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ANTAGONISTIC ACTIVITY OF *AZOTOBACTER VINELANDII* IMV B-7076 AGAINST PHYTOPATHOGENIC MICROORGANISMS

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Bacteria of the genus Azotobacter are known for their ability to stimulate plant growth and development. Azotobacter vinelandii IMV B-7076 strain was isolated from Zhytomyr region soil of Ukraine. It is one of the components of the "Azogran" complex bacterial preparation for plant growing. It has been established that A. vinelandii IMV B-7076 synthesizes biologically active substances that promote plant development. At the same time, the antagonistic activity of A. vinelandii IMV B-7076 against phytopathogens has not yet been studied, so this became the ***aim*** *of this work.* ***Methods.*** *The antagonistic activity of A. vinelandii IMV B-7076 was determined by agar well diffusion and agar blocks methods.* ***Results.*** *It was shown that A. vinelandii IMV B-7076 had antagonistic activity against some phytopathogenic fungi. In particular, the diameter of growth inhibition zones of Alternaria alternata 16861, Fusarium avenaceum 50720, Fusarium verticillioides 50463, Fusarium lactis 50719, Fusarium oxysporum 54201, Fusarium poae 50704 was 14÷37 mm, Bipolaris sorokiniana 16868 and Fusarium solani – 11÷13 mm. Fusarium culmorum 50716 and Fusarium graminearum 50662 were not sensitive to A. vinelandii IMV B-7076 metabolites. Notably, the antagonistic effect was demonstrated in mycelial growth and spore formation inhibition, in fungal mycelium discoloration. It was also demonstrated that A. vinelandii IMV B-7076 did not show antagonistic activity against phytopathogenic bacteria Agrobacterium tumefaciens 8628, Pectobacterium carotovorum subsp. carotovorum 8982, Pseudomonas fluorescens 8573, Pseudomonas syringae pv. syringae 8511, Clavibacter michiganensis subsp. michiganensis 13a, Xanthomonas campestris pv. campestris 8003b.* ***Conclusions.*** *Studied A. vinelandii IMV B-7076 strain is characterized by antagonistic activity against phytopathogenic fungi and does not have antibacterial properties against phytopathogenic bacteria. The antifungal activity of A. vinelandii IMV B-7076, as a component of "Azogran", will be useful for this bacterial preparation application in plant growing.*

Keywords: Azotobacter vinelandii IMV B-7076, antagonistic activity, antifungal activity, phytopathogenic fungi, phytopathogenic bacteria.

Bacteria of the genus *Azotobacter* are known for their ability to stimulate plant growth and development [1]. They synthesize biologically active substances, fix molecular nitrogen from the atmosphere and protect plants from stress factors [2, 3]. *Azotobacter vinelandii* IMV B-7076 was isolated from Zhytomyr region soil of Ukraine and identified in the Department of Microbiological Processes on Solid Surfaces of D.K. Zabolotny Institute of Microbiology and Virology of NAS of Ukraine [4]. This strain is one of the components of the ″Azogran″ complex bacterial preparation for plant growing [5]. It has been established that *A. vinelandii* IMV B-7076 synthesized biologically active substances that promote plant development [6, 7]. There is some information in the scientific literature about *Azotobacter* antifungal activity [8, 9]. At the same time, antagonistic activity of *A. vinelandii* IMV B-7076 against phytopathogens has not yet been studied, so this became the aim of this work.

Materials and methods. *A. vinelandii* IMV B-7076 strain was used in this study [4]. This bacterial strain was cultivated in liquid and on solid Ashby's or Burke's media depending on the experiment objective. Ashby's medium contained (g/l of distilled water): sucrose – 20.0, K_2HPO_4 – 0.4, $MgSO_4 \cdot 7H_2O$ – 0.2, NaCl – 0.2, K_2SO_4 – 0.1, $CaCO_3$ – 2.0, Fedorov's microelements – 1 ml. pH 7.0–7.5. Burke's medium contained (g/l of distilled water): sucrose – 20.0, K_2HPO_4 – 0.8,

KH_2PO_4 – 0.2, $MgSO_4 \cdot 7H_2O$ – 0.2, sodium citrate – 0.5, $CaCl_2$ – 0.1, $FeSO_4$ – 0.015, $Fe_2(SO_4)_3$ – 0.005, Na_2MoO_4 – 0.005. pH 7.0–7.4. Cultivation of bacteria was carried out for 1, 2, 3, 4 days. In a number of experiments bacteria were cultivated in media with 0.1, 2.0, 5.0 g/l of silicon dioxide, bentonite or palygorskite.

Phytopathogenic fungi from the Collection of the Department of Physiology and Taxonomy of Micromycetes were used as test cultures: *Alternaria alternata* 16861, *Bipolaris sorokiniana* 16868, *Fusarium avenaceum* 50720, *Fusarium culmorum* 50716, *Fusarium graminearum* 50662, *Fusarium verticillioides* 50463, *Fusarium lactis* 50719, *Fusarium oxysporum* 54201, *Fusarium poae* 50704, *Fusarium solani* 50718; as well as phytopathogenic bacteria provided by the Department of Phytopathogenic Bacteria: *Agrobacterium tumefaciens* 8628, *Pectobacterium carotovorum* subsp. *carotovorum* 8982, *Pseudomonas fluorescens* 8573, *Pseudomonas syringae* pv. *syringae* 8511, *Clavibacter michiganensis* subsp. *michiganensis* 13a, *Xanthomonas campestris* pv. *campestris* 8003b.

Antagonistic activity of *A. vinelandii* IMV B-7076 strain was determined by agar well diffusion and agar blocks methods. Studies with fungi were carried on potato-glucose agar, with phytopathogenic bacteria – on potato agar. The fungi were washed from the surface of potato-glucose agar and were added to the molten and cooled medium to reach a concentration of 10^6 spores/ml. Suspensions of phytopathogenic bacteria ($5 \cdot 10^8$ cells/ml) were prepared by washing from potato agar medium. Every 0.1 ml of these suspensions was dispensed on potato agar plates.

8 mm diameter wells were drilled in agar with phytopathogens. 0.15 ml of *A. vinelandii* IMV B-7076 strain suspension or agar blocks with *A. vinelandii* IMV B-7076 strain were added in wells. The plates were incubated at 28^0 C.

Data were statistically analyzed using variation statistics methods [10].

Results. It was shown that *A. vinelandii* IMV B-7076 strain had antagonistic activity against some phytopathogenic fungi (Fig. 1). In particular, the diameter of growth inhibition zones of *A. alternata* 16861, *F. avenaceum* 50720, *F. verticillioides* 50463, *F. lactis* 50719, *F. oxysporum* 54201, *F. poae* 50704 was 14÷37 mm, *B. sorokiniana* 16868 and *F. solani* – 11÷13 mm. *F. culmorum* 50716 and *F. graminearum* 50662 were not sensitive to *A. vinelandii* IMV B-7076 strain metabolites (Fig. 1). Notably, the antagonistic effect was demonstrated in mycelial growth and spore formation inhibition, in fungal mycelium discoloration (Fig. 2).

It is known that the composition of cultivation media influence on bacteria metabolism and, accordingly, synthesis of biologically active substances. Therefore, the influence of cultivation medium on *A. vinelandii* IMV B-7076 antagonistic activity against phytopathogenic fungi was studied. Antagonistic activity was detected after strain cultivation on Ashby's medium. However, the zones of fungal growth inhibition on Burke's medium were in some cases slightly larger. The exception was *F. lactis* 50719 strain that was not affected by *A. vinelandii* IMV B-7076 strain grown on Ashby's medium (Table 1). Some contrasting experimental data also attract attention. For example, the absence of *F. lactis* 50719 growth inhibition zone caused by *A. vinelandii* IMV B-7076 strain that was cultivated in Burke's liquid medium and added in the well, while around the agar block with *A. vinelandii* IMV B-7076 strain from Burke's medium the fungal growth inhibition zone was detected (Fig. 1, Table 1). Also, there was no growth inhibition zone of *F. oxysporum* 54201 around the agar block with *A. vinelandii* IMV B-7076 strain on Ashby's medium, while around the well such zone was 16.8 ± 0.7 mm (Table 1).

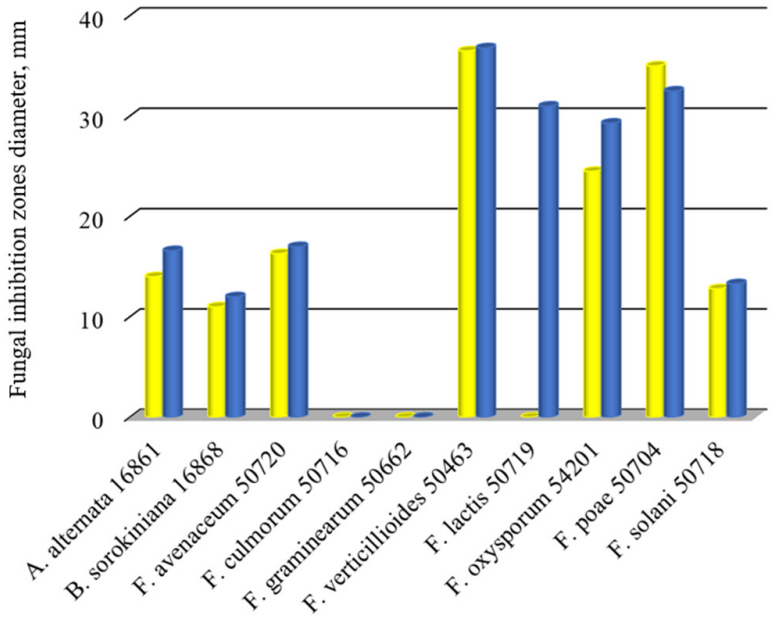
Fungi with largest zones of growth inhibition were used in further work. A study of *A. vinelandii* IMV B-7076 cultivation period influence on the antagonistic activity against *A. alternata* 16861, *F. verticillioides* 50463, *F. oxysporum* 54201 and *F. poae* 50704 demonstrated that *A. vinelandii* IMV B-7076 showed antagonism to these fungi from the first day of cultivation. The fungal growth inhibition zones did not change significant during 1–4 days of bacteria cultivation (Table 2).

It was found that silicon dioxide, palygorskite and bentonite nanomaterials in concentrations of 0.1, 2.0 and 5.0 g/l did not affect the antagonistic activity of *A. vinelandii* IMV B-7076 strain against fungi. Thus, the zones of fungal growth inhibition and spore formation were similar in the experiments when *A. vinelandii* IMV B-7076 strain was cultivated with nanomaterials and without them (Table 3).

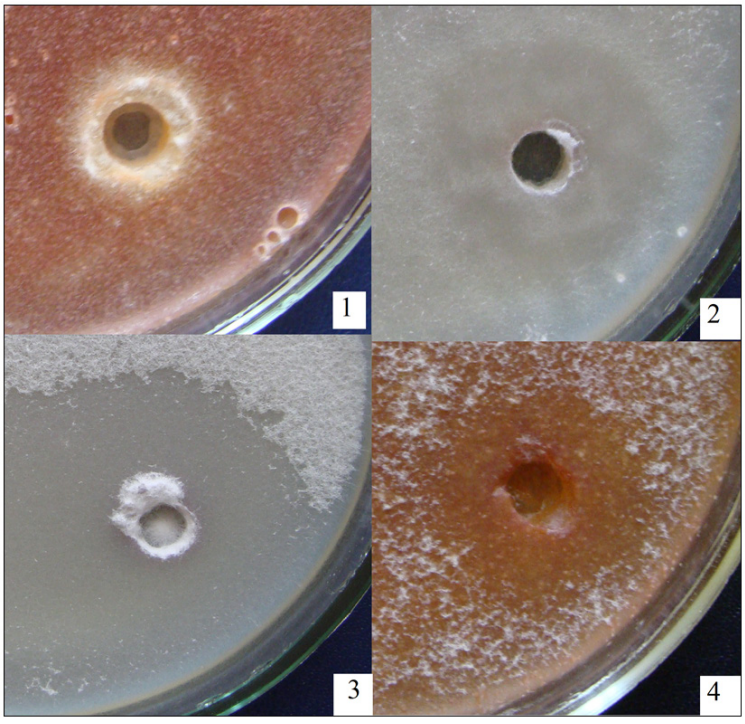
It was also demonstrated that *A. vinelandii* IMV B-7076 did not show antagonistic activity against phytopathogenic bacteria *A. tumefaciens* 8628, *P. carotovorum* subsp. *carotovorum* 8982, *P. fluorescens* 8573, *P. syringae* pv. *syringae*

8511, *C. michiganensis* subsp. *michiganensis* 13a, *X. campestris* pv. *campestris* 8003b. The cultivation period and medium also did not influenced on *A. vinelandii* IMV B-7076 antagonistic properties against phytopathogenic bacteria.

Thus, growth inhibition zones of phytopathogenic bacteria were not detected after *A. vinelandii* IMV B-7076 strain cultivation in Ashby's and Burke's media for 1, 2, 3, 4 days. The addition of bentonite, palygorskite and silicon dioxide at a concentration of 0.1 g/l in Burke's liquid medium also did not facilitate to the antagonism against phytopathogenic bacteria: zones of their growth inhibition were not observed.



F i g.1. Antagonistic activity of *A. vinelandii* IMV B-7076 against phytopathogenic fungi. – agar well diffusion method, – agar blocks method. $p < 0.01$.



F i g. 2. Inhibition zones of *F. avenaceum* 50720 (1), *F. verticillioides* 50463 (2), *F. oxysporum* 54201 (3), *F. poae* 50704 (4) caused by *A. vinelandii* IMV B-7076 suspension.

Table 1

Effect of cultivation media on antagonistic activity of *A. vinelandii* IMV B-7076 against phytopathogenic fungi

Phytopathogenic fungus, strain	Zone diameters (mm) of growth inhibition of phytopathogenic fungi after *A. vinelandii* IMV B-7076 strain cultivation on medium			
	Ashby's		Burke's	
	suspension in wells	agar blocks	suspension in wells	agar blocks
A. alternata 16861	15.7±0.6	16.6±1.9	22.9±3.7	17.9±1.4
B. sorokiniana 16868	9.7±0.8	9.2±0.3	10.3±0.3	11.0±0.5
F. avenaceum 50720	0	23.0±3.2	11.6±0.8	23.4±1.6
F. culmorum 50716	0	0	0	0
F. graminearum 50662	0	0	0	0
F. verticillioides 50463	20.6±1.5	36.0±1.6	29.5±1.6	39.2±4.7
F. lactis 50719	0	0	0	27.4±3.8
F. oxysporum 54201	16.8±0.7	0	19.7±2.4	21.4±1.9
F. poae 50704	24.0±0.7	11.2±0.3	25.3±1.8	28.5±5.4
F. solani 50718	9.2±0.6	9.6±0.6	11.7±0.9	10.4±0.6

Legends: *A. vinelandii* IMV B-7076 strain was cultivated for 3 days in a liquid medium and for 4 days – on a solid medium.

Table 2

Influence of *A. vinelandii* IMV B-7076 cultivation period on its antagonistic activity against phytopathogenic fungi

Phytopathogenic fungus, strain	Zone diameters (mm) of growth inhibition of phytopathogenic fungi after adding in wells *A. vinelandii* IMV B-7076 strain suspension that was cultivated in Burke's medium for			
	1 day	2 days	3 days	4 days
A. alternata 16861	14.2±0.3	14.8±1.1	14.5±0.6	14.5±0.5
F. verticillioides 50463	28.5±1.2	27.0±1.3	25.3±2.0	25.5±1.7
F. oxysporum 54201	19.8±1.7	19.1±1.4	20.0±2.5	20.5±1.5
F. poae 50704	36.8±2.6	29.5±3.5	35.0±2.1	33.0±1.0

Table 3

Influence of nanomaterials on *A. vinelandii* IMV B-7076 antagonistic activity against phytopathogenic fungi

Phytopathogenic fungus, strain	Zone diameters (mm) of growth inhibition of phytopathogenic fungi after adding in wells *A. vinelandii* IMV B-7076 strain suspension that was cultivated in Burke's medium									
	without nanomaterials	with silicon dioxide, g/l			with palygorskite, g/l			with bentonite, g/l		
		0.1	2.0	5.0	0.1	2.0	5.0	0.1	2.0	5.0
A. alternata 16861	14.5±0.6	14.2±0.3	13.8±0.7	14.8±1.3	13.4±0.8	14.5±0.6	14.9±0.8	15.2±0.7	15.8±0.7	13.5±0.8
F. verticillioides 50463	16.3±3.0	15.0±0.7	19.0±2.8	15.5±0.5	15.5±0.4	21.0±1.9	15.3±0.4	15.0±1.3	19.7±1.8	15.5±0.4
F. oxysporum 54201	22.6±5.2	24.6±0.4	28.3±5.4	18.5±0.9	26.0±0.7	28.7±5.0	21.7±2.0	23.5±1.5	30.7±6.3	23.0±1.9
F. poae 50704	26.6±1.6	26.2±1.2	27.0±1.9	26.0±1.0	26.0±1.1	27.1±1.7	26.2±1.7	26.2±1.1	26.9±1.8	26.0±1.0

Legends: *A. vinelandii* IMV B-7076 strain was cultivated for 3 days.

Discussion. In recent decades, more and more attention is paid to the use of microbial preparations for agriculture. This is environmentally friendly and makes it possible to obtain plant products without harmful chemicals. The practice of scientists is constantly aimed at creating bacterial preparations with a wide spectrum of action that could facilitate to the maximize development and productivity of plants. One of the plants growing problems is phytopathogenic microorganisms [5]. Therefore, antagonistic properties against phytopathogens are important for the bacterial species that are components of preparations for plants.

Our studies indicate that *A. vinelandii* IMV B-7076 (a component of the complex bacterial preparation ″Azogran″) had the highest antagonistic activity against phytopathogenic fungi *A. alternata* 16861, *F. avenaceum* 50720, *F. verticillioides* 50463, *F. lactis* 50719, *F. oxysporum* 54201, *F. poae* 50704, less – against *B. sorokiniana* 16868 and *F. solani* 50718 and did not affect *F. culmorum* 50716 and *F. graminearum* 50662 (Fig. 1, Table 1). There is also information about the varying degrees of antifungal activity of *A. vinelandii* IB 4 against phytopathogenic fungi [11]. Thus, the largest growth inhibition zones caused by this strain were observed for *A. alternata*, *F. avenaceum*, *F. culmorum* and *F. gibbosum* (18.0÷20.0 mm) [11]. Inhibition zones of *B. sorokiniana* caused by metabolites of *A. vinelandii* IB 4 [11] were similar to the zones detected for strain of the same species in our studies with *A. vinelandii* IMV B-7076 (Fig. 1) – 12.0 mm. In contrast to our data, *F. solani* was the least sensitive culture with the growth inhibition zone of 8.0 mm [11].

The efficiency of *Azotobacter* use against *Fusarium* infection of maize, sorghum and wheat is also known. The largest inhibition under the influence of *A. nigricans* AZT 54 was detected for *F. sporotrichioides, F. graminearum, F. poae* and *F. equiseti*, the middle – for *F. crookwellense*, *F. culmorum*, *F. sambucinum*, and the minimum – for *F. avenaceum*, *F. acuminatum*, and *F. nivale* [12]. Cavaglieri et al. showed that *Azotobacter armeniacus* RC2 significantly reduced the *F. verticillioides* root colonization. *F. verticillioides* produces fumonisins, toxins that have potential toxicity for humans and animals [9].

In turn, Bhuyan et al. studied the relationship of endophytic *Piriformospora indica* and five different strains of *Azotobacter chroococcum*, demonstrated strain differences in the interaction of these rhizosphere microorganisms [13]. In particular, *A. chroococcum* WR5 exhibited stimulation, while *A. chroococcum* M4 – inhibition of fungal growth. Electron microscopy of co-culture indicated an association of the bacterium with the fungus [13]. Eyini et al. proved the antagonistic role of *Azotobacter* sp. as bioinoculant against *Trichoderma viride* and *Trichoderma reesei* [14]. These fungi prevented the cultivation of *Pleurotus eous*. The interaction between mushrooms and azotobacter was synergistic [14]. Thus, our experimental results and the data of other researchers showed the multivector interaction between fungi and bacteria of the genus *Azotobacter*.

Bhosale et al. studied in detail the cultivation conditions of *A. vinelandii* isolated from soil of India for their maximum antifungal activity against *F. oxysporum* [8]. It was determined that the optimal was *A. vinelandii* cultivation in a medium with 20 g/l of sucrose, pH 7–8, for 3 days. The composition of the Ashby's and Burke's media used in our studies match these basic conditions. As noted above (Table 1), the zones of *A. vinelandii* IMV B-7076 antagonism against fungi in most cases were larger after the use of Burke's medium. At the same time, the absence of antagonism of *A. vinelandii* IMV B-7076 cultivated on Ashby's medium against *F. lactis* 50719 indicates that under such cultivation conditions, the bacteria did not synthesize active metabolites against this fungus. The presence or absence of growth inhibition zones around agar blocks or wells with suspensions of *A. vinelandii* IMV B-7076 strain cultivated on the same medium previously described for *F. lactis* 50719 and *F. oxysporum* 54201 (Table 1) can be explained by the probable synthesis of only cellular or extracellular active bacterial metabolites under certain growing conditions. The presence of growth inhibition zones of the studied fungi by *A. vinelandii* IMV B-7076 that was cultivated on Burke's medium for 1-4 days (Table 2), and the absence of significant differences in the diameter of these zones indicates the synthesis of substances with antagonistic action during growth on this medium from the first day of cultivation. Therefore, we would like to conclude that the use of Burke's medium is more expedient for *A. vinelandii* IMV B-7076 cultivation.

″Azogran″ is made on the basis of bentonite, in addition, under natural conditions bacteria can interact with other clay minerals that are components of many soil types. In turn, clay minerals are aluminosilicates containing 70% of silicon oxide and aluminum oxide. A certain

model of individual components of these complex compounds are synthetic highly dispersed materials based on silicon dioxide. Microorganisms can contact with highly dispersed materials, which often leads to changes in their physiological properties [15]. Therefore, it was useful to investigate the influence of *A. vinelandii* IMV B-7076 cultivation with bentonite, palygorskite and silicon dioxide nanoparticles on the antagonistic activity of this bacterial strain. Our hypothesis about the effect of these materials on *A. vinelandii* IMV B-7076 antagonistic activity included a possible increase of growth inhibition zones due to increasing synthesis of active substances or simplification of their extracellular production, or, conversely, decrease of zones due to sorption of metabolic substances on the above dispersed materials. However, as follows from the obtained results, we did not observe any of the above: the cultivation of *A. vinelandii* IMV B-7076 strain with bentonite, palygorskite and silicon dioxide did not affect the diameter of fungi growth inhibition zones (Table 3).

There is only some information about the mechanisms of antifungal action of bacteria from the genus *Azotobacter*. They mainly regard the synthesis of antibiotic metabolites by these bacteria. In particular, *A. chroococcum* 92 produces an ester of aliphatic tetraenic acid, this molecule contains hydroxyl, methoxyl and carboxyl groups [16]. *A. vinelandii* IB 4 synthesizes sucrose polythiophosphates of tetraamine (α-D-2,3-diaminoglucopyranosyl-β-D-3,4-diaminofructofuranose) [11]. *A. vinelandii* isolated from the soil of India has among the metabolites aldehyde, C-N, ester, aromatic ring, P-H stretch, C-N stretch of alkyl amine [8]. Along with this, there are data on the differential expression of many metabolic proteins of the fungus *P. indica* grown in the presence of *A. chroococcum* WR5 and *A. chroococcum* M4 [13].

It should be noted that KEGG GENOME database contains the information about the presence in *A. vinelandii* DJ genome the antibiotic biosynthesis genes, in particular streptomycin and vancomycin. Therefore, it was possible to suggest the presence of *A. vinelandii* IMV B-7076 antagonistic activity against phytopathogenic bacteria. Along with this, other evidences of the ability of *Azotobacter* genus bacteria to synthesize antibacterial substances is not found in the available literature. We did not also find any antagonistic action of *A. vinelandii* IMV B-7076 against phytopathogenic bacteria.

Thus, studied *A. vinelandii* IMV B-7076 is characterized by antagonistic activity against phytopathogenic fungi and does not have antibacterial properties against phytopathogenic bacteria. The antifungal activity of *A. vinelandii* IMV B-7076, as a component of ″Azogran″, will be useful for this bacterial preparation application in plant growing.

АНТАГОНІСТИЧНА АКТИВНІСТЬ *AZOTOBACTER VINELANDII* ІМВ В-7076 ЩОДО ФІТОПАТОГЕННИХ МІКРООРГАНІЗМІВ

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Резюме

Бактерії роду *Azotobacter* відомі здатністю стимулювати ріст та розвиток рослин. Штам *Azotobacter vinelandii* ІМВ В-7076 виділено з ґрунту Житомирської області України. Він є одним із компонентів комплексного бактеріального препарату для рослинництва Азогран. Раніше було встановлено, що *A. vinelandii* ІМВ В-7076 синтезує біологічно активні речовини, які сприяють розвитку рослин. В той же час антагоністична активність *A. vinelandii* ІМВ В-7076 щодо фітопатогенів до цього часу була не вивченою, тому це стало **метою** даної роботи. **Методи.** Антагоністичну активність *A. vinelandii* ІМВ В-7076 визначали методами лунок та агарових блоків. **Результати.** Показано, що *A. vinelandii* ІМВ В-7076 проявив антагоністичну активність щодо деяких фітопатогенних мікроміцетів. Зокрема, діаметр зон пригнічення росту *Alternaria alternata* 16861, *Fusarium avenaceum* 50720, *Fusarium verticillioides* 50463, *Fusarium lactis* 50719, *Fusarium oxysporum* 54201, *Fusarium poae* 50704 складав 14÷37 мм, *Bipolaris sorokiniana* 16868 і *Fusarium solani* 50718 – 11÷13 мм. Не чутливими до метаболітів азотобактера були *Fusarium culmorum* 50716 і *Fusarium graminearum* 50662. Слід зазначити, що антагоністичний вплив проявлявся у пригніченні росту міцелію та формування спор, зміні кольору міцелію мікроміцетів. Відомо, що у процесі культивування на середовищах різного складу метаболізм бактерій та, відповідно, синтез ними біологіч-

но активних речовин може відрізнятися. Показано, що за культивування на середовищі Ешбі антагоністична активність *A. vinelandii* IMB B-7076 проявлялась, однак за застосування середовища Берка зони пригнічення розвитку грибів у деяких випадках були більшими. За дослідження впливу терміну культивування на антагоністичну активність *A. vinelandii* IMB B-7076 щодо *A. alternata* 16861, *F. verticillioides* 50463, *F. oxysporum* 54201 і *F. poae* 50704 встановлено, що азотобактер проявляв антагонізм до цих мікроміцетів вже з першої доби культивування в середовищі Берка, а впродовж 1–4 діб культивування бактерій зони затримки росту грибів змінювались незначною мірою. Азогран виготовляють на основі бентоніту, до того ж в природних умовах бактерії можуть взаємодіяти з іншими глинистими мінералами, які є компонентами багатьох типів ґрунтів. Глинисті мінерали на 70% складаються з оксиду кремнію і оксиду алюмінію, тому синтетичний діоксид кремнію часто використовують як модельну речовину для досліджень. Мікроорганізми можуть вступати в контактну взаємодію з високодисперсними матеріалами, що часто призводить до змін їх фізіологічних властивостей. Нами з'ясовано, що культивування *A. vinelandii* IMB B-7076 в середовищах із наноматеріалами (діоксидом кремнію, палигорськітом і бентонітом у концентраціях 0,1, 2,0 і 5,0 г/л) не впливало на антифунгальну активність *A. vinelandii* IMB B-7076. Визначено, що *A. vinelandii* IMB B-7076 не проявляв антагоністичної активності до фітопатогенних бактерій *Agrobacterium tumefaciens* 8628, *Pectobacterium carotovorum* subsp. *carotovorum* 8982, *Pseudomonas fluorescens* 8573, *Pseudomonas syringae* pv. *syringae* 8511, *Clavibacter michiganensis* subsp. *michiganensis* 13a, *Xanthomonas campestris* pv. *campestris* 8003б.

Висновки. Досліджений нами штам *A. vinelandii* IMB B-7076 характеризується антагоністичною активністю щодо фітопатогенних мікроміцетів і не проявляє антибактеріальних властивостей до фітопатогенних бактерій. Антифунгальна активність *A. vinelandii* IMB B-7076 як компонента Азограну буде корисною за застосування цього бактеріального препарату в рослинництві.

Ключові слова: Azotobacter vinelandii IMB B-7076, антагоністична активність, антифунгальна активність, фітопатогенні гриби, фітопатогенні бактерії.

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