Efficacy of Sterol-Inhibiting Fungicides on the Control of Scab Disease (*Venturia Inaequalis*) in Apple Tree

Edlira Shahinasi and Ferdi Brahushi

***Abstract*—Apple scab, caused by Venturia Inaequalis is one of the most problematic diseases of apples in Korça region. The control of this disease requires different applications of fungicides. The aim of the study was the estimation of efficacy of sterol-inhibiting fungicides such as myclobutanil and penconazole on the control of scab disease. The effectiveness of fungicides was evaluated for two cultivars Golden Delicious and Starking and the minimum and the maximum recommended doses were applied. The obtained results showed that scab prevalence in leave ranges from 79.2% to 85.6% respectively in untreated trees of Golden Delicious and Starking cultivars. The scab prevalence of leaves in apples treated with pesticides ranges from 18.1% in Golden Delicious cultivar to 22.2% in Starking cultivar, meanwhile the scab prevalence in fruit varies from 4.2% in Starking cultivar to 6.1% in Golden Delicious cultivar. The disease index of leave in untreated control varies from 38.4% to 40.1% respectively for Golden Delicious cultivar and Starking cultivar, while the severity of fruit in untreated trees varies from 45.6% in Starking cultivar to 49.0% in Golden cultivar. Therefore, the data showed that the uses of sterol-inhibiting fungicides were effective in the control of scab disease.**

***Index Terms*—Efficacy, Apple Scab, Prevalence, Sterol-Inhibitor, Severity.**

I. Introduction

Apple scab caused by *Venturia Inaequalis* is a devastating disease of apples in the world, and the poor control of it can lead to reduction of quality and quantity of the fruit. In some circumstances, the losses from apple scab can be 70% or more of the total fruit. Over the years, fungicides have become the sole means to control apple scab and there has been little effort to commercialize alternative strategies [1-3]. Most apple cultivars are susceptible to scab, and not only in the commercial treatments are needed frequent fungicide applications (up to 15-20 different types of fungicides annually), but even in Integrated Pest Management systems [1, 4].

Among many classes of fungicides, sterol demethylation inhibitors (DMI) are the most effective. DMI They serve as backbone of apple disease management programs with the main focus on the control of apple scab [5].

According to Fungicide Resistant Action Committee (FRAC) this class of fungicides belongs to Code Group 3 and represents single-site inhibitor [6]. They bind to the cytochrome P450 a monooxygenase enzyme, thereby inhibit the biosynthesis of ergosterol which is responsible for the fluidity and stability of the membrane [7, 8].

The current study estimates the effectiveness of sterol-inhibiting fungicides such as myclobutanil and penconazole on the control of apple scab.

II. Materials And Methods

A. Experimental field

The experiment was conducted in an apple orchard in the region of Korça during the growing seasons of 2015 and 2016. The orchard was divided in blocks with three replications. Each replicate consisted of five trees. Two apple cultivars Golden Delicious and Starking were tested during the experiment, as the most affected cultivars by the scab disease. The control of apple scab disease was investigated by application of two fungicides myclobutanil and penconazole, with two levels of concentrations. Fungicide concentrations were: (1) myclobutanil (Brik 24; 24g/liter myclobutanil) at 15 mg/liter and 25 mg/liter, and (2) penconazole (PEN 10 EC; 10g/liter) at 25 mg/liter and 40mg/liter. The applications of the fungicides were applied by a tractor in which two sprays were mounted.

B. Scab incidence and severity

Disease incidence and severity were assessed after the last application. Thus, 10 leaves/fruits were taken randomly from each tree. The leaves and fruits where chosen from different sides of the tree, then were transferred to the laboratory for the analyses. The incidence and severity were estimated visually based on the analyses of leaves and fruits.

C. Disease incidence

The incidence was calculated using formula (1)

$$P = \frac{n}{N} x100 \quad (1)$$

where,
n - number of infected leaves/fruits screened
N – the total number of leaves/fruits screened

D. Disease index (severity)

Disease assessment was calculated using a scale developed by Tomerlin and Jones. The scale consisted at five categories: (0) no visible lesions; (1) < 5% leave/fruit surface infected; (2) 5-15% leave/fruit surface infected; (3) 15-25% leave/fruit surface infected; (4) 25- 50 leave/fruit surface infected, (5) >50% leave/fruit surface infected. Leave and fruit severity was calculated using Townsend-Huberger's formula (2):

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$$I = \frac{\sum n_i k_i}{NxK} x100 \quad (2)$$

where,
I – Index of disease
ni – the number of leaves/fruits per category
ki – degree of infection according to the scale
N – total number of leaves/fruits taken for analysis
K – the highest degree of category

E. Estimation of fungicides' effectiveness

The effectiveness of myclobutanil and penconazole was calculated using equation (3) [9]

$$Efficacy\ (\%) = \frac{X-Y}{X} x100 \quad (3)$$

where, X – disease incidence/severity in untreated trees Y – disease incidence/severity in treated tree

F. Statistical analysis

Statistical analyses were done using the analysis of variance, two ways ANOVA. To identify significant treatment effects, the mean values were separated using Fisher's least significant difference (LSD) at 95% confidence level (P<0.05)

III. Results and Discussion

Obtained data are presented in the Table I. These data indicated that decease prevalence in leaves and fruits of untreated trees in Golden Delicious cultivar was very high. Thus, the prevalence in leaves and fruits in untreated tree was 79.2% and 95.0%, respectively. The similar situation was observed even in Starking cultivar. The prevalence in leaves and fruits in untreated trees of this cultivar was 85.6% and 97.8%, respectively. The scab incidence of leaves in apples treated with pesticides ranges from 18.1% in Golden Delicious cultivar to 22.2% in Starking cultivar, meanwhile the scab incidence in fruit varies from 4.2% in Starking cultivar to 6.1% in Golden Delicious cultivar (Table I). The efficacy of sterol-inhibiting fungicides in leaves varies from 74.1% to 77.1%, respectively for Starking and Golden Delicious cultivar, meanwhile the efficacy in the fruits ranges from 94.4% to 95.7% for Golden Delicious and Starking cultivar, respectively.

The statistical analysis of disease incidence data in leaves and fruits showed no significance differences between minimum and maximum doses of applied fungicides, whereas a great significance difference was observed between application of fungicides in apple trees and untreated apple trees.

TABLE I: Progress of disease incidence in leaves (L) and fruits (F) of Golden Delicious and Starking cultivars

Cultivar	Treatment	Disease prevalence (%)				Mean*		Efficacy (%)	
		2015		2016					
		L	F	L	F	L	F	L	F
Golden	Untreated tree	74.5	97.0	83.9	93.0	79.2^{b}	95.0^{b}		
	Maximum	17.2	5.0	18.9	6.5	18.1^{a}	5.3^{a}	77.1	94.4
	Minimum	17.2	5.6	18.9	6.7	18.1^{a}	6.1^{a}	77.1	93.6
Starking	Untreated tree	77.2	98.0	77.2	98.0	85.6^{b}	97.8^{b}		
	Maximum	17.2	3.9	19.4	4.5	18.3^{a}	4.2^{a}	78.6	95.7
	Minimum	19.5	4.5	25.0	5.2	22.2^{a}	4.9^{a}	74.1	94.9
	LSD					**6.49**	**2.89**		

*Means within columns with different letters are significantly (P<0.05) different according to Fisher's least significant difference

The presented data in the Table II showed that the severity as well as the prevalence was very high in the untreated trees. The severity of leave in untreated trees varies from 38.4% to 40.1% respectively for Golden Delicious and Starking cultivar, while the disease index of fruit in untreated trees varies from 45.6% in Starking cultivar to 49.0% in Golden cultivar.

The disease index of leaves in treated apples tree with pesticides ranges from 8.9% in Golden Delicious cultivar to 13.5% in Starking cultivar, meanwhile the disease index in fruit varies from 1.2% in Starking cultivar to 2.2% in Golden Delicious cultivar.

The efficacy of sterol-inhibiting fungicides in leaves varies from 66.3% to 76.8% respectively for Starking and of Golden Delicious cultivar, meanwhile the efficacy in the fruits ranges from 95.5% to 97.4% for Golden Delicious and Starking cultivar, respectively. Despite the fact that some studies have reported resistance of *Venturia inaequalis* to sterol-inhibiting fungicides [10, 11] they still provide excellent control of apple scab.

TABLE II: Progress of disease severity in leaves (L) and fruits (F) of Golden Delicious and Starking cultivars

Cultivar	Treatment	Disease severity (%)				Mean		Efficacy (%)	
		2015		2016					
		L	F	L	F	L	F	L	F
Golden	Untreated tree	36.9	47.0	39.8	51.0	38.4^{c}	49.0^{c}		
	Maximum	8.7	1.6	9.1	1.8	8.9^{a}	1.7^{a}	76.8	96.5
	Minimum	9.0	2.1	9.7	2.3	9.3^{a}	2.2^{a}	75.8	95.5
Starking	Untreated tree	38.5	43.7	41.7	47.5	40.1^{d}	45.6^{b}		
	Maximum	12.2	1.0	12.5	1.4	12.4^{b}	1.2^{a}	69.1	97.4
	Minimum	13.2	1.3	13.9	1.7	13.5^{b}	1.5^{a}	66.3	96.7
	LSD					**1.28**	**1.48**		

*Means within columns with different letters are significantly (P<0.05) different according to Fisher's least significant difference

The statistical analysis of disease severity data in leaves and fruits showed no significance differences between minimum and maximum doses of applied fungicides, whereas a great significance difference was observed

between treated and untreated apple trees. Thus, the obtained data demonstrated that apple scab disease can be controlled successfully by application of sterol-inhibiting fungicides as myclobutanil and penconazole.

Based on statistical analyses, using maximum of doses of fungicides has not significant effect on apple scab efficacy compared to minimum fungicide concentration and its application can only contribute on the residues in apple fruits and environmental pollution.

IV. Conclusions

The results of the study indicate that the application of sterol-inhibiting fungicides reduce significantly incidence and severity of apple scab in leaves and fruits as well. The data related to the effectiveness of scab control provided by these fungicides demonstrate that they were very effective for the control of the scab disease in apple trees. The efficacy of these fungicides ranges from 66.3% to 76.8% in leaves and from 95.5% to 97.4% in fruits. The statistical analyses showed that between two treatments (mimimum and maximum doses) had no significant differences therefore, minimum recommended doses of fungicides myclobutanil and penconazole can be applied to control the apple scab disease, as they were very effective and can reduce possible pesticides residues in apple fruits and environment.

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