t) and PGR Stimpo (0.025 l/t) for processing and application of Panda herbicide against this background at the rate of 3.0 and 4.0 l/ha ensures an increase in the content of chlorophylls (*a* + *b*) in chick-pea leaves by an average of 11–14% by phase, which may indicate the creation of more favorable conditions for the passage of physiological and biochemical processes in plants, includingphotosyntheticones.

– for the rate of growth of application of Panda herbicide up to 5.0 and 6.0 l/ha, applied both separately and against the background of treatment treatment before sowing PGR Stimpo and NPP Rhizobofit, decrease in the leaves of the internal content of chlorophylls *a* and *b* and their sum, which obviously, can be partly caused by their oxidative destruction and decrease in their synthesis during adaptive changes.

4. The influence of herbicide, plant growth regulator and microbial preparation on the formation of the area of the leaf apparatus

On average, over three years of research (Fig. 2), under the independent effect of NPP Rhizobophyte (1.0 l/t) in the phase of five leaves, the area of the leaf apparatus of chick-pea plants increased by 5% relative to control I and by 3% relative to control II. Under the independent action of PGR Stimpo (0.025 l/t), the area increased by 6% relative to control I and by 5% relativetocontrol II.

In the variants where only Panda herbicide was applied at the rate of 3.0; 4.0; 5.0 l/ha, the area of leaves in the phase of five leaves of the culture increased by 6 compared to control I; 37; 2%. With the introduction of the herbicide in the same rates against the background of the use of Stimpo plant growth regulator (0.025 l/t), the area of leaves compared to control I increased by 9; 49; 15 and 6%, and against the background of the use of the microbial preparation Rhizobofit (1.0 l/t) – by 9; 42; 17 and6%.

With the use of Panda herbicide at rates of 3.0–4.0 l/ha against the background of the combined use of NPP (1.0 l/t) and PGR (0.025 l/t), the area of chick-pea leaves increased relative to control I by 49– 66% and by 35–50% – to control II, and at application rates of 5.0 and 6.0 l/ha by 28–11% – to control I and by 15% – to control II at rates of 5.0 l /ha, at the norm of 6.0 g/ha – was at the level of control II.

In the flowering phase, on average over the three years of research, the area of chick-pea leaves under the action of the microbial preparation Rhizobophyt increased by 12% relative to control I, under the action of the plant growth regulator Stimpo (0.025 l/t) – by 16%, in the case of the simultaneous application of the microbial preparation Rhizobophyte (1.0 l/t) and plant growth regulator Stimpo (0.025 l/t) – by 19%.

Under the independent action of the Panda herbicide in rates of 3.0; 4.0; 5.0; 6.0 l/ha, the area of the leaves of the chick-pea crop grew by 10 compared to control I; 33; 20 and 14%, respectively.

With the use of herbicide in the same rates against the background of the use of Stimpo plant growth regulator (0.025 l/t), the area of chick-pea leaves increased relative to control And by 28; 80; 46 and 28%, and against the background of the use of the microbial preparation Rhizobofit (1.0 l/t) – by 23; 53; 34 and 21%, respectively.

For the complex use of the plant growth regulator Stimpo (0.025 l/t) and the microbial preparation Rhizobofit (1.0 l/t) for seed treatment and the introduction of the Panda herbicide at the rate of 3.0 against this background; 4.0; 5.0; 6.0 l/ha, the area of leaves in chick-pea crops increased by 40 compared to the option without the use of preparations (control I); 84; 70 and 31%, respectively.

In the phase of formation of chick-peas and beans, the area of the leaf apparatus of plants on average over the three years of research under the action of the microbial preparation increased by 20% relative to control I, under the action of the plant growth regulator – by 13%, and in the case of combined application microbial preparation Rhizobofit (1.0 l/t) and plant growth regulator Stimpo (0.025 l/t) – by 15%.

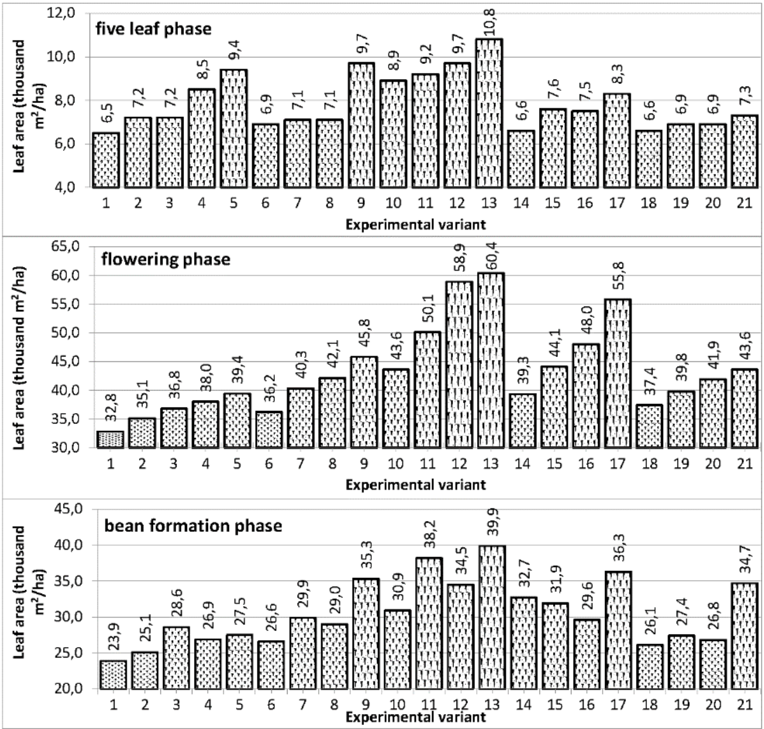

Fig. 2. The area of the leaf apparatus of chick-pea depending on the action of the herbicide Panda, PGR Stimpo and NPP Rhizobophyt (average for 2015–2017):

1.Without the use of biological preparations and herbicide (control I); 2. Without the use of biological preparations and herbicide + manual weeding during the growing season (control II); 3. NPP Rhizobofit 1.0 l/t; 4. PGR Stimpo 0.025 l/t; 5. NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t; 6. Panda 3.0 l/ha; 7. Panda 3.0 l/ha, NPP Rhizobophyte 1.0 l/t; 8. Panda 3.0 l/ha, PGR Stimpo 0.025 l/t; 9. Panda 3.0 l/ha, NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t; 10. Panda 4.0 l/ha; 11. Panda 4.0 l/ha, NPP Rhizobophyte 1.0 l/t; 12. Panda 4.0 l/ha, PGR Stimpo 0.025 l/t; 13. Panda 4.0 l/ha, NPP Rhizobofit 1.0 l/t+ PGR Stimpo 0.025 l/t; 14. Panda 5.0 l/ha; 15. Panda 5.0 l/ha, NPP Rhizobophyte 1.0 l/t; 16. Panda 5.0 l/ha, PGR Stimpo 0.025 l/t; 17. Panda 5.0 l/ha, NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t; 18. Panda 6.0 l/ha; 19. Panda 6.0 l/ha, NPP Rhizobophyte 1.0 l/t; 20. Panda 6.0 l/ha, PGR Stimpo 0.025 l/t; 21. Panda 6.0 l/ha, NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t.

Under the independent action of the Panda herbicide in rates of 3.0; 4.0; 5.0; 6.0 l/ha, the area of chick-pea leaves increased by 11 compared to control I; 29; 37 and 9%, respectively.

With the use of herbicide in the same rates against the background of the use of Stimpo plant growth regulator (0.025 l/t), the area of leaves of chick-pea plants increased by 21 compared to control I; 44; 24 and 12%, and against the background of the use of the microbial preparation Rhizobofit (1.0 l/t) – by 25; 60; 33 and 15%, respectively.

For the complex use of the plant growth regulator Stimpo (0.025 l/t) and the microbial preparation Rhizobofit (1.0 l/t) for seed treatment and the application of the herbicide Panda in rates of 3.0 against this background; 4.0; 5.0; 6.0 l/ha, the area of leaves in chick-pea crops increased by 48 relative to control I; 67; 52 and 45%, respectively.

From the above experimental material, it can be summarized that the area of the leaf apparatus of chick-pea plants varied both by year and depending on the use of different rates of Panda herbicide in crops, applied both separately and against the background of treatment before sowing seeds with biological preparations, at the same time, certain regularities can be ascertained in formation of the area of the leaf apparatus: in the phase of five leaves of the culture, a larger area was formed plants in experimental variants under the action of Stimpo plant growth regulator, which can be explained by the stimulating effect of the preparation on seed germination and faster adaptation of plants to environmental conditions; starting from the flowering phase, the area of the leaf apparatus under the action of the microbial preparation Rhizobophyt and PGR Stimpo had almost equal indicators, and in the phase of bean formation, an increase in the area was noted under the action of NPP Rhizobophyt, which is obviously related to the improvement of nitrogen nutrition of plants.

As a result of the dispersion analysis, it was established that in the phases of five leaves and flowering of the crop, the predominant influence on the formation of leaves was exerted by the herbicide Panda (54–56%), and PGR Stimpo and NPP Rhizobophyt – 18–19%. In the phase of bean formation, the effect of the studied factors was balanced and was within 33–34% of each. The interaction of the investigated factors was noticeable by 28–25%.

By calculating the correlation coefficient, a close relationship (correlation coefficient 0.48) was noted between the indicators of the area of the leaf apparatus I yield of chick-pea crops.

Thus, the following conclusions can be drawn:

– the formation of the area of the leaf apparatus of chick-pea is closely dependent on weather conditions and rates of application of herbicide separately and against the background of the use of biological preparations;

– the largest area of chick-pea leaves in the experiment is formed in variants of the complex use of preparations, in particular, the herbicide Panda at the rate of 4.0 l/ha with the plant growth regulator Stimpo (0.025 l/t) and the microbiological preparation Rhizobophyt (1.0 l/t), where on average, by phases of plant development, the area of leaves exceeded control I by 66–84%;

– some decrease in the area of the leaf apparatus can be traced under the action of the herbicide at rates of 5.0 and 6.0 l/ha, which may be due to the suppression of the passage of the main physiological and biochemical processes in plants at high rates of the xenobiotic.

5. The influence of herbicide, plant growth regulator and microbial preparation on the dynamics of growth processes

The intensity of plant growth may depend on the use of biologically active substances – herbicides, which reduce competition from weedy vegetation and biological preparations that can intensify growth processes [59].

As established by studies [60,61], the height of the plants in the collection forms of chick-pea ranges from 15 to 95 cm. In fact, there is a positive correlation of productivity with the height of the plants (r=0.38–0.52). Low-growing forms, as a rule, with a short growing season, form small seeds, are not very productive, and in acutely dry years, their height decreases by 30–40%, which can cause large harvest losses during harvesting. In addition, plant height is positively correlated with the duration of the flowering period. However, too tall varieties in years with excessive moisture even with little wind can lie down, especially this is observed in varieties with high attachment of lower beans. On the basis of long-term observations, the optimal plant height for the conditions of southern Ukraine was determined to be 50–60 cm [62]. However, in the conditions of the Right Bank Forest-Steppe of Ukraine, such studies were not carried out, which determined the relevance of one of the tasks in our research.

On average, in 2015–2017 (Fig. 3), the biomass growth of chick-pea plants under the independent action of NPP Rhizobophyte (1.0 l/t) in the phase of five leaves of chick-pea exceeded control I by 16%, under the independent

[59] Грицаєнко З. М., Івасюк Ю. І. Анатомічна будова рослин сої за інтегрованого застосування гербіциду із рістстимулювальними препаратами. Вісник Уманського національного університету садівництва. 2014. №2.С. 80–85.

[60] Singh R. P., Singh B. D. Recovery of rare interspecific hybrids of gram C.arietinum L.x C.cuneatum L. through tissue culture. Curr. Sci. 1989. V. 58. P. 874–876.

[61] Gupta Y. P. Developmental algometry and plant type in chickpea. Int. Chickpea Newslett. 1981. №4. P. 8–9.

[62] Скитський В. Ю., Шевченко А. М., Степанова Т. Є. Аналіз зразків колекції нуту за продуктивністю та придатністю до використання в селекції на сході України. Генетичні ресурси рослин. Харків, 2009. №7. С. 134–139.

action of PGR Stimpo (0.025 l/t) – by 20%, in the variants of simultaneous use of NPP Rhizobophyt (1.0 l/t) with PGR Stimpo (0.025 l/t) – by 41% [63].

The use of Panda herbicide in rates of 3.0; 4.0; 5.0; 6.0 l/ha led to an increase in above-ground chick-pea biomass in the five-leaf phase by 13; 18; 16; 6.

With the use of herbicide in the same rates against the background of the use of the plant growth regulator Stimpo (0.025 l/t), the above-ground biomass of chick-pea compared to control I increased by 25; 36; 30 and 15%, respectively, and against the background of the use of the microbial preparation Rhizobofit (1.0 l/t) – by 25; 35; 25 and 11%.

The most intensive growth of chick-pea biomass occurred with the complex use of the plant growth regulator Stimpo (0.025 l/t) with the microbial preparation Rhizobophyt (1.0 l/t) and the introduction of the Panda herbicide at the rate of 3.0 against this background; 4.0; 5.0; 6.0 l/ha, where the excess to control I was 48; 59; 37 and 28%.

In the flowering phase of chick-peas in the experimental variants, an average of three years of research using the Panda herbicide in rates of 3.0; 4.0; 5.0; 6.0 l/ha above-ground plant biomass exceeded control I by 6; 5; 4; 3%, for the introduction of these herbicide norms against the background of the use of Stimpo plant growth regulator (0.025 l/t) – by 8; 16; 40 and 11%, respectively, and against the background of the use of the microbial preparation Rhizobofit (1.0 l/t) – by 15; 37; 20 and 9%.

For the complex use of plant growth regulator Stimpo (0.025 l/t) with the microbial preparation Rhizobophyt (1.0 l/t) and the use of Panda herbicide against this background in rates of 3.0; 4.0; 5.0; 6.0 l/ha biomass of chick-pea plants increased by 65 compared to the option without the use of preparations (control I); 71; 41 and 25%.

In the phase of formation of chick-peas and beans on average in 2015–2016, the activity of biomass growth under the independent action of NPP Rhizobophyt (1.0 l/t) was 19% compared to control I, under the independent action of PGR Stimpo (0.025 l/t) – by 16%, with the combined effect of the NPP Rhizobophyt (1.0 l/t) and PGR Stimpo (0.025 l/t) – by 34%.

The use of Panda herbicide in rates of 3.0; 4.0; 5.0; 6.0 l/ha provided an increase in biomass in the phase of formation of chick-peas and beans by 7; 16; 14; 3%, and for introduction of herbicide in the same rates against the background of the use of Stimpo plant growth regulator (0.025 l/t) – by 12; 71; 50 and 6%, and against the background of the use of the microbial preparation Rhizobofit (1.0 l/t) – by 15; 68; 37 and 9%.

[63] Коробко О. О. Біологічне обгрунтування застосування гербіциду, регулятора росту рослин і мікробного препарату у посівах нуту в умовах Правобережного Лісостепу України: дис. кандидата сільськогосподарських наук: 03.00.12 фізіологія рослин / Коробко Олександр Олександрович. Умань, 2019. 218 с.

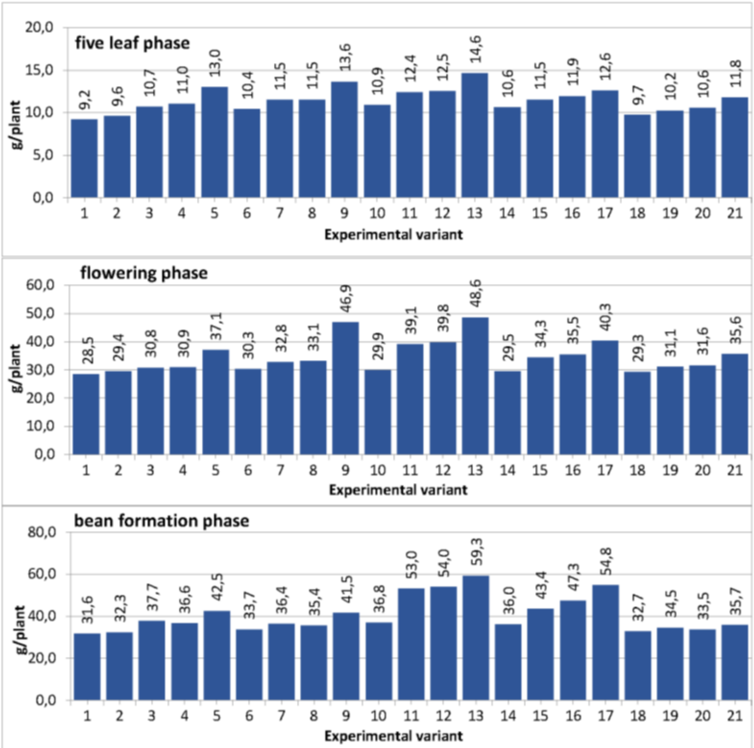

Fig. 3. Above-ground biomass of chickpea plants under the action of Panda herbicide, RRR Stimpo and MPB Rhizobophyt (average for 2015-2017)[61]:

1.Without the use of biological preparations and herbicide (control I); 2. Without the use of biological preparations and herbicide + manual weeding during the growing season (control II); 3. NPP Rhizobofit 1.0 l/t; 4. PGR Stimpo 0.025 l/t; 5. NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t; 6. Panda 3.0 l/ha; 7. Panda 3.0 l/ha, NPP Rhizobophyte 1.0 l/t; 8. Panda 3.0 l/ha, PGR Stimpo 0.025 l/t; 9. Panda 3.0 l/ha, NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t; 10. Panda 4.0 l/ha; 11. Panda 4.0 l/ha, NPP Rhizobophyte 1.0 l/t; 12. Panda 4.0 l/ha, PGR Stimpo 0.025 l/t; 13. Panda 4.0 l/ha, NPP Rhizobofit 1.0 l/t+ PGR Stimpo 0.025 l/t; 14. Panda 5.0 l/ha; 15. Panda 5.0 l/ha, NPP Rhizobophyte 1.0 l/t; 16. Panda 5.0 l/ha, PGR Stimpo 0.025 l/t; 17. Panda 5.0 l/ha, NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t; 18. Panda 6.0 l/ha; 19. Panda 6.0 l/ha, NPP Rhizobophyte 1.0 l/t; 20. Panda 6.0 l/ha, PGR Stimpo 0.025 l/t; 21. Panda 6.0 l/ha, NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t.

The highest indicators of the biomass of chick-pea plants during the three years of the study were formed by the complex use of the plant growth regulator Stimpo (0.025 l/t) with the microbial preparation Rhizobofit (1.0 l/t) and the introduction of the herbicide Panda at the rate of 3.0 against this background; 4.0; 5.0; 6.0 l/ha, where the biomass of chick-pea plants increased by 31 relatively to the variant without the use of preparations (control I); 88; 73 and 13%.

Analyzing the above experimental material, it can be asserted that the use of herbicide against the background of biological preparations ensures the improvement of chick-pea growth processes, which can indicate both an increase in the level of metabolic processes in plants from the side of the action of PGR Stimpo, and the creation of more favorable phytosanitary conditions in crops due to destruction of weeds, as a result of which the competition for moisture and nutrients is reduced.At the same time, in a complex with NPP Rhizobophyte, the supply of nitrogen to plants improves, which is the main element that determines the growth activity of plants. Other scientists report this in their research[64].

The results of variance analysis indicate that in the phases of five leaves and flowering, the influence on the growth processes of PGR Stimpo and NPP Rhizobophyte plants dominated, which ranged from 33–36%, under the influence of the herbicide – 12–14%. In the phase of bean formation, the effect of the studied factors was 23–24% of each. The interaction of the studied factors was noticeable (23–29%).

Thus, from the above experimental material, the following conclusions can be drawn:

– growth processes of chick-peas are closely dependent on weather conditions, varietal characteristics, herbicide usage rates, both separately and against the background of applying PGR Stimpo and NPP Rhizobophyt;

– under the combined effect of the herbicide with PGR Stimpo and NPP Rhizobophyt in chick-pea crops, the greatest activation of growth processes is observed, which is manifested in the formation of the appropriate height and biomass of plants;

– the highest height and above-ground biomass of chick-pea plants were formed during three years of research with the complex use of PGR Stimpo (0.025 l/t) with NPP Rhizobophyt (1.0 l/t) and application of Panda herbicide at the rate of 4.0 l/ha against this background, where the excess to control I was 20–37% (for height) and 59–88% (for biomass) on average by phase.

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[64] Лісовий М. М., Пархоменко О. Л., Дідович С. В., Пархоменко Т. Ю., Чайка В. М. Розробка системи комплексного застосування мікробних препаратів в агротехнології вирощування нуту. Сільськогосподарська мікробіологія. 2010. Вип. 11. С. 90–101.

6. Effect of herbicide, plant growth regulator, and microbial preparation on net photosynthetic productivity

It was established that the neat photosynthetic productivity (NPP) of chick-pea sowing during the five-leaf-flowering and flowering-bean formation phases varied both by year and depending on the use of different rates of herbicide and the action of biological preparations.

On average, over the years of research (Fig. 4), in the period of the phases of five leaves – flowering under the independent action of the microbial preparation Rhizobophyt (1.0 l/t), the neat photosynthetic productivity of chick-pea sowing increased by 8% relative to control I, under the action of PGR Stimpo (0.025 l/t) – by 14%, in the case of the combined use of the microbial preparation Rhizobofit (1.0 l/t) and plant growth regulator Stimpo (0.025 l/t) – by 21%.

For the use of Panda herbicide in rates of 3.0; 4.0; 5.0; 6.0 l/ha against the background of the use of Stimpo plant growth regulator (0.025 l/t), the neat photosynthetic productivity of chick-pea sowing increased compared to the control and by 30; 58; 40 and 28%, and against the background of the use of the microbial preparation Rhizobofit (1.0 l/t) – by 35; 65; 43 and 31%, respectively.

For the complex use of plant growth regulator Stimpo (0.025 l/t) with the microbial preparation Rhizobophyt (1.0 l/t) and the application of Panda herbicide against this background in rates of 3.0; 4.0; 5.0; 6.0 l/ha, the neat productivity of photosynthesis in chick-pea crops increased by 43 compared to the option without the use of preparations (control I); 65; 43 and 31%.

The averaged data for the period of the phases of flowering – formation of beans showed that under the independent effect of the microbial preparation Rhizobophyt (1.0 l/t) the neat productivity of photosynthesis increased relative to control I by 7%, under the action of the plant growth regulator Stimpo (0.025 l/t) – by 14%. In the case of the combined application of the microbial preparation Rhizobofit (1.0 l/t) and the plant growth regulator Stimpo (0.025 l/t), the neat photosynthetic productivity of the crop increased by 22% relative to control I.

At application rates of Panda of 3.0 and 4.0 l/ha, the neat photosynthetic productivity of crops increased by 24–40% compared to control I. With the application of 5.0 and 6.0 l/ha of Panda, the neat photosynthetic productivity of the crop increased by 24–16% relative to control I. Such a trend, as in the phases of five leaves – flowering, is obviously associated with the improvement of the conditions of growth and development of plants due to the reduction of competition from weedy vegetation.

With the simultaneous use of the microbial preparation Rhizobofit (1.0 l/t) and the plant growth regulator Stimpo (0.025 l/t) before sowing chick-pea seeds and the application of Panda herbicide against this background at rates of 3.0 and 4.0 l/ha neat productivity photosynthesis of chick-pea during the flowering phase – formation of beans exceeded control I by 32 and 65%, and at application rates of 5.0 and 6.0 l/ha – by 40 and 28%.

From the obtained data, it can be stated that the highest level of indicators of the neat productivity of photosynthesis of chick-pea sowing was formed in the variant of using the herbicide Panda at the rate of 4.0 l/ha against the background of seed treatment before sowing with the plant growth regulator Stimpo (0.025 l/t) and the microbial preparation Rhizobophyt (1.0 l/t). In this version of the experiment, the neat productivity of photosynthesis increased by 65% during the interphase periods of five leaves – flowering, flowering – bean formation.

According to the results of dispersion analysis, the net productivity of chick-pea photosynthesis during the five-leaf-flowering phase depended 49% on factor A (Panda herbicide) and 11% on factor B (biological preparations), as well as 2% on the interaction of the studied factors, other factors (weather conditions) accounted for 38%. During the phases of flowering and formation of beans, the share of influence depended on factor A (Panda herbicide) by 75% and factor B (biological preparations) by 12%, and by 2% on the interaction of the studied factors, other factors accounted for 11%.

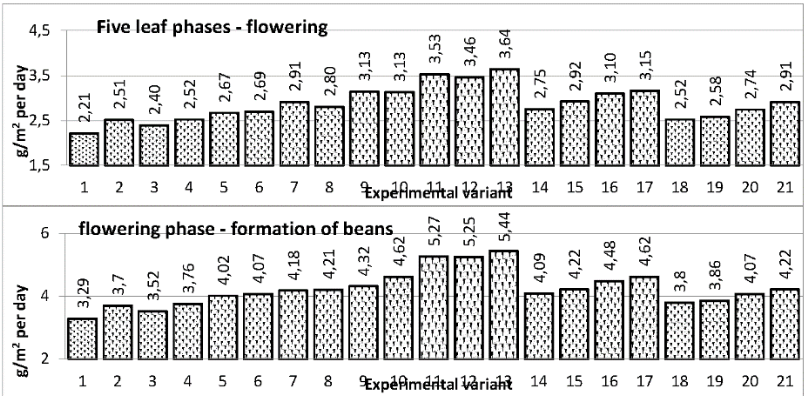

Fig. 4. Neat photosynthetic productivity of Memory chick-pea crop depending on the use of Panda herbicide, Stimpo plant growth regulator and *Rhizobophyt microbial preparation* (phases of flowering – formation of beans):

1.Without the use of biological preparations and herbicide (control I); 2. Without the use of biological preparations and herbicide + manual weeding during the growing season (control II); 3. NPP Rhizobofit 1.0 l/t; 4. PGR Stimpo 0.025 l/t; 5. NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t; 6. Panda

3.0 l/ha; 7. Panda 3.0 l/ha, NPP Rhizobophyte 1.0 l/t; 8. Panda 3.0 l/ha, PGR Stimpo 0.025 l/t; 9. Panda 3.0 l/ha, NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t; 10. Panda 4.0 l/ha; 11. Panda 4.0 l/ha, NPP Rhizobophyte 1.0 l/t; 12. Panda 4.0 l/ha, PGR Stimpo 0.025 l/t; 13. Panda 4.0 l/ha, NPP Rhizobofit 1.0 l/t+ PGR Stimpo 0.025 l/t; 14. Panda 5.0 l/ha; 15. Panda 5.0 l/ha, NPP Rhizobophyte 1.0 l/t; 16. Panda 5.0 l/ha, PGR Stimpo 0.025 l/t; 17. Panda 5.0 l/ha, NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t; 18. Panda 6.0 l/ha; 19. Panda 6.0 l/ha, NPP Rhizobophyte 1.0 l/t; 20. Panda 6.0 l/ha, PGR Stimpo 0.025 l/t; 21. Panda 6.0 l/ha, NPP Rhizobofit 1.0 l/t + PGR Stimpo 0.025 l/t.

Thus, from the obtained data, it can be concluded that the highest indicators of neat photosynthetic productivity of chick-pea sowing were formed in the variant of using the herbicide Panda at a rate of 4.0 l/ha against the background of seed treatment before sowing with the plant growth regulator Stimpo (0.025 l/t) and a microbial preparation Rhizobophyte (1.0 l/t).

Starting from the application rate of Panda herbicide of 5.0 l/ha and at 6.0 l/ha of the preparation, in the phases of five leaves – flowering and during the phases of flowering – formation of beans, a decrease in the neat photosynthetic productivity of the crop and chick-pea yield was observed, which, obviously, due to the suppressive effect of these herbicide norms on the passage of the main physiological and biochemical processes, which determined the resistance of the plant organism to the growth conditions [65,66].

7. Yield and quality of chick-pea grain under the effects of herbicide, plant growth regulator and microbial preparation

Research by scientists has established that herbicides, plant growth regulators, microbial preparations, and their combinations affect the activity of physiological processes aimed at both overcoming stress and increasing plant productivity [67]. However, the effects of high rates of herbicides can

[65] Karpenko V. P., Korobko O. O. Influence of herbicide and biological preparations on the dynamics of chlorophyll content in chickpea leaves. Proceedings of the Uman National University of Horticulture. Uman. 2018. №93(1). P. 47–55

[66] Karpenko V. P., Korobko O. O. Influence of herbicide and biological preparations on photosynthetic productivity and yield of chickpeas. Bulletin of the Nikolaev National University. Mykolaiv. №4(100). 2018. P. 48–54.

[67] Бушулян О. В. Модель високопродуктивного сорту нуту для степової зони України. Збірник наукових праць СГІ. Одеса, 2009. Випуск 14 (54). С.160–165.

reduce crop productivity[68]. At the same time, it has been proven [69] that with the combined use of herbicides and plant growth regulators, application rates of herbicide agents can be reduced by 20–30%, which has a positive effect on crop productivity.

Increased growth of the root system, on the one hand, ensures improvement of water exchange and mineral nutrition, and on the other hand, it activates physiological and biochemical processes and the development of useful microorganisms, especially nitrogen-fixing ones, which increase nitrogen nutrition, which is reflected in the yield of crops [70,71].

However, among the numerous studies on the iformation of the productivity of cultivated plants under the complex action of biological preparations, the reaction of chick-pea plants is poorly studied. In this regard, it was expedient to establish how different rates of herbicide, microbiological preparation and plant growth regulator affect the formation of yield and quality indicators of chick-pea grain.

As a result of the conducted research, it was established that chick-pea yield and its quality indicators varied both by year and depended on the use of different rates of Panda herbicide, introduced separately and in combination with PGR Stimpo and NPP Rhizobophyt. Yes, under the action of the herbicide Panda in rates of 3.0; 4.0; 5.0 and 6.0 l/ha yield in 2015 was 0.99; 1.14; 1.03; 1.10 t/ha, when using the herbicide in the same rates compatible with Stimpo growth regulator (0.025 l/t) – 1.02; 1.57; 1.12; 1.16 t/ha, and in combination with the microbial preparation Rhizobofit (1.0 l/t) – 1.05; 1.44; 1.03; 1.06 t/ha (Fig. 5). Under the action of the combination of the growth regulator Stimpo (0.025 l/t) with the microbial preparation Rhizobofit (1.0 l/t) and the introduction of the herbicide Panda at the rate of 3.0 against this background; 4.0; 5.0; 6.0 l/ha chick-pea yield was 1.08; 1.61; 1.21 and 1.25 at 0.91 t/ha in the variant without the use of preparations (control I) and 1.01 t/ha in the variant with manual weeding.

A similar relationship with the formation of chick-pea productivity was observed in 2016 and 2017. However, the highest yield in the variants of the

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[68] Москалець В. В. Вплив екологічних чинників на фотосинтетичну діяльність агрофітоценозів тритикале озимого. Наукові доповіді Національного університету біоресурсів і природокористування України. 2013. №6. Режим доступу: http://nbuv.gov.ua/UJRN/Nd_2013_6_9.

[69] Івасюк Ю. І. Продуктивність посівів сої за роздільного та інтегрованого застосування мікробіологічного препарату, регулятора росту рослин і гербіциду. Вісник аграрної науки Причорномор’я. 2016. №.3.

С. 89–95.

[70] Yadav, Shyam & Redden, Robert & Chen, W & Sharma, B. Chickpea breeding and management. CAB Int. 2007. P. 538–554.

[71] Січкар В Пестициди та азотфіксація зернобобових культур. Спецвипуск ж. Пропозиція. Сучасні агротехнології із застосування біопрепартав та регуляторів росту. 2015. С. 32–34

experiment was noted in 2016. Thus, in the variant without the use of preparations (control I), the yield of chick-peas in 2016 was 1.0 t/ha, while in 2015 and 2017 the yield of chick-peas was lower and amounted to 0.91 and 0.88 t/ha, respectively. These grain yield data by year are in agreement with the indicators of weather conditions, which were the most optimal for chick-pea sowing in 2015 and 2016.

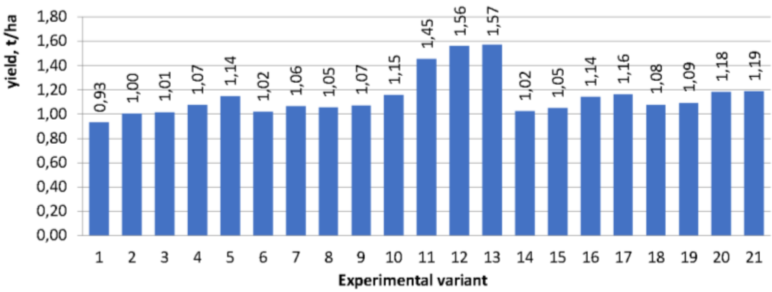

Fig. 5. Yield of chick-peas of the Memory variety depending on the effect of the herbicide Panda, PGR Stimpo and NPP Rhizobophyt, t/ha (LSD*05* 2015 = 0,08; 2016 = 0,07; 2017 = 0,1; 2015-2017 = 0,07)[72]

On average, over three years of research in options without the use of preparations (control I), the yield of chick-peas was 0.93 t/ha in the version with manual weeding (control II) – 1.0 t/ha.

Under the independent effect of NPP Rhizobophyt, relative to control I, an increase in crop yield was observed by 9% and by 1% – relative to control II. Under the action of PGR Stimpo (0.025 l/t), the growth of chickpea grain yield relative to controls I and II was 15% and 7%.

In variants with the combined use of NPP Rhizobofit (1.0 l/t) and PGR Stimpo (0.025 l/t), the yield of chick-pea grain compared to controls I and II increased by 23% and 13%, respectively. The increase in yield due to the combination of these drugs can be due to the activation of metabolic processes in plants, due to the action of the plant growth regulator against the background of increased nitrogen nutrition from the activity of nodule bacteria, as indicated by other authors.

Under the action of Panda herbicide 3.0 and 4.0 l/ha, chick-pea yield increased by 10 and 24% on average over the years of research compared to control I.

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When applying 5.0 and 6.0 l/ha, the chick-pea grain yield increased by 10 and 16% relative to control I. For the combination of the use of Panda herbicide in rates of 3.0; 4.0; 5.0 and 6.0 l/ha against the background of the use of NPP Rhizobophyte, chick-pea yield increased by 14 compared to control I; 53; 13 and 17%; on the background of PGR Stimpo – 13; 58; 23 and 27%; on the background of PGR Stimpo + NPP Rhizobophyte – 15; 69; 25 and 28%.

From the obtained data, it can be seen that the highest yield of chic-kpea grain was obtained with the complex use of biological preparations and the introduction of Panda herbicide at the rate of 4.0 l/ha against this background. These data are consistent with the indicators of the highest physiological and biochemical activity of chick-pea plants with the above combination of preparations.

Thus, the following conclusions can be drawn from the above experimental material:

– the highest indicators of yield and quality of chick-pea grain are formed in the variant of using the herbicide Panda at the rate of 4.0 l/ha against the background of seed treatment before sowing PGR Stimpo (0.025 l/t) and NPP Rhizobophyt (1.0 l/t), where with this combination of preparations, the crop yield increases by 0.64 t/ha;

– comparing the yield and quality indicators of chickpea grain with the requirements of DSTU 6019:2008, it can be stated that in all variants of the experiment, the quality indicators met the requirements of the standard and the description of varietal characteristics

CONCLUSIONS

The publication provides a new solution to the scientific task, which consists in the biological justification of the use of different rates of the Panda herbicide in chick-pea crops separately and in combination with biological preparations – the plant growth regulator Stimpo and the microbial preparation Rhizobophyt.

1. It was found that at increased rates of use of the herbicide Panda (5.0; 6.0 l/ha), regardless of the combination with biological preparations, a decrease in the content of chlorophylls *a* and *b* and their sum was observed in chick-pea leaves, which may be as a result of inhibiting their synthesis under the influence of the herbicidal agent. With the complex use of the plant growth regulator Stimpo, the microbial preparation Rhizobophyte and the herbicide Panda (3.0; 4.0 l/ha) in chick-pea crops, the content of the sum of chlorophylls a and b increased by 11–14% on average by the phases of crop development, which was caused by for this combination of preparations, the greatest activation of the passage of physiological and biochemical processes in plants, including photosynthetic ones.

2. It was investigated that with the complex use of herbicide (Panda 3.0–6.0 l/ha) with the plant growth regulator Stimpo (0.025 l/t) and the microbial preparation Rhizobophyt (1.0 l/t) in chick-pea crops in comparison with variants of self-use of the herbicide, a fairly noticeable activation of growth processes was observed, which was manifested in the formation of a larger area of the leaf apparatus, height and above-ground biomass of plants, in particular, under the action of Panda 4.0 l/ha in a complex with biological preparations, the above indicators increased by an average of 20 – 88%.

3. It was established that the highest rates of neat productivity of photosynthesis were formed when the herbicide Panda was used in chick-pea crops at a rate of 4.0 l/ha against the background of seed treatment before sowing with the plant growth regulator Stimpo (0.025 l/t) and the microbial preparation Rhizobophyt (1.0 l/t), where on average during the interphase period of five leaves of the crop – the formation of beans, this indicator increased by 65%. Starting from the rate of herbicide application of 5.0 l/ha and at 6.0 l/ha, a decrease in the net photosynthetic productivity of chick-pea crops was observed, which was due to the suppressive effect of these rates of herbicide on the passage of physiological and biochemical processes in plants, which determine the resistance of the plant organism to growth conditions.

4. It was found that the highest yield of chick-pea sowing was formed by pre-sowing seed treatment with a mixture of Stimpo (0.025 l/t) and Rhizobofit (1.0 l/t) followed by the application of Panda herbicide at the rate of 4.0 l/ha against this background where the excess to the control was 0.64 t/ha for an increase in the mass of 1000 grains by 98%, protein content – 7%.

SUMMARY

The paper presents a biologically-based approach to chickpea (*Cicer arietinum L.*) cultivation, focusing on the combined effect of herbicide (Panda), plant growth regulator (Stimpo), and microbial preparation (Rhizobophyt). A comprehensive set of physiological, biochemical, and agrochemical indicators was analyzed over multiple growing seasons to evaluate their impact on crop productivity, chlorophyll accumulation, photosynthetic efficiency, growth dynamics, and the formation of the leaf area.

The results demonstrate that the application of biological preparations, both independently and in combination with herbicide, enhances the tolerance of chickpea plants to xenobiotic stress, improves the functioning of the photosynthetic apparatus, and leads to a significant increase in yield and grain quality. In particular, the combined use of Stimpo (0.025 l/t) and Rhizobophyt (1.0 l/t) with Panda herbicide at a rate of 4.0 l/ha provided the best physiological responses and yield increases up to 0.64 t/ha compared to control.

The study proves the effectiveness of biologized technologies in chickpea cultivation under the conditions of the Right-Bank Forest-Steppe of Ukraine and outlines the scientific basis for the development of environmentally friendly and sustainable agrotechnologies.

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