Selenium nanocomposites as a protection agent from potato ring rot

O.A. Nozhkina[1]*, A.I. Perfileva[1], I.A. Graskova[1, 3], B.G. Sukhov[2, 3]

[1] *Siberian Institute of Plant Physiology and Biochemistry, SB RAS, Irkutsk, Russia*
[2] *Irkutsk Institute of Chemistry named after A.E. Favorsky, SB RAS, Irkutsk, Russia*
[3] *Irkutsk Scientific Center, Irkutsk, Russia*

DOI 10.18699/ICG-PlantGen2019-35

* e-mail: smallolga@mail.ru

Abstract: Nanocomposite substances based on natural matrices – arabinogalactan, starch, carrageenan – were used in the work. Studies have been conducted on the effect of nanocomposites on the pathogen of ring rot of potatoes, as well as the growth and development of plants *in vitro*. The data obtained did not show a negative effect on plants, but showed an antibacterial effect on the growth and biofilm formation of bacteria.
Key words: nanocomposite substances; ring rot; plants *in vitro*.

1. Introduction

Potato plants are susceptible to various bacterial diseases that have a negative impact on yield (Anisimov et al., 2009). One such disease is ring rot caused by the bacterium *Clavibacter michiganensis* ssp. *sepedonicus*. The disease is characterized by withering of plants at the stage of vegetation, metabolic disorders. Bacteria have the ability to overwinter in the affected tubers and are not stored in the soil, but can be stored for several years in the form of dried mucus on the surface of the container, on the harvesting equipment and in storage facilities. All known measures to combat the disease are reduced to disinfection with aggressive reagents (Eichenlaub et al., 2011). Therefore, it became necessary to search for safe resources of control and such resources are nanocomposite substances in a polysaccharide matrix containing selenium.

2. Materials and methods

The paper used potato plants *in vitro*, variety Lukyanovsky, which is susceptible to ring rot of potatoes (Romanenko et al., 1999), nanocomposites with selenium (NC) in the natural polysaccharide matrices arabinogalactan (AG), starch (St), carrageenan (Car), as well as bacteria *Clavibacter michiganensis* ssp. *sepedonicus* (Cms) strain Ac-1405 obtained from the All-Russian Collection of Microorganisms, Pushchino, Moscow region. Plants were propagated by cuttings on microclonal apparitional nutrient Murashige-Skoog medium (4.2 g/l) supplemented with 30 g/l sucrose. The plants were cultivated for 20 days at 26 °C and 5-6 KLC illumination. A liquid culture for *Cms* to investigate bacteriostatic activity with selenium nanocomposite against ring rot of potatoes was grown in the dark at 26 °C on a rocker (80 rpm) in flasks containing a GPY nutrient medium, pH 7.2 (Roozen et al., 1991). When considering the effect of NC on the plants we investigated the following biometric indicators: the growth rate of plants, growth of leaves of plants, increase in root mass of plants, the growth of the ground part of the plant, the activity of the enzyme peroxidase in plant tissues, and the content of active forms of oxygen in the tissues of plant roots. The effect of NC on the causative agent of the disease was checked using the method of optical density measurement of bacterial suspension and biofilm formation.

For experiments, we used solutions of nanocomposites, in which the content of selenium was 0.000625 %. All nanocomposites were synthesized at the Irkutsk Institute of Chemistry. All synthesized substances are highly soluble in water and easy to use their aqueous solutions. Synthesis of NC Se was performed by oxidation of readily available sodium with hydrogen peroxide. The synthesis process was described in detail previously (Rodionova et al., 2015).

3. Results and discussion

As a result of the experiments conducted on bacteria, bactericidal and bacteriostatic effects were found in NC Se/AG (6.4 % Se), compared with other starch- and carrageenan-based nanocomposites. This nanocomposite inhibited the growth of bacterial suspension, reduced the formation of biofilms, one of the important abilities of bacteria (Figure 1).

Furthermore, when studying the effect of nanocomposites on potato plants, no negative effect was observed. During the observation it was found that there was no stretching of the plant. Next, we examined the effects of NC at the infection of plants by the pathogen. A closer examination of the indicators revealed a stimulating effect in all the studied nanocomposites, both in infection and without. NC Se/St and NC Se/Car had a more pronounced effect (Figure 2).

During incubation of plants with NC Se/AG and *Cms* a decrease was found in the activity of peroxidase in relation to control plants, which indicates a decrease in stress in plants during infection. The accumulation of Se in plant tissues a day after NC treatment by the method of x-ray energy dispersive microanalysis (ReDMA) was also investigated. The analysis showed the absence of selenium within the detection limits of the device (Table 1). The effect of NK on soil bacteria was also studied. A pronounced negative effect of the duration of the experiment was not revealed.

4. Conclusions

The experiments revealed bacteriostatic and bacteriological effects of the selected selenium-containing nanocomposites. Experiments have shown the effect on the important ability of bacteria to form biofilms. NC Se prevents the formation of biofilms. NC Se/AG has a pronounced effect. It was shown that selenium does not accumulate in plant tissues after treatment with nanocomposites and infection. It helps cope with the disease (reduces the biometric index of plant activity peroxidase, one of the indicators of stress). These experimental results

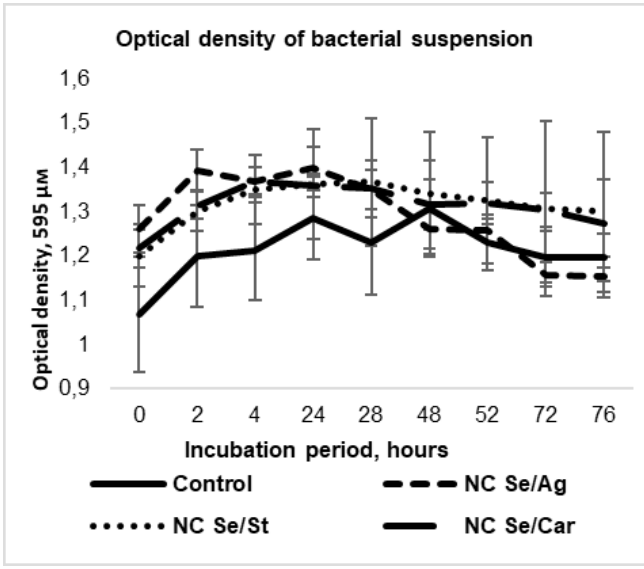

Figure 1. Effect of nanocomposites of selenium (NC Se) and arabinogalactan (AG), starch (St) and carrageenan (Car).

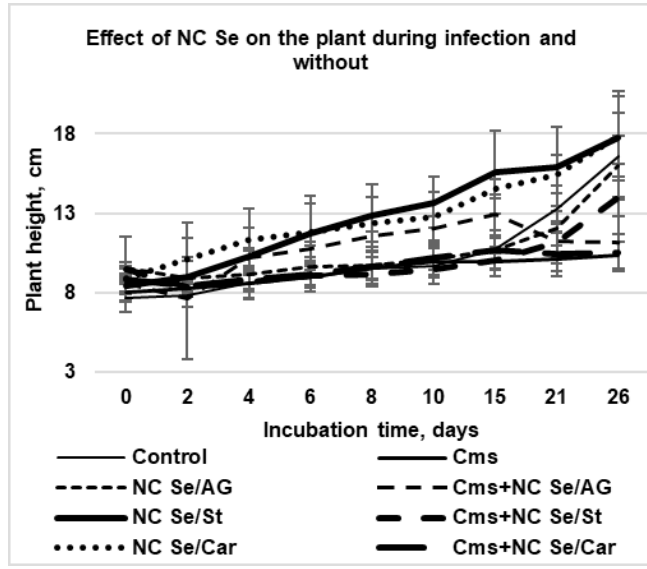

Figure 2. Effect of selenium nanocomposites (NC Se) in infection (*Cms*+NC Se) and without it (AG, arabinogalactan; St, starch; Car, carrageenan).

Table 1

The results of x-ray energy-dispersive spectral microanalysis of potatoes plant tissue after processing on nanocomposites

Element	Norm. C [wt.%]	Atom. C [at.%]	Error [%]
Oxygen	45.77	39.54	5.1
Carbon	45.36	52.19	5.0
Nitrogen	7.92	7.82	1.1
Phosphorus	0.69	0.31	0.1
Magnesium	0.26	0.15	0.0
Sodium	0.00	0.00	0.0
Selenium	0.00	0.00	0.0
Total:	100.0	100.0	

allow us to consider these nanocomposite saline substances as an environmentally safe means to combat bacterial diseases of agricultural plants.

References

Anisimov B.V., Belov G.L., Varichev A.Yu., Elansky S.N., Zhuromsky G.K., Zavriev S.K., Zarouk V.N., Ivanyuk V.G., Kuznetsov M.A., Pliakhnevich M.P., Pshechenkov K.A., Simakov E.A., Sklyarova N.P., Staszewski Z., Uskov A.I., Yashin I. M. Protection of potato from diseases, pests and weeds. Moscow: Potato, 2009; 272 p.

Eichenlaub R., Gartemann K.H. The *Clavibacter michiganensis subspecies*: molecular investigation of grampositive bacterial plant pathogens. *Ann. Rev. Phytopathol*. 2011;49:445–464.

Romanenko A.S., Riffel A.A., Graskova I.A., Rachenko M.A. The role of extracellular pHhomeostasis in potato resistance to ring rot pathogen *J. Phytopathol.* 1999;147(11–12).

Roozen N.J.M., Van Vuurde J.W.L. Development of a semi-selective medium and an immunofluorescence colony-staining procedure for the detection of *Clavibacter michiganensis* subsp. *sepedonicus* in cattle manure slurry. *Netherlands J. Plant Pathol*. 1991;97(5): 321–334.

Rodionova L.V., Shurygina I.A., Sukhov B.G., Popova L.G., Shurygin M.G., Artemyev A.V., Pogodaeva N.N., Kuznetsov S.V., Gusarova N.K., Trofimov B.A. Nanobiocomposite of selenium and arabinogalactan: synthesis, structure and application. *Journal General Chemistry*. 2015;85(2);314–316.

Acknowledgements. The work was supported by grants of the President of the Russian Federation No. MK-1220.2019.11 and the Federal Property Fund of the Russian Federation and the Government of the Irkutsk region (project No. 17-416-380001).

Conflict of interest. The authors declare no conflict of interest.