

## CONTROL OF *UNCINULA NECATOR* (SCHWE.) BURRILL IN GRAPEVINE BY USING THE FUNGICIDES FROM THE ANNEX I LIST

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### Abstract

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The research was conducted in Gevgelija – Valandovo vine-growing region during 2007, 2008 and 2009, in two commercial vineyards, on the wine grape variety Vranec and the table grape varieties Michelle Palieri and Italia (Muscat). The experiment consisted of six treated variants and one untreated control, in randomized block design with four replicates per treatment. In 2007 and 2008, grape powdery mildew had not been registered on the clusters in the examined vineyards, while in 2009 *Uncinula necator* was registered on the clusters in all of the studied variants. The tested fungicides Metrafenone, Tebuconazol and Boscalid + Krezoxim-methyl showed higher efficacy on the grapevine, than the fungicides Triadimenol + Folpet, Spiroxamine + Tebuconazol + Triadimenol and Propiconazole.

**Key words:** grape powdery mildew, *Uncinula necator*, fungicide, control, efficacy

**Abbreviations:** infection intensity (Inf.In.), fungicide efficacy (FE)

### Introduction

Vineyards cover 5% of total arable land in the Republic of Macedonia, out of which 70% are consisted of wine grape varieties, while the other 30% are table grape varieties (Ministry of agriculture, forestry and water economy, 2010). *Uncinula necator* – the cause of the powdery mildew of grapevine is one of the major problems in grape production in the Republic of Macedonia. Depending on the climate conditions, production area and variety, *Uncinula necator* can cause serious damage on grape vine (Mihajlovikj, 2000).

A recent report from the European Union points out that although vineyards represent only 8% of the total arable land in the member countries, around 70% of the total fungicides used, are applied for cultivation of grape vine (Montgomery and Hansen, 2000; Hayes, 2006).

In the European Union, the evaluation, marketing and usage of pesticides (herbicides, insecticides, fungicides etc.) for plant protection, is directed with the Directive from the Council, number 91/414/EEC. With the Annex I from the Directive 91/414/EEC, a list of approved active ingredients is established and the EU members can use only pesticides which active ingredients are on this list. Moreover, it must be proven that every active ingredient on this list is safe regarding the health of the people, biodiversity and the environment.

In 1993, the European commission has initiated a revision of all the active ingredients which were used in the plant protection in the EU countries (loc.cit. [http://ec.europa.eu/food/plant/protection/evaluation/dir91-414eec\\_en.htm](http://ec.europa.eu/food/plant/protection/evaluation/dir91-414eec_en.htm)). In 2009, a new EU Regulative no. 1107/2009 for plant protection products was established. This Regulative especially emphasizes that active ingredients which are carcinogens, mutagens, en-

doctrine disturbers or substances toxic for reproduction and that are very persistent will not be approved (loc.cit. [http://ec.europa.eu/food/plant/protection/evaluation/dir91-414eec\\_en.htm](http://ec.europa.eu/food/plant/protection/evaluation/dir91-414eec_en.htm)).

Taking into consideration all of that is said above, the aim of this study was to investigate the possibility of controlling *Uncinula necator* in the Republic of Macedonia with fungicides that are placed on the Annex I list.

## Materials and Methods

The research was conducted during 2007, 2008 and 2009 in Gevgelija – Valandovo region on two localities: Kjud and Moin on the wine grape variety Vranec, which is a leading variety in the Republic of Macedonia, and the table grape varieties Michele Palieri and Italia (Muscat).

The experiment consisted of seven variants for each grape variety, in randomized block design with four replicates per treatment. Six of the variants were treated with fungicides which active ingredients were on the Annex I list (Table 1), while one was untreated and used as control. Each variant consisted of four rows, in which the middle two rows were used in determining the infection intensity of powdery mildew on the leaves and the cluster.

During 2007 and 2008, in the two tested locations four fungicide treatments were performed (end of May, middle of June, end of June and middle of July), while in 2009 five fungicide treatments were performed (end of May, middle of June, end of June, middle of July and end of July) on the grape vine. In the first two years of the trial, two evaluations of the infection intensity were conducted (after the second and the fourth treatment). In 2009, a third evaluation was performed after the fifth treatment.

According to Jovanchev (2007), from every variant by random choice 400 leaves and 50 clusters were collected and were classified in separate categories. For that purpose, the Untersten-höfer scale from 0 to 5 was used (Stojanovikj et al., 1971):

- Leaf: 0 = healthy leaf; 1 = up to 10% infected leaf area; 2 = 10 – 25% infected leaf area; 3 = 25 – 50% infected leaf area; 4 = 50 – 75% infected leaf area; 5 = 75 – 100% infected leaf area.

- Cluster: 0 = healthy cluster; 1 = up to 10% infected grains in the cluster; 2 = 10 – 25% infected grains in the cluster; 3 = 25 – 50% infected grains in the cluster; 4 = 50 – 75% infected grains in the cluster; 5 = 75 – 100% infected grains in the cluster.

The infection intensity was calculated by the formula of Townsend-Heuberger (1943), while the fungicide efficacy was evaluated by the formula of Abbott (1925).

The statistical differences among fungicide efficacy were assessed using Tukey's HSD test.

## Results and Discussion

The results for the infection intensity and fungicide efficacy obtained during the three year trials are presented separately for each studied year.

### - Infection intensity and fungicide efficacy in 2007

The results for infection intensity (Inf.In.) and fungicide efficacy (FE) in the varieties Michele Palieri, Italia (Muscat) and Vranec in 2007 are presented in Table 2.

In Table 2, only results from the leaf infection intensity are presented, because in 2007 there were no infections on the cluster in all of the tested varieties.

The leaf infection with grape powdery mildew was observed to be very low among the treated variants and in the control. However, high statistically significant difference was observed between the control and the treated variants. In the control variants, the Inf.In. varied from 1.42% in the first, to 8.33% in the second evaluation.

The lowest Inf.In. among the treated variants in all of the tested varieties was observed in the treatments with the fungicides Tebuconazol and Metrafenone (0.04% in the first evaluation and 0.08% in the second), with the highest FE. The high-

**Table 1**  
**Type of variants in the trial for control of *U. necator***

Active ingredient	Content of a. i.	Concentration %
Boscalid + Krezoxim-methyl	200 + 100 g/l	0.04
Spiroxamine + Tebuconazol + Triadimenol	250 + 167 + 43 g/l	0.04
Tebuconazol	250 g/l	0.04
Propiconazole	250 g/l	0.015
Triadimenol + Folpet	15 + 700 g/kg	0.2
Metrafenone	500 g/l	0.02
Control		

est Inf.In. in the first (0.17%) and the second evaluation (0.29% and 0.33%) was observed in the treatments with Spiroxamine + Tebuconazol + Triadimenol and Propiconazole.

The treatments with Tebuconazol and Metrafenone were significantly different compared to the treatments performed with Spiroxamine + Tebuconazol + Triadimenol in almost all of the evaluations, except during the first evaluation in the variety Vranec. Significant difference between the treatments with Tebuconazol and Metrafenone and the treatment performed with Propiconazole was observed during the first evaluation in the variety Michele Palieri and during both evaluations in the variety Vranec.

From all of the tested fungicides in 2007, the highest FE, above 97%, in all of the three varieties had the fungicides Tebuconazol and Metrafenone. The lowest FE, below 90%, had the treatment with Spiroxamine + Tebuconazol + Triadimenol.

#### - Infection intensity and fungicide efficacy in 2008

The results for infection intensity (Inf.In.) and fungicide efficacy (FE) in the varieties Michele Palieri, Italia (Muscat) and Vranec in 2008 are presented in Table 3.

In Table 3O, only results from the leaf infection intensity are presented, because in 2008, as it was in the previous 2007, no cluster infections in all of the tested varieties were monitored.

The leaf infection was observed to be very low among the control and the treated variants. In the control variants, the Inf.In. varied from 1.04% in the first, to 5.17% in the second evaluation, which is even lower than the previous 2007. Again, high statistically significant difference was observed between the control and all of the treated variants.

In the first evaluation, FE of 100% was observed in the treatments with Tebuconazol, Metrafenone and Boscalid + Krezoxim-methyl, where no infections were found (0%). The

**Table 2**  
**Results of Inf.In. and FE in controlling of *Uncinula necator* in 2007**

	Conc., %	Infection intensity and fungicide efficacy, %			
		Leaf (I evaluation)		Leaf (II evaluation)	
		Inf.In.	FE	Inf.In.	FE
<b>Plantation Kjøp - variety Michele Palieri</b>					
Spiroxamine+Tebuconazol+Triadimenol	0.04	0.17 bc	88.30	0.29 c	95.23
Tebuconazol	0.04	0.04 a	97.20	0.13 ab	97.86
Boscalid+Krezoxim-methyl	0.04	0.08 ab	94.37	0.13 ab	97.86
Metrafenone	0.02	0.04 a	97.20	0.08 a	98.68
Propiconazole	0.015	0.13 bc	90.85	0.17 ab	97.20
Triadimenol+Folpet	0.20	0.13 bc	90.85	0.21 bc	96.55
Control		<b>1.42 d</b>		<b>6.08 d</b>	
<b>Plantation Kjøp - variety Italia (Muscat)</b>					
Spiroxamine+Tebuconazol+Triadimenol	0.04	0.17 b	91.33	0.29 b	95.36
Tebuconazol	0.04	0.04 a	97.96	0.08 a	98.72
Boscalid+Krezoxim-methyl	0.04	0.08 ab	95.92	0.13 a	97.92
Metrafenone	0.02	0.04 a	97.96	0.08 a	98.72
Propiconazole	0.015	0.08 ab	95.92	0.13 a	97.92
Triadimenol+Folpet	0.20	0.13 ab	93.38	0.21 ab	96.64
Control		<b>1.96 c</b>		<b>6.25 c</b>	
<b>Plantation Moin - variety Vranec</b>					
Spiroxamine+Tebuconazol+Triadimenol	0.04	0.13 ab	93.75	0.33 c	96.47
Tebuconazol	0.04	0.04 a	98.10	0.08 a	99.04
Boscalid+Krezoxim-methyl	0.04	0.08 ab	96.16	0.13 ab	98.44
Metrafenone	0.02	0.04 a	98.10	0.08 a	99.04
Propiconazole	0.015	0.17 b	91.83	0.25 bc	96.99
Triadimenol+Folpet	0.20	0.13 ab	93.75	0.21 abc	96.03
Control		<b>2.08 c</b>		<b>8.33 d</b>	

\*The values marked with the same letter are not significantly different

highest Inf.In. was observed during the second evaluation (0.25% and 0.29%) in the variants treated with Propiconazole and Spiroxamine + Tebuconazol + Triadimenol.

Although the Inf.In. was low in all treated variants, statistically significant differences among various treatments were detected. A significant difference was observed between the treatments with Metrafenone and Tebuconazol and the treatment with Spiroxamine + Tebuconazol + Triadimenol in all of the treated variants in almost all evaluations. The treatment with Boscalid + Krezoxim-methyl showed significant difference regarding the treatment with Spiroxamine + Tebuconazol + Triadimenol only in the variety Italia (Muscat). In the variety Vranec a significant difference was observed between the treatments with Tebuconazol, Metrafenone and Boscalid + Krezoxim-methyl and the treatments with Propiconazole and Triadimenol + Folpet. In the variety Italia (Muscat) a significant difference was observed between the

treatments with Metrafenone and Tebuconazol and the treatment with Triadimenol + Folpet.

In 2008, the highest FE, above 97.5%, in all of the three varieties had the fungicides Tebuconazol, Metrafenone and Boscalid+Krezoxim-methyl. The lowest FE, below 90%, had the treatment with Spiroxamine + Tebuconazol + Triadimenol.

The Inf.In. of grape powdery mildew was lower in 2008, compared to 2007. This was probably due to the climatic conditions in the studied years. The impact that the climatic conditions have on the infections caused by *Uncinula necator* were studied by various authors (Mihajlovikj, 1996; Postolovski et al., 2007, 2008).

#### - Infection intensity and fungicide efficacy in 2009

Unlike the previous two studied years, in 2009 higher infection intensity on the leaves and on the cluster was observed. The results for infection intensity (Inf.In.) and fungicide effi-

**Table 3**  
**Results of Inf.In. and FE in controlling of *Uncinula necator* in 2008**

	Conc., %	Infection intensity and fungicide efficacy, %			
		Leaf (I evaluation)		Leaf (II evaluation)	
		Inf.In.	FE	Inf.In.	FE
<b>Plantation Kjup - variety Michele Palieri</b>					
Spiroxamine+Tebuconazol+Triadimenol	0.04	0.13 b	87.50	0.21 b	95.13
Tebuconazol	0.04	0.00 a	100	0.08 ab	98.14
Boscalid+Krezoxim-methyl	0.04	0.04 ab	96.15	0.08 ab	98.14
Metrafenone	0.02	0.00 a	100	0.04 a	99.07
Propiconazole	0.015	0.08 ab	92.30	0.13 ab	96.99
Triadimenol+Folpet	0.20	0.08 ab	92.30	0.17 ab	96.06
Control		<b>1.04 c</b>		<b>4.32 c</b>	
<b>Plantation Kjup - variety Italia (Muscat)</b>					
Spiroxamine+Tebuconazol+Triadimenol	0.04	0.17 c	87.21	0.29 c	94.06
Tebuconazol	0.04	0.00 a	100	0.04 a	99.18
Boscalid+Krezoxim-methyl	0.04	0.04 ab	96.99	0.08 ab	98.36
Metrafenone	0.02	0.04 ab	96.99	0.04 a	99.18
Propiconazole	0.015	0.04 ab	96.99	0.13 ab	97.34
Triadimenol+Folpet	0.20	0.13 bc	90.22	0.17 a	96.52
Control		<b>1.33 d</b>		<b>4.89 d</b>	
<b>Plantation Moin - variety Vranec</b>					
Spiroxamine+Tebuconazol+Triadimenol	0.04	0.13 ab	92.21	0.17 bc	96.71
Tebuconazol	0.04	0.04 a	97.60	0.04 a	99.22
Boscalid+Krezoxim-methyl	0.04	0.00 a	100	0.08 ab	98.45
Metrafenone	0.02	0.04 a	97.60	0.04 a	99.22
Propiconazole	0.015	0.13 ab	92.21	0.25 c	95.16
Triadimenol+Folpet	0.20	0.17 ab	89.82	0.21 c	95.93
Control		<b>1.67 c</b>		<b>5.17 d</b>	

\*The values marked with the same letter are not significantly different

cacy (FE) in the varieties Michele Palieri, Italia (Muscat) and Vranec in 2009 are presented in Tables 4 and 5.

In 2009, leaf infection was observed in all of the variants after the three evaluations (Table 4). After the first evaluation no cluster infection was observed, but during the second and the third evaluation, cluster infection of *Uncinula necator* was monitored. That is why in Table 5 results from the second and the third evaluation for cluster Inf.In. are presented.

In the control variants, the leaf and the cluster Inf.In. were the highest during the second evaluation (31.65% leaf Inf.In. and 11.36% cluster Inf.In. in the variety Vranec) due to favorable climatic conditions.

The lowest leaf Inf.In. among the treated variants in all of the tested varieties was observed in the treatments with the fungicides Tebuconazol, Metrafenone and Boscalid + Krezoxim-methyl (from 0.21% in the first evaluation to 1.42% in the second). The lowest cluster Inf.In. (0.17% - 0.71%) was

established with the same treatments. The highest leaf Inf.In. (0.46% - 2.04%) was observed in the treatments with Spiroxamine + Tebuconazol + Triadimenol, Triadimenol + Folpet and Propiconazole. The treatments with the same fungicides had the lowest FE in the clusters, where the highest cluster Inf.In. was observed (from 0.67% in the third to 1% in the second evaluation).

Generally, no statistically significant difference was detected between different treatments. During the first evaluation of the fungicides for the leaf FE significant difference was observed between all of the treated varieties, but as the conditions became more favorable for the disease, the differences disappeared. During the first evaluation, significant difference was observed between the treatment with Metrafenone and the treatment with Spiroxamine + Tebuconazol + Triadimenol in all of the tested varieties. In the variety Michele Palieri, a significant difference was also observed

**Table 4**  
**Results of leaf Inf.In. and FE in controlling of *Uncinula necator* in 2009**

	Conc., %	Infection intensity and fungicide efficacy, %					
		Leaf (I evaluation)		Leaf (II evaluation)		Leaf (III evaluation)	
		Inf.In.	FE	Inf.In.	FE	Inf.In.	FE
<b>Plantation Kijup - variety Michele Palieri</b>							
Spiroxamine+Tebuconazol+Triadimenol	0.04	0.33 b	94.93	1.33 a	95.16	0.83 a	96.47
Tebuconazol	0.04	0.29 ab	95.55	1.29 a	95.30	0.79 a	96.64
Boscalid+Krezoxim-methyl	0.04	0.25 ab	96.16	1.08 a	96.06	0.58 a	97.53
Metrafenone	0.02	0.21 a	96.77	1.13 a	95.88	0.67 a	97.15
Propiconazole	0.015	0.33 b	94.93	1.33 a	95.16	0.79 a	96.64
Triadimenol+Folpet	0.20	0.46 c	92.94	1.67 a	93.92	0.96 a	95.92
Control		<b>6.52 d</b>		<b>27.48 b</b>		<b>23.57 b</b>	
<b>Plantation Kijup - variety Italia (Muscat)</b>							
Spiroxamine+ Tebuconazol+ Triadimenol	0.04	0.46 b	93.45	1.96 a	93.45	1.29 a	94.80
Tebuconazol	0.04	0.33 ab	95.30	1.38 a	95.30	0.88 a	96.45
Boscalid+Krezoxim-methyl	0.04	0.38 ab	94.59	1.67 a	94.59	1.00 a	95.97
Metrafenone	0.02	0.25 a	96.44	1.33 a	96.44	0.92 a	96.29
Propiconazole	0.015	0.38 ab	94.59	1.71 a	94.59	1.00 a	95.97
Triadimenol+Folpet	0.20	0.42 ab	94.02	1.92 a	94.02	1.38 a	94.43
Control		<b>7.03 c</b>		<b>28.91 b</b>		<b>24.82 b</b>	
<b>Plantation Moin - variety Vranec</b>							
Spiroxamine+Tebuconazol+Triadimenol	0.04	0.50 bc	94.29	1.96 a	93.80	1.54 a	94.52
Tebuconazol	0.04	0.33 ab	96.23	1.54 a	95.13	1.25 a	95.55
Boscalid+Krezoxim-methyl	0.04	0.33 ab	96.23	1.42 a	95.51	1.17 a	95.83
Metrafenone	0.02	0.29 a	96.68	1.46 a	95.38	1.21 a	95.69
Propiconazole	0.015	0.54 c	93.83	2.04 a	93.55	1.71 a	93.91
Triadimenol+Folpet	0.20	0.46 abc	94.74	1.83 a	94.21	1.46 a	94.80
Control		<b>8.76 d</b>		<b>31.65 b</b>		<b>28.11 b</b>	

\*The values marked with the same letter are not significantly different

between the treatment with Metrafenone and the treatments with Triadimenol + Folpet and Propiconazole. In the variety Vranec, the treatments with Tebuconazol, Metrafenone and Boscalid + Krezoxim-methyl were significantly different from the treatment with Propiconazole.

Regarding the cluster FE, the only significant difference between the various treatments was observed during the first evaluation in the variety Michele Palieri. It was identified that the treatments with Metrafenone and Boscalid + Krezoxim-methyl showed statistically significant difference compared with the treatments with Propiconazole, Triadimenol + Folpet and Spiroxamine + Tebuconazol + Triadimenol. No statistically significant differences were detected between the other treatments in the other varieties.

Due to the favorable climatic conditions in 2009, the examined fungicides were put on a serious test and they showed satisfactory chemical protection, especially in the protection

of clusters. In all evaluated grapevine varieties, high statistically significant difference was observed between the control and all of the treated variants.

From all of the tested fungicides, Tebuconazol, Metrafenone and Boscalid + Krezoxim-methyl had FE above 97% on the leaves and 96 – 97% on the clusters.

## Conclusion

The results from the three year trials showed that all of the tested fungicides are effective in the control of *Uncinula necator*. However, the highest fungicide efficacy is established with the fungicides Metrafenone, Tebuconazol and Boscalid + Krezoxim-methyl on the leaves and on the clusters. Lower fungicide efficacy is detected in the treatments with Triadimenol + Folpet, Spiroxamine + Tebuconazol + Triadimenol and Propiconazole, but still with satisfactory protection

**Table 5**  
**Results of cluster Inf.In. and FE in controlling of *Uncinula necator* in 2009**

	Conc., %	Infection intensity and fungicide efficacy, %			
		Cluster (II evaluation)		Cluster (III evaluation)	
		Inf.In.	FE	Inf.In.	FE
<b>Plantation Kjup - variety Michele Palieri</b>					
Spiroxamine+Tebuconazol+Triadimenol	0.04	0.58 c	93.34	0.50 a	92.74
Tebuconazol	0.04	0.54 bc	93.80	0.46 a	93.32
Boscalid+Krezoxim-methyl	0.04	0.21 a	97.58	0.17 a	97.53
Metrafenone	0.02	0.29 ab	96.67	0.21 a	96.95
Propiconazole	0.015	0.63 c	92.76	0.54 a	92.16
Triadimenol+Folpet	0.20	0.79 c	90.92	0.67 a	90.27
Control		<b>8.71 d</b>		<b>6.89 b</b>	
<b>Plantation Kjup - variety Italia (Muscat)</b>					
Spiroxamine+Tebuconazol+Triadimenol	0.04	0.83 a	91.01	0.54 a	92.92
Tebuconazol	0.04	0.33 a	96.42	0.50 a	93.44
Boscalid+Krezoxim-methyl	0.04	0.58 a	93.72	0.17 a	97.77
Metrafenone	0.02	0.25 a	97.29	0.29 a	96.19
Propiconazole	0.015	0.67 a	92.74	0.58 a	92.39
Triadimenol+Folpet	0.20	0.63 a	93.18	0.71 a	90.69
Control		<b>9.24 b</b>		<b>7.63 b</b>	
<b>Plantation Moin - variety Vranec</b>					
Spiroxamine+Tebuconazol+Triadimenol	0.04	1.00 a	91.19	0.88 a	91.26
Tebuconazol	0.04	0.71 a	93.75	0.63 a	93.74
Boscalid+Krezoxim-methyl	0.04	0.75 a	93.39	0.67 a	93.34
Metrafenone	0.02	0.79 a	93.04	0.67 a	93.34
Propiconazole	0.015	1.00 a	91.19	0.92 a	90.86
Triadimenol+Folpet	0.20	0.92 a	91.90	0.83 a	91.75
Control		<b>11.36 b</b>		<b>10.07 b</b>	

\*The values marked with the same letter are not significantly different

(above 87% FE). These results confirm that grape powdery mildew can be controlled in the conditions of the Republic of Macedonia with the fungicides which active ingredients are on the Annex 1 list. Highly significant differences were observed between the untreated, control variants and the different treatments with various fungicides from this list.

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