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Growth-Promoting and Fungicide Characteristics of Cyanobacterial Communities from Ecosystems of the Astrakhan Region

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ABSTRACT

Cyanobacteria are known for their essential contribution to fertility of soil and to support active processes for growth of higher plants, and also to occupy an important place among natural antagonists of mushrooms. In laboratory experiments, the influence of cyanobacterial communities, allocated from water and soil eco-systems of the Astrakhan region, against phytopathogenic fungi was studied. Fungicidal efficiency of cyanobacteria were tested against fungal strains namely: Fusarium graminearum, Fusarium sporotrichoides,and Alternaria tennuisima. Growth-promoting activity of cyanobacterial communities was tested by means of the test for pepperwort-salad seeds. The results showed that 5 out of 16 communities displayed significant growth-promoting and fungicidal activities.

KEYWORDS: cyanobacteria, soil algae, fungicidal properties, growth-promoting activity, bacterial fertilizers, Astrakhan region.

INTRODUCTION

One of the objectives of modern biotechnology is ecologization of agriculture, in which no chemicals causing damage to the environment and human health can be used. Biological activities by the microbial community of the soil are alternative to different kinds of chemical fertilizers and pesticides. Soil microorganisms form numerous autacoids which enter the roots of plants and promote their growth, increasing plant healthy as well as enhancing crop quality and yield. In addition, antifungal- antibiotics produced suppress the development of phytopathogens. Various microorganisms can be introduced into the agro-ecosystem, including microbial preparations comprise a complex of bacterial cultures.

A particular place in soil cenosis is taken by phototrophic microbial communities, whose structure is formed by algae and cyanobacteria. Unlike other soil algae, cyanobacteria take molecular nitrogen from the atmosphere, fulfilling the role of the first link in food chains and forming primary production of organic matter (Pankratova, 1987; Shtina, *et al*; 1998, Abed *et al*. 2009). In natural conditions cyanobacteria always develop in association with many other organisms, due to the mucous cases, and therefore obtain great adaptation abilities and resistance to overcome physicochemical and environmental conditions. It creates preconditions for a more effective adaptation of cyanobacterial communities on their introducing into the soil. Besides, cyanobacteria are economical and require minimal nutrition in the culture and have a high growth rate, which is very important for the production of biological preparations.

In agro-biotechnology, cyanobacteria are poorly studied except in rice fields (Kovina, 2001; Pankratova, *et al*; 2008; Trefilova, 2008; Domracheva, *et al*; 2009, Abdel-Raouf *et al*. 2012). In the present study, antagonistic activity of cyanobacteria against Fusarium fungi is evaluated. Fungicidal and growth-promoting activities of cyanobacterial communities, sorted out of the ecosystems of the Astrakhan region, were investigated.

MATERIALS AND METHODS

In this research, efficiency of cyanobacterial communities, sorted out of the ecosystems of the Astrakhan region, against strains of phytopathogenic fungi; namely: *Fusarium graminearum, Fusarium sporotrichoides*, and *Alternaria tennuisima* were investigated.

Cultures of cyanobacteria were incubated in liquid medium BG-11 with the following compound (g/l): $NaNO_3$-1,5; K_2HPO_4-0,04; $MgSO_4 \cdot 7H_2O$-0,075; $CaCl_2 \cdot 2H_2O$-0,036; Na_2CO_3-0,02; EDTA-0,001; citric acid -0,006; ferric ammonium citrate-0,006; microelements-1ml (Rippka et al., 1979), in Erlenmeyer bottles ranging from 100-250 ml luminostat with illumination of 2 thous. lx. and temperature of 22-25 ºC (Netrusov, *et al*. 2005). Cyanobacteria and algae were identified by morphological characters, using the method reported by Gollerbah *et al*. (1953) and the manual of Zenova and Shtina (1990). Fungicidal activity of cyanobacterial communities was studied using the disk technique during 3-5 days. To estimate their fungicidal activity, cyanobacterial communities were put on the "lawns" of fungi grown on leguminous agar. The level of antagonistic activity was defined according to the diameter of fungus growth inhibition zone around the disk from biomass of cyanobacteria (Netrusov, *et al*., 2005).

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RESULTS AND DISCUSSIONS

In this study the structure and composition of 16 cyanobacterial communities show a great variety comprises cyanobacteria as well as green and diatomic algae. However, the cyanobacteria, *Phormidium* and *Oscillatoria* were found to be predominant.

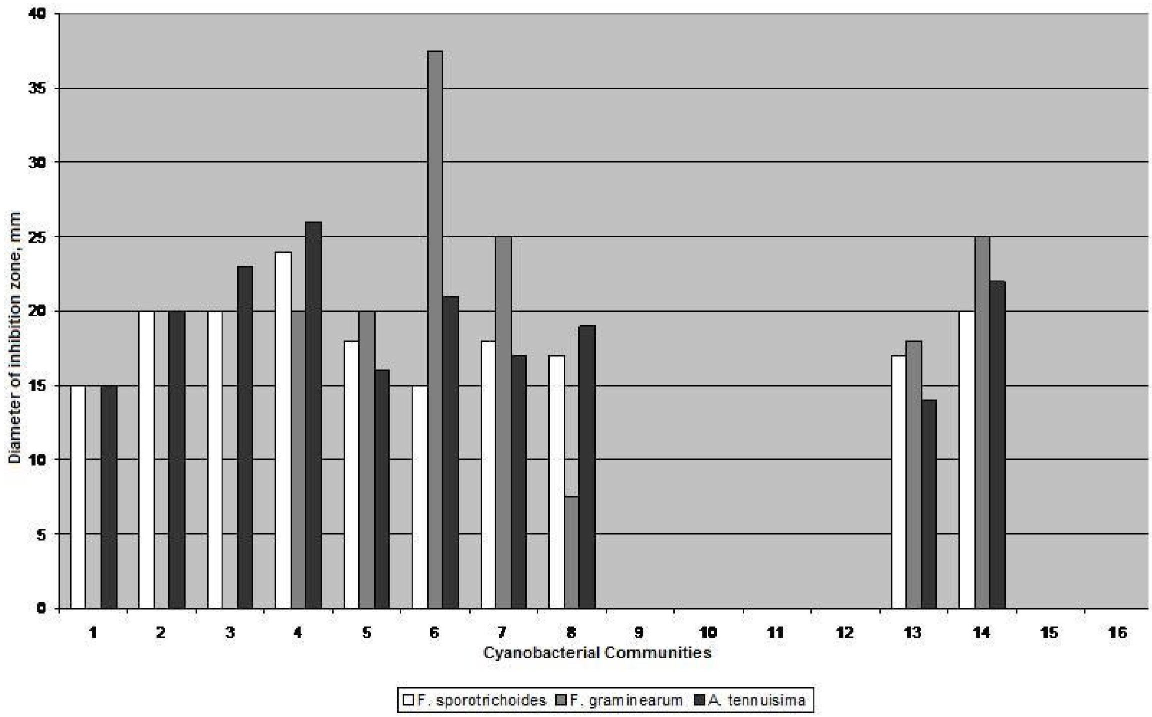

Fig. 1. Fungicidal activity of cyanobacterial communities towards phytopathogenic fungi *F. sporotrichoides, F. graminearum* and *A. tennuisima*

Estimation of fungicidal activity by cyanobacterial communities in *in vitro* tests showed that their impact resulted in a complete inhibition of growth of the phytopathogens and depression of hyphae regeneration. Zones of inhibition of fungal growth varied from 7,5 - 37,5 mm (Fig. 1).

The results showed also that 10 out of 16 studied cyanobacterial communities exhibited fungicidal activity towards *Fusarium sporotrichoides* and *Alternaria tennuisima*, whereas, 7 out of 16 revealed varied activities towards *Fusarium graminearum* (Fig. 1). Communities 9,10,11,12,15,16 display no fungicidal activity (Fig.1). The most active towards all the tested fungi were cyanobacterial communities 4,5,6,7,14.

In relation to *F. sporotrichoides* the largest inhibition zone was displayed by cyanobacterial communities 4 (24 mm), and the smallest is occurred by cyanobacterial communities 1 and 6 (15mm). Regarding cyanobacterial communities 2,3,14, the inhibition zone reached 20 mm. Towards *F. graminearum,* cyanobacterial communities 6 displayed maximal antagonistic activity (37,5 mm), whereas cyanobacterial communities 8 displayed the minimal inhibition (7,5 mm). Communities 1,2,3 showed no antagonistic activity towards *Fusarium graminearum* (Fig. 1), unlike cyanobacterial communities 4 and 5, which displayed an equal degree of fungicidal activity (20 mm). On deposition of cyanobacterial communities pellicles on the lawn of fungus *Alternaria tennuisima* the highest fungicidal activity was displayed by cyanobacterial communities 4, while the lowest was occurred by cyanobacterial communities 13.

Growth form studies of the tested phytopathogens showed that the impact of cyanobacteria led not only to a growth inhibition of the fungi, but also to transfer from active developmental stage to reproduction, especially with *Fusarium graminearum*. Almost in all *in vitro* experiments with *Alternaria tennuisima* a complete inhibition of the fungus was observed, unlike with *F. graminearum,* when along with the inhibition of fungus growth there was a medium or an enhanced conidiogenesis.

The estimation of phyto-toxicity and phyto-stimulation activity was held by means of test on cress seeds. For the experiment on toxicity the cress seeds were put into the moist chambers (Petri plates with filter paper and cotton wool), in each chamber there were 50 seeds, which were moistened with suspension of 0,5 g of experimental biomass of cyanobacterial communities. Seeds, processed with suspension, were couched in luminostat during 3 days. Check seeds were soaked in sterile distilled water. To determine toxicity of suspension for plants: 1) the number of sprouted seeds was calculated; 2) the length of root and stem in cress seeds was measured to determine phyto-stimulation activity of suspension; and 3) the ability of cyanobacterial communities-base suspension to promote growth was calculated (as % of the control response). The results are represented in Tables 1 and 2.

Table 1. Toxicity of cyanobacterial communities in the bioassay with cress seeds

Number of cyanobacterial community	Number of sprouted seeds (% of the control response)
1	118
2	130
3	133
4	100
5	136
6	100
7	130
8	93
9	91
10	85
11	97
12	91
13	111
14	120
15	88
16	91

As shown in Table 1, cyanobacterial communities 8,9,10,11,12,15,16 appeared to be toxic for cress seeds. On other hand, the same communities, except the community 8, display no fungicidal activity (Fig. 1).

Table 2. Phyto-stimulation activity of cyanobacterial communities in the bioassay with cress seeds

Number of cyanobacterial community	Length of cress seedlings (% of the control response	
	Root	Stem
1	105	108
2	158	169
3	145	115
4	157	92
5	160	123
6	93	108
7	160	138
8	95	85
9	85	83
10	85	83
11	102	92
12	105	83
13	145	142
14	155	150
15	77	75
16	82	67

The data received from the studying of phyto-stimulation activity are ambiguous. The highest phyto-stimulation activity was displayed by cyanobacterial communities 2 on the basis of alluvial-meadow soil of the ash forest, and 5 sorted out of urbanozem, while 7 on the basis of the soil for agricultural use and 14 sorted out of sewage. On other hand, the cyanobacterial communities 6, 8, 9, 10, 15, 16 almost completely inhibited the growth-promoting activity in the bioassay with cress seeds (Table 2).

Results showed that 5 out of 16 communities displayed significant fungicidal activity towards all tested phytopathogenic fungi and further detailed research might be conducted for cropper fungoid disease control. Six different communities display no fungicidal activity towards three phytopathogenic fungi and appeared to be toxic for cress seeds. It might deal with high concentration of phytohormones in cyanobacteria that stimulate plant emergence of small concentration.

The results of conducted experiments showed that cyanobacterial communities 3, 4, 6, 7, 14 can be tested for further investigations for the agro-biotechnology applications.

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