THE LEVEL OF GRAPEVINE PATHOGEN INFECTION RATE REDUCTION IN THE APPLICATION OF TITANIUM AND SILICON-BASED PLANT STRENGTHENERS

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ABSTRACT

Field experiments were carried out in the vineyards to study the effect of adding Tytanit® (MgO 65 g/l, SO_3 130 g/l, Ti 8.5 g/l) and Optysil® (SiO_2 200 g/l, Fe 24 g/l) plant straighteners to fungicides, constituting the integrated spray program on the level of reduction of pathogen infection rate (*Peronospora*, *Botrytis*, *Oidium*). Adding a preparation of Optysil 3 to 4 times a season at a dose of 0.5 l / ha to fungicide sprays in a standard integrated spray program during a seasons with moderately favourable conditions for the development of the diseases, can reduce the downy mildew infection rate on leaves up to 27% and on bunches up to 33%, the powdery mildew rate on leaves up to 55% and on bunches up to 64 % and the grey mould rate from 42 to 49%. Adding a preparation of Tytanit 2 to 3 times a season at a dose of 0.2 l / ha, to fungicide sprays can reduce the downy mildew infection rate on leaves up to 33% and on bunches up to 39%, the powdery mildew rate on leaves up to 28 % and on bunches up to 33% and the grey mould rate from 21 to 29%. With frequent use of the preparations Tytanit and Optysil, the amount of applied conventional fungicides could be slightly reduced. Frequent combined use of both products can increase the yield of grapes for at least 12,9 to 17,7%.

Key words: grapevine, plant biostimulators, diseases

IZVLEČEK

STOPNJA ZMANJŠANJA OKUŽBE OD POVZROČITELJEV BOLEZNI VINSKE TRTE PRI UPORABI TITANOVIH IN SILICIJEVIH PRIPRAVKOV ZA KREPITEV RASTLIN

V poljskih poskusih izvedenih v vinogradih smo analizirali vpliv dodajanja pripravkov za krepitev rastlin Tytanit® (MgO 65 g/l, SO_3 130 g/l, Ti 8,5 g/l) in Optysil® (SiO_2 200 g/l, Fe 24 g/l) integriranim škropilnim programom na stopnjo zmanjšanja okužbe od povzročiteljev bolezni (*Peronospora*, *Botrytis*, *Oidium*). Dodajanje pripravka Optysil 3 do 4-krat letno v odmerku 0,5 l/ha siceršnjim integriranim škropilnim programom v povprečno ugodnih razmerah za razvoj bolezni lahko zmanjša stopnjo okužbe pri

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peronospori na listju do 27 % in na grozdju do 33 %, pri oidiju trte na listju do 55 % in na grozdju do 64 % in pri sivi plesni na grozdju za 42 do 49 %. Dodajanje pripravka Tytanit 2 do 3-krat letno v odmerku 0,2 l/ha siceršnjim integriranim škropilnim programom v enakih razmerah za razvoj bolezni lahko zmanjša stopnjo okužbe pri peronospori pri listju do 33 % in pri grozdju do 39 %, pri oidiju trte na listju do 28 % in na grozdju do 33 % ter za 21 do 29 % pri sivi plesni na grozdju. Pri pogosti uporabi pripravkov Tytanit in Optysil bi bilo mogoče nekoliko zmanjšati porabo klasičnih fungicidov. Pogosta uporaba obeh pripravkov hkrati lahko poveča pridelek grozdja vsaj za 12,9-17,7 %.

Ključne besede: vinska trta, stimulatorji, bolezni

1 INTRODUCTION

To control grapevine fungal diseases fungicides are applied quite frequently throughout a season. During the last years, grape growers have been trying to reduce the number of fungicide treatments per season to lower the pressure of agrochemicals on the environment and human health. One possibility to lower the amount of fungicides applied to vineyards is to apply plant stimulators which change the grapevine's disease defence response. Due to the changed grapevine defence response, we can protect it against diseases with much less fungicide applications per season. Often plant biostimulators are formulated as foliar fertilisers. This approach makes the registration process easy. In our trial we tested the effects of applying soluble titanium Ti (Tytanit) and silicon oxide SiO_2 (Optysil) based products on the rate of grapevine fungal disease control. Products were tested as additives to fungicide spray programs and not as direct disease control agents. According to legislation, plant stimulators cannot be directly advertised as disease control agents. At the moment, hundreds of different plant stimulators are available which confuses grape producers. As many as possible tests need to be carried out to provide information about the biostimulants' real efficacy level at lowering the fungal disease pressure. The potential of Tytanit and Optysil for disease suppression was proven in a filed crop and vegetable production system (Zbigniew, 2014). Only very few data are available about the effects on grapevine diseases (Bunescu, 2014). Mechanisms of titanium and silicon plant stimulation are different (Whitted-Haag *et all*, 2014). The titanium modifies the plants' nutrient intake and partitioning of nutrients in plants, photosynthetic activity, enhances the pollination process by acting in receptacles and the pollinic tube and increases the capacity of the plant to tolerate both biotic and abiotic stresses (Carvajal and Alcaraz, 1998; Hruby *et all*, 2002; Kuzel *et all*., 2003; Anonymus, 2016). Silicon, on other hand, interferes with the plants' cuticle formation. It regulates the mechanical resistance of the cuticle to pest and pathogen injuries and influences the fluxes of water through the stomata and plant surfaces (Savvas *et all*, 2009; Kamenidou *et all*, 2011; Whitted-Haag *et all*, 2014). By regulating the water consumption and storage, it helps the plant to survive the drought stress. Both Ti and Si have multiple, so called, anti-stress effects. There is not enough data available about the potential of these two stimulators for the suppression of fungi causing grapevine diseases, therefore we decided to test their potential.

2 MATERIALS AND METHODS

2.1 Trial design

Two trials were carried out in the 2016 season. One at the location Meranovo and another at the location Ploderšnica. The trials were designed as field trials with small randomly arranged plots over four repetitions. The individual plot area was 40 m^2 (24 vine stocks in a row). At both locations vines were trained in a single-Guyot training system. Three spray programmes based on the applications of foliar fertilisers were compared with an untreated control plot (no treatments with foliar fertilisers).

Table 1: Characteristics of grapevine plantations at trial locations.

Location:	GIS location:	Cultivar (age years) and rootstock:	Planting density:	No. of vines per ha
Meranovo	46°32′16.99″N 15°33′23.51″E	Italian Riesling (17y.) Kober 5BB	2.4 m (between rows) x 0.95 m (within a row)	4.300
Ploderšnica	46°38′42.32″N 15°45′49.23″E	Sauvignon (9 years) Kober 5BB	2.3 m (between rows) x 0.90 m (within a row)	4.800

2.2 Tested foliar fertilisers and application technique

Foliar fertilisers were applied with the backpack sprayer Stihl which delivered 400 l of spray per hectare. At both locations we had three different spray programs and untreated control plots (not treated with fertilisers). The data about applications and use of fertiliser preparations are presented in Tables 2 and 3. All experimental plots at the individual locations were treated with the exact same fungicide spray programme.

Table 2: Nutrient composition of tested fertiliser preparations.

Commercial brand code: **INTERMAG Ltd**	Content of nutrients:
Tytanit	0.8 % Ti (m/m), i.e. 8.5 g Ti in 1 litre of product + 5 % MgO (m/m) + 10 % SO_3 (m/m)
Optysil	2.0% Fe (m/m), i.e. 24 g Fe in 1 litre + 16.5% SiO_2 (m/m), i.e. 200 g SiO_2 in 1 litre
Mikrovit Bor	Boron ethanol amine 150 g B / l
Mikrochelat Fe	Fe EDTA chelated 150 g / l
Plonvit Loza	B 2.8 g/l, Cu EDTA chelated 1.5 g/l, Fe EDTA chelated 24 g/l, Mn EDTA chelated 10 g/l, Mo 0.54g/l, Zn EDTA chelated 3.5 g/l
Plonvit Fosfor	NH_2 (amid form) 70 g/l, P_2O_5 500 g/l
Plonvit Kalij	NH_2 (amid form) 44 g/l, K_2O 400 g/l
Plonvit Kalcij	NO_3 (nitrate form) 150 g/l, CaO 260 g/l, B 0.75g/l, Cu 0.3 g/l, Mo 0.015g/l, Zn 0.3g/l
Mikrochelat Zn	Zn EDTA chelated 150 g / l

Table 3: Periods of fertiliser applications and rates.

Growth stage / date Ploderšnica	Growth stage / date Meranovo	Type of fertiliser and dose (l/ha)
Spray program Optysil		
BBCH 11, 26.04.2016		Optysil 0,5 l/ha
	BBCH 13, 04.05.2016	Optysil 0,5 l/ha
BBCH 67–71, 27.06.2016		Optysil 0,5 l/ha
BBCH 75, 06.07.2016	BBCH 75, 06.07.2016	OptySil 0,5 l/ha
BBCH 81, 2.08.2016	BBCH 81, 02.08.2016	OptySil 0,5 l/ha
Spray program Tytanit		
BBCH 13, 04.05.2016	BBCH 17, 11.05.2016	Tytanit 0,2 l/ha
BBCH 17, 11.05.2016	BBCH 53, 26.05.2016	Tytanit 0,2 l/ha
Spray program Intermag IM		
BBCH 11, 26.04.2016	BBCH 13, 04.05.2016	Mikrovit Bor – 1 l/ha
		Mikrochelat Fe-5 – 1 l/ha
		OptySil – 0,5 l/ha
BBCH 13, 04.05.2016	BBCH 15, 09.05.2016	Plonvit Loza – 1,5 l/ha
		Mikrochelat Fe-5 – 1 l/ha
		Tytanit – 0,2 l/ha

Table 3: Continued - Periods of fertiliser applications and rates.

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Growth stage / date Ploderšnica	Growth stage / date Meranovo	Type of fertiliser and dose (l/ha)
Spray program Intermag IM		
BBCH 17, 17.05.2016	BBCH 17, 11.05.206	Plonvit Loza – 1,5 l/ha
		Mikrovit Bor – 1 l/ha
		Mikrochelat Fe-5 – 1 l/ha
		Mikrochelat Zn-6 – 1 l/ha
		Tytanit – 0,2 l/ha
BBCH 53, 31.05.2016	BBCH 53, 26.05.2016	Plonvit Fosfor – 2 l/ha
		Mikrochelat Mn-6 – 1 l/ha
BBCH 67, 27.06.2016	BBCH 65, 27.06.2016	Plonvit Loza – 1,5 l/ha
		Plonvit Kalij – 3 l/ha
		Mikrochelat Mn-6 – 1 l/ha
		Mikrochelat Fe-5 – 1 l/ha
		OptySil – 0,5 l/ha
BBCH 75, 06.07.2016	BBCH 75, 06.07.2016	Plonvit Kalij – 3 l/ha
		OptySil – 0,5 l/ha
BBCH 77, 19.7.2016	BBCH 77, 19.07.2016	Plonvit Kalcij – 5 l/ha
		Mikrochelat Zn-6 – 1 l/ha
		Mikrochelat Cu-9 – 1 l/ha
BBCH 81, 2.08.2016	BBCH 81, 5.08.2016	Plonvit Kalij – 3 l/ha
		Mikrovit Bor – 1 l/ha
		OptySil – 0,5 l/ha

2.3 Fungicide spray programs and application technique

All experimental plots at the individual locations were treated with the exact same fungicide spray programme. In season 2016 the conditions for disease development were good. At the Ploderšnica location spraying was carried out very frequently to ensure a high level of disease control and at the Meranovo location it was done less frequently to perform less intensive disease control. Data about applications and used preparations are presented in Tables 4 and 5. Fungicides were applied by a standard tractor mounted axial fan sprayer which delivered 300 l of spray solution per hectare.

Table 4: Periods of fungicide applications and fungicide rates (location Meranovo).

Date:	Applied product:	Product composition (a.i.):	Hectare dose:
18.5.	Pergado F Cosan	folpet 40% mandipropamid 5% sulphur 79.6%	0,5 kg/ha 1,7 kg/ha
9.6.	Pergado F Karathan gold	folpet 40% mandipropamid 5% metildinokap 35%	1 kg/ha 0,33 l/ha
17.6.	Univerzalis Cosan	azoksistrobin 9,35% folpet 50% sulphur 79.6%	1 l/ha 2,5 kg/ha
18.8.	Mildicut Cosan Switch	ciazofamid 2,5% sulphur 79.6% ciprodinil 37,5% fludioksonil 25%	2 l/ha 3 kg/ha 1 kg/ha

2.4 Fungal disease assessment

Three fungal diseases were assessed: powdery mildew (*Uncinula necator*), downy mildew (*Plasmopara viticola*) and grey mould (*Botrytis cinerea*). The disease rate was determined via visual scouting for % of attacked area. In each assessment, 200 leaves or 100 clusters were randomly selected per plot. The methodology was conducted following the EPPO standards (European Plant Protection Organisation; http://archives.eppo.int/EPPOStandards/efficacy.htm). The EPPO standards used were: powdery mildew PP1 1/4(4), downy mildew PP1 1/31(3) and grey mould PP1 1/17(2).

2.5 Weather conditions and disease pressure

At the beginning of the growing period the weather condition were very bad. We had long periods of low temperatures and several nights with temperatures below 0 ^{o}C and the grapevine suffered moderate frost damage. The plants were damaged by frost four times and the first part of May was cold and rainy. The grapevine developed slowly and flowering started with a delay. The temperatures in June were suitable for grape development. Rain fall was frequent and the plants had a very good supply of water. During the summer, the plants were not exposed to drought conditions. At the end of summer, there was a lot of rain again which enabled disease development and decreased the plant photosynthetic activity. The ripeness period of the grapes started in the middle of September and the grapes were fully ripe after 20. September. At the first part of the season until the end of June, there were no notable infections by any of the usual grape fungal pathogens. First infections started at the end of June. Disease pressure was higher at the end of the season, because during the second part of summer of 2016 we had many longer rainy periods.

Table 5: Periods of fungicide applications and fungicide rates (location Ploderšnica).

Date:	Applied product:	Product composition (a.i.):	Hectare dose:
12. 4.	Pepelin	sulphur 79.6%	8 kg/ha
23. 4.	Delan Pepelin	dithianon 70% sulphur 79.6%	0.75kg/ha 8 kg/ha
07. 5.	Delan	dithianon 70%	0.75 kg/ha
18. 5.	Pergado F Topas 100EC Pepelin	folpet 40% mandipropamid 5% penconazol 10% sulphur 79.6%	2.5 kg/ha 0.3 l/ha 3 kg/ha
27. 5.	Orvego Pepelin Domark	ametoktradin 30% dimetomorph 22.5% sulphur 79.6% tetraconazol 10%	0.8 l/ha 8 kg/ha 0.3 l/ha
07. 6.	Mikal premium Collis Break Thru	folpet 25% fosetil-Al 50% iprovalicarb 4% boscalid 20% krezoxym- methil 10% adjuvant	3 kg/ha 0.4 l/ha
18. 6.	Mikal flash Domark	folpet 25% fosetil-Al 50% tertaconazole 10%	4 kg/ha 0.3 l/ha
29. 6.	Mikal flash Nativo Break Thru	folpet 25% fosetil-Al 50% tebuconazol 50% trifloxystrobin 25% adjuvant	4 kg/ha 0.16 kg/ha
12. 7.	Orvego Nativo Pepelin	ametoktradin 30% dimetomorph 22.5% tebuconazol 50% trifloxystrobin 25% sulphur 79.6%	0.8 l/ha 0.16 kg/ha 8 kg/ha
12. 7.	Pyrinex Break Thru	chlorpyrifos-methil 22.5% adjuvant	1 l/ha
25.7.	Antracol combi Falcon Pepelin Break Thru	propineb 58% cymoxanil 4.8% spiroxamin 25% tebuconazol 16.7% triadimenol 4.3% sulphur 79.6% adjuvant	2.5 kg/ha 0.4 l/ha 8 kg/ha
08.8.	Champion Falcon Break Thru	Copper in form of Cu-hydroxide 50% spiroxamin 25% tebuconazol 16.7% triadimenol 4.3% adjuvant	2 kg/ha 0.4 l/ha

3 RESULTS AND DISCUSSION

3.1 Disease rate assessment

The weather conditions of the 2016 season were moderately favourable for the development of downy mildew (*Peronospora*) at both locations. First easily visible infections were noticed at Meranovo in the middle of July when we reduced the application of fungicides to provoke the disease. Since we stopped applying fungicides in the middle of July we got increased infection rates at the second assessment. 3 – 6% of leaf and cluster areas were attacked at that time. The highest infection rate was in the IM plots and the lowest in the Tytanit plots. The Tytanit treatments provided better results than the Optysil treatments. In August, the disease attack rate increased fast in the leaves, but not in the bunches. The differences between Tytanit and the other two spray variants increased. At Ploderšnica location the downy mildew pressure was higher than in Meranovo. In 2016 at the location Ploderšnica we had many periods of rain and dry weather following each other in cycles. In the middle of June, at the first assessment, the downy mildew just started to develop and the infections exploded at the beginning of July. The frequency of fungicide application was increased to save the bunches. A few layers of leaves at the top of the canopy were heavily infected. The highest protective effect was observed in Tytanit plots. The reduction of infected area was surprisingly high (70 %). The attack rate in IM plots was grater because the vigorousness of plants was higher there. Prior to the harvest, the infection rate on the new grown leaves fell because of the very intensive fungicide applications. Also, prior the harvest the lowest infection rate was observed in Tytanit plots and the highest in control plots. The level of infection rate was directly related to the level of plant vigorousness. It looks like Tytanit's plant strengthening effect against the downy mildew is stronger than the effect of Optysil. Optysil has a stronger effect against the powdery mildew.

Table 6: Downy mildew attack rate (%) in relation to the spraying programme.

Program:	Location Ploderšnica		Location Meranovo	
	% leaf area	% cluster area	% leaf area	% cluster area
1. assessment	(15. 06. BBCH 62)			
TYTANIT	0.00 a	0.00 a	0.00 a	0.00 a
OPTYSIL	0.05 a	0.00 a	0.00 a	0.00 a
IM PROGRAMME	0.07 a	0.00 a	0.00 a	0.00 a
CONTROL	0.15 a	0.02 a	0.05 a	0.00 a
2. assessment	(10. 07. BBCH 75-76)			
TYTANIT	4.59 b	0.45 c	0.12 b	0.05 b
OPTYSIL	5.22 b	0.60 c	0.18 b	0.08 b
IM PROGRAMME	6.90 b	2.55 b	0.23 b	1.03 ab
CONTROL	15.20 a	5.15 a	4.36 a	3.45 a
3. assessment	(22. 09. BBCH 88)			
TYTANIT	2.16 b	1.45 b	6.50 c	0.80 b
OPTYSIL	3.38 ab	2.60 b	8.33 b	1.53 ab
IM PROGRAMME	5.23 ab	3.55 ab	9.57 ab	3.04 a
CONTROL	6.43 a	4.15 a	11.55 a	2.37 a

*Values marked with the same letter do not differ significantly statistically (Tukey Hsd test; $\alpha<0.05$).
Compare values within the same location and the same assessment period.

At the Meranovo location, powdery mildew started to develop slowly in the middle of June. At the second assessment, the attack rate on the leaves was low (3 – 7% of leaf area). The differences among spray variants were very small at that time. In July we stopped the fungicide applications and caused an increase of the powdery mildew attack rate. Fungus also started to develop on bunches. The effect of applying Optysil was already visible at that time. We observed significantly less mildew on Optysil treated plots. The Tytanit effect was not comparable to the effect of Optysil, but we were surprised because the effect was still strong, when compared to the control plots (compare 3.55 % with 12.50 %). We did not expect such a high reduction in disease attack rate. In September, the mildew increased fast and the attack rate on the leaves reached 30% and in the bunches from 3 to 7%. The increase in mildew attack rate influenced the photosynthetic activity of the leaves.

Table 7: Powdery mildew attack rate (%) in relation to the spray programme.

Program:	Location Ploderšnica		Location Meranovo	
	% leaf area	% cluster area	% leaf area	% cluster area
1. assessment	(15. 06. BBCH 62)			
TYTANIT	0.10 a	0.00 a	0.15 b	0.03 c
OPTYSIL	0.00 a	0.00 a	0.00 b	0.00 c
IM PROGRAMME	0.14 a	0.00 a	0.19 b	0.95 b
CONTROL	0.80 a	0.10 a	3.99 a	1.94 a
2. assessment	(10. 07. BBCH 75-76)			
TYTANIT	2.14 c	1.03 b	3.55 bc	0.93 c
OPTYSIL	0.80 c	0.27 c	1.40 c	0.13 d
IM PROGRAMME	4.87 b	0.95 b	6.07 b	3.50 b
CONTROL	5.45 a	2.12 a	12.50 a	7.25 a
3. assessment	(22. 09. BBCH 88)			
TYTANIT	4.14 b	2.97 b	24.6 ab	4.06 b
OPTYSIL	0.74 c	0.21 c	16.2 c	1.83 c
IM PROGRAMME	3.04 b	2.90 b	21.77 b	2.67 c
CONTROL	6.15 a	3.92 a	31.1 a	8.42 a

*Values marked with the same letter do not differ significantly statistically (Tukey Hsd test; $\alpha<0.05$). Compare values within the same location and the same assessment period.

At Ploderšnica, the powdery mildew attack rate at the beginning of the season (June and the first part of July) was also moderate because of the high frequency of fungicide applications. In the middle of July, the infections started to become more visible and afterwards disease increased all the time until harvest. At first assessment, differences among treatments were not significant. At the second assessment date (10. 07.) we noticed an increase in infection rate at the control plots and at IM program plots. The difference between the Tytanit and Optysil effect was significant. Optysil had a much higher protection rate against powdery mildew when compared to Tytanit. It seems that Optysil stimulates the formation of strong leaf and berry coticules which causes a higher resistance to powdery mildew infections. The same conclusions can be drawn for the third disease attack rate assessment. The powdery mildew attack rate influenced the marketable yield.

Table 8: Grey mould attack rate in relation to the spray programme.

Program:	Location Ploderšnica		Location Meranovo	
	% leaf area	% cluster area	% leaf area	% cluster area
1. assessment	(10. 08. BBCH 81)		(8. 08. BBCH 78)	
TYTANIT	/	0.93 a	/	1.40 b
OPTYSIL	/	0.44 a	/	1.93 b
IM PROGRAMME	/	0.94 a	/	2.49 ab
CONTROL	/	1.05 a	/	2.81 a
2. assessment	(22. 9. BBCH 88)		(28. 9. BBCH 89)	
TYTANIT	/	2.94 ab	/	3.28 b
OPTYSIL	/	2.10 b	/	2.46 c
IM PROGRAMME	/	3.18 ab	/	3.59 ab
CONTROL	/	3.98 a	/	4.20 a

*Values marked with the same letter do not differ significantly statistically (Tukey Hsd test; $\alpha<0.05$).
Compare values within the same location and the same assessment period.

Weather conditions for grey mould development were moderately favourable in 2016 at both locations. In August and September, it rained quite often. The grape berries did not crack due to sudden increase in berry juice pressure. The attack rate on bunches was low at both assessment periods. During the first assessment period in the beginning of August, the lowest attack rate was noticed in the Tytanit treated plots. The differences among variants were small. Prior to harvesting, the disease attack rate increased a little. The best result was obtained with the Optysil application. The results show that spraying with silicon can make the berry skin stronger and less susceptible to grey mould. Differences between the attack rates on Tytanit or Optysil treated plots were significant. At IM program the attack rate was a little higher. This is due to the more vigorous growth of vines that were treated with a full fertiliser program.
It was raining many times during September at Ploderšnica location. The green wall was well managed and bunches were developing in the zone which had very good aeration. During the first assessment, on 10. August, the attack rate was very low and differences among different treatments were not significant. The attack rate of fungus was also low at harvest. The highest decrease in the attack rate was observed in plots treated with Optysil. The silicon in Optysil reinforced the cuticle of the berries and that increased the resistance of the bunches to infection by Botrytis fungus. The protective effect of Optysil was not significantly greater than that of Tytanit.

3.2 Yield assessment

The grapes were harvested on September 30th at the Ploderšnica location. At harvesting time, all clusters were removed carefully and their ripening statuses and disease attack rate status were determined. Clusters developed on the lateral shoots with low sugar contents (less than 60 °Oe) were separated (category unripe clusters) and the parts of clusters heavily diseased by grey mould or powdery mildew were removed with scissors and weighed separately (category diseased clusters). The yield in 2016 was surprisingly high considering the facts that the vineyard was exposed to frost during sprouting. The highest marketable yield was determined to be in the IM plots (see Table 9). It was 1.096 kg/ha higher than in the control plots (compare 12184 with 11088 kg/ha in Table 9). The differences between the Optysil program and the IM program were not significant, but were significant between the Tytanit and IM program. The same also goes for the comparisons on marketable yield.

Table 9: Yield per hectare.

TRIAL VARIANT:	Total yield (Kg/ha)	Marketable yield (Kg/ha)	Diseased clusters (Kg/ha)	Unripe clusters (Kg/ha)
Location Ploderšnica (26. 09. BBCH 89)				
TYTANIT	11108.4 b	11035.0 b	60.2 b	13.2 a
OPTYSIL	11650.8 ab	11621.0 ab	19.8 b	10.0 a
IM PROGRAM	12258.6 a	12184.0 a	54.8 b	19.8 a
CONTROL	11386.0 b	11088.0 b	278.2 a	19.8 a
Location Meranovo (29. 09. BBCH 89)				
TYTANIT	7468.3 ab	7105.8 b	271.9 a	90.5 b
OPTYSIL	8217.1 a	7886.3 ab	43.6 b	200.6 a
IM PROGRAM	8796.2 a	8153.1 a	158.8 ab	84.2 b
CONTROL	6784.5 b	6385.5 c	240.4 a	158.5 ab

*Values marked with the same letter do not differ significantly statistically (Tukey Hsd test; α<0.05). Compare values within the same location.

At Meranovo, the harvest was carried out on September 29th when the ripening stage of the grapes was suitable for processing into standard wine. The grape yield in 2016 was lower than in previous years. The reason lies in the delay of plant development during the first part of the season, in a smaller number of inflorescences per stock and in a higher disease pressure as a consequence of less frequent fungicide applications. The highest losses caused due to the disease attack were observed in the Tytanit program (see Table 9). Loses in the Tytanit program were higher than in the Optysil program and were also a little bit higher than in the control plots. The diseases influenced the results significantly (especially powdery mildew). A lover powdery mildew attack rate on bunces at Optysil plots attributed to better result in this variant than in the Tytanit program. The Optysil treatment provided a much better result than the Tytanit treatment. The sugar content in 2016 was much lower than in previous years (data not shown). The reason lies mostly in less photosynthetic activity in September and in the powdery mildew attack rate on the leaves. Powdery mildew reduced the photosynthetic activity of leaves and that caused a lower accumulation of sugar in the grapes. The differences between Tytanit treated plants and the IM program treated plants were bigger than the differences between Optysil treated plants and IM program. When analysing the yield and marketable yield we can see that the best results were obtained in the IM programme.

4 CONCLUSIONS

Trial results show measurable effects of adding the stimulators Optysil and Tytanit to the standard fungicide spray program to control grapevine fungal diseases. The effect on the yield was also measurable. At the Plodrešnica location the application of tested foliar fertilisers increased the marketable yield from 11088 kg/ha achieved at control plots to 12184 kg/ha with the IM program and to 11621 kg/ha with the Optysil program. At the Meranovo location the increase in yield was also quite high. In the IM program it increased from 6385.5 kg/ha at control to 8153.1 kg/ha.

The effect of Tytanit (titanium) was not the same as the effect of Optysil (silicon oxide). With Tytanit we can expect better suppression of downy mildew and with Optysil a better suppression of powdery mildew. Optysil can also provide better results in the suppression of grey mould.

The effects of the stimulators depend on the disease pressure and the yielding capacity of a specific vineyard. When the yielding capacity of the vineyard is very high and disease pressure is low, we do not expect such a significant effects of stimulators as in situations where the grapevine is under stress caused by diseases, nutrient lack and harsh weather conditions.

The increase in yield achieved in our trial and ratio between prices of fertilisers (stimulators) and grapes in season 2016 show that the application of stimulators is feasible.

Additional trials are needed to check the consequences of significant reduction in number of fungicide treatments and the replacement with applications of biostimulators.

5 LITERATURE

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