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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

MODELING RESTORATION OF GRAY BROWN SOIL FERTILITY ACCORDING TO MICROBIOLOGICAL INDICATORS

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INTRODUCTION

The degree of actuality and study of the topic. One of the highlights of the century in which we live is the increased anthropogenic impact on the environment against the background of global climate change, the consequences of which are primarily manifested in their ecosystems associated with soil. More precisely, soil cenoses and their biota are characterized as the space in which anthropogenic impacts are most strongly felt. The result of man-made impacts is manifested both in the structure and in the functional activity of soil biocenoses, which has been confirmed in studies conducted in various scientific centers of the world.

Factors affecting both the structure and functional activity of soil, against the background of the growing number of the world's population, include *"prevention of industrial and transport pollution, urbanization, use of land with intensive technologies for agricultural purposes, etc."*[1]. The impact of all these mentioned ones on the environment, primarily on soil, causes changes and, unfortunately, all these changes are also characterized from a negative side and lead to the transformation of those ecosystems. An example is urbanization. Thus, only 3% of the Earth's territory falls on cities, but 50% of the world's population lives in cities. Given the pace of urbanization in the modern era, *"it is assumed that urban areas will increase by 3 times by 2030."*[2]. By itself, this fact leaves no room for doubt that the area of man-made soil, which are increasingly formed as a result of human activity, will increase significantly. The fact that this also leads to undesirable situations is no longer probable today, it is accepted as real and even clearly felt. Similar examples can be said about the influence of other factors mentioned above.

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[1] Марфенина О.Е. Антропогенная экология почвенных грибов. М.: Медицина для всех, 2005, 195 с.

[2] Setoa K.C, Güneralpa B., Hutyra L.R. Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools // PNAS, 2012, v.109, № 40, p.16083– 16088

The growth of the world population within a stable territory and the expansion of urbanization, on the one hand, the increase in the burden of anthropogenic and man-made impact on the environment, on the other hand, the reduction of arable land, which is of indispensable importance in meeting human needs for food, is the most dangerous of the obvious negative phenomena. If we add global climate change to the already difficult situation, then research aimed at preventing these issues, more precisely at making the changes that have taken place in the desired direction manageable and restoring the former state of the defunct territories, keeps its relevance in full force.

In accordance with the above said, it is also worth noting that the loss of soil cover as a result of urbanization and man-made impacts is a process that occurs all over the Earth, and by itself, on a large scale, and currently the area of territories of this type is about 20 million km^2. This is even more than the area of their land that is currently used for growing crops all over the world. *"Only as a result of the intensification of construction works, the development of the mining industry, desertification, salinization, 50-70 thousand km^2 of soil suitable for agriculture is annually withdrawn from circulation"*[3].

If we look at the Republic of Azerbaijan accordingly, it becomes clear that the problems noted in these territories, as in a small piece of the world, exist to one degree or another. Thus, the Republic of Azerbaijan is characterized as an industrial and agrarian country.

This is due to both the reduction of arable land and the presence of land plots subject to man-made impacts. If we add to the above said that in the recent past (in the XX century) the territory of the Republic of Azerbaijan, rich in natural resources, was used mainly as a source of raw materials, and at best for the primary processing of minerals, it becomes clear that this issue is becoming more important in our country. As a result, Azerbaijan

[3] Андроханов, В.А., Куляпина Е.Д., Курачев В.М. Почвы техногенных ландшафтов: генезис и эволюция. Новосибирск: Изд-во СО РАН, 2004, 151 с

has a significant number of land plots subject to pollution from man-made impacts, and the largest number of them is concentrated in the Absheron Peninsula. It is no coincidence that the Absheron Peninsula is one of the most arid regions of the Caucasus, as well as a critical area with geological and ecological problems, whose soil are not so fertile. Increasing the efficiency of land use in Absheron, where the capital of Azerbaijan-Baku, one of the largest cities of the country-Sumgait, as well as the largest industrial enterprises of the country are located, requires increased attention. Thus, it is no exaggeration to say that the soil of the Absheron Peninsula can also be characterized as an ecosystem under stress.

The result of what has been noted in Azerbaijan, both in the world and as part of it, has a negative impact on the biota of soils, and their role in the formation of biological productivity of soil is known from numerous studies. Soil biota includes organisms that differ in their ecological functions and taxonomic significance, which includes *"plants, fungi, bacteria, soil invertebrates, etc"*[4]. All these creatures are sensitive to anthropogenic and technogenic influences, but the degree of their susceptibility varies. Nevertheless, many studies have confirmed that microorganisms that are part of the soil biota, primarily bacteria and fungi, play an important role in the formation of biological fertility of soils, restoring their former state.

Bacteria and fungi are living creatures that play an important role in the biota of soils, so that the number of individuals of one and the amount of biomass of the second is higher than that of other living creatures included in the biota of the soil. The great importance of fungi, due to their share of participation in all ecological functions occurring in nature, opens up great prospects for their use in soil restoration, and now in some parts of the world it has even become possible to put this into practice. However, since the natural soil and climatic conditions of the area also play a role in these issues, sometimes the results obtained do not give the proper effect, depending on local specific conditions. Therefore, it is sometimes considered more promising to implement this in a

[4] https://www.soils4teachers.org/biology-life-soil/

specific region, with specific approaches.

Objectivies and tasks. The purpose of the presented work was devoted to the development of scientific and practical foundations for restoring the fertility of gray brown soils of Absheron according to microbiological indicators.

To achieve this goal, it was considered expedient to solve the following tasks:

- Assessment of the biota of fungi of gray brown soils of Absheron by numerical and species composition;
- Study of antagonists of fungi isolated from gray brown soils of Absheron to phytopathogens and selection of active producents;
- Improving the phytosanitary condition of soils from selected fungi crops as active producents and optimizing the conditions for obtaining substances that stimulate plant growth;
- Determination of the order of use of solids obtained from fungi that affect soil fertility.

Research methods. To achieve this goal, both classical and currently widely used methods by microbiologists were used in the course of the work. The degree of purity of the reagents used for various analyses, the accuracy of the instruments on which measurements are made, have become the basis for obtaining honest data. Setting up all the experiments in the studies in at least 4 repetitions allowed for statistical processing of the results obtained. However, for the degree of honesty of the experimental results, the formula $S/M=P\leq 0.05$ was considered basic.

The main provisions for defense are : Fungi involved in the formation of mycobiota in relatively clean soils of Absheron are characterized by a wide variety both in species composition and ecotrophic relationships, and in the forms of manifestation of their ecotrophic specialization;

- Although both phytopathogens and epiphytic microorganisms participate in the formation of the mycobiota of soils, there is an anatomism between them, which finds its high expression in species of the genus *Trichoderma*;
- Proper use of culture solution and suspension of spores

obtained from fungi of the genus *Trichoderma* is of fundamental importance for increasing germination and overall yield of seeds of various crops;

- A number of abiotic factors, primarily the moisture factor, is the main indicator limiting the viability of the spores contained in the preparation *Trichodermin*.

Scientific novelty of the research. In the course of the conducted studies, 324 strains were derived from relatively clean soils of Absheron, the rhizosphere of wild and cultivated plants growing there, samples from irrigated soils and their belonging to 67 species was established. It has been determined that 75 registered species of fungi have properties related to phytopathogens, toxigens and opportunistic pathogens to one degree or another, and 25 species -to species involved in the formation of epiphytic mycobiota of plants.

During the assessment of the nature of the relationship of fungi belonging to epiphytic mycobiota to phytopathogenic fungi, it was found that according to the 5-point evaluation system used, the greatest antagonism is observed only in strains of the genus *Trichoderma T.koningi* G-43 and *T. asperellum* G-3.

To obtain the maximum amount of biomass from strains selected as active producents among the fungi of the genus *Trichoderma*, it is advisable to use a Chapek medium in which the glucose content is 25-26 g/ l, NH_4NO_3 is 1.8-1.9% (nitrogen), the growing temperature is 28^0C, up to 5.7 initial acidity of the medium, it is advisable to use a suspension of spores as planting material obtained from biomass grown in bleached malt juice and cultured for 120 hours.

The culture solution (CS) obtained from active products in an environment optimized in accordance with its basic parameters and vegetative mycelium (VM) have antibiotic activity against strong phytopathogenic fungi such as *Alternaria alternata, Bipolaris nodulosa, Botrytis cinerea*, *Fusarium moniliforme* and *Fusarium oxysporum*, and in all cases have strong (>29), while moderate (20-29) activity is observed when using a VM.

Obtained from fungi *T.asperellum* G-3 and *T.koningi* G-43, selected as active producents, CS promotes plant growth, yield, etc.

during the clarification of its effect on properties, it was found that the germination of seeds of tomatoes, cucumbers, wheat and peas increases by 4.7-6.7%, for this purpose 50-fold spraying CS obtained from fungi under optimal conditions allows for more favorable results. Thus, 50-fold spraying leads to an increase in plant germination by 1.4-1.5 times in the fungus *T.asperellum* G-3 and by 1.3-1.8 times in the fungus *T.koningi* G-43 compared to the initial one.

It was found that the pretreatment of tomato seeds in CS before sowing affects both the morphometric dimensions of the plant and the yield per plant, as a result of which the yield per bush of the plant obtained from the fungus *T. asperellum* G-3, compared with the control, increased by 1.25 times, and the fungus *T. koningi* G-43 -1.20 times.

With sequential cultivation of such species of the genus *Trichoderma* as *T. harzianum* G-17 and *T. koningi* G-43 in deep and surface conditions on various nutrient media, the preparation Trichodermin was obtained, the density of which varies between 3.6-4.9 x 109 pcs/ l. the number of viable spores contained in it is 90-93%, humidity after drying is 6.3-6.7%. The resulting preparations completely retain their original activity for 4-6^{0}C when stored for 1 year, when this process is carried out at room temperature, the period is 3 months.

Theoretical and practical significance of the research. As a result of research, biologics obtained from fungi of the genus Trichoderma can increase the yield of agricultural crops, primarily tomatoes, cucumbers, beans, etc. At the same time, the use of these funds promises prospects for improving the phytosanitary condition and fertility of soils under stress in the conditions of Absheron.

Publication, approbation and implementation of the dissertation. A total of 17 scientific papers on the topic of the dissertation were published. The materials of the dissertation were presented at the Republican Scientific Conference "Modern Problems of Biology" (Sumgait, 2018), the scientific conference "Innovations in Biology and Agriculture to solve Global Challenges" (Baku, 2018), the scientific and practical conference "Actual problems of Modern Biology" (Baku, 2019), the conference "Trends in the XXXI international scientific and practical conference Development of Modern Science“ (Canada, Vancouver, 2021), Republican scientific conference “Ways to restore biodiversity in liberated territories” (Sumgait, 2022), at the Republican scientific and practical conference “New trends and innovations: Prospects for the development of microbiology in Azerbaijan” (Baku, 2022), International Scientific and Practical Conference “Actual issues of modern scientific research” (Russia F., Penza, 2023).

The organization in which the dissertation is performed. The dissertation work was carried out in the laboratories of microbiological biotechnology and biologically active substances of the Institute of Microbiology of Ministry of Science and Education of the Republic of Azerbaijan.

The structure and Scope of the dissertation. The dissertation work is written on the basis of generally accepted principles and consists of sections such as introduction, summary of literature (Chapter I), materials and methods (Chapter II), experimental part (Chapters III and IV), final analysis of research, main conclusions, list of literature used in the dissertation, and list of abbreviations used in the dissertation. All these mentioned consist of 150 computer pages and a total of 215300 characters.

LITERATURE REVIEW

CHAPTER I
FACTORS CAUSING STRESS IN SOIL, THEIR NEGATIVE IMPACT ON THE BIOLOGICAL PARAMETERS OF SOILS AND THE ROLE OF MICROORGANISMS IN ITS ELIMINATION

Section 1.1 of the dissertation provides information about stress factors and their characteristics, section 1.2 analyzes the influence of stress-forming factors on the biological indicators of soils, section 1.3 clarifies the role of microorganisms in restoring and increasing the fertility of soils under stress, and section 1.3 provides information about stress factors and their characteristics, first of all microbiological studies on the restoration of fertility of soils under stress on Absheron are analyzed and questions are clarified, important for the level of study and solution of the planned problem.

CHAPTER II
MATERIALS AND METHODS OF RESEARCH

2.1. General characteristics of the researched territories

The research was carried out on the Absheron Peninsula. The choice of the Absheron Peninsula is due to the fact that the country is a more densely populated place, and the soils are more susceptible to anthropogenic impact. Thus, 40% of the country's population and 70% of the industrial potential is concentrated on the Absheron Peninsula. On the Absheron Peninsula, with a total area of 222 thousand hectares, one of the main environmental problems is associated with soil pollution and their unsuitability. The total area of unusable land is 33 thousand hectares, of which about 1/3 is contaminated with oil. The main causes of environmental problems are oil and reservoir water pollution of the lands where oil and gas production and drilling are carried out, the formation of dirty lakes and ponds due to the uncontrollability of reservoir waters for many years, the accumulation of waste generated during oil refining in the areas. Sewage systems are one of the factors contributing to the emergence of environmental problems. In Baku, the largest city of the Absheron Peninsula, 560 million m^3 of wastewater is collected during the year, of which 164 million m^3 undergo biological treatment, and 23 million m^3-mechanical, but 373 million m^3 of them are discharged into the sea and inland reservoirs without treatment. Through them, oil products, suspended substances, inorganic compounds of various compositions, surfactants, phenols, etc.materials also enter the water bodies. It is no coincidence that the Absheron Peninsula is considered an ecological, *"critical area with geological problems"*[5].

2.2.Methods used for analysis

The samples for the study were taken from soils that are mainly located on Absheron, are generally considered relatively

[5] https://files.preslib.az/projects/eco/az/eco_m2_2.pdf

clean and are used for planting crops, and are also contaminated with oil. The corresponding samples were also taken from the lands located in the Kura-Araz lowland, where a comparative analysis was carried out. Sampling was carried out according to *"known methods"*[6]. Sampling was also carried out by families. In the samples taken, microscopic fungi were mainly separated, for which bleached malt juice and Saburo agar were used as a nutrient medium. Before transferring soil samples to the nutrient medium, a 10% suspension was prepared and passed into the nutrient medium through a sterile pipette, sometimes directly, and sometimes by dilution (10, 50 and 100 times). Cultivation was carried out in a thermostat with a temperature of 28^0C.

Since the colonies began to form, those that visually looked the same were transferred to a new nutrient medium, and the process continued until a homogeneous colony was obtained. The cleanliness of the colony was monitored using a microscope. Identification of the obtained pure cultures was carried out mainly by *"determinants"*[7,8] compiled on the basis of cultural, morphological and physiological characteristics of fungi.

The species of fungi bred and identified in pure culture were screened for antagonistic activity, or rather for their relation to phytopathogenic fungi, while the fungi *Altermnaria alternata, Biopolaris nodulosa, Botrytis cinerea, Fusarium moniliforme* and *Fusarium oxysporum* were used as test cultures. When performing these works, a *"5-point scale and rating system"*[9] of various authors was used.

The phytotoxic activity of fungi, their stimulating properties, and

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[6] Нетрусов А.И., Егорова М.А., Захарчук Л.М. и др. Практикум по микробиологии. М.: Издательский центр «Академия», 2005, 608 с.

[7] Саттон Д., Фотергилл А., Риналди М. Определитель патогенных и условно патогенных грибов/ - Москва: Мир, 2001, 486 с.

8 Kirk, P.M. Cannon P.F., Minter D.W. et al.Dictionary of the fungi. -UK, 2008, 747 p

[9] Садыкова В.С. Экология грибов рода *Trichoderma* (Pers: Fr.) бассейна реки Енисей, их биологические свойства и практическое использование. Дисс... д.б.н. Москва, 2012, 417 с.

the effect of stressors were carried out mainly by *"known methods"*[10,11,12,13] both in the field, laboratory, and in closed condition.

All experiments were performed in at least 4 repetitions, and the results obtained were processed *"statistically"*[14].

CHAPTER III
SPECIES COMPOSITION OF THE MYCOBIOTA OF ABSHERON SOIL, THE ROLE OF STRESSORS INVOLVED IN THE FORMATION OF MYCOBIOTA

3.1. Study of the microbiota of the researched territories by species composition, eco-trophic relations and forms of ecotrophic specialization

From 300 samples taken in total from the studied territories, 324 strains were bred into pure culture and their species composition was determined (Table 1). Apparently, the strains isolated from Absheron Peninsula, as well as samples taken for comparison from the Kura-Araz lowland, belong to 75 species.

Table 1

Quantitative characteristics of the distribution of registered fungi by individual taxa

Branch	Class	Range	Family	Genus (species)
2	5	9	12	23(75)

[10] Baxşəliyeva, K.F. Azərbaycanda yayılan toksigen göbələklərin ekobioloji xüsusiyyətləri/biologiya üzrə elmlər doktorluğu dissertasiyanın avtoreferatı/ - Bakı, 2017, -45 s.

[11] Методы экспериментальной микологии / Под. ред. Билай В.И. Киев: Наукова думка, 1982, 500 с.

12 Соромотина, Т.В. Практикум по овощеводству / Т.В. Соромотина. – Пермь: ИПЦ «Прокрость», 2016. – 305 с.

[13] Литвинов, С.С. Методика полевого опыта в овощеводстве. -М: -2011. - 650 с.

[14] Кобзарь А.И. Прикладная математическая статистика. М.: ФИЗМАТЛИТ, 2006, 816 с.

Screening of registered fungi was initially carried out on the basis of literature data, and in various studies, species were selected whose phytopathogenicity, as well as severe toxicity, is unknown, i.e. those that are mainly involved in the formation of epiphytic, and saprotrophic mycobiota of plants. It was clear that among the registered fungi there are toxigens (for example, *Aspergillus flavus, Aspergillus fumigatus*, species belonging to the genus *Fusarium, Penicillium citrinum, Penicillium cuclopium,* etc.).), *Phytopathogens (Ascochyta pisi, Alternaria alternata, Botrytis cinerea, Colletotrichum lagenarium, Erysiphe communis, Fusarium moniliforme, Fusarium solani, Sclerotinia sclerotiorum, Septoria melongenae, Trichothecium roseum, Verticillium dahliae,* etc.) and opportunists (*Aspergillus niger, Candida albicans, mucor hiemalis, Penicillium notatum,* etc.). The use of fungi with these properties was not considered appropriate at a later stage of research. In accordance with the purpose of the study, 25 species were selected *[Aspergillus*(4 species), *Mucor*(4), *Pencillium*(5), *Trichoderma*(5), *cephalosporium* (1), *Gliocladium*(1), *Sordaria*(2), *Aureobasidium*(1), *Chaetomium*(1) and *Rhizopus*(1)] of 10 genera. The number of species belonging to the fungal genera selected for this stage ranges from 1-5, so that the genera *Penicillium* and *Trichoderma* are characterized by the maximum indicator in this matter.

3.2. The effect of abiotic stressors on the growth of fungi

From studies with living creatures belonging to various taxonomic groups, it became clear that all abiotic factors that cause stress (salinity, temperature, lack of water, etc.)) for growth, productivity, etc. they negatively affect their performance. Taking this into account, in the course of the research, the issues related to the elucidation of the influence of abiotic stress factors on the growth of selected fungi in laboratory conditions were clarified. From the studies conducted in this regard, it became clear that the influence of stressors (temperature, salinity and humidity) on fungi is different, in the formation of which both the biological characteristics of fungi and the nature of stressors play a certain role. Thus, the vast majority of the selected fungi belonged to *mesophiles* (that is, to those whose optimal temperature for growth is in the range of 26-30^{0}C) in relation to temperature, so that only 2 species of fungi selected for the next stage of research (*Aspergillus versicolor* and *Mucor cornealis*) had an optimal temperature index for growth above 30^{0}C. As for salinity, the vast majority refers to *mesohalophiles*, that is, they retain their viability at a salinity of up to 20%, and at a salinity of 2-10%, there is no weakness in their growth. The lethal dose of salinity for some fungi was even higher than 20%.

Studies on the influence of some of the stress factors (moisture, pollution, irrigation, etc.) were carried out in the field conditions, and the assessment was carried out according to the number of fungi. From the results obtained, it became clear that even with the moisture content of the selected soils less than 10%, there are units that give rise to fungal colonies (100-150 CFU/g of soil). Nevertheless, the presence of relatively clean soils selected within 22-30% humidity leads to the fact that the fungi are characterized by a maximum index of numerical composition (6.5-7.7x10^3 CFU/g). As for the nature of residual contamination, it follows from the results obtained that the number of fungi on relatively clean soils is characterized by a higher indicator. So, on relatively clean soils, close to the quantitative indicator of humidity, the number of fungi is 7. 2x10^3, on irrigated soils - 4. 3x10^3, and on oil-contaminated soils-2.6x10^3 CFU/g.

From the studies conducted at this stage, both in the field and in the laboratory, it became clear that fungi, both individual species and general-purpose fungi, with certain indicators of abiotic stressors, are able to perform their functions. It also promises certain prospects for their use in the management of the necessary land indicators

3.3. Annotated list of fungi registered in researches

An annotated list of 75 species of fungi registered in the studies was determined based on information about their current name and the substrates on which they were isolated.

CHAPTER IV
BIOLOGICAL ACTIVITY OF SPECIES INVOLVED IN THE FORMATION OF THE MYCOBIOTA OF ABSHERON AND THEIR USE TO IMPROVE THE FERTILITY OF SOIL UNDER STRESS

4.1. Evaluation of fungi registered in researches by biological activity

After the initial screening, the selected fungi species were evaluated for their use in restoring the fertility of soils under stress, which was associated with clarifying their relationship to phytopathogenic fungi. From the results obtained, it became clear that among the selected fungi there are also fungi that have antagonistic relations with phytopathogenic fungi, but the degree of its activity is different (Table 2). Apparently, fungi of the genus *Trichoderma* can be considered promising in this aspect, having reached the highest point of their development in *T.koningi G-43* and *T.asperellum G-3* strains. Based on this, the mentioned strains of fungi were considered the most active as a result of this stage of research, and they were used in subsequent studies.

Table 2

Evaluation of the fungi selected in the studies according to their relationship with the phytopathogen (on a 5-point scale)

Tested genera of fungi (number of strains)	Phytopathogenic fungus				
	Alternaria alternata	*Bipolaris nodulosa*	*Botrytis cinerea*	*Fusarium moniliforme*	*F.oxysporum*
Aspergillius(14)	1-2	1-2	1-2	1-2	1-2
Mucor(12)	1-2	1-2	1-2	1-2	1-2
Pencillium(15)	1	2	1	1	2
Trichoderma(16)	3-5	3-5	2-4	4-5	4-5
Cephalosporium (1)	3	2	2	3	3
Gliocladium(1)	3	3	3	3	3
Sordaria(3)	2-3	1-2	2	1-3	2
Aureobasidium(1)	2	1	2	1	1
Chaetomium(1)	1	2	2	1	1
Rhizopus(2)	1	1	1	1	1

4.2. Finding optimal conditions for the growth of active producents

It should be noted that BAS for various purposes from fungi were used either from the fruiting body formed by them in natural conditions, from the biomass formed by them in the vegetative growth phase, as well as from the culture solution left after separating the formed biomass. Due to the fact that none of *T.koningi* G-43 and *T. asperellum* G-3 fungi selected in the studies did not form a fruit body under natural conditions, studies were carried out on finding an environment that allows maximum biomass output for them. For this purpose, Chapek medium was used, which was optimized for carbon and nitrogen sources, cultivation temperature, initial pH, etc., and it was determined that the optimal medium parameters for them were very close (table. 3).

Table 3

Optimal conditions necessary for growing fungi *T.asperellum* G-3 and *T.koningi* G-43

Producent	Carbon source (g/l)	Nitrogen source (g/l)	Growing temperature	pH	Inoculum	Cultivation time (hours)
T.asperellium G-3	Glucose (25,0)	NH_4NO_3 (1,8)	28^0C	5,7	BMJ, suspension of spores	120
T.koningi G-43	Glucose (26,0)	NH_4NO_3 (1,9)	28^0C	5,7	BMJ, suspension of spores	120

Culture solution (CS) and biomass (BM) obtained from the fungus were also evaluated for antibiotic activity in the mentioned optimal environment. In this case, the Chala method was used and it was clear that both CS and BM obtained in the fungus have antibiotic activity against the phytopathogenic fungi tested, and the results recorded in all cases are characterized by a higher form of expression in the BM (table. 4). Apparently, the use of CS is characterized as strong in all cases in relation to phytopathogens, and the use of BM is characterized as moderate activity. Thus, according to the adopted rules, the dialysis zone up to 20 mm is characterized as weak, between 20-29 is medium, and above 29 is characterized as strong activity

Table 4

Antibiotic activity of CS and BM fungi *T. asperellum* G-3 and *T.koningi* G-43 (mm)

Producent	Means	Phytopathogenic fungi				
		Alternaria alternata	*Bipolaris nodulosa*	*Botrytis cinerea*	*Fusarium moniliforme*	*F.oxysporum*
T.asperellum G-3	CS	31	35	30	31	32
	BM	26	28	24	25	23
T.koningi G-43	CS	30	34	31	32	30
	BM	27	29	25	25	26

4.3. Influence of fungi selected as active producents on plant growth and productivity

In the studies carried out, the effect of CS obtained from *T.asperellum* G-3 and *T.koningi* G-43 fungi, selected as active produsent, on the growth, productivity, etc.characteristics of plants was studied. In studies conducted in this direction, the influence of CS obtained from the mentioned fungi on both seed germination and final yield has been clarified. In the course of clarifying the effect of CS from fungi on the germination of plant seeds, primarily seeds of tomatoes, cucumbers, wheat and peas, it became clear that both strains have a positive effect on the germination of plant seeds (Table 5). As can be seen, it increases significantly compared to the control, but there are also some quantitative differences depending on the seeds, the source of the preparation. For example, the effect of CS from the fungus *T. asperellum* G-43 is 4.7-6.7%, depending on the tested plants.

Table 5

The effect of CS of plant seeds from fungi on germination

№			*T.asperellum* G-3		*T.koningi* G-43	
			Number of germinated seeds (pcs)	The effect of increasing the proportion to control (%)	Number of germinated seeds (pcs)	The effect of increasing the proportion to control (%)
1	Tomatoes/control	250	224/209	6,7	220/209	5,0
2	Cucumber / control		211/201	4,7	214/201	6,1
3	Wheat / control		230/215	6,5	228/215	5,7

It should be noted that from the studies conducted to clarify the effect of the CS density obtained during fungi cultivation on seed germination, it became clear that higher results are obtained when using fungi in deep cultivation by 50-fold rinsing of 5-day CS (Table 6). Apparently, a 50-fold dilution of the resulting CS leads to an increase in plant germination by 1.4-1.5 times in the fungus *T.asperellum* G-3 and by 1.3-1.8 times in another fungi compared to the original one, which causes the mention of CS obtained from both fungi as favorable for use with 50-fold rinsing of sterile with water.

Table 6

The effect of various CS solids obtained from fungi on the germination of plant seeds

№		*T.asperellum* G-3				*T.koningi* G-43			
		The effect of the diluted solution of CS on the germination capacity of seeds (due to the growth effect relative to the control, %)							
		0	10	50	100	0	10	50	100
1	Tomatoes	6,7	8,3	9,5	9,1	5,0	7,4	9,2	8,8
2	Cucumbers	4,7	5,6	7,0	6,2	6,1	6,9	7,7	7,3
3	Wheat	6,5	8,6	9,4	8,6	5,7	6,7	8,9	8,5

At the next stage of the research, it was also carried out to clarify how the primary processing of seeds with CS before sowing affects the overall productivity of plants, and as a control, the approach currently used in the primary processing of seeds during the cultivation of plants was taken as a basis and these experiments were carried out. From the results obtained, it was clear that the initial processing of tomato seeds in CS leads to a change in both the morphometric dimensions of the plant and its productivity per unit plant in a positive way (Table 7). As it turned out, according to all indicators, CS from the fungus *T. asperellum G-3* leads to an increase in productivity per unit plant bush by 1.25 times compared to control, and in the fungus *T.koningi* G-43 -by 1.20 times.

Table 7

The effect of CS obtained from fungi on morphometric indicators and overall yield of a tomato plant

№	Producent	Height measurement of the plant (first/last, sm)	Flowering time of the plant	Yield per unit plant (kg)
1	*T.asperellum* G-3	12±1/95±2	31±1	2,5±0,08
2	*T.koningi* G-43	12±1/94±2	32±2	2,4±0,02
3	Control	12±1/88±2	33±1	2,0±0,08

4.4. Phytopathogenic fungi and their influence on plant productivity

Plants, especially cultivated plants, lose their biological productivity every year for various reasons, which plays an important role in the occurrence of diseases caused by various living beings, including fungi. From mycobiota studies of tomatoes, potatoes, beans, eggplant, cucumbers, corn, peas and pumpkin in the Greater Caucasus, i.e. Absheron Peninsula, as well as in the Kura-Araz lowland, it became clear that phytopathogenic fungi such as *A.alternata, A.solani, B.cinerea, C.melongenae, F.avenaceum, F.culmorum, F.gibbosum, F.oxysporum, F.solani, S.sclerotiorum, St.ilicis, T.roseum, V.dahliae* and others are involved in the formation of mycobiota of all mentioned plants and they cause diseases such as spottyness, alternariosis, fusariosis, septoriosis, mealy dew and others in host plants. As a result of these diseases, both the overall productivity of the mentioned plants decreases and the quality indicators of the products produced deteriorate. For this reason, in most parts of the world, studies are carried out aimed at limiting these issues, primarily the activity of microorganisms causing diseases in cultivated plants, and the preparation of effective measures to combat them, and the results obtained are applied. In these applied studies, chemical and biological methods of combating disease pathogens are used. So, in order to limit the activity of causative agents of diseases, it is necessary to remove the soil, as well as various fungicides, insecticides, pesticides, etc.in the plants themselves.they use the preparation, many of which are also obtained chemically. Most chemical remedies do not have a selective effect, and they cause the destruction of useful organisms and contribute to the emergence of environmental problems. For this reason, the growing demand for biological methods of struggle is growing, and the fact that this method of struggle is favorable for environmental considerations is gaining more supporters among both theorists and practitioners. Among the fighting measures developed in this direction, the relationship between microorganisms, especially the selective antagonism to be controlled, are some of the issues of particular focus.

4.5. Possibilities of using biomass of fungi of the genus *Trichoderma*

Many species of fungi of the genus *Trichoderma* have an antagonistic relationship with phytopathogenic fungi and use these properties of them to improve the phytosanitary state of agrocenoses. The effect obtained during the application of these preparations is also influenced by biotic and abiotic factors specific to the regions where these agrocenoses are located, and in a number of cases, fungal strains separated from local conditions are relatively more effective when used in those areas. Taking this into account, in the course of research, studies were carried out aimed at obtaining similar preparations from fungi of the genus *Trichoderma* extracted into pure culture. For this purpose, its species such as *T.harzianum* and *T.viride* of the genus *Trichoderma*, which were extracted into pure culture, were used in studies. It was carried out to use as trichodermin a suspension made from spores formed as a result of storage of biomass obtained in deep cultivation conditions from fungis in a thermostat using various nutrient media. More precisely, as a result of successive deep and superficial cultivation, there was an abundant formation of spores and its use as trichodermin. As a result, a period of 90 hours for *T.viride* and 96 hours for *T.harzianum* was considered optimal for abundant spore formation. Thus,the amount of spores formed by the fungus *T. koningi* and counted in the chamber during this period was $3.8\text{-}4.9 \times 10^9$ pcs/l, and in the fungus *T.harzianum* $-3.6\text{-}4.6 \times 10^9$ pcs/l. The number of spores in the obtained viable preparations is 90-93%, the moisture content after drying is 6.3-6.7%. The resulting preparations, when stored at $4\text{-}6^0$C, fully retain their original activity for 1 year, when this process is carried out at room temperature, the period is 3 months (Table 8). As a result of the methodological approach applied as a result of the studies carried out at this stage, it allowed to shorten the duration of the processes intended for taking the preparation and to use the preparation for a longer period of time.

Table 8

The effect of the storage conditions of the obtained preparation on its viability (%)

preparation		Duration (month)							
		3	4	5	6	7	12	18	24
TH-1	A	100	80	56	25	0	0	0	0
	B	100	100	100	100	100	100	90	71
TK-1	A	100	76	50	20	0	0	0	
	B	100	100	100	100	100	100	82	65

A – at room temperature
B – at 4-6^{0}C

FINAL ANALYSIS OF THE RESEARCH

The territory of the Republic of Azerbaijan, which is part of the world, is 86.6 thousand km^2. "*77% of it is also currently used for one purpose or another. Of the lands suitable for agriculture (4,200 thousand hectares), 44% are arable land, 4% are perennial plantations, 26% are hayfields and pastures. And those that are not used in agriculture make up up to 40% of the land fund*" [https://gsaz.az/articles/view/81/Azarbaycan-torpaqlari]. In general, the land area per capita in Azerbaijan is about 1 hectare, and gradually this figure will decrease, so that population growth is a natural process. The above-mentioned problems are not alien to the Republic of Azerbaijan either, as cases of salinization, pollution, and soil fertility decline are also found in Azerbaijan, which is relatively noticeable in the Absheron Peninsula. On the Absheron Peninsula with a total area of 222 thousand hectares, two of the 3 largest cities of the country are located here, and this region is one of the most arid zones of the Caucasus. In addition, it is here that most of the country's industrial potential is located. As a consequence of all this, currently 33 thousand hectares of land in the Absheron Peninsula are more or less polluted. Therefore, there is a need to take a more careful approach to the use of lands located in this region and increase their productivity.

Taking into account the above said, the presented work sets as a goal the possibility of using microorganisms, primarily fungi, spreading on the Absheron itself, in restoring the fertility of soils under stress in the Absheron Peninsula.

During the implementation of the tasks considered important for the realization of the set goal, samples were first taken from the lands of different nature(relative clean, polluted, irrigated, etc.) in Absheron Peninsula, some agricultural plants, as well as soil and plants in Kura-Araz lowland for comparison.

As a result of the analysis of the samples taken, a total of 75 species of fungi were isolated. also, a total of 25 species were selected for the next stage, more or less corresponding to the purpose of the work. The fact that the remaining fungi were not used at a later stage of research was due to their belonging to toxigens, phytopathogens and opportunists.

From studies conducted both in the field and in the laboratory to clarify the effect of abiotic stressors on fungi, it became clear that among the fungi there are species resistant to stressors, the expediency of their use in the future in the management of soils under stress has been established.

Studies to identify anatomical relationships of 25 species selected at the initial stage of research with strong phytopathogenic fungi have shown that the species of fungi of the genus *Trichoderma* are characterized by relatively high rates, and for these purposes it was found that the use of fungi *T. koningi* G-43 and *T.asperellum* G-3, of which, as well as the fungi *T. harzianum* G-17, is more favorable is the optimal environment and conditions for purchase found. It has been experimentally proved that the culture solution obtained from these fungi, as well as its biomass, are favorable for use in stressful conditions, that is, when growing crops, primarily tomatoes, in Absheron Peninsula. The result of all this is expressed in the following 7 conclusions and 2 practical recommendations.

RESULTS

1. 324 strains were extracted from the relatively clean lands of Absheron, the rhizosphere of wild plants growing there, irrigated and oil-polluted lands, the risosphere of cultivated plants (tomatoes, cabbage, cucumbers, various greens, etc.), and for comparison, from the samples taken from the territory of the Kura-Araz lowland, and their belonging to 75 species were determined. 50 registered species of fungi were to some extent related to phytopathogens, oxygenates and conditionally pathogenic, and 25 species were species involved in the formation of epiphytic mycobiota of plants.
2. During the evaluation of fungal species belonging to the epiphytic mycobiota, according to the antagonism between them and phytopathogenic fungi, it was revealed that according to the 5-point evaluation system used for these purposes, only strains of the genus *Trichoderma T.koningi* G-43 and *T.asperellum* G-3 have the greatest antagonism (5 points).
3. To obtain the maximum amount of biomass from strains selected as active producers among the fungi of the genus *Trichoderma,* it is advisable to use a Chapek medium, the presence of the following components in it is considered optimal: Glucose – 25-26 g / l, NH_4 NO_3 – 1.8-1.9% (according to nitrogen), growing temperature – 28^0C, pH = 5.7, the planting material is a suspension of spores from biomass grown in bleached malt juice, and the cultivation time is 120 hours.
4. The culture solution (CS) obtained from active producents in an environment optimized in accordance with its basic parameters and vegetative mycelium (VM) have antibiotic activity against phytopathogenic fungi such as *Alternaria alternata, Bipolaris nodulosa, Botrytis cinerea, Fusarium moniliforme* and Fusarium oxysporum, and in all cases have strong (>29) action when using CS, while the use of VM is accompanied by moderate (20-29) activity.

5. The research results showed that the active CS product obtained from selected fungi *T.asperellum* G-3 and *T.koningi* G-43 affects plant growth, yield, etc. during the clarification of its effect on properties, it was found that the germination of seeds of tomatoes, cucumbers, wheat and peas increases by 4.7-6.7%, with this the goal of 50-fold spraying of km obtained from fungis under optimal conditions allows to obtain more favorable results. So, 50-fold spraying reduces the germination of plants compared to the initial one taken from the fungus *T. asperellum* G-3 by 1.4-1.5 times, i.e. on the other hand, *T.koningi* G-43 causes an increase of 1.3-1.8 times.
6. It was found that the initial processing of tomato seeds with CS before sowing affected both the morphometric dimensions of the plant and the yield per unit plant, in which the CS obtained from the fungus *T. asperellum* G-3 increased the yield per unit plant bush by 1.25 times compared with the control, and in *T. koningi* G-43 by 1.20 times.
7. During the consistent cultivation of the species of *Trichoderma* genus *T.harzianum* and *T.viride* in deep and superficial conditions in different nutrient media,the concentration of trichodermin ranging from 3.6-4.9 to 109 pcs/l was obtained, the number of viable spores of the spores contained in it is 90-93%, the moisture after drying is 6.3-6.7%. When stored at 4-6^{0}C, the preparations fully retain their initial activity for 1 year, when this process is carried out at room temperature, the period is 3 months.

PRACTICAL TIPS

1. In order to obtain a biological product to increase crop yields, it is more appropriate to separate this source from the appropriate place, and this can also be applied to soils under stress.
2. In order for the preparation obtained from fungi of the genus *Trichoderma* and given the common name "*Trichodermin*"

to be used throughout the year, it is extremely important to take into account the storage temperature and humidity that it possesses during storage. Thus, an increase in temperature above 10^0C and humidity above 8% can reduce the activity of the preparation for a shelf life of up to 3 months.

THE LIST

of published works on the topic of the dissertation

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