Types of biologically active substances, methods of their application as factors of increasing resistance of varieties of various potatoes in an effort to realize greater productivity when exposed to pathogenic organisms

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Abstract. All countries in the world strive not to repeat the potato famine of Ireland. Potatoes infect more than 100 pathogens, one of the most serious is late blight. In the world, the average loss of potato yield from late blight is 10-15% per year. This article briefly discusses various safe, effective and environmentally friendly methods of preventing and controlling late blight of potatoes.

1. Introduction

Potato (Solanum tuberosum L.) is one of the most important non-grain, high-yielding food crops in the world. Potatoes have been cultivated for over 7000 years and come from the Andean region. [1,2].

It is the world's fourth most important crop after rice, wheat, and corn [3,4]. Various pathogens cause global yield losses and negatively affect potato crops [5]. One of the serious diseases is late blight caused by oomycete Phytophthora infestans [4].

Late blight was first reported in the United States in Philadelphia in 1843, and then spread throughout the country [6]. Late blight was reported in Europe in 1845, where it spread to Austria, Belgium, Denmark, France, Germany, Sweden, Switzerland and the Netherlands, England and Ireland [7-9]. In Ireland, most of the potato crop that year rotted in the fields. This partial crop failure was followed by more devastating failures in 1846-1849, as each year's potato crop was almost completely destroyed by late blight [10,11]. After the potato was affected by late blight, an Irish potato famine arose, which subsequently provoked a migration of the population. This is how late blight spread throughout the world.

Phytophthora infestans is a hemibiotrophic pathogen that, after a short biotrophic phase, causes extensive necrosis of leaves and stems, which can completely destroy the photosynthetic ability of the plant in a short period of time.

This disease, under favorable climatic conditions and a susceptible potato variety, can produce up to 300,000 spores per lesion every 3-5 days [12,13]. Tubers also become infected depending on environmental conditions when spores from leaves are washed to the soil surface and can infect tubers in the soil through wounds, lenticels, or eyes. Many spores can travel long distances through the air and cause infections of leaves and tubers [12,14]/
The presence of even a small percentage of late blight can lead to complete loss of the crop during storage [15]. Tubers from fields can also be infected by spores dispersed through the air from neighboring fields. Late blight can lead to enormous storage losses and is also a mechanism for pathogen survival and spread. Late blight prevention is an essential value of growing potatoes.

Currently, a large number of commercially grown potato varieties are susceptible to late blight. Thus, control of potato late blight is largely dependent on the frequent application of fungicides. In countries with moderately humid climates, potato growers during the growing season are spraying 12 or more times (during wet growing seasons). The costs are estimated at hundreds of millions of Euro per year to treat potatoes against late blight, and besides that the frequent application causes side effects to the environment (soil compaction and additional CO₂ emissions) [16,17].

The aim of this paper is to review the disease of potato phytophthora and methods of controlling it.

2. Results and discussion
Climate change and pathogens pose a threat to potato seed quality and production. The spread of late blight in potatoes (Phytophthora infestans) poses a threat to potatoes [18].

Environmental parameters such as temperature, moisture and moisture content of leaves influence the development of late blight disease [19].

The protection of potatoes from late blight is complex and it is still solved mainly by the use of fungicides, so the development of a method for the prevention and control of late blight is relevant [20].

In the study of scientists [20], chitosan has a direct antimicrobial effect on potato late blight and can be used as an inducer and synergist in vitro.

Studies of the authors showed that phosphoric acid can inhibit late blight [21]. When phosphanates are applied to foliage, they move to the tubers to suppress late blight of tubers and leaves.

Azospirillum lipoferum has a good effect to control late blight in greenhouse and field conditions for potato production [22].

Bacillus subtilis is a safe, non-toxic microorganism for humans and a non-pathogen for plants. It effectively destroys bacterial, viral and fungal cells against various plant diseases worldwide by synthesizing various cyclic lipopeptides [23-26].

Essential oils including juniper, thyme, cinnamon, clove, pepper, rosemary and tea tree contain a number of volatile and natural bioactive compounds such as tannins, carvacrol, sterols, flavonoids, phenols, borneol, quinones, alkaloids and others. Such natural bioactive compounds have a wide range of biological activities including antibacterial, anti-inflammatory, antioxidant, antiseptic, insecticidal, antiviral and antifungal [27].

But unfortunately, essential oils are very sensitive to the environment (light, temperature and humidity), which lead to chemical decomposition reactions [28]. For the application of essential oils, they are used in new compositions as nanoparticles and encapsulations, which increase the antimicrobial effectiveness and resistance against plant pathogenic fungi and bacteria [29-31].

Potassium phosphite can have an inhibitory direct effect on oomycetes (growth and sporulation) and, in turn, counteract the development of potato late blight [32].

3. Conclusions
Further climate change and diseases pose a threat to both seed quality and food potato production.

Most commercially grown potato varieties are susceptible to phytophthora, so the control of potato late blight is largely dependent on the frequent application of fungicides.

That said, frequent fungicide application has undesirable side effects for the environment.

As the production environment evolves rapidly, finding a balance on the doorstep of potato science will be critical to its continued success. But as things change, they remain largely the same.

Success will come as we learn to understand the environment, the needs of the crop, and the resources available. Then we must learn to use these factors to our advantage. The details will change, the tools will evolve, but the general principles will remain the same.
Various safe, effective and environmentally friendly methods of prevention and control of potato late blight, which are very important to reduce the use of fungicides [33].

Thanks to new technological advances, created preparations and various types of new varieties of potatoes, it is possible to avoid mistakes in the loss of potato productivity from harmful organisms.

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