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BIOLOGICAL CONTROL OF *VENTURIA INAEQUALIS* – THE CAUSE OF APPLE SCAB IN APPLE

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Abstract
The main goal of the experiment was to study the possibility for biological control of apple scab by use of innovative biofungicide Vacciplant (a.m. Laminarin) and to compare the results of biological control with those from standard chemical control of this disease. Experiment was conducted during the 2016 in region of Prespa and region of Tetovo, on two apple varieties, idared and golden delicious. In untreated variant in region of Tetovo, was observed very high level of infection (77.21% on the leaves and 24.35% on the fruits), which demonstrated the destructive potential of this apple disease in our country. In region of Prespa, significantly lower level of infection was observed in untreated variant (30% on the leaves and 9.5% on the fruits). Regarding the efficacy of tested fungicides, in region of Tetovo, standard fungicide Merpan (a.m. captan) used in chemical variant provided considerably lower degree of efficacy on leaves and fruits (71.38% and 60.86% respectively), compared with biofungicide used in biological variant (95.13% and 94.78% respectively). In region of Prespa, the efficacy performance of standard fungicides on the leaves and fruits (98.33% and 100% respectively) was almost equal with the performance of biofungicide (99.16% and 100%).

Keywords: apple scab, biological control, Vacciplant.

Introduction

Apple scab, caused by *Venturia inaequalis* (Cooke) G. Wint., is the most important apple disease, which causes economic losses in apple production worldwide. Without the application of appropriate control measures, the damages can reach up to 100%, especially in susceptible varieties (Ivanovic, 1992). Besides, it leads to early defoliation (Urbanovich and Kazlovskaya, 2008). Its significance is indicated by the fact that up to 30 fungicide treatments are performed per season to control apple scab disease (Soriano et al., 2009; Mac Hardy et al., 2001; Eccel et al., 2009). Such a large number of chemical treatments raise a range of environmental issues, human health problems and cost increases (Lespinasse et al., 2002). Forecasting models which are based on weather data can reliably predict infection periods, but the success of the control strategies mainly depends on the availability of efficient curative fungicides. In the integrated production several chemical fungicides have been used until *V. inaequalis* developed resistances against these active ingredients (Jones, 1981; Kunz et al., 1997). Biological control of apple scab is has been investigated for over 50 years, but most of this researches are focused on overwintering stage of *Venturia inaequalis* (Kohl et al, 2015). Laminarin, the active ingredient of Vacciplant, is an oligosaccharide extracted from the seaweed *Laminaria digitata*. It is an elicitor which triggers plant natural resistance via the induction of plant defense mechanisms. Vacciplant included in protection programs against scab ensures similar protection to conventional programs and can results with the reduction of chemical fungicide treatments before harvesting allowing reducing the quantity of residues and the number of detected fungicide molecules in apple (Mery and Joubert, 2012).

The main goal of the experiment was to study the possibility for biological control of apple scab by use of innovative biofungicide Vacciplant (a.m. Laminarin) and to compare the results of biological control with those from standard chemical control of this disease.

Material and methods

Experiment was conducted during the 2016 in two main regions for apple production in the Republic of Macedonia, Prespa and Tetovo, on two apple varieties, idared and golden delicious. In both tested regions, the experiment was comprised of 3 variants and in each variant 10 apple trees were included. Two variants were treated with fungicides, while the third one served as control (Table 1).

Table 1. Variants included in both tested regions (Prespa and Tetovo)

No.	Active ingredient	a.m. in formulation	Dosage
1.	Laminarin	45 g/L	1 L/ha
2.	Captan	80%	2.5 L/ha
3.	Control (untreated)		

The treatments were performed with a pesticide sprayer with a volume of 10 L. During the trial, total of 5 treatments of apple trees were performed, with spraying interval of 7-10 days. Evaluation of the efficacy of the tested fungicides was performed 7 days after the last treatment. For that purpose, scale from 0 to 5 was used. The intensity of infection was calculated according to the formula of Townsend-Heuberger (1943), while the fungicide efficacy was evaluated by the formula of Abbott (1925).

Results and discusion

The obtained results regarding the intensity of infection and efficacy of tested fungicides in the control of apple scab (*V. inaequalis*) are presented in Table 2 and Table 3.

Table 2. Intensity of infection and efficacy of tested fungicides in control of *Venturia inaequalis* in region of Prespa

Variant	Intensity of infection on leaves (%)	Efficacy of fungicides on leaves (%)	Intensity of infection on fruits (%)	Efficacy of fungicides on fruits (%)
Laminarin	0.25	99.16	0	100
Captan	0.5	98.33	0	100
Control	30	-	9.5	-

In untreated variant in region of Tetovo, very high level of infection was observed (77.21% on the leaves and 24.35% on the fruits), which demonstrated the destructive potential of this apple disease in our country. In region of Prespa, significantly lower level of infection was observed in untreated variant (30% on the leaves and 9.5% on the fruits).

Regarding the efficacy of tested fungicides, in region of Tetovo, standard fungicide Merpan (a.m. captan) used in chemical variant provided considerably lower degree of efficacy on leaves and fruits (71.38% and 60.86% respectively), compared with biofungicide used in biological variant (95.13% and 94.78% respectively). In region of Prespa, the efficacy performance of standard fungicides on the leaves and fruits (98.33% and 100% respectively) was almost equal with the performance of biofungicide (99.16% and 100%). Similar results regarding the efficacy of biofungicide Vacciplant in the control of apple scab, were obtained in other two studies. Thus, Mery and Joubert (2012) and Bernardon et al. (2013), reported that a.i. laminarin used to control secondary infections of apple scab (from July till harvest), ensured protection which was equivalent to conventional programmes for control of apple scab.

Table 2. Intensity of infection and efficacy of tested fungicides in control of *Venturia inaequalis* in region of Tetovo

Variant	Intensity of infection on leaves (%)	Efficacy of fungicides on leaves (%)	Intensity of infection on fruits (%)	Efficacy of fungicides on fruits (%)
Laminarin	3.76	95.13	1.27	94.78
Captan	22.09	71.38	9.53	60.86
Control	77.21	-	24.35	-

Conclusions

Management of apple scab can be achieved by planting resistant cultivars, cultural practices and fungicide applications. Still, the management is mainly based on repeated fungicide applications in the season, that result in high costs in terms of money for the fungicide applications and in time dedicated to scab management. Because of increasing pressure on apple growers to reduce pesticide use and reduce production costs, while maintaining a high level of crop quality, it is crucial to simplify and optimize apple scab management. Moreover, development of resistance to synthetic fungicides complicates the situation further.

The development of novel antagonists for biological control of apple scab may offer alternative options for disease control. The results obtained in this study showed that the novel biofungicide Vacciplant (a.i. laminarin) achieved almost equal reduction of apple scab incidence and has a prospective use for control of *Venturia inaequalis* in apple production.

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