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MICROBIOTA OF GREENHOUSE SOILS IN WHEAT SELECTION

*A system of agrotechnical and reclamation works is used to obtain a high-yielding and high-quality selection wheat. These works result in significant changes in both the components of the original landscape and the whole complex. It is known that the quantitative and qualitative composition of soil microbiota adequately reflects the degree of anthropogenic load, therefore it is used as a diagnostic indicator when estimating the ecological state of soil. The aim of this work was to analyze the soil microbiota of the phytotron-selection complex of the V.M. Remeslo Myronivskyi Wheat Institute using various agricultural technologies to obtain high-quality breeding material for winter wheat (*Triticum aestivum* L.). The specialization of this plant-breeding center was instrumental in using grow rooms according to the monoculture phylum. **Methods.** Classical microbiological and statistical techniques were used in the research. Microbiological analyses were performed by the technique of dilution of soil suspensions using nutrient-selective media. The total number of ammonifying, spore-forming bacteria, streptomycetes, bacteria that absorb mineral nitrogen, oligonitrophilic and cellulose-destroying microorganisms, microscopic fungi, as well as bacteria growing on agar soil, was taken into account. Microbial biomass was calculated on the basis of data on the number and size of cells, taking their specific gravity at 1.08 g/cm³. Indicators of the frequency and density of species were used to determine typical and dominant species. Additionally, the qualitative composition of bacteria, microscopic fungi, and streptomycetes has been determined. **Results.** It has been established that use of cattle manure at a rate of 100 t/ha as well as the cultivation of break crops (radish, winter bird rape) has positive effects on the biological activity of soil and the biomass of soil microorganisms. The intensity of CO₂ emission in this variant with fertilization was 2.5 times higher than in control. Similar patterns were observed for O₂ absorption. It was noticed that*

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the processes of mineralization of the organic component of grow rooms soil are more active than in a field. The mechanism of managing the microbiological condition of greenhouse soil through the introduction of crop rotation of vegetables (cucumber, tomato) and medicinal tropical crops (kalanchoe), break crops (radish, winterbirdrape) and the application of organic fertilizers and growing green manure had a positive effect on the quality of winter wheat. The mastered crop rotation in these facilities was carried out without using electricity to maintain light and temperature conditions of cultivation. It has been established that the index of earth-balls biofouling with azotobacter did not change in these constructions over the research period. The dynamics of the amount of streptomycetes, myxomycetes, and spore bacteria testifies to the fact that, on the average, these indices in the grow rooms and in the field do not significantly differ. **Conclusions.** The microbiological analysis of soil in the grow rooms and the research results show that it is expedient to introduce crop rotation in grow rooms. Unlike field conditions, where the study of microbiological relationships in the system «soil - microorganism - plant» determines soil fertility trends, in the artificial climate of knowledge and management of such relationships will largely determine the success of breeding practice, including obtaining high-quality primary breeding material of winter wheat and will significantly increase the profitability of the use of such objects of artificial climate.

Keywords: soil microbiota, biological activity of soil, wheat, crop rotations, green crops, medicinal-tropical crops.

Any anthropogenic impact on soil destroys the development of soil processes, which significantly disrupts of the soil microbial community, as the microorganisms are highly sensitive reagents to any environmental changes. It is known that qualitative and quantitative composition of soil microbiota adequately reflects the level of the anthropogenic load, therefore it is used as a diagnostical index when estimating an ecological state of soil (Patyka et al., 2008; Patyka et al., 1993; Patyka et al., 2007; Patyka & Volkogon, 2024; Salesda et al., 2020).

The development of certain soil microbial and their community, as well as the nature of soil-formation process depends on the number of anthropogenic factors — the dose and the forms of manure, soil treatment, unvaried crops growing and crops rotation, the use of growth regulators and pesticides etc. (Furdychko, 2014; Patyka et al., 1993; Patyka et al., 2007).

A system of agrotechnical and reclamation works is used to obtain a high-yielding and high-quality selection wheat. These works result in significant changes in the components of the original landscape as well as to the whole complex (Gadzalo et al., 2019; Patyka et al., 1993; Petrychenko et al., 2018). To have a high-quality and ecological produce, it is expedient to improve a fertilizer system as well as to develop scientific basis for its use in land husbandry (Badreiner & Talak, 1998; Patyka et al., 2008; Patyka et al.,

1993; Patyka et al., 2007; Patyka & Volkogon, 2024; Symochko et al., 2010; Melnyk, 2005). A theoretical basis of the fertilizer system in a crop rotation is plants-soil environment relation, including microorganisms which live in it.

In the process of its activity, microbiota creates some conditions for the development of other forms of life. But the array of questions related to some changes in the activity of microorganisms as well as in biochemical processes, which take place in soil in the process of plants growing, is rather complicated and in many aspects has not been elucidated yet (Gadzalo et al., 2019; Patyka et al., 2008; Patyka et al., 2007; Patyka & Volkogon, 2024).

Therefore, the study of the peculiarities of the functioning of the microbial cenosis of the soil of greenhouses in the cultivation of Triticum is certainly of theoretical interest and is of great practical importance, particularly in terms of selection of this culture. The **aim** of this work was to study the soil microbiota of the phytotron-selection complex of the Myronivskiy Wheat Institute. Using different agricultural technologies to obtain high-quality breeding material for winter wheat (*Triticum aestivum L.*).

Materials and Methods. On the basis of selection stationary experiments in the greenhouses of the phytotron-selection complex at the V.M. Remeslo Myronivskiy Institute of Wheat, the influence of different agricultural technologies for

the selection of winter wheat on the composition and biological activity of soil microbiota was studied (Table 1).

Soil samples from *Triticum* were taken from a layer of 1–15 cm. The research was conducted for 3 years from 2022 to 2024. The tables, graphs and figures below present the average data for the research period.

Microbiological studies of the soil were performed on fresh samples by the soil dilutions method on dense and liquid nutrient media, guided by appropriate methods in the laboratory of soil microbiology at the Institute of Agricultural Microbiology, NAAS, Chernihiv (Volkogon et al., 2010).

Microbiological analyses were performed by the dilution method of soil suspensions using nutrient-selective media (Pisarenko et al., 2008; Volkogon et al., 2010). The following microorganisms were considered: the total number of ammonifying bacteria on meat peptone agar (MPA), spore-forming bacteria — meat-wort agar (MPA + WA), streptomycetes and bacteria that absorb mineral nitrogen — starch-ammonia agar, microorganisms (SAA) in Ashby's medium, cellulose-destroying in Hutchinson's medium, microscopic fungi — wort agar (WA); in addition, bacteria growing on agar soil extract (SE) were taken into account.

When studying the species composition of non-spore bacteria, we used a nutrient medium of the following composition: 1 liter of cabbage broth (100 g of cabbage per 1 liter of water), 25 mL of beer wort, 1.25 mL of corn extract, pH 7.0–7.2 (Philippot et al., 2012).

Microbial biomass was calculated on the basis of data on the number and size of cells, taking their specific gravity at 1.08 g/cm^3 (Kucherenko et al., 2001; Pisarenko et al., 2008; Volkogon et al., 2010). The time of one generation of bacteria was calculated by the formula: $g = \text{tlg}2/(\text{lg}\beta - \text{lg}b)$ (Morgan et al., 2018; Volkogon et al., 2010), and the number of generations — by dividing the total number of hours over the periods of increasing cell numbers by the average generation time. The size of bacterial cell productivity and bacterial biomass production were

determined by summing all significant increases in the number or, accordingly, bacterial biomass during the observation period (Kucherenko et al., 2001; Philippot et al., 2012; Volkogon et al., 2010).

To determine the typical and dominant species of microorganisms, we used an average soil sample based on 20–25 samples taken from different locations in the study area. Indicators of frequency and density of species were used to determine the typical and dominant species. The typical species accounted for more than 33%, and dominant ones — for at least 10% of all species.

The number of microorganisms in the main groups (in three replications) was determined by

Table 1. Crops rotation in grow rooms and greenhouses

Object	Year	Crop
Winter wheat sowing without crop rotation	2022	winter wheat
	2023	winter wheat
	2024	winter wheat
Field 2 winter wheat, Fields 1,3 tomatoes	2022	tomatoes
	2023	winter wheat
	2024	tomatoes
Vegetables	2022	cucumber
	2023	tomatoes
	2024	cucumber
Field 1 winter wheat, Fields 2, 3 tomatoes	2022	winter wheat
	2023	tomatoes
	2024	tomatoes
Field 1 tomatoes, Fields 2, 3 cover crop	2022	tomatoes
	2023	kalanchoe
	2024	cover crop
Fields 1, 3 winter wheat, Field 2 tomatoes	2022	winter wheat
	2023	tomatoes
	2024	winter wheat
Field 1 winter wheat, Field 2 kolanchoe, Field 3 cucumber	2022	winter wheat
	2023	kalanchoe
	2024	cucumber
Fields 1, 2 spring wheat, Field 3 tomatoes	2022	spring wheat
	2023	spring wheat
	2024	tomatoes

the method of microbiological sowing of soil suspension on solid nutrient media and expressed in colony-forming units (CFU): the total number of microorganisms in the soil — on Zviahintsev's medium; the total number of aerobic nitrogen-fixing bacteria (oligotrophic, azotobacter) — on Eshbi's medium; microorganisms of inorganic nitrogen-compounds assimilation and actinomycetes — on starch-and-ammonia agar; fungal microbiota — on wort agar-agar; and oligotrophic bacteria — on starvation agar (Kucherenko et al., 2001; Philippot et al., 2012; Volkogon et al., 2010).

For statistical processing of the data, calculations of the arithmetic mean and its standard error were performed.

Qualitative bacteria composition was determined according to the characteristics given in Bergey's manual (Brenner et al., 2005).

The intensity of soil «breathing» was determined by CO₂ emission and O₂ absorption applying a manometric technique using a Warburg's apparatus (Volkogon et al., 2010). Ammonifying soil activity was determined according to the intensity of peptone mineralization, nitrifying soil activity was determined when forming soil into compost adding a solution of (NH₄)₂SO₄ (Kucherenko et al., 2001; Philippot et al., 2012; Volkogon et al., 2010).

Statistical experimental data processing was handled according to B. A. Dospehov's technique (Docherty & Gutknecht, 2019; Patyka & Volkogon, 2024).

Results. The concentration and specialization of selection centers having special grow rooms (such as the V.M. Remeslo Myronivskyi Institute of Wheat) resulted in saturation with grain crops. However, after repeated sowings of these crops in the same place, in grow rooms or greenhouses, the so called «soil exhaustion» is observed and the crop yield decreases.

When studying the reason for this, it was shown that systematic penetration of grain crops remnants (of wheat) into the soil has a negative impact on soil microbiota. This is manifested by the decreased activity of all biological processes

which take place in the soil, as well as in deterioration in the conditions for plant growth.

Growing wheat under monoculture conditions results in some changes in the proportion of the main physiological groups of microorganisms: the amount of micromycetes, streptomycetes, and sporebacteria increases, and the amount of active metabolizing bacteria and free nitrogen fixers decreases (Table 2). It has been shown that different groups responded differently to the crops. Wheat growing under conditions of monoculture results in decreasing both microorganism's amount and biomass in the soil. Thus, the number of bacteria able to form colonies on soil agar under growing cover crops in crop rotation was 3.6 times that under monoculture, under kalanchoe and cucumber growing — 3.1 times, and under spring wheat and tomatoes growing — 3.7 times that under monoculture.

It was established that the use of cattle manure at a rate of 100 t/ha and the cultivation of break crops (radish, winter bird rape) have positive effects on the biological activity of soil as well as on the biomass of soil microorganisms. The intensity of CO₂ emission in this variant with fertilization was 2.5 times that in control. Similar patterns were observed for O₂ absorption.

The bacterial biomass in the cultivation of cover crops, spring wheat, tomatoes doubled that when growing in monoculture; the number of oligotrophic bacteria involved in the conversion of organic matter residues and streptomycetes doubled as well. The content of microscopic fungi remained at the same level (Table 2).

An increase in the number of bacilli and streptomycetes in soil when using cover crops and growing vegetable crops plants testifies to a much higher destruction of an organic substance. These groups of organisms consume compounds that are beyond the reach of non-spore bacteria but are developed on a substrate that is poor in available compounds (Patyka et al., 2008; Symochko et al., 2010). If compare the variants with the use of cover crops or vegetable crops and the control variant, they are fare worse

than mentioned above variants. Cellulose-fermenting microorganisms are indicators of mobilizing processes in soil. By our data (Table 2), the content of these microorganisms is 2.5 — 7.2 times higher than in the cultivation of vegetable and medicinal tropical crops in comparison with the control (sowing cereals without crop rotation). Growing of wheat selection material using crop rotation supplies 60% and more and is far worse in the number of cellulose-fermenting microorganisms than in the variants when growing cover crops and vegetable plants.

Thus, the obtained data confirm the research results of other authors (Patyka et al., 2008; Patyka et al., 2007; Symochko et al., 2010) concerning the fact that mobilizing processes in the soil intensify under the application of green manure.

The same changes were found out in the dynamics of microflora number, which was, evidently, conditioned by certain processes of the supply of organic matter and dissimilation, which conforms to the literature data. The group of saprophyte microorganisms is the most numerous one (Fig. 1). Bacilli are more numerous in the soil with cover crops during the blooming period, while the number of oligotrophic bacteria in this

period significantly decreases. For streptomycetes and fungi, the difference between the experiment variants is not significant (Fig. 1).

The results of our studying the biological activity when growing wheat using different technologies are shown in Fig. 2 and Table 3. As listed in Table 3, the cultivation of wheat in monoculture, compared to the option with using cover crops, leads to an increase in CO₂ emissions by 2.4 times. Similar patterns were observed under O₂ absorption. This testifies to the fact that when growing wheat without fertilizers under conditions of monoculture, there are less favourable conditions for microorganism's activity, thus its biological activity decreases. However, the variants with cover crops when growing wheat as compared to the variant under conditions of monoculture (Fig. 1) do not have any significant impact on the ammonifying and nitrifying soil ability.

Studying the species composition of the bacteria has shown that in most cases, the same species could be found when growing wheat under conditions of monoculture and cover crops. However, the frequency of their occurrence and the species density were significantly different (Table 4).

Table 2. The quantity and biomass of soil microorganisms in greenhouses and hothouses for a long period of use

Variant	Bacterial biomass, t/ha	Medium			Oligonitrophilic bacteria	Fungi	Streptomycetes	Cellulose-fermenting bacteria, th/g of dry soil
		BEA	BEA+ BWA	SE				
		10 ⁶ g of dry soil						
Grain crop monoculture — control	3.9	9	4.0	76	107	2.9	45	4.8
Field 2 winter wheat, Fields 1, 3 tomatoes	8.0	15	8.2	164	201	2.3	80.0	30.5
Vegetables	7.7	20	7.8	167	230	3.1	93	24.1
Field 1 winter wheat, Fields 2, 3—tomatoes	7.4	25	7.3	165	218	3.0	100	16.2
Field 1 tomatoes, Fields 2,3 cover crops	8.8	32	8.1	201	287	3.0	101	22.7
Fields 1, 3 winter wheat, Field 2 tomatoes	5.9	17	6.7	134	202	2.6	85	12.2
Field 1 winter wheat, Field 2 kalanchoe, Field 3 cucumbers	7.5	28	8.2	170	254	3.6	110	34.5
Fields 2, 3 spring wheat, Field 1 tomatoes	8.7	33	8.8	189	222	2.4	105	32.6
Cattle manure at a rate of 100 t/ha	9.1	34	9.0	202	290	3.9	117	37.2
HCP _{0,5}	0.9	1.9	1.1	12	19	0.3	15	2.4

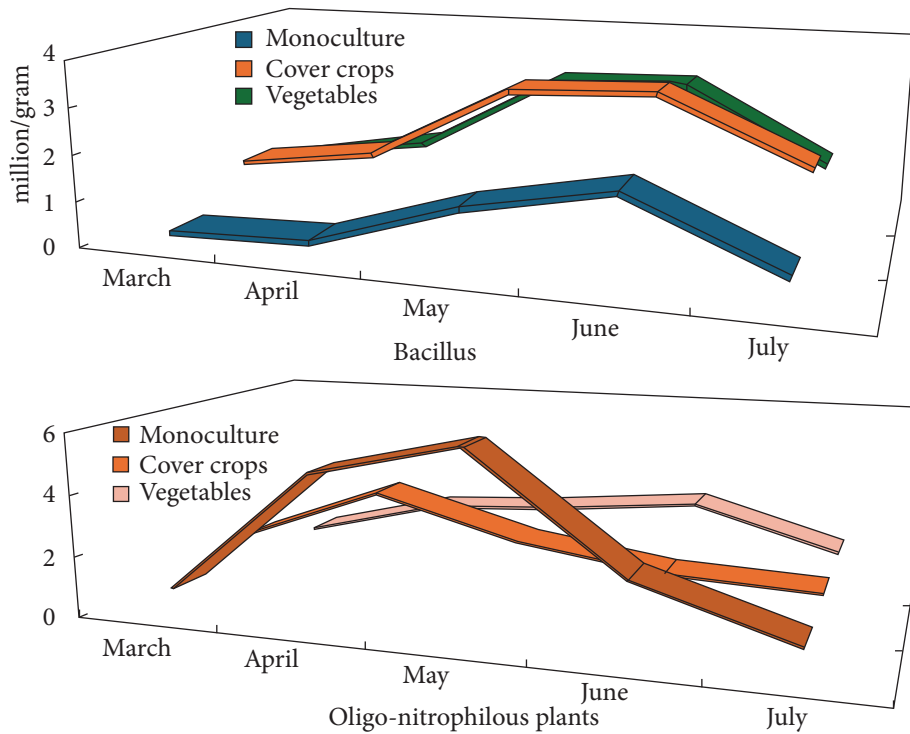


Fig. 1. Dynamics of bacilli and oligotrophic bacteria amount in the grow room's soil under wheat growing using different technologies

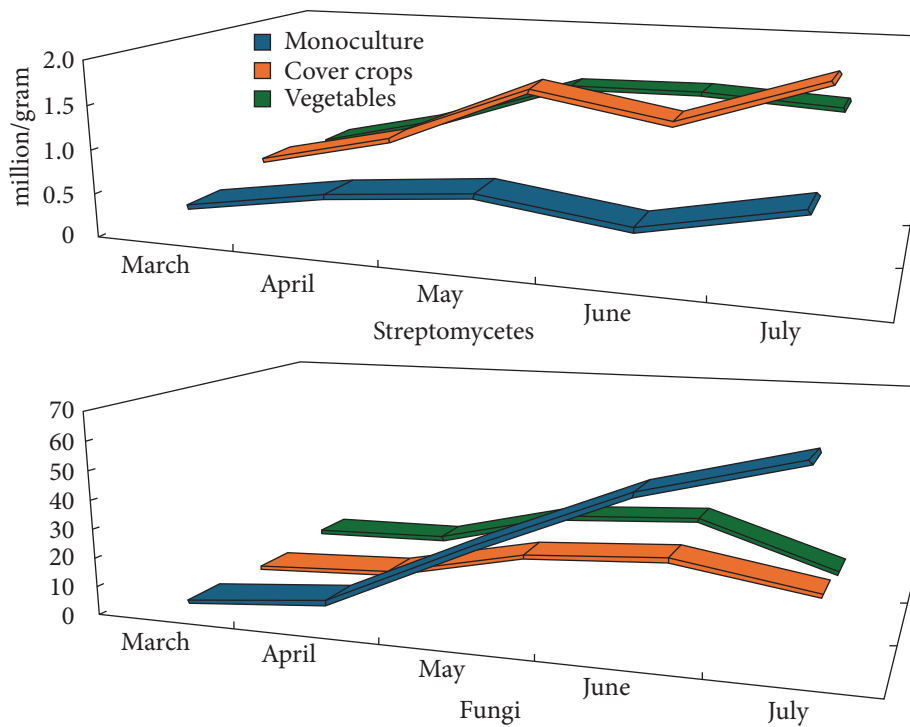


Fig. 2. Dynamics of the amount of streptomycetes and fungi in grow room's soil when growing wheat using different agrotechnologies

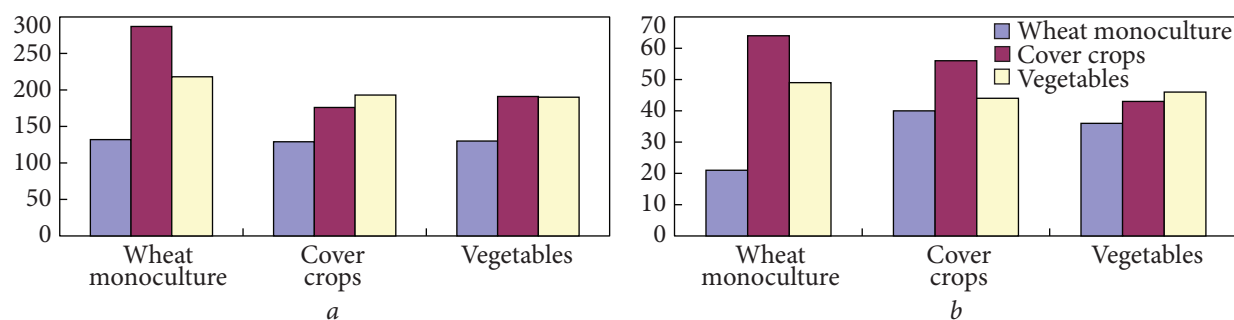


Fig. 3. Ammonifying (a) and nitrifying (b) ability of grow room's soil when growing different crops

Table 3. The intensity of CO₂ emission and O₂ absorption in grow room's soil when growing wheat using different agrotechnologies

Variant	Intensity of CO ₂ emission and O ₂ up-take mcg /g/hour	
	CO ₂	O ₂
Wheat monoculture	2.1	2.3
Cover crops	5.9	5.6
Vegetables	4.9	5.0
Cattle manure at a rate of 100 t/ha	6.3	6.2

Note: $x/P = 0.05$; $t_{st} = 3.11$

Table 4. Typical and dominating species of non-spore bacteria in the rhizosphere of *Capsicum annum* L. under conditions of monoculture and growing cover crops

Species	Wheat monoculture		Cover crops	
	I	II	I	II
<i>Agrobacterium radiobacter</i>	—	2	10	5
<i>Agrobacterium radiobacter</i> pv. <i>tumefaciens</i>	78	15	62	9
<i>Arhtrobacter pascens</i>	82	14	2	2
<i>Arhtrobacter simplex</i>	95	10	2	1
<i>Arhtrobacter urea faciens</i>	2	—	62	6
<i>Brevibacterium fuscum</i>	74	2	2	—
<i>Flavobacterium diffusum</i>	67	6	41	5
<i>Flavobacterium harrisonii</i>	50	5	1	2
<i>Flavobacterium suaveolens</i>	2	—	83	7
<i>Mycobacterium lacticum</i>	61	6	1	—
<i>Nocardia albicans</i>	2	2	41	4
<i>Nocardia rubropertincta</i>	—	—	72	4
<i>Pseudomonas fluorescens</i>	95	17	67	8
<i>Pseudomonas fragi</i>	80	11	—	—
<i>Pseudomonas putida</i>	89	9	2	—
<i>Pseudomonas rathonis</i>	1	—	91	7
<i>Serratia plymuthica</i>	—	—	62	6

Note: I — species occurrence rate, %; II — species density, %.

Discussion. Thus, a significant effect on soil microbiota can be noticed when growing wheat under conditions of monoculture, herein with decreases in the amount of microbiota, massing soil can be observed. The number of bacilli, oligotrophic and cellulose-fermenting microorganisms as well as the biological activity of soil decrease as well. Some changes can be observed in the dynamics of microorganism's number, conditioned by the peculiarities of the processes of organic matter supply and biodestruction in the variants with organic fertilizers and without them. The given data testify to the fact that the mobilization processes in soil with break crops are more intensive than when growing vegetable crops.

In ecological studies, it is not necessary to determine the existing species of microorganisms in a given soil, but it is sufficient to establish the dominating groups only or to reveal processes caused by them. The microorganisms of such physiological groups as ammonifying bacteria, bacteria that take-in nitrogen, nitrifying bacteria, streptomycetes, and myxomycetes belong to these dominating groups (Docherty & Gutknecht, 2019; Gadzalo et al., 2019; Kumar & Sai Gopal, 2015; Patyka et al., 2017; Ferreira et al., 2020). The group of ammonifying bacteria was not randomly chosen as diagnostic. Under the conditions of growing wheat in monoculture, the content of microscopic fungi and their conidia is at its maximum, whereas the content of ammonifying bacteria, on the contrary, is minimal.

It has been established that in the soils, under conditions of using break crops and taking some measures toward increasing the potential and effective fertility, the correlation between the ammonifying bacteria and fungi is higher than that for the identity element, that is, there are significantly more ammonifying elements, which is confirmed by the research results of other authors (Badreiner & Talak, 1998; Kumar & Sai Gopal, 2015; Patyka et al., 2017; Patyka et al., 1993; Tsiuk et al., 2017).

Conversely, in soils where plants are more infected by root rot and have a high rate of fun-

gi microflora, this correlation is less significant than that for the identity element. This may serve as an indicator of applying different agrotechnical techniques, which cause significant changes in the biological activity of the soil.

A high potential capability of keeping the system in balance under the constantly changing environmental conditions is a specific characteristic of microorganisms that distinguishes them from higher plants.

The fungi, as compared to other soil organisms, have such an important characteristic as a sustainable metabolism. They are able to use large amount of carbon and nitrogen from the compounds broken down by them to form their biomass. Up to 60% of substances that were broken down by fungi, are available in fungi (Docherty & Gutknecht, 2019; Gadzalo et al., 2019; Kumar & Sai Gopal, 2015; Ferreira et al., 2020; Volkogon et al., 2010).

Soil formation and the formation of soil fertility are connected with the activity of microorganisms that take an active part in the transformation of mineral and organic soil components, which was earlier admitted by the authors (Badreiner & Talak, 1998; Patyka et al., 2008; Patyka et al., 2007; Petrychenko et al., 2018; Ferreira et al., 2020; Volkogon et al., 2010). Theoretical substantiation and practical implementation of crop rotation will contribute to the prolongation of the period of using the soil of grow rooms without crop rotation, which will be instrumental in increasing their profitability.

Conclusions. The microbiological analysis of soil in grow rooms and the results of the research show that it is expedient to introduce crop rotation in the grow rooms. Unlike field conditions, where the study of microbiological relationships in the system «soil — microorganism — plant» determines soil fertility trends, in the artificial climate, the knowledge and management of such relationships will largely determine the success of breeding practice, including obtaining high-quality primary breeding material of winter wheat and will significantly increase the profitability of the use of such objects of artificial climate.

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МІКРОБІОТА ТЕПЛИЧНИХ ҐРУНТІВ ПРИ СЕЛЕКЦІЇ ПШЕНИЦІ

Для отримання високоврожайної та якісної селекційної пшениці використовується система агротехнічних та меліоративних робіт. Ці роботи призводять до істотних змін як компонентів оригінального ландшафту, так і всього комплексу. Відомо, що кількісний та якісний склад мікробіоти ґрунту адекватно відображає ступінь антропогенного навантаження, тому використовується як діагностичний показник при оцінці екологічного стану ґрунтів. Тому метою даної роботи було вивчити мікробіоту ґрунту фітотронно-селекційного комплексу Миронівського інституту пшениці імені В.М. Ремесла з використанням різних агротехнологій для отримання високоякісного селекційного матеріалу для озимої пшениці (*Triticum aestivum* L.). Спеціалізація даного рослинницького центру сприяла використанню кімнат вирощування за типом монокультури. **Методи.** У дослідженні були використані класичні мікробіологічні та статистичні методики. Мікробіологічні аналізи проводили за методикою розведення ґрунтових суспензій на живильних селективних середовищах. Враховували загальну кількість амоніфікуючих, спороутворюючих бактерій, стрептоміцетів та бактерій, що поглинають мінеральний азот, олігонітрофільних та целюлозоруйнівних мікроорганізмів, мікроскопічних грибів, а також враховували бактерії, що ростуть на агаровому ґрунті. Мікробну біомасу розраховували на основі даних про кількість і розмір клітин, приймаючи їх питому масу за 1,08 г/см³. Для визначення типових і домінантних видів використовували показники частоти та щільності видів. Крім того, визначали якісний склад бактерій, мікроскопічних грибів, стрептоміцетів. **Результати.** Встановлено, що використання гною великої рогатої худоби в розрахунку 100 т/га, а також вирощування злакових культур (редька, озимий ріпак) позитивно впливають на біологічну активність ґрунту, а також на біомасу ґрунтових мікроорганізмів. Інтенсивність викиду CO₂ у цьому варіанті з підгодівлею була у 2,5 рази вищою в порівнянні з контролем. Подібні закономірності спостерігалися при поглинанні O₂. Помічено, що процеси мінералізації органічної складової ґрунту протікають активніше при вирощуванні рослин у фітотронно-селекційного комплексу в порівнянні з полем. Механізм управління мікробіологічним станом тепличного ґрунту шляхом запровадження сівозміни овочевих (огірок, помідор) та лікарських тропічних культур (каланхое), обриву посівів (редька, ріпак озимий), внесення органічних добрив та вирощування сидератів позитивно впливав на якість озимої пшениці. Освоєну сівозміну в цих приміщеннях одержали без витрат електроенергії на підтримання світлових і температурних умов вирощування. Встановлено, що показник біообростання земляних куль азотобактером за період досліджень був незмінним. Динаміка кількості стрептоміцетів, міксоміцетів, а також спорових бактерій свідчить про те, що в середньому ці показники у вирощуваних приміщеннях та в польових умовах суттєво не відрізняються. **Висновки.** Мікробіологічний аналіз ґрунту у вирощувальних приміщеннях та результати досліджень показують, що у вирощувальних приміщеннях доцільно запровадити сівозміну. На відміну від польових умов, де вивчення мікробіологічних взаємозв'язків у системі «ґрунт — мікроорганізм — рослина» визначає тенденції родючості ґрунту, у штучному кліматі знання та управління такими взаємозв'язками значною мірою будуть визначати успіх селекційної практики, у тому числі й отримання якісного первинного матеріалу для вирощування озимої пшениці та значно підвищить рентабельність використання таких об'єктів штучного клімату.

Ключові слова: ґрунтова мікробіота, біологічна активність ґрунту, пшениця, сівозміни, зелені культури, лікарсько-тропічні культури.