ANTIMICROBIAL ACTIVITY OF ACTINOBACTERIA ISOLATED FROM WATER COLUMN AND BIOFILM OF THE LAKE SYSTEM LA IZVOR (REPUBLIC OF MOLDOVA)

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Abstract. The paper deals with the research results of studies of antimicrobial activity of actinobacteria isolated from water column and biofilm of the lake system La Izvor (Republic of Moldova). Antimicrobial activity of 34 strains of actinobacteria (*Actinomadura*, *Actinoplanes*, *Frankia*, *Geodermatophilus*, *Micromonospora*, *Nocardia*, *Rhodococcus*, *Streptomyces*) was determined by the disk diffusion method, as test cultures served pathogenic bacteria and fungi which are common on territory of Republic of Moldova and cause diseases of crops. According to results of antibacterial activity, the diameter of growth inhibition zones varied from 9.0 to 16.3 mm (active strains are represented by genera *Streptomyces* and *Micromonospora*). The best results of antifungal activity were noted by strains of genera *Actinomadura*, *Actinoplanes*, *Micromonospora*, and *Streptomyces*. Diameter of growth inhibition zones of such phytopathogenic fungi as *Alternaria alternata*, *Aspergillus niger*, and *Fusarium solani* varied within 20.7-24.0 mm. New strains of *Actinoplanes*, *Actinomadura*, *Micromonospora*, and *Streptomyces* will replenish the National Collection of Non-pathogenic Microorganisms of the Institute of Microbiology and Biotechnology.

Keywords: actinobacteria; water column; biofilm; antibacterial activity; antifungal activity.

INTRODUCTION

The natural community is the most important reservoir of potential microbial resources and cannot be replaced by any of the most complete and carefully maintained microbial collections. Only it can serve as a source of microbial objects for various kinds of research and its valuable components. Resources of bacteriological material, the most available for present biotechnological purposes, consist not only of collection strains, but also of natural communities [60].

For example, actinobacteria occupy the largest place among microorganisms – potential sources of antibiotics [27]. It is well known that up to 80% of the currently known antibiotics are synthesized by streptomycetes [53].

At present, an active interest in streptomycetes as an inexhaustible source of various natural biologically active substances has arisen again. It is believed that the chemical diversity of biologically active compounds produced by streptomycetes arose as a result of their interaction in nature with many other organisms [30, 31, 36, 37, 48]. The high activity of streptomycetes against representatives of the genera *Fusarium*, *Verticillium*, *Rhizoctonia*, *Botrytis*, and *Alternaria* was especially noted [8, 28, 36, 49, 54, 58].

Screening, synthesis, production of biologically active substances and natural products by microorganisms represents one of the most important research trends in biopharmaceutical research around the world [5, 34, 56].

Microorganisms play a huge role in the control of plant diseases. The last decades of research into the biological control of plant pathogens have received a great boost, which is associated with the risk of using synthetic pesticides. Therefore, a promising element of modern agroecology is the use of preparations based on microorganisms or their metabolites, which exhibit phytoprotective and growth-regulating properties, increase plant resistance to pests, diseases and stress factors [23, 43, 55].

Currently, approximately 1500 different pathogens, more than 10000 insect species, 1500 nematode species and over 1800 weed species cause significant damage to cultivated plants. Bacterial, fungal and viral plant diseases cause significant damage to agricultural production. Despite the annual costs aimed at combating plant diseases, up to 80% of the crop dies during the years of epiphytotics [33, 41].

An important task of modern biotechnology is the development of safe and effective means in the fight against pathogenic microorganisms. One of the solutions to this problem involves the widespread use of preparations based on actinobacteria and their metabolites, which are active against a wide range of phytopathogens. Actinobacteria are considered in recent years as the most important source of biologically active substances of various chemical origins. For example, out of 23000 registered biologically active secondary metabolites produced by microorganisms, more than 10000 compounds are produced by actinobacteria, which is 45% of all biologically active metabolites of microbial origin. Moreover, it should be noted that these metabolites can play the role of antibiotics, immunosuppressants, insecticides, and fungicides [26, 54, 55].

As a result of several years of research, strains of actinobacteria with antibiotic properties were isolated from Lake Baikal. Among them were representatives of the genus *Streptomyces*, *Saccharopolyspora*, *Nonomuraea*, *Rhodococcus*, and *Micromonospora*. Some strains have shown antimicrobial activity against Gram+ and Gram- bacteria, yeasts; and are of interest for both biopharmacy, and biotechnology of insecticides and fungicides [2, 3, 44, 52].

Thus, actinobacteria are considered as potential agents of biocontrol in comparison with chemical preparations, in particular, pesticides in the cultivation of cereals, vegetables, and other crops. Biological control and activation (stimulation) of plant growth by beneficial microorganisms are also taken into account as an alternative to the use of not only pesticides, but also fertilizers.

Actinobacteria and fungi are known to naturally associate with plants and have a beneficial effect on plant growth by relieving both biotic and abiotic stresses [12, 42, 45, 50, 55].

According to the largest modern natural scientist, a classic of microbiology, academician Zavarzin G.A., functions of fungi and actinobacteria are very close in the ecosystems. Both of these groups of microorganisms have a powerful secretion of exoenzymes, are able to hydrolyze stable biopolymers that are inaccessible to other organisms, despite the fact that the chemical and cytotoxic bases of fungi and actinobacteria are completely different [60].

Actinobacteria in the scientific world are an important chain in obtaining half of the known metabolites as antibiotics and antitumor agents [9, 16].

Nowadays, the agriculture of the Republic of Moldova is facing challenges. Yield loss is mainly associated with diseases caused by various phytopathogenic bacteria and fungi.

The following are common examples: *Agrobacterium tumefaciens* – the causal agent of crown gall disease (the formation of tumours); *Bacillus subtilis* – caused potato disease of bread; *Clavibacter michiganensis* – the causative agent of soft rot disease on tomato; *Erwinia carotovora* – the agent of soft rot disease; *Xanthomonas campestris* –caused black rot; *Alternaria alternata* – caused black spot on numerous crops; *Aspergillus niger* – the agent of black mold on various plants; *Botrytis cinerea* – had a very wide range of host plants in which various tissues and organs are infected, it caused gray mold of fruits, berries and vegetables both in greenhouses and in open field; *Fusarium oxysporum* – cause *Fusarium* Wilt in many horticultural crops; *Fusarium solani* – caused root rot diseases.

Thus, the purpose of this study was to determine the antimicrobial activity of new strains of actinobacteria isolated from the aquatic environment of the lake system La Izvor in relation to phytopathogenic bacteria and fungi, common on the territory of the Republic of Moldova.

MATERIALS AND METHODS

Research area was located in the lake system La Izvor (Republic of Moldova, Municipality of Chisinau). The geographical coordinates of lakes where samples were collected are: 1) 47°02'44.2"N, 28°47'18.9"E; 2) 47°02'53.7"N, 28°47'42.5"E; 3) 47°02'59.6"N, 28°47'59.3"E. Altogether 11 points were sampled in June and August 2020. Random samples were collected in sterile bottles from water column and biofilm. The samples were not pre-treated. After that, serial dilutions were carried out using distillate water to dilute the samples to 10^{-1}, 10^{-2}, and 10^{-3} [22, 59].

For study were isolated 8 genera on special selective nutrient media in Petri dishes by inoculation of diluted samples:

Actinomadura – soluble starch (20.0 g/L); K_2HPO_4 (0.5 g/L); $MgSO_4$ (0.5 g/L); KNO_3 (1.0 g/L); NaCl (0.5 g/L); $FeSO_4$ (10.0 mg/L); streptomycin (50 mcg/mL); nystatin (50 mcg/mL); agar; pH=7.2-7.4.

Actinoplanes – oatmeal (2.5 g/L); K_2HPO_4 (1.0 g/L); KCl (0.5 g/L); $MgSO_4*H_2O$ (0.5 g/L); $FeSO_4*7H_2O$ (0.01 g/L); streptomycin (50 mcg/mL); nystatin (50 mcg/mL); agar; pH=7.0.

Frankia – propionic acid (0.5 g/L); NH_4Cl (0.1 g/L); $CaCl_2*2H_2O$ (0.1 g/L); $MgSO_4*H_2O$ (0.2 g/L); $NaH_2PO_4*2H_2O$ (0.67 g/L); agar; pH=6.8-7.2.

Geodermatophilus – yeast extract (1.0 g/L); glucose (1.0 g/L); soluble starch (1.0 g/L); $CaCO_3$ (1.0 g/L); streptomycin (50 mcg/mL); nystatin (50 mcg/mL); agar; pH=7.0.

Micromonospora – soluble starch (20.0 g/L); K_2HPO_4 (0.5 g/L); $MgSO_4$ (0.5 g/L); KNO_3 (1.0 g/L); NaCl (0.5 g/L); $FeSO_4$ (0.01 g/L); gentamicin (1 mcg/mL); streptomycin (25 mcg/mL); agar; pH=7.2-7.4.

Nocardia – $NaNO_2$ (2.0 g/L); Na_2CO_3 (1.0 g/L); K_2HPO_4 (0.5 g/L); gentamicin (1 mcg/mL); agar; pH=7.0.

Rhodococcus – KNO_3 (1.0 g/L); K_2HPO_4 (1.0 g/L); KH_2PO_4 (1.0 g/L); NaCl (1.0 g/L); $MgSO_4*H_2O$ (0.2 g/L); $CaCl_2*2H_2O$ (0.2 g/L); $FeCl_3$ (0.0001 g/L); yeast extract (1.0 g/L); propionic acid (0.5 g/L); levomycetin (20 mcg/mL); agar; pH=7.0.

Streptomyces – glucose (20.0 g/L); KNO_3 (1.0 g/L); NaCl (0.5 g/L); $MgSO_4$ (0.5 g/L); K_2HPO_4 (0.5 g/L); $CaCO_3$ (3.0 g/L); streptomycin (50 mcg/mL); agar; pH=6.8-7.0.

As result were isolated 34 strains of actinobacteria group. After purification by several passages on selective media, the strains were tested for determination of potential antimicrobial activity.

The selected strains were subcultured for 2 weeks on agar medium Gause at 28°C in Petri dishes to obtain a bacterial lawn with diffusion of antimicrobial substances in agar substrate [15].

In order to evaluate the biocidal activity of actinobacteria, various plant pathogens were taken for research. Antibacterial efficacy was tested against *Agrobacterium tumefaciens* (*Rhizobium radiobacter*) 8628, *Bacillus subtilis* B-117, *Clavibacter michiganensis* (*Corynebacterium michiganense*) 13[a], *Erwinia carotovora* (*Pectobacterium carotovorum*) 8982, *Xanthomonas campestris* 8003[b]; while antifungal activity was tested against *Alternaria alternata*, *Aspergillus niger*, *Botrytis cinerea*, *Fusarium oxysporum*, *Fusarium solani* [10, 35, 47, 61]. Antifungal and antibacterial activities have been tested on these cultures, as these pathogens cause severe disease and cause losses to many agricultural crops in the Republic of Moldova.

Phytopathogenic bacteria tests were subcultured on nutrient agar (pH: 7.0-7.5), and fungi tests were subcultured on wort agar (5.0 Blg, pH: 5.8-6.0) [32].

The biocidal activities were determined by the disk diffusion method. The tested cultures were subcultured in Petri dishes. The 8 mm agar blocks were cut with a sterile cork borer from the nutrient substrate where the strains of *Actinobacteria* spp. grew abundantly. The agar blocks were then transferred to prepared cavities in agar nutrient medium with instantly subcultured tests. Petri dishes were kept in a cool place for 1 hour before incubation to allow the diffusion of biocidal substances. The diameter of the growth inhibition zones was measured after incubation at 37°C for 24 h for bacteria, and at 28°C for 72 h for fungi, respectively [15, 46].

RESULTS

Determination of the inhibition activities of the actinobacteria isolates showed a vary inhibition zones of 9.0 to 16.3 mm in diameters (Tabel 1), and these were practically strains assigned to the genus *Streptomyces* (strains A 8.2 - A 8.9), and only 2 strains from the genus *Micromonospora* (strains A 5.1 and A 5.3). From the 8 strains of *Streptomyces*, 5 strains had the ability to inhibit the growth of 5 test cultures with varying degrees. The best results were seen in strains *Streptomyces* A 8.2 and A 8.8, which metabolites caused the formation of growth inhibition zones from 9.7 to 16.0 mm. The ability to inhibit the growth of these phytopathogenic bacteria was also noted by strain *Micromonospora* A 5.1 (with inhibition zones from 9.7 to 14.3 mm in diameter).

Nine strains of actinobacteria isolated from the biofilm showed low to moderate activities of antibacterial, with only 3 strains (*Micromonospora* B 5.1, *Streptomyces* B 8.1, and *Streptomyces* B 8.3) showed the ability to inhibit the growth of test bacteria with a diameter of 9.0-15.3 mm. Strain *Streptomyces* B 8.3 deserves special attention, which delays their growth by 11.7-15.3 mm (Table 2).

The lack of antibacterial properties was found in actinobacteria isolated from the water of the lake system La Izvor; there was practically no such properties in representatives of the genera *Actinomadura* (2 strains), *Actinoplanes* (3 strains), *Frankia* (1 strain), *Geodermatophilus* (3 strains), *Micromonospora* (2 strains), *Nocardia* (2 strains), and *Rhodococcus* (2 strains).

From 9 strains assigned to the genus *Streptomyces*: one strain (A 8.1) had no antibacterial activity; 2 strains (A 8.5 and A 8.6) had practically insignificant activities (with only – 0 or 10.0 mm diameter of inhibition zones), the ability to inhibit growth of test bacteria was noticed in the remaining strains from 10.0 to 16.3 mm (Fig. 1).

Actinobacteria isolated from the biofilm also showed almost no ability to inhibit the growth of test bacteria: these were strains of the genera *Actinoplanes*, *Frankia*, *Geodermatophilus*, *Nocardia*, and 1 strain of genus *Streptomyces* (B 8.2), while the other 3 strains of the genus *Streptomyces* showed the ability to inhibit the growth of test bacteria with diameters from 9.0 to 15.3 mm.

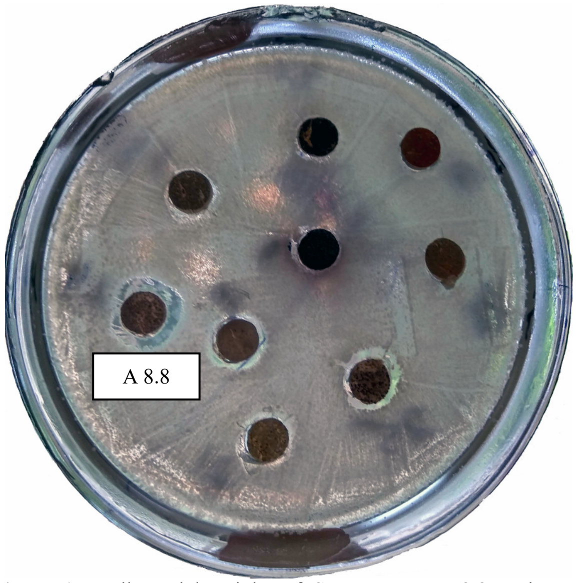

Figure 1. Antibacterial activity of *Streptomyces* A 8.8 against *X. campestris* 8003[b]

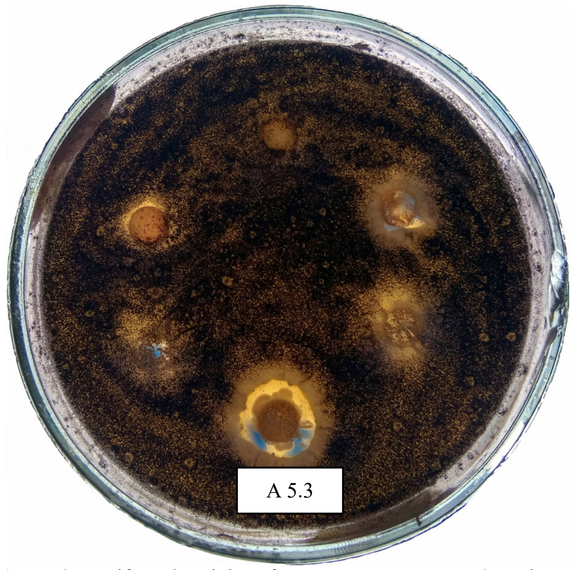

Figure 2. Antifungal activity of *Micromonospora* A 5.3 against *A. niger*

It should be noted that among the isolated new strains of actinobacteria in the water of the studied complex, strains with a complete absence of antifungal activity were also noticed. These are strains of the genus *Actinomadura* A 1.1, *Frankia* A 3.1, *Geodermatophilus* A 4.1 – A 4.3, *Micromonospora* A 5.2, *Rhodococcus* A 7.2, and from the genus *Streptomyces* (A 8.1, A 8.3, A 8.6, A 8.8). Whereas, out of 9 isolated from biofilms, the lack of ability to inhibit the growth of test fungi was noted only in 3 strains of genus *Frankia* B 3.1, *Nocardia* B 6.1, and *Streptomyces* B 8.2.

Table 1. Antibacterial activity of strains of actinobacteria isolated from the water column of the lake system La Izvor

Genus		Diameter of inhibition growth test-microorganisms zone, mm				
		A. tumefaciens 8628	*B. subtilis* B-117	*C. michiganensis* 13[a]	*E. carotovora* 8982	*X. campestris* 8003[b]
Actinomadura	**A 1.1**	0	0	0	0	0
	A 1.2	0	0	0	0	0
Actinoplanes	**A 2.1**	9.0±0	0	0	0	0
	A 2.2	0	0	0	0	0
	A 2.3	0	0	0	0	0
Frankia	**A 3.1**	0	0	0	0	0
Geodermatophilus	**A 4.1**	0	0	0	0	0
	A 4.2	0	0	0	0	0
	A 4.3	0	0	0	0	0
Micromonospora	**A 5.1**	10.7±0.7	9.7±0.7	14.3±0.7	0	12.7±0.7
	A 5.2	0	0	0	0	0
	A 5.3	9.0±0	0	0	0	0
Nocardia	**A 6.1**	0	0	0	0	0
	A 6.2	0	0	0	0	0
Rhodococcus	**A 7.1**	0	0	0	0	0
	A 7.2	0	0	0	0	0
Streptomyces	**A 8.1**	0	0	0	0	0
	A 8.2	9.7±0.7	12.7±0.7	15.0±0	11.7±0.7	15.3±0.7
	A 8.3	9.0±0	9.3±0.7	10.7±0.7	11.0±0	11.0±0
	A 8.4	10.0±0	10.0±0	13.0±0	12.7±0.7	12.7±0.7
	A 8.5	0	9.0±0	9.3±0.7	0	10.0±0
	A 8.6	0	9.3±0.7	0	9.3±0.7	9.0±0
	A 8.7	0	0	0	10.0±0	12.7±0.7
	A 8.8	11.3±0.7	13.3±0.7	14.3±0.7	14.7±0.7	16.3±0.7
	A 8.9	9.3±0.7	11.7±0.7	12.0±0	13.3±0.7	12.7±0.7

Note: p=0.05

Table 2. Antibacterial activity of strains of actinobacteria isolated from biofilm of the lake system La Izvor

Genus		Diameter of inhibition growth test-microorganisms zone, mm				
		A. tumefaciens 8628	*B. subtilis* B-117	*C. michiganensis* 13[a]	*E. carotovora* 8982	*X. campestris* 8003[b]
Actinoplanes	**B 2.1**	0	0	0	0	0
Frankia	**B 3.1**	0	0	0	0	0
Geodermatophilus	**B 4.1**	0	0	0	0	0
Micromonospora	**B 5.1**	9.0±0	12.0±0	14.0±0	10.3±0.7	0
Nocardia	**B 6.1**	0	0	0	0	0
Streptomyces	**B 8.1**	10.7±0.7	12.3±0.7	14.7±0.7	13.3±1.3	13.3±0.7
	B 8.2	0	0	0	0	0
	B 8.3	12.0±0	11.7±0.7	13.7±0.7	15.3±0.7	14.0±0
	B 8.4	0	9.3±0.7	9.0±0	0	12.0±0

Note: p=0.05

Thus, the determination of the ability of new strains of actinobacteria isolated from the lake system La Izvor showed that a number of strains produce antifungal activity to a large extent: the diameter of the growth inhibition zones of phytopathogenic fungi is from 20.7 to 24.0 mm, and the strain of the genus *Streptomyces* A 8.5 – 24.0 mm (*Alternaria alternata*) (Table 3).

Determination of antifungal activity in the studied strains of actinobacteria isolated from water showed that they are able to inhibit the growth of the selected phytopathogenic fungi to a greater extent than phytopathogenic bacteria.

For example, out of 25 strains of actinobacteria, 4 strains had the ability of their metabolites to actively inhibit the growth of such phytopathogens as *Alternaria alternata* and *Aspergillus niger* (zones 20.7-24.0 mm).

The results of the determination of antifungal activity in strains isolated from water showed that there is a strict selectivity, that is, strains were identified that have the activity to retard the growth of one or another test culture.

As example, strain *Actinomadura* A 1.2, at the background of weak antifungal activity against 3 test fungi, the ability to retard the growth of *A. alternata* with a zone up to 22.0 mm was noted; or strain of the genus *Micromonospora* A 5.3 also actively retarded the growth of *A. niger* by 22.3 mm (Fig. 2), against *Fusarium solani* 14.3 mm and against *Fusarium oxysporum* 19.0 mm. It should also be noted that strain of genus *Streptomyces* A 8.5 has the ability to inhibit the growth of *A. alternata* with zones up to 24.0 mm in the complete absence of inhibiting the growth of other test bacteria (Table 3).

Actinobacteria strains isolated from biofilm, showed a lower antifungal activity, and only strain *Actinoplanes* B 2.1 pays attention, capable of inhibiting the growth of *A. alternata* and *F. solani* with zones up to 20.7 mm, and *A. niger* and *F. oxysporum* with zones up to 16.0 and 14.3 mm, respectively.

Table 3. Antifungal activity of strains of actinobacteria isolated from the water column of the lake system La Izvor

Genus		Diameter of inhibition growth test-microorganisms zone, mm				
		A. alternata	*A. niger*	*B. cinerea*	*F. oxysporum*	*F. solani*
Actinomadura	A 1.1	0	0	0	0	0
	A 1.2	22.0±0	9.7±0.7	10.0±0	10.0±0	0
Actinoplanes	A 2.1	20.7±0.7	12.0±0	0	13.7±0.7	0
	A 2.2	13.0±0	9.0±0	0	14.0±0	0
	A 2.3	17.3±1.3	10.0±0	0	10.0±0	9.3±0.7
Frankia	A 3.1	0	0	0	0	0
Geodermatophilus	A 4.1	0	0	0	0	0
	A 4.2	0	0	0	0	0
	A 4.3	0	0	0	0	0
Micromonospora	A 5.1	0	9.7±0.7	0	0	9.7±0.7
	A 5.2	0	0	0	0	0
	A 5.3	0	22.3±0.7	0	19.0±1.1	14.3±0.7
Nocardia	A 6.1	16.3±0.7	10.0±0	0	9.7±0.7	0
	A 6.2	17.7±0.7	10.0±0	0	0	12.0±0
Rhodococcus	A 7.1	0	10.0±0	0	0	0
	A 7.2	0	0	0	0	0
Streptomyces	A 8.1	0	0	0	0	0
	A 8.2	12.0±0	0	0	0	0
	A 8.3	0	0	0	0	0
	A 8.4	0	10.0±0	10.0±1.1	10.3±0.7	0
	A 8.5	24.0±1.1	0	0	0	0
	A 8.6	0	0	0	0	0
	A 8.7	0	9.3±0.7	0	0	0
	A 8.8	0	0	0	0	0
	A 8.9	0	10.3±0.7	0	0	0

Note: p=0.05

Table 4. Antifungal activity of strains of actinobacteria isolated from biofilm of the lake system La Izvor

Genus		Diameter of inhibition growth test-microorganisms zone, mm				
		A. alternata	*A. niger*	*B. cinerea*	*F. oxysporum*	*F. solani*
Actinoplanes	B 2.1	20.7±0.7	16.0±0	0	14.3±0.7	19.7±0.7
Frankia	B 3.1	0	0	0	0	0
Geodermatophilus	B 4.1	18.3±0.7	12.0±0	9.7±0.7	12.0±0	12.3±0.7
Micromonospora	B 5.1	0	12.0±0	0	0	11.0±0
Nocardia	B 6.1	0	0	0	0	0
Streptomyces	B 8.1	0	13.7±0.7	0	0	15.0±1.1
	B 8.2	0	0	0	0	0
	B 8.3	15.7±0.7	0	0	0	12.0±0
	B 8.4	15.0±0	0	0	0	10.0±0

Note: p=0.05

The representatives of the genus *Streptomyces* showed a low antifungal activity: the best zones up to 15.0-15.7 mm were noted under the influence of exometabolites of strains B 8.1, B 8.3, and B 8.4 against *A. alternata* and *F. solani*.

DISCUSSION

The results obtained in our studies are consistent with the literature, which also noted the ability of certain representatives of actinobacteria to inhibit the growth of phytopathogens (bacteria or fungi). For example, strains of the genus *Actinomadura* have been identified that are capable of inhibiting the growth of *Alternaria* sp. (27.0 mm), *F. oxysporum* (16.0 mm), *B. subtilis* (30.0 mm), and other conditionally pathogenic strains [4]. A strain of the genus *Actinoplanes*, active against Gram+ bacteria, as well as *B. subtilis*, *B. cereus*, and others [13]. Strains of the genus *Micromonospora* also synthesize substances with antifungal activity [25, 40].

A number of studies show the possibility of using streptomycetes as a biocontrol agent against various pathogens both in greenhouses and in the field. So, for example, the strain *Streptomyces* sp. UHPRS4 contributed to the reduction of diseases in greenhouse plants by 67.9%, and also activated the growth and development of plants [1, 57]. The effect of streptomycetes on strains of the genus *Fusarium*, *Xanthomonas*, *Staphylococcus aureus*, and a number of sugar beet pathogens also differed [18, 29, 59].

Representatives of the genus *Actinomadura* have been used since the middle of the 20th century for the targeted search for new antibiotics, active against Gram+ and Gram- bacteria, fungi, conidia, as well as antitumor antibiotics (carnomycin) and unique sulfur-containing antibiotics with a variety of chemical structures and biological effects, therapeutic action [17, 20, 39, 51].

Strains of the genus *Micromonospora* which are notable producers of antibiotics used in agriculture, isolated from sea water have the ability to synthesize an antimicrobial alkaloid – diazepinomicin [11].

The ability of the *Micromonospora* strain to produce aminoglycosides, which are used to treat diseases caused by Gram- pathogens; as well as against

Pseudomonas, the fortimycin A was revealed. From macrolides, a strain of the genus *Micromonospora* synthesizes rovamycin, rifamycin (antitumor and antiviral antibiotic) etc. [6, 39].

According to the literature, natural isolates of the genus *Frankia* are mainly considered plant growth activators, siderophore producers, but also have an inhibitory effect against phytopathogens, in particular representatives of the genera *Pseudomonas* and *Fusarium* [38].

In addition, information is known about the ability of strains of actinobacteria to synthesize such important and widely used in medicine and veterinary antibiotics as pradimycin, macrolactams (antifungal antibiotics), produced by members of the genus *Actinomadura*; macrolide and aminoglycoside antibiotics produced by strains of *Micromonospora*; anticancer antibiotics (gentamicin and nonamycin) and others [7, 14, 19, 21, 24].

That is, the data obtained are consistent with the literature, according to which it follows that in order to replenish the National Collection of Non-pathogenic Microorganisms of the Institute of Microbiology and Biotechnology with new strains of actinobacteria, one should choose representatives of the genera *Actinoplanes*, *Actinomadura*, *Micromonospora*, and *Streptomyces*, known as a real source of metabolites with antimicrobial properties, that is, clinically useful antibiotics of natural origin, such as neomycin, cypemycin, bothromycin, chloramphenicol, carminomycin, rubomycin, sisomicin, etc.

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