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INFLUENCE OF BIOLOGICAL AGENTS ON YIELD AND QUALITY OF VEGETABLE PEAS UNDER THE CONDITIONS OF STEPPE ZONE

The use of chemical herbicides is a critical problem in terms of sustainable land use requiring the alternative ways of treatment and protection of agricultural crops. The problem is manifested in the long-term chemization of agricultural lands which critically influenced the quality of soils. Along with this, the problem is exacerbated by the inappropriate environmental cleanliness of the crop harvested on chemically treated lands, as well as by the quantity and quality of these agricultural products. The use of non-chemical agents for the treatment of agricultural crops is indeed a crucial direction in agriculture which contributes to sustainable development as it helps preserve soil fertility, reduce the negative impact on the environment, and supports production without the use of synthetic pesticides. An analysis of available sources has shown that the practical study of the influence of reducing the use of chemical fertilizers and increasing the use of organic fertilizers for the treatment of main agricultural crops remain pertinent and inadequately researched. Therefore, the aim of this article was to show the results of the practical research on the influence of the pre-sowing seed treatment with boron (B), molybdenum (Mo) and Rhizohumin on the yield vegetable pea and its quality. The practical investigation was conducted on the experimental plots located in the Steppe zone of the southern Ukraine. Vegetable peas is a valuable source of dietary protein, the plant is often used for sideration that is why this particular plant was chosen for research. The research was based on treatment of vegetable pea's seeds with different combination of mineral fertilizers containing boron, molybdenum and with Rhizohumin – agent based on active strains of nodular bacteria, and comparison of the obtained results with

control – fertilizing the soils using ammonium sulfate and superphosphate ($N_{30}P_{40}$). It was established the positive impact of seed treatment with B, Mo, and Rhizohumin on the number of flowers and pods during flowering and pod formation stages compared with control. It was studied the positive influence of mineral fertilizers on the yield of vegetable peas as well as on its quality. Conducted research may be considered by agricultural producers during farming activities.
***Keywords*: vegetable peas; weeds; molybdenum; boron; Rhizohumin; biological agents; quality of yield.**

Formulation of the problem. Under the dry conditions of the southern Steppe combining with lack of nutrients in soils after long-time and intensive application of chemicals, vegetable peas experience a significant reduction in yield. The flowers drop, the peas become less moist, and the 1000 kernel weight decreases. Therefore, according to last investigations, it is more advantageous to cultivate vegetable peas on irrigated lands where soil moisture is maintained at around 70% of field capacity. However, excessively high moisture levels can also negatively impact the yield of vegetable peas. The plants grow excessive vegetative mass, requiring more nutrients, which leads to reduced grain yield. Additionally, in these conditions, plants often become susceptible to diseases. That is why in our experimental investigation it was chosen the lands irrigated by sprinkler, which helped to regulate moisture regime within the necessary limits [12, P. 675].

Analysis of recent research and publications. A number of conducted researches proved that vegetable pea is collaborating with nitrogen-fixing nodular bacteria, allowing them to accumulate a significant amount of nitrogen from the atmosphere. Rhizohumin agent was produced on the basis of such bacterium that is why it was chosen for our experimental investigation [9, P. 680]. Thanks to this interaction, in a single growing season, one hectare of crops is accumulating between 50 to 90 kilograms of nitrogen, depending on the kind of soil, and in irrigated conditions, this indicator reach up to 140 kilograms per hectare. This is equivalent to applying 2–4 hundredweights of ammonium nitrate or up to 15 tons of manure [4, P. 162].

Vegetable pea is a crop sensitive to excessive weed infestation, and its productivity is reducing by up to 55% due to the harmful effects of weeds [8, P. 160]. The herbocritical period of vegetable pea is about 28–35 days and lasts from the three-leaf stage of crop development to the stage of the beginning of flowering. The level of crop loss depends on the number, species composition of weeds and the duration of their competitive relationship [1, P. 202]. Weeds, besides competing with crop plants for vital resources such as light, water, minerals, and others, is also cause technological damage, which affect the productivity of crops and the quality of their harvest. This is especially relevant for vegetable peas during harvesting, as weeds are leading to increased losses during threshing and deterioration in the quality of green peas. Therefore, the article is taking into account this specific factor of vegetable peas growing and studying the influence of seed treatment by B, Mo and Rhizohumin on the quantity of competitive weeds [11, P. 189].

Previous studies of the influence of micronutrients on the vegetable pea yield have established that molybdenum affects symbiotic nitrogen fixation [14, P. 935]. It also has a significant influence on the nitrogen metabolism of plants, nitrogen-fixing bacteria, as well as certain algae and fungi. Molybdenum plays a crucial role in the fixation of molecular nitrogen by nodular bacteria in symbiosis with leguminous plants. The yield increase due to molybdenum application according to different studies varies from 0.3 to 0.4 tons per hectare [6, P. 17]. Boron is also an essential element in the mineral nutrition of vegetable peas. A deficiency of boron in plant nutrition hinders the synthesis of proteins and nucleic acids [5, P. 217]. The development of ovaries and seeds is disrupted when there is a boron deficiency, affecting the normal growth, and the processes of seed ripeness are disturbed. Boron, like molybdenum, enhances nitrogen uptake in pea plants [3, P. 631]. Rhizohumin is a bio-fertilizer, which is used to treat pea seeds in order to improve nitrogen nutrition of plants and increase crop productivity. The composition of the preparation includes specially prepared peat with bacterial cells of Rhizobium leguminosarum multiplied in it, physiologically active substances of biological origin (auxins, cytokinins, amino acids, humic acids), microelements in chelated form and compounds of macroelements in starting concentrations. Therefore, boron, molybdenum and Rhizohumin in various combinations were chosen in this study to identify the effect of treatment of vegetable pea seeds [2, P. 233].

The objective of the research. The objective of the study was to prove experimentally the positive influence of the treatment of vegetable pea's seeds with Rhizohumin and biological agents containing boron and molybdenum on the weeds infestation, crop yield, and its quality under the conditions of the Steppe zone of the Southern Ukraine.

Materials and methods. Agricultural lands chosen for the research are located in the southern part of the Kherson region. The climate here is arid and moderately hot. This region has a limited precipitation and a high rate of evaporation, leading to increased water evaporation from the soil. The soil's nutrient content in the plow layer of the soil is characterized as insufficient for obtaining high yields of bean and other agricultural crops. Agrochemical indicators are on the level: the content of easily hydrolysable nitrogen is 28.0–43.0 mg/kg, nitrates are 2.8–13.6 mg/kg, absorbed ammonium is 3.8–4.2 mg/kg, available phosphorus is 36.0–40.0 mg/kg, and exchangeable potassium is 254.0–292.0 mg/kg of soil. The cation exchange capacity of dark-chestnut soils is 22.3–24.6 mg-eq. per 100 g of soil. Sodium content ranges from 0.9–1.1 mg-eq. per 100 g of soil. The reaction of the soil solution is neutral or slightly alkaline (pH of the soil extract is 7.0–7.2), at a depth of 50 cm, the pH is 7.2–7.5, and at 100 cm, it is 7.5–7.8 [10, P. 157].

To achieve high yields of agricultural crops on soils with this kind of agrochemical state under irrigation, it is necessary to replenish the soil primarily with nitrogen and partially with phosphorus in forms that are accessible for plants. Therefore the soils of study area used for growing vegetable peas without seed treatment were fertilized with $N_{30}P_{40}$ using ammonium sulfate and superphosphate. This was the control for the comparison of obtained results. The predecessor of vegetable peas in crop rotation was winter wheat. Irrigation was carried out by sprinklers "Fregat" with irrigation rate of 800 m^3/ha. The area of the experimental accounting plots were 50–100 m^2 [13, P. 139].

The quality of the vegetable pea crop was determined by the 1000 kernel weight – a quality test applied to pea to determine its potential milling yield and by the diameter of seeds. The hardness of the pea grains for determination of commercial quality and conformity of the vegetable pea class was determined using a Finometer F-4 (Table 1).

Table 1

Scale of vegetable pea class according to hardness

Hardness, units	Class of pea according
28–41	High
42–58	First
59–69	Second
70 and higher	Non-standard

The study of influence of seeds treatment by agents containing boron (B) and molybdenum (Mo) and by Rhizohumin was conducted during field crop rotation on the fields of the Southern Steppe of Ukraine during 2020–2021 according to the following scheme presented on Figure 1.

Factor A. Pre-sowing treatment:

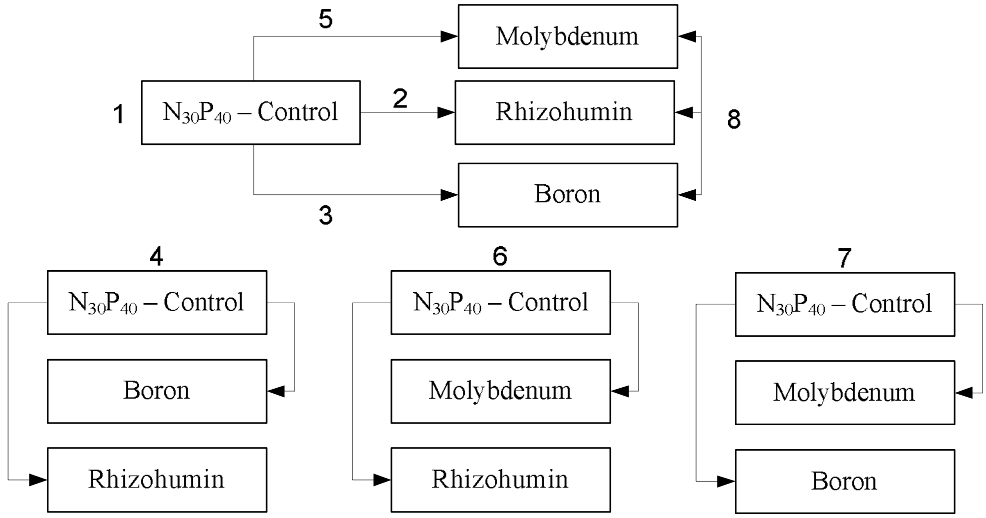

Fig. 1. Scheme of pre-sowing treatment

Factor B. Dates of sowing: early period (the third decade of March); late period (the first decade of April).

The scheme of the experiment included seed treatment before sowing in various combinations with boron (boric acid) – 75 g/t, molybdenum (ammonium molybdenum acid) – 50 g/t and Rhizohumin – 200 g/t. This operation was carried out together with pre-sowing (two months before sowing) treatment of pea seeds with the Fundazol agent, which does not affect the spores of nodule bacteria contained in Rhizohumin. For the object of research it was chosen vegetable peas of the Alfa variety, which is the national standard of Ukraine and entered in the register of varieties [7, P. 538].

The research was conducted on a dark-chestnut soils, their characteristic feature is a shallow humus horizon (25–30 cm), low humus content (1.7–1.9%), and a weakly aggregated structure. The physical and mechanical properties of the soil in the research area are presented in Table 2.

Table 2

Physical and mechanical properties of the soil in the research area

Horizon, cm	Sum of fractions in% to dry soil		Bulk density, g/cm	Solid phase density, g/cm	Porosity, %
	Clay > 0.01 mm	0.01 mm			
0–20	49.7	50.3	1.22	2.58	54.4
20–40	51.9	48.1	1.26	2.60	50.7
40–60	51.2	48.8	1.29	2.64	48.7
60–80	45.5	54.5	1.32	2.68	47.4
80–100	47.4	52.5	1.33	2.67	46.6

The degree of crop weed infestation by weeds was assessed using a five-point scale, which measures the density of weeds per square meter (m^2). The scale is presented in Table 3.

Table 3

Five-point scale of the weeds infestation level, pcs/m^2

Point	Level of infestation	Number of weeds per m^2
1	Very weak	1–4
2	Weak	5–14
3	Moderate	15–49
4	Strong	50–99
5	Very strong	over 100

This scale helps farmers, agronomists, and researchers to evaluate the severity of weed infestations on agricultural fields and make informed decisions about weed control and management strategies.

Main research materials. During field research, a FLUS ET-952 lux meter was used to determine the illumination of crops. The lowest level of illumination of the ground layer of vegetable peas was recorded, both during the first and second sowing periods, when the pea seeds were treated with boron, molybdenum and rhizorthorphin and was 3200–4000 lx. This indicator of illumination of the ground layer is the threshold for most light-loving weeds in the steppe zone of Ukraine, such as Atriplexpatula, A. tatarica, Amaranthus retroflexus, Xanthium strumarium, Sisymbrium altissimum, and Descurainia Sophia L. Therefore, between the illumination indicators of the ground layer and weediness of crops a correlation is traced during the first sowing period. It illustrates that when pea seeds were treated with boron, molybdenum and rhizorthorphin, plants developed more actively, due to the fact that the pea crops fully used the light factor for photosynthesis because of a clearly visible leaf mosaic (the leaves of the upper, ground and middle layers do not shade each other), as a result of which the illumination of the space under the crops worsened due to a more developed above-ground mass of peas, which led to a decrease in the competitiveness of weeds, which in turn reduced their number per m^2. During the second sowing period, weediness was 15% less, this was due to the pre-sowing cultivation and post-emergence harrowing, which was made when most of the weeds had already emerged (Table 4).

Analyzing Table 4, it is clear that due to the applied agricultural measures, weed infestation almost in all experimental variants did not exceeded 5 plants per 1 square meter, which corresponds to 1 point on the 5-point weed infestation scale (Table 3). But the application of various combinations of biological agents laded to the decrease of the weeds number. This indicates that during the experiment vegetable peas did not suffer significant yield losses because of weeds, and weed infestation was below the damage threshold. The lowest weed infestation was in variant 8 and amounted, in average, 1.7 plants/m^2 – during the first sowing period and 1.6 plants/m^2 during the second sowing period representing respectively 31% and 40% of the weed infestation level in the control (Figure 2).

Table 4

Influence of the treatment on the weeds infestation, pcs/m^2

№	Variant of experiment	2020			2021			Average
		I iterat.	II iterat.	average	I iterat.	II iterat.	average	
	I sowing period							
1	$N_{30}P_{40}$ – control	6.0	7.0	6.5	5.0	4.0	4.5	5.5
2	Cont. + Rhizoh.	5.0	6.0	5.5	4.0	3.0	3.5	4.5
3	Cont. + B	4.5	5.0	4.7	4.0	3.0	3.5	4.1
4	Cont. + B + Rhizoh.	4.0	4.0	4.0	3.0	3.0	3.0	3.5
5	Cont. + Mo	4.0	4.0	4.0	3.0	4.0	3.5	3.7
6	Cont. + Mo + Rhizoh.	3.0	3.0	3.0	3.0	2.0	2.5	2.7
7	Cont. + B+ Mo	3.0	2.0	2.5	2.0	2.0	2.2	2.3
8	Cont. + B + Mo + Rhizoh.	2.0	2.0	2.0	1.0	2.0	1.5	1.7
	II sowing period							
1	$N_{30}P_{40}$ – control	5.0	4.0	4.5	3.0	4.0	3.5	4.0

Continuation of the table 4

2	Cont. + Rhizoh.	4.0	4.0	4.0	3.0	3.0	3.0	3.5
3	Cont. + B	4.0	3.5	3.7	3.0	3.0	3.0	3.3
4	Cont. + B + Rhizoh.	3.0	4.0	3.5	3.0	2.0	2.5	3.0
5	Cont. + Mo	3.0	2.5	2.7	2.0	3.0	2.5	2.8
6	Cont. + Mo + Rhizoh.	3.0	2.0	2.5	2.0	2.0	2.0	2.3
7	Cont. + B+ Mo	2.0	2.0	2.0	1.0	2.0	1.5	1.7
8	Cont. + B + Mo + Rhizoh.	1.5	2.0	1.7	2.0	1.0	1.5	1.6

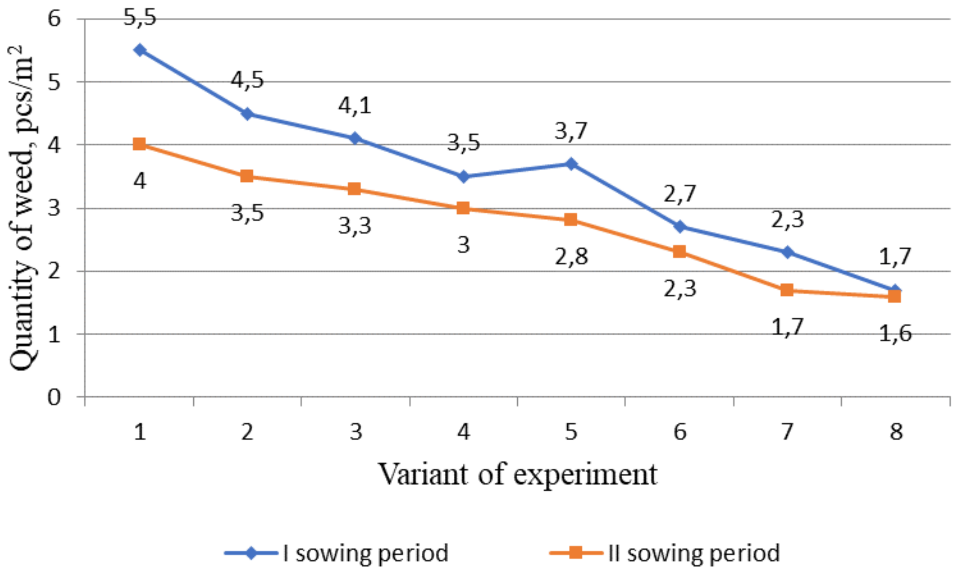

Fig. 2. The influence of treatment on the weed infestation
(average for 2020–2021)

Obtained data indicating the influence of boron, molybdenum and Rhizohumin seed treatment on the number of flowers, beans during the interphase period "flowering – bean formation" are shown in Table 5. It indicates that the number of flowers and beans over the two years of research, both in the early and late sowing periods, did not differ significantly, and the influence of the studied factors on them was significant.

The research has shown that the increase in yield occurs due to the growth in the number of pods per plant, rather than the number of seeds per pod. Analyzing the obtained data, it was established that in two variants of treatment with Mo + Rhizohumin and B + Mo the number of flowers during flowering stage during early sowing period was the same and were higher by 1.4 times comparing with control.

Table 5

Average number of pods and seeds in one pod during 2020–2021

№	Variant of experiment	Stages of development		
		Number of pods	Number of seeds per pod	
		Flowering-pod formation	Green pea stage	Technical ripeness
I sowing period				
1	$N_{30}P_{40}$ – control	8.1	5.4	5.2
2	Cont. + Rhizohumin	10.2	5.6	5.4
3	Cont. + B	10.1	5.6	5.3
4	Cont. + B + Rhizohumin	10.4	5.3	5.2
5	Cont. + Mo	10.7	5.6	5.4
6	Cont. + Mo + Rhizohumin	11.3	5.8	5.6
7	Cont. + B+ Mo	11.3	5.6	5.5
8	Cont. + B + Mo + Rhizohumin	11.0	6.0	5.8
II sowing period				
1	$N_{30}P_{40}$ – control	7.4	5.0	4.7
2	Cont. + Rhizohumin	9.6	5.4	5.3
3	Cont. + B	9.6	5.4	5.4
4	Cont. + B + Rhizohumin	10.0	5.4	5.3
5	Cont. + Mo	10.5	5.7	5.7
6	Cont. + Mo + Rhizohumin	10.6	5.9	5.7
7	Cont. + B+ Mo	11.1	5.6	5.4
8	Cont. + B + Mo + Rhizoh.	10.7	6.3	6.3

Regarding the yield, Table 6 presents data indicating the impact of seed treatment with boron, molybdenum, and Rhizogumin on the yield of vegetable peas both in green pea stage and technical ripeness of seeds. In the early sowing period, the maximum yield of dry peas (Table 6) was 2.51 tons per hectare (+ 22.3% compared to control) when treating seeds with boron and molybdenum, and in the late sowing period, it was 2.36 tons per hectare (+ 26.3% compared to control) when using molybdenum and Rhizogumin.

Table 6

Yield of green and dry vegetable pea depending on treatment (ton/ha)

№	Variant of experiment	Green pea			Dry pea		
		2020	2021	average	2020	2021	average
I sowing period							
1	$N_{30}P_{40}$ – control	5.62	6.56	6.09	1.85	2.05	1.95
2	Cont. + Rhizohumin	6.54	7.37	6.96	2.10	2.32	2.21
3	Cont. + B	6.45	7.24	6.85	2.12	2.31	2.22
4	Cont. + B + Rhizohumin	6.72	7.52	7.12	2.18	2.38	2.28
5	Cont. + Mo	7.23	8.16	7.70	2.33	2.55	2.44
6	Cont. + Mo + Rhizohumin	7.04	7.98	7.51	2.25	2.50	2.38
7	Cont. + B+ Mo	7.40	8.29	7.85	2.38	2.63	2.51
8	Cont. + B + Mo + Rhizohumin	7.18	8.09	7.64	2.29	2.57	2.43
II sowing period							
1	$N_{30}P_{40}$ – control	4.82	6.04	5.43	1.55	1.93	1.74
2	Cont. + Rhizohumin	5.66	6.92	6.29	1.81	2.20	2.01
3	Cont. + B	6.08	7.31	6.70	1.98	2.35	2.17
4	Cont. + B + Rhizohumin	6.35	7.58	6.97	2.04	2.42	2.23
5	Cont. + Mo	6.48	7.82	7.15	2.07	2.48	2.28
6	Cont. + Mo + Rhizohumin	6.64	8.04	7.34	2.14	2.57	2.36
7	Cont. + B+ Mo	6.40	7.93	7.17	2.07	2.53	2.30
8	Cont. + B + Mo + Rhizohumin	6.58	8.00	7.29	2.11	2.54	2.33

The yield of green pea amounted to 7.85 tons per hectare for the first sowing period when treating seeds with boron and molybdenum and 7.34 tons per hectare for the second sowing period when treating seeds with boron and Rhizohumin, while the variants without seed treatment yielded 6.09 and 5.43 tons per hectare, respectively. In the early sowing period, dry vegetable peas in the variants of seed treatment with molybdenum (2.44 t/ha) and with boron, molybdenum, and Rhizohumin (2.43 t/ha) took second and third places in terms of yield, with minimal difference between them that did not exceed the experimental error. In the late sowing period, the second and third places in terms of yield were occupied by the variants with seed treatment with boron, molybdenum, and Rhizohumin, which resulted in dry pea of 2.33 tons per hectare and 2.30 tons per hectare, when treating seeds with boron and molybdenum (or 8.00 and 7.93 tons per hectare of green pea).

An important indicator that affects the yield and quality of vegetable peas is the percentage of green peas from the total weight of pods. For the studied Alfa variety, according to data from various researchers, this indicator varies from 41% to 59%. Data reflecting the impact of seed treatment with boron, molybdenum, and Rhizohumin on the structure of the vegetable pea yield is presented on Figure 3.

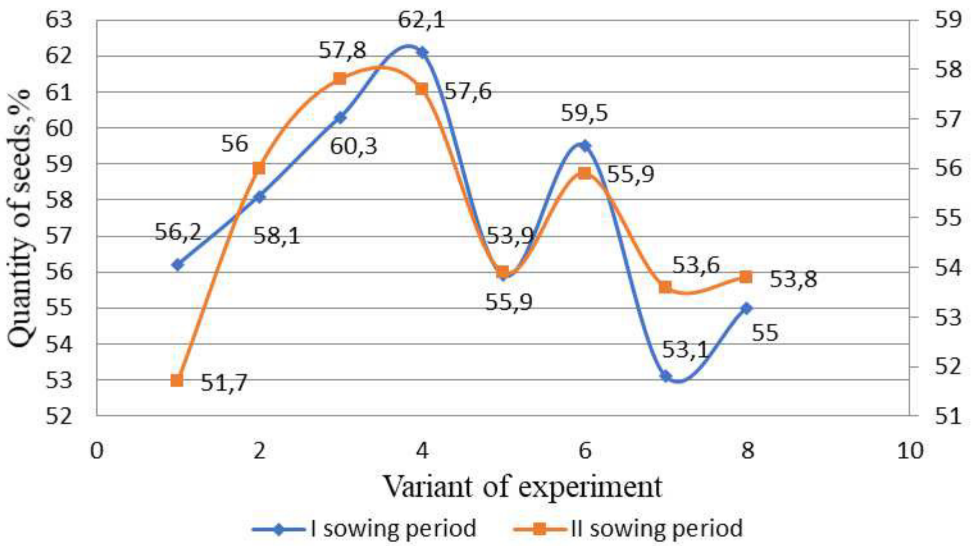

Fig. 3. Impact of treatment on the seed output from vegetable pea pods, %

From obtained data, it is clear that in the variants of combination boron and molybdenum during the first sowing period and molybdenum and Rhizohumin during the second sowing period, which provided the highest yield for this crop, the percentage of green peas from the total weight of pods was 53.1% and 59.5%, respectively. This exceeded the control variants by 1.9% and 2.8%.

The results of conducted studies on the influence of biological agents on the quality indicators of vegetable peas are presented in Table 7.

Analyzing the obtained data it is clearly seen that 1000 kernel weight when treating vegetable pea seeds with biological agents during the first and second sowing periods reduced comparing with the control almost in all variants, except Rhizohumin and Rhizohumin plus boron. Grain diameter also decreased compared to the control in almost all variants. The decrease in 1000 kernel weight and seed diameter did not affect the yield of vegetable peas compared to the control due to the increase in the number of pods per plant, which we described earlier.

According to the vegetable pea class table, the obtained peas from all experimental fields can be classified as high and first classes, except the variant with boron treatment which classified as second class.

Table 7

Influence of seed treatment on quality indicators of vegetable peas

№	Variant of experiment	1000 kernel weight	Diameter of seeds	Hardness, units	Technical ripeness, days
I sowing period					
1	$N_{30}P_{40}$ – control	355.6	6.7	53	45
2	Cont. + Rhizohumin	373.3	6.3	45	+2
3	Cont. + B	355.0	7.2	62	-2
4	Cont. + B + Rhizohumin	374.6	7.1	56	+2
5	Cont. + Mo	334.0	5.3	40	+4–6
6	Cont. + Mo + Rhizohumin	316.3	5.1	32	+5–6
7	Cont. + B+ Mo	294.6	5.8	38	+4–6
8	Cont. + B + Mo + Rhizoh.	308.0	5.5	35	+6
II sowing period					
1	$N_{30}P_{40}$ – control	365.0	6.5	50	43
2	Cont. + Rhizohumin	373.0	6.3	43	-6–8
3	Cont. + B	344.0	7.0	59	+4–6
4	Cont. + B + Rhizohumin	375.0	6.9	52	+8–10
5	Cont. + Mo	301.0	5.2	38	+10–11
6	Cont. + Mo + Rhizoh.	292.0	5.0	36	+11–12
7	Cont. + B+ Mo	277.0	5.5	42	+10–12
8	Cont. + B + Mo + Rhizoh.	297.6	5.4	40	+11–12

Thanks to the improvement of nitrogen nutrition of vegetable peas as a result of the stimulation of nodule bacteria with boron, molybdenum and Rhizohumin, a delay in the beginning of technical ripeness of seeds by 4–6 days was observed in the studied variants, which allows to double the period of harvesting during the best technological phase, obtaining products of the high and first class for the green peas.

When sowing in second period, the optimal harvesting period can be extended by 10–12 days compared to the control, which makes it possible to increase the length of the processing the yield and the area of vegetable pea crops.

Conclusions. The indicators of weed infestation clearly demonstrate a direct relationship of crop illumination, with a particular impact observed in the ground layer where weed seedlings are deprived of sufficient light. This limited exposure to light restricts the growth and development of weeds and subsequently results the elongation and etiolation of their leaf blades. Etiolation is a consequence of reduced chlorophyll synthesis, which is essential for photosynthesis and, therefore, profoundly affects the overall vigor and competitive ability of weeds in these shaded areas.

The analysis of illumination of the ground layer of crops and weed infestation reveals a notable correlation during the first sowing period. This link suggests that treating vegetable pea seeds with boron, molybdenum, and Rhizohumin contributes to a reduction of competing weeds by diminishing the amount of light reaching the lower tier of the crops. This reduction of illumination is caused by the increased above-ground biomass of pea plants.

Seed treatment of vegetable pea with boron, molybdenum, and Rhizohumin during the first sowing period, and with molybdenum and Rhizohumin during the second sowing period, has led to significant increase of the pods number per plant. This suggests that these treatments have a positive impact on pea plant development and pod production, which is an advantage for farmers and growers seeking to enhance their crop yields.

The maximum vegetable peas yield of technical ripeness 2.51 tons of dry peas per hectare were achieved with pre-sowing seed treatment with boron and molybdenum during the first sowing period. A highest yield of 2.36 tons of dry peas per hectare was attained with molybdenum and Rhizohumin treatment during the second sowing period. These results show the importance of seed treatments at specific sowing periods to optimize the technical production of vegetable peas, enabling farmers to obtain the higher yields from the crops. This information is valuable for agricultural practices aimed at improving pea cultivation.

In the studied variants, the seed output from pods was 1.9% higher in the early sowing period and 2.8% higher in the late sowing period compared to the control variants. The increase in seeds output from pods shows a positive impact of treatment and both of early and late sowing periods on the efficiency of seed output from pea pods. Farmers and researchers can consider this information when planning their sowing schedules to optimize seed extraction and overall crop productivity.

Using the finometr it was proved that the treatment of pea seeds by biological agents is improving the class of vegetable peas harvested during the green pea stage comparing with control. Harvested green peas were of a high and first class when treating by all variants of combination of biological agents except the variant of pure boron. In general, the experimental work shows the positive effect of treating the seeds of vegetable peas with biological agents containing boron and molybdenum and by Rhizohumin.

1. 12 – Effects of heavy metals present in sewage sludge, their impact on soil fertility, soil microbial activity, and environment / M. S. Ansari, A. Tauseef, M. Haris, A. Khan, H. Touseef, A. A. Khan. *Development in Waste Water Treatment Research and Processes.* 2022. P. 197–214, DOI: https://doi.org/10.1016/B978-0-323-85584-6.00013-3. **2.** Breus D., Yevtushenko O. Agroecological Assessment of Suitability of the Steppe Soils of Ukraine for Ecological Farming. *Journal of Ecological Engineering*. 2023. № 24(5). P. 229–236. DOI: https://doi.org/10.12911/22998993/161761. **3.** Breus D. S., Skok S. V. Spatial modelling of agro-ecological condition of soils in steppe zone of Ukraine. *Indian Journal of Ecology*. 2021. № 48(3). P. 627–633. **4.** Breus D. S., Yevtushenko O. T. Modeling of Trace Elements and Heavy Metals Content in the Steppe Soils of Ukraine. *Journal of Ecological Engineering*. 2022. № 23(2). P. 159–165. DOI: https://doi.org/10.12911/22998993/144391. **5.** Boron in plant biology / P. H. Brown at al. *Plant Biology*. 2002. № 4. P. 205–223. **6.** Dudiak N., Pichura V., Potravka L., Stratichuk N. Environmental and economic effects of water and deflation destruction of steppe soil in Ukraine. *Journal of Water and Land Development*. 2021. № 50. P. 10–26. DOI: https://doi.org/10.24425/jwld.2021.138156. **7.** Dudiak N. V., Potravka L. A., Stroganov A. A. Soil and climatic bonitation of agricultural lands of the steppe zone of Ukraine. *Indian Journal of Ecology*. 2019. № 46(3). P. 534–540. **8.** Fakkar A. A. O., El-Dakkak A .A. A. Effect of crop sequence and weed control treatments on weeds and pea crop productivity. *Annals of Agricultural Sciences*. 2015. № 60(1). P. 157–168. DOI: https://doi.org/10.1016/j.aoas.2015.05.002.
9. Kamran A., Mushtaq M., Arif M., Rashid S. Role of biostimulants (ascorbic acid and fulvic acid) to synergize Rhizobium activity in pea (Pisum sativum L. var. Meteor). *Plant Physiology and Biochemistry.* 2023. № 196. P. 668–682.

DOI: https://doi.org/10.1016/j.plaphy.2023.02.018. **10.** Pichura V., Domaratskiy Y., Potravka L., Biloshkurenko O., Dobrovol'skiy A. Application of the Research on Spatio-Temporal Differentiation of a Vegetation Index in Evaluating Sunflower Hybrid Plasticity and Growth-Regulators in the Steppe Zone of Ukraine. *Journal of Ecological Engineering*. 2023. № 24(6). P. 144–165. DOI: https://doi.org/10.12911/22998993/162782. **11.** Pichura V., Potravka L., Dudiak N., Stroganov A., Dyudyaeva O. Spatial differentiation of regulatory monetary valuation of agricultural land in conditions of widespread irrigation of steppe soils. *Journal of Water and Land Development*. 2021. № 48(1–3). P. 182–196. DOI: https://doi.org/10.24425/jwld.2021.136161. **12.** Pichura V., Potravka L., Dudiak N., Vdovenko N. Space-time modeling of climate change and bioclimatic potential of steppe soils. *Indian Journal of Ecology*. 2021. № 48(3). P. 671–680. **13.** Skok S., Breus D., Almashova V. Assessment of the effect of biological growth-regulating preparations on the yield of agricultural crops under the conditions of Steppe zone. *Journal of Ecological Engineering*. 2023. № 24(7). P. 135–144. DOI: https://doi.org/10.12911/22998993/163494. **14.** Wysokinski A., Lozak I., Kuziemska B. The Dynamics of Molybdenum, Boron, and Iron Uptake, Translocation and Accumulation by Pea (Pisum sativum L.). *Agronomy*. 2020. № 12(4). P. 935. DOI: 10.3390/agronomy12040935.

REFERENCES:

1. 12 – Effects of heavy metals present in sewage sludge, their impact on soil fertility, soil microbial activity, and environment / M. S. Ansari, A. Tauseef, M. Haris, A. Khan, H. Touseef, A. A. Khan. *Development in Waste Water Treatment Research and Processes.* 2022. P. 197–214, DOI: https://doi.org/10.1016/B978-0-323-85584-6.00013-3. **2.** Breus D., Yevtushenko O. Agroecological Assessment of Suitability of the Steppe Soils of Ukraine for Ecological Farming. *Journal of Ecological Engineering*. 2023. № 24(5). P. 229–236. DOI: https://doi.org/10.12911/22998993/161761. **3.** Breus D. S., Skok S. V. Spatial modelling of agro-ecological condition of soils in steppe zone of Ukraine. *Indian Journal of Ecology*. 2021. № 48(3). P. 627–633. **4.** Breus D. S., Yevtushenko O. T. Modeling of Trace Elements and Heavy Metals Content in the Steppe Soils of Ukraine. *Journal of Ecological Engineering*. 2022. № 23(2). P. 159–165. DOI: https://doi.org/10.12911/22998993/144391. **5.** Boron in plant biology / P. H. Brown at al. *Plant Biology*. 2002. № 4. P. 205–223. **6.** Dudiak N., Pichura V., Potravka L., Stratichuk N. Environmental and economic effects of water and deflation destruction of steppe soil in Ukraine. *Journal of Water and Land Development*. 2021. № 50. P. 10–26. DOI: https://doi.org/10.24425/jwld.2021.138156. **7.** Dudiak N. V., Potravka L. A., Stroganov A. A. Soil and climatic bonitation of agricultural lands of the steppe

zone of Ukraine. *Indian Journal of Ecology*. 2019. № 46(3). P. 534–540. **8.** Fakkar A. A. O., El-Dakkak A .A. A. Effect of crop sequence and weed control treatments on weeds and pea crop productivity. *Annals of Agricultural Sciences*. 2015. № 60(1). P. 157–168. DOI: https://doi.org/10.1016/j.aoas.2015.05.002.
9. Kamran A., Mushtaq M., Arif M., Rashid S. Role of biostimulants (ascorbic acid and fulvic acid) to synergize Rhizobium activity in pea (Pisum sativum L. var. Meteor). *Plant Physiology and Biochemistry.* 2023. № 196. P. 668–682. DOI: https://doi.org/10.1016/j.plaphy.2023.02.018. **10.** Pichura V., Domaratskiy Y., Potravka L., Biloshkurenko O., Dobrovol'skiy A. Application of the Research on Spatio-Temporal Differentiation of a Vegetation Index in Evaluating Sunflower Hybrid Plasticity and Growth-Regulators in the Steppe Zone of Ukraine. *Journal of Ecological Engineering*. 2023. № 24(6). P. 144–165. DOI: https://doi.org/10.12911/22998993/162782. **11.** Pichura V., Potravka L., Dudiak N., Stroganov A., Dyudyaeva O. Spatial differentiation of regulatory monetary valuation of agricultural land in conditions of widespread irrigation of steppe soils. *Journal of Water and Land Development*. 2021. № 48(1–3). P. 182–196. DOI: https://doi.org/10.24425/jwld.2021.136161. **12.** Pichura V., Potravka L., Dudiak N., Vdovenko N. Space-time modeling of climate change and bioclimatic potential of steppe soils. *Indian Journal of Ecology*. 2021. № 48(3). P. 671–680. **13.** Skok S., Breus D., Almashova V. Assessment of the effect of biological growth-regulating preparations on the yield of agricultural crops under the conditions of Steppe zone. *Journal of Ecological Engineering*. 2023. № 24(7). P. 135–144. DOI: https://doi.org/10.12911/22998993/163494. **14.** Wysokinski A., Lozak I., Kuziemska B. The Dynamics of Molybdenum, Boron, and Iron Uptake, Translocation and Accumulation by Pea (Pisum sativum L.). *Agronomy*. 2020. № 12(4). P. 935. DOI: 10.3390/agronomy12040935.

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ВПЛИВ БІОЛОГІЧНИХ ПРЕПАРАТІВ НА УРОЖАЙНІСТЬ ТА ЯКІСТЬ ГОРОХУ ОВОЧЕВОГО В УМОВАХ ЗОНИ СТЕПУ

Застосування хімічних гербіцидів є критичною проблемою з точки зору сталого землекористування, що потребує альтернативних способів обробки та захисту сільськогосподарських культур. Проблема проявляється в тривалій

хімізації сільськогосподарських угідь, яка критично вплинула на якість ґрунтів. Разом з цим, проблему загострює неналежна екологічна чистота врожаю, зібраного на хімічно оброблених землях, а також кількість і якість цієї сільськогосподарської продукції. Застосування нехімічних препаратів для обробки сільськогосподарських культур дійсно є ключовим напрямком у сільському господарстві, який сприяє сталому розвитку, оскільки допомагає зберегти родючість ґрунту, зменшити негативний вплив на навколишнє середовище та підтримує виробництво без використання синтетичних пестицидів. Аналіз наявних джерел показав, що практичні дослідження впливу зменшення використання хімічних добрив та збільшення використання органічних добрив для обробки основних сільськогосподарських культур залишаються актуальними та недостатньо дослідженими. Тому метою даної статті було висвітлити результати практичних досліджень впливу передпосівної обробки насіння бором, молібденом та Ризогуміном на урожай гороху овочевого та його якість. Практичні дослідження проводили на дослідних ділянках, розташованих у степовій зоні Півдня України. Овочевий горох є цінним джерелом харчового білка, рослина часто використовується для сидерації, тому для дослідження була обрана саме ця рослина. Дослідження базувалися на обробці насіння гороху овочевого різною комбінацією мінеральних добрив із вмістом бору, молібдену та Ризогуміну – препарату на основі активних штамів бульбочкових бактерій та порівняння отриманих результатів з контролем – удобренням ґрунтів сульфатом амонію та суперфосфатом. ($N_{30}P_{40}$). Встановлено позитивний вплив обробки насіння В, Мо та Ризогуміном на кількість квіток і стручків на етапах цвітіння та формування стручків порівняно з контролем. Вивчено позитивний вплив мінеральних добрив на урожай гороху овочевого та його якість. Проведені дослідження можуть бути враховані сільськогосподарськими товаровиробниками під час господарської діяльності.

Ключові слова: горох овочевий; бур'яни; молібден; бор; Ризогумін; біопрепарати; якість врожаю.