NEW OPPORTUNITIES FOR CHEMICAL CONTROL OF *VENTURIA INAEQUALIS* AND *PODOSPHAERA LEUCOTRICHA* IN APPLE ORCHARDS IN MACEDONIA

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Abstract
The possibility of simultaneous effective control of apple scab and apple powdery mildew, by using single fungicidal active substance, and to compare the obtained results with those from standard chemical control, were the main goal of these experiments. In this study two fungicides were included: Sercadis (a.m. fluxapyroxad) and Indar 5 EW (a.m. fenbuconazole). 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, significantly high level of infection of apple scab (43%) and apple powdery mildew (18,2%) were recorded. In region of Prespa, the situation with the control variant was quite the opposite (15,2% apple scab and 36% apple powdery mildew infection). Regarding the efficacy of tested fungicides, in region of Tetovo, the standard fungicide Indar 5 EW (a.m. fenbuconazole) provided protection efficiency of 94,58% against apple scab and 98,18% against apple powdery mildew. In the same region, the efficacy in variants treated with fungicide Sercadis was quite similar (92,65% efficacy protect against apple scab and 98,68 against apple powdery mildew). In region of Prespa, the efficacy performance of standard fungicide against apple scab and powdery mildew (95,65% and 94,44% respectively) was almost equal with the performance of fungicide Sercadis (94,53% and 96,66%).

Keywords: apple scab, apple powdery mildew, Sercadis.

Introduction

Apple scab (*Venturia inaequalis*) and powdery mildew (*Podosphaera leucotricha*) are the economically most important apple diseases in all temperate climate production regions worldwide (Ivanovic, 1992). In the absence of proper and adequate control measures, both pathogenic fungi, can cause severe economically losses, which can reach up to 100%, especially in susceptible varieties (Ivanovic, 1992). Applications of fungicides throughout the growing season at weekly intervals, have been the foundation of apple scab management for the past 70 years (Kerik, 2015). In commercial plantations, from 10 up to 30 fungicidal treatments are performed throughout the vegetation (Soriano et al., 2009, Mac Hardy et al., 2001, Eccel et al., 2009). The excessive use of synthetic fungicides, raised a range of environmental issues, human health problems and increased the costs of production (Lespinasse et al., 2002). In this regard, apple producers continually seek to reduce the number of fungicide applications and improve the timing of applications by capitalizing on postinfection activity. As older broad-spectrum fungicides with postinfection activity were taken off from the market due to health concerns in the 1960s, only the “modern” single-site fungicides introduced in the later part of the twentieth and beginning of the twenty-first centuries could offer postinfection activity. Unfortunately, the introduction of new single-site fungicide, occurred in a slow successive manner and led to the unfortunate practice of overreliance and development of fungicide resistance in many of the fungicide classes effective for the management of apple scab and powdery mildew (Kerik, 2015). Numerous apple growers have lost or are in danger of losing several classes of highly effective fungicides for control of apple scab and powdery mildew, due to the development of

resistance (Turechek and Köller, 2004). For these reasons, the search for new active molecules, or the improvement of the existing, combination of old improved active molecules with new and similar, are a constant task of the manufacturers of fungicides (Kerik, 2015).
SDHI fungicides are derived from a diverse range of chemistry and, depending on the host and pathogen, have protectant, translaminar or systemic activity. They have been given the FRAC activity group code number 7 (NZPPS 2009) and comprise seven chemical groups including phenyl-benzamides and pyridinyl-ethyl-benzamides as well as furan-, oxathiin-, thiazole-, pyrazole- and pyridine-carboxamides (Beresford, 2011). SDHI fungicides specically inhibit fungal respiration by blocking the ubiquinone-binding sites in the mitochondrial complex II (Avenot and Michailides 2010). Generation I of SDHIs, including carboxin and oxycarboxin, have been used internationally since the late 1960s and are highly effective against basidiomycete pathogens such as rusts or *Rhizoctonia* spp. The newer generation II of SDHIs, such as boscalid, fluxapyroxad, penthiopyrad, isopyrazam and fluopyram, have a spectrum of activity against a broader range of fungal pathogens of various crops (Avenot and Michailides 2010). Generation II of SDHIs are intended for use in integrated disease management programmes, or as mixing or alternation partners to prevent fungicide resistance. Fungicides from this class are effective against various diseases of cereals, grape, stonefruit, strawberry, kiwifruit, apple and cucurbit (Beresford, 2011).
The main goal of the experiment was to study the possibility for control of apple scab and powdery mildew, by use of innovative fungicide Sercadis (a.m. fluxapyroxad) and to compare the results with those from standard chemical control of this disease.

Material and methods

The trial was conducted during the 2016 in two regions in the Republic of Macedonia: Prespa (variety Idared) and Tetovo (variety Golden delicious). In both tested regions, the experiment was consisted of 3 variants. Each variant was comprised of 10 apple trees. Two variants were treated with fungicides, while the third one served as control (Table 1). The treatments were performed with a pesticide sprayer with a volume of 10 L. During the trial, total of 3 treatments of apple trees were performed, with spraying interval of 7 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).

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

No.	Active ingredient	a.m. in formulation	Dosage
1.	Fluxapyroxad	300 g/L	0,3 L/ha
2.	Fenbuconazole	50 g/L	1 L/ha
3.	Control (untreated)		

Results and discussion

The obtained results regarding the intensity of infection and efficacy of the tested fungicides in the control of apple scab (*V. inaequalis*) and powdery mildew (*P. leucotricha*) are presented in Table 2 and Table 3.
The destructive potential of these two economically important diseases was confirmed in the control variants in two tested regions. In untreated variant in region of Tetovo, significantly high level of infection of apple scab (43%) and apple powdery mildew (18,2%) were recorded. In region of Prespa, the situation with the control variant was quite the opposite (15,2% apple scab and 36% apple powdery mildew infection).

Table 2. Intensity of infection and efficacy of tested fungicides in control of *Venturia inaequalis* in both tested regions

	Region of Prespa		Region of Tetovo	
Variant	Intensity of infection (%)	Efficacy of fungicides (%)	Intensity of infection (%)	Efficacy of fungicides (%)
Fluxapyroxad (Sercadis)	0,83	94,53	3,16	92,65
Fenbuconazole (Indar)	0,66	95,65	2,33	94,58
Control	15,2	-	43	-

Table 3. Intensity of infection and efficacy of tested fungicides in control of *Podosphaera leucotricha* in both tested regions

	Region of Prespa		Region of Tetovo	
Variant	Intensity of infection (%)	Efficacy of fungicides (%)	Intensity of infection (%)	Efficacy of fungicides (%)
Fluxapyroxad (Sercadis)	1,2	96,66	0,24	98,68
Fenbuconazole (Indar)	2	94,44	0,33	98,18
Control	36	-	18,2	-

Regarding the efficacy of tested fungicides, the results clearly showed that the novel fungicide Sercadis achieved extremely high efficacy in the control of the apple scab (94,53% and 92,65% respectively) and powdery mildew (96,66% and 98,68 resprectively) in both tested regions. The standard fungicide Indar 5 EW (a.m. fenbuconazole) has also achieved high efficacy in the control of apple scab and powdery mildew, in both tested regions. This, in the region of Prespa, the efficacy performance of standard fungicide against apple scab and powdery mildew (95,65% and 94,44% respectively) was almost equal with the performance of fungicide Sercadis (94,53% and 96,66%).
Similar results were obtained by other authors in the control of apple scab and apple powdery mildew (Cox, 2015; Beresford, 2011; Villani and Nance, 2017; Berrie and Xu, 2010). These authors, considered that SDHI fungicides, especially the II generation (such as boscalid, fluxapyroxad, penthiopyrad, isopyrazam and fluopyram), have a spectrum of activity against a broader range of fungal pathogens of various crops, and their efficiency in apple production is currently high (Avenot and Michailides, 2010). Generation II SDHIs are intended for use in integrated disease management programmes, or as mixing or alternation partners to prevent fungicide resistance. Fungicides from this class are effective against various diseases of cereals, grape, stonefruit, strawberry, kiwifruit, apple and cucurbit (Beresford, 2011).

Conclusions

Apple scab and powdery mildew are diseases with devastating impact in apple production, which can result in decreased fruit quality and yield. Moreover, severe foliar infection can lead to premature defoliation and reduced tree vigor, which in turn may restrict or prevent formation of fruit buds for the next year. The obtained results in this study showed that two tested fungicides (Sercadis and Indar) achieved very high level of efficacy in the control of the two economically most important apple diseases (*Venturia inaequalis* and *Podosphaera leucotricha*). Still, fungicide applications require careful attention to timing, as preventing early infection is the most important step toward successfully controlling later infections. Moreover, good sanitation and cultural control practices can also minimize the need for fungicide sprays at some extent.

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