

CONTROL OF POWDERY MILDEW IN VINEYARDS USING SEVERAL APPLICATIONS OF UNPOLLUTANT TREATMENTS OF SULPHUR FUNGICIDES IN ROMANIA

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Abstract

*Powdery mildew is one of the most damaging and common diseases of the vine, being caused by the fungus *Uncinula necator*. In the years with favorable conditions for the disease infection, especially for the sensitive varieties, it may produce important damages in the vineyards, because it can manifest throughout the growing season. This disease can affect from the beginning of the vegetation the young leaves and shoots, flowers and grapes in a situation of severe infection. The wine – making process is also affected and the wines are of poor quality. Sulphur-based products are contact fungicides that provide good protection against powdery mildew without polluting the environment. The mechanism of action is a multi - site, with low risk of occurrence of the pathogen resistance phenomenon. This paper highlights the effectiveness of the two sulphur – based on products in controlling powdery mildew in three vineyards where no other fungicides have been applied. The products tested in the trials were: Polisulf (sulphur 18%, calcium hydroxide 10%), Sulfomat 80 PU (sulphur 80%) and Kumulus DF (sulphur 80% - standard reference). Data obtained demonstrated that the efficacy of Polisulf and Sulfomat 80 PU was equivalent to the efficacy of the reference product Kumulus DF against *Uncinula necator* in vines.*

Keywords: Powdery mildew, vineyards, sulphur - based on products, effectiveness

1. INTRODUCTION

In Romania, viticulture has an ancestral antiquity, being practiced since ancient times. Each historical region of Romania has extensive vineyards where a wide range of table and wine grape varieties is grown. From the north of the country (Cotnari - Moldova, Lechința - Transylvania, Seini - Maramureș), passing through Banat (Recaș, Miniș), the center of Transylvania (Târnave, Jidvei), the center and south of Moldova (Huși, Odobești, Panciu), Muntenia (Dealul Mare, Ștefănești), Oltenia (Drăgășani, Sâmburești, Segarcea), Dobrogea (Sarica - Niculițel, Murfatlar, Ostrov), the vineyard benefits from very favorable conditions for very good quantitative and qualitative productions.

Romania is one of the great wine-growing countries of the world. The most recent data show that in 2017 the area cultivated with vines increase to 182.363 hectares. Thus, Romania is on the 5th place in the EU in the area planted with vines, after Spain, France and Italy (*2018). Grapevine oidium or powdery mildew (*Erisiphe necator*, formerly *Uncinula necator*) affects grape berry yield and quality worldwide, and it is recognized as a major disease that results in economic losses in the grape and wine industry (Chellemi, D.O. & Marois, J.J., 1992, Cordero-Bueso, G et al, 2011, Magarey, P.A. et al., 1997, Ough, C.S. & Berg, H.W., 1979). The pathogen is obligately parasitic on genera within the *Vitaceae*, including *Vitis*, *Cissus*, *Parthenocissus* and *Ampelopsis* (Pearson, R.C. & Gadoury, D.M., 1992, Braun, U., Cook, R.T.A., Inman, A.J. & Shin, H.-D., 2002, Brewer, M.T. & Milgroom, M.G., 2010,). The most economically important host is grapevine (*Vitis*), particularly the European grape, *V. vinifera*, which is highly susceptible to powdery mildew. P. mildew is the first disease identified in vines, known in North America, the pathogen being reported in 1834 on spontaneous vines by Schweinitz (Schweinitz, L. D., 1834). In Europe, grape powdery mildew was first reported in 1845 by Tucker in England, then in 1847 Berkeley carried out studies on the disease and named its etiological agent *Oidium tucker*, which is the anamorphic form of the fungus. In the same year 1847, the disease

is reported in France, after which it spreads over and is found in almost European countries. (Baicu, T. & Sesan, T.E., 1996).

Vine powdery mildew can occur throughout the growing season, from spring to late autumn. It affects all aerial parts of the plant: shoots, leaves, tendrils, inflorescences, fruits. From the young leaves and shoots, the pathogen can be observed in the form of grayish-whitish stained spots. A powdery layer of conidiophores and conidia covers the infected organs that twist and deform. Their growth stops, their development no longer happens. Also, characteristic symptoms can be seen on the petiole of the leaf, on the mature leaves, on the tendrils and on the rachis. When flowers are attacked (quite rarely), the disease becomes very harmful. When the disease manifests itself after the formation of bunches, their berries are covered by the bluish - whitish mycelium of the fungus, later powdery, causing the epidermis to crack and spill off the contents of the berries. Cracked berries can be gateways for other diseases. The development of the pathogen is favoured by dry weather, with temperatures around 22 ° C, but the limits are quite wide, from 7-8 ° C, up to 29-30 ° C. The optimal relative humidity is rated at 70-75%, but the fungus grows well from 50-80% (Carroll, J.E. & Wilcox, W.F., 2003, Gheorghies, C. & Geamăn, I., 2003). In rainy weather, the mycelium and conidia are washed away and the development of fungus is prevented. The maximum sensitivity of the grapes to the attack of powdery mildew is between the stages of separate floral buds and the stage of the end of the grapes development (BBCH 57 - 71). Among the products used to control powdery mildew, sulfur has a leading place (Dejeu, L.C., 2010).

Elemental sulphur is known, undeniably, the oldest pesticide ever to control powdery mildew. Ancient Greeks were aware of its pesticide properties as early as 1000 B.C. In the scientific published literature, Forsyth (1802), cited by Tweedy (1969), was the first to suggest the application of sulphur for disease control. Unfortunately, the fungicidal properties of sulphur were apparently forgotten during the middle ages and were not rediscovered until the beginning of the nineteenth century (Fry, 1982). Ever after, sulphur have been used in various forms for disease and pest control, especially against powdery mildew and mites on plants (Gadoury, D.M., Seem, R.C., Magarey, P.A., Emmett, R. & Magarey, R., 1997). It still remains the most used go-to natural choice for limiting the powdery mildew damages in organic grapevine growing. Unlike synthetic materials, natural sulfur carries no risk of disease-causing fungi developing resistance to it. And, it costs considerably less than synthetic products. As a result, sulfur offers an affordable option where resistance may be developing in a vineyard. One advantage of micronized dry flowable sulfur products is the smaller and tighter range of size of the particles compared to wettable powders (**2017).

The aim of this study was to account the evolution of the pathogen *Uncinula necator* infection and to determine the effectiveness of the applied sulphur – based on products in three vineyards located in distinct places under different pedoclimatic conditions.

2. MATERIALS AND METHODS

The research was carried out in 3 distinct locations in Southern Romania grapevine growing areas, known as ones of the most appreciated:

- the vineyard of Ostrov-Hills of Dobrudja, situated in the SE of the country, in Constanta County nearby Danube river, on a typical cambic chernozem soil with a sandy structure, pH 6.8-7.2 and a humus content of 2.5-3.2%. The assortment of cultivars included the Muscat-Otonel variety, 7 years old.
- the vineyard of Vișoara- the plateau of Middle Dobrogea, on blackish – brown chernoziom with an organic matter content of 3,1% and pH 7,2 clay loam texture. The assortment of cultivars included the Merlot variety, 6 years old.
- the vineyard of Dealu Mare-Hills of Muntenia, situated in Prahova county, on a brown reddish soil with an organic matter content of 2,8% and pH 8, clay loam texture. The chosen variety was Chardonnay, 9 years old.

Six field trials on these vineyards (2 for each location) were established on a set of complete randomized blocks in 4 replications per treatment. Each experimental plot had 30 m² (3x10m). Vine are grown with a 100-cm space between them, and row length of 2.2 m or 2.5 m (Dealul Mare).

Conventional tillage was carried out consisting in autumn plowing on intervals between rows during plant dormancy. Early spring pruning was then carried out so as to thin out of the fruit and grow and to eliminate unuseful branches and shoots and internal canopy..The training system is the spurred cordon (Ostrov, Viisoara) and double Guyot in Dealu Mare.

Chemical application was by dilute spraying using hydraulic nozzles. Fungicide sprays were applied at high volume in 1000 litres/ha using a portable Grünman 3 WF-3 knapsack mist blower (sprayer, atomizer).

Sprays were applied between March and July, at 10-15 day intervals during the primary infection season and also during the second one. Four treatments with Polisulf and Kumulus DF and five treatments with Sulfomat 80 PU and Kumulus DF were proceeded. The tested products are shown below (table 1):

Sample	Active ingredient	Rate (kg,l/ha)	Volume of water(l)
Untreated check	-	-	-
Polisulf	sulphur thiosulphuric 3%+ sulphur polisulfhydic 12%	20	1000
Sulfomat 80 PU	sulphur 800 g/kg	0.4% (4)	1000
Kumulus DF	sulphur 80%	0.4% (4)	1000

Table 1. Fungicides used to control powdery mildew in the trials

Treatments were scheduled at the following stages:

Polisulf and Kumulus DF:

- 1st treatment: Bud burst: green shoot tips clearly visible (BBCH 9);
- 2nd treatment: 4th leaves unfolded (BBCH 14);
- 3rd treatment: At the end of flowering (BBCH 69);
- 4th treatment: Berries groat-sized, bunches begin to hang (BBCH 73);

Sulfomat 80 PU and Kumulus DF:

- 1st treatment: 4th leaves unfolded (BBCH 14);
- 2nd treatment: Inflorescences clearly visible (BBCH 53);
- 3rd treatment: At the end of flowering (BBCH 69);
- 4th treatment: Berries groat-sized, bunches begin to hang (BBCH 73);
- 5th treatment: Beginning of ripening: berries begin to develop variety-specific colour (BBCH 81).

All the treatments were made under a temperature lower than 26 °C.

Foliar powdery mildew incidence (Pesinc%) and severity (Pessev%) were evaluated before each spray and after ten days until the latest treatment by visually rating 100 leaves and 100 bunches on twenty shoots per vine for percent area covered by powdery mildew. Consequently, the degree of attack (DA%) was evaluated following the formula: $DA (\%) = \frac{Pesinc \% \times Pessev\%}{100}$. Phytotoxicity on the foliage was evaluated at the same time by recording any visible damage to foliage that was not due to powdery mildew.

The assessment of efficacy in the treated plots was made in relation to the untreated plot on an overall plot basis (scale 0-100%, 0% =no efficacy). The efficacy of fungicide was calculated according to Abbott's formula: (degree of attack in untreated control - degree of attack in treated plot)/ degree of attack in untreated control x 100. All data were subjected to statistical analysis provided by ARM-9 (P=.05, Student-Newman-Keuls) software (Jalobă, D. & Grădilă, M., 2019).

Polisulf is a fungicide that acts directly by the decomposition of elemental sulphur as a protective fungicide. Thus, sulphur interrupts the transfer of electrons, causing sulfur reduction in hydrogen sulphide (H₂S). Sulfur also forms a protective layer, which inhibits germination of spores.

Sulfomat 80 PU is a dust free, flowable micronised sulphur granules, containing 80% sulphur as active ingredient and balance adjuvants, easy of measuring and handling. It has a lot of advantages as follow: It has instant dispersion and high suspensability in water, therefore it don't cause scorching; It has triple action as fungicide, micronutrient (Sulphur) and miticide; It has sustained action for longer effect; There are no stains on fruits and leaves after spraying, nor do leaves get burnt.

3. RESULTS

In the trials fields of the three locations, the weather conditions were quite atypical, sometimes different from the normal ones. The condensed data are presented below (table 2). As one can see, in Ostrov location there was a high quantity of rain in May and in July, values that are higher than multiannual average of the area which is considered the driest in Romania. More than that, in Dealul Mare area (Muntenia region, with a large amount of rain), the quantity of rain was below the annual average.

Location	Ostrov			Vișoara			Dealul Mare		
Parameters / Month	Precipitation (mm)	Temp. Min.	Temp. max.	Precipitation (mm)	Temp. Min.	Temp. max.	Precipitation (mm)	Temp. Min.	Temp. max.
April	46,8	-4-11	9-22	32.3	3-12	10-21	29.1	0-9	10-26
May	129.3	6-12	12-29	41	8-19	14-30	47.4	6-17	12-29
June	76.9	14-20	23-34	9.5	17-23	25-33	64	15-20	24-34
July	46.4	10-19	24-36	58	15-22	24-34	22.5	12-19	23-36

Table 2. Weather conditions in the trials fields

In this conditions, assessments made on the Pest Incidence (Pesinc %) and Pest Severity (Pessev %) of pathogen attack were recorded in the database table 3 and table 4, both on leaves and bunches:

<i>U. necator</i>		Ostrov		Vișoara		Dealul Mare	
		Leaf	Bunch	Leaf	Bunch	Leaf	Bunch
0 DA-A (0 day after first treatment)	Pesinc.	5.0	-	8.5	-	9.0	-
	Pessev.	2.5	-	5.0	-	6.0	-
10 DA-A (10 days after treatment A)	Pesinc.	10.0	-	12.6	-	18.0	-
	Pessev.	5.0	-	10.0	-	12.1	-
10 DA-B (10 days after treatment B)	Pesinc.	24.0	-	35.3	-	32.8	-
	Pessev.	15.0	-	16.8	-	21.8	-
10 DA-C (10 days after treatment C)	Pesinc.	41.3	25.5	53.0	35.0	55.8	36.5
	Pessev.	26.8	17.5	22.8	25.0	25.2	21.5

10 DA-D	Pesinc.	45.0	31.8	56.6	51.5	58.0	49.0
(10 days after treatment D)	Pessev.	30.0	22.0	24.5	26.8	28.0	34.0

Table 3. Development of the pathogen *U. necator* at untreated check – Polisulf trial

<i>U. necator</i>		Ostrov		Viisoara		Dealul Mare	
		Leaf	Bunch	Leaf	Bunch	Leaf	Bunch
0 DA-A	Pesinc.	10.0	-	12.5	-	18.0	-
	Pessev.	5.0	-	9.5	-	12.1	-
10 DA-A	Pesinc.	23.5	-	26.5	-	32.0	-
	Pessev.	14.0	-	13.5	-	15.0	-
10 DA-B	Pesinc.	26.0	-	35.3	-	32.8	-
	Pessev.	18.0	-	16.8	-	21.8	-
10 DA-C	Pesinc.	41.3	25.5	53.0	35.0	55.8	36.0
	Pessev.	26.8	17.5	22.8	25.5	25.2	22.0
10 DA-D	Pesinc.	48.0	31.8	58.6	52.0	58.0	49.0
	Pessev.	32.0	22.0	28.5	27.0	28.0	34.0
10 DA-E	Pesinc.	50.0	65.3	65.0	68.5	60.0	75.0
	Pessev.	34.0	41.0	30.0	41.8	35.0	43.3

Table 4. Development of the pathogen *U. necator* at untreated check – Sulfomat trial

As a result of Pest Incidence and Pest Severity evaluations, the degree of attack (DA %) on leaves and bunches was calculated. (DA %) evolution on leaves for each trial is shown in figure 1 and figure 2. (DA %) evolution on bunches for each trial is shown in figure 3 and figure 4.

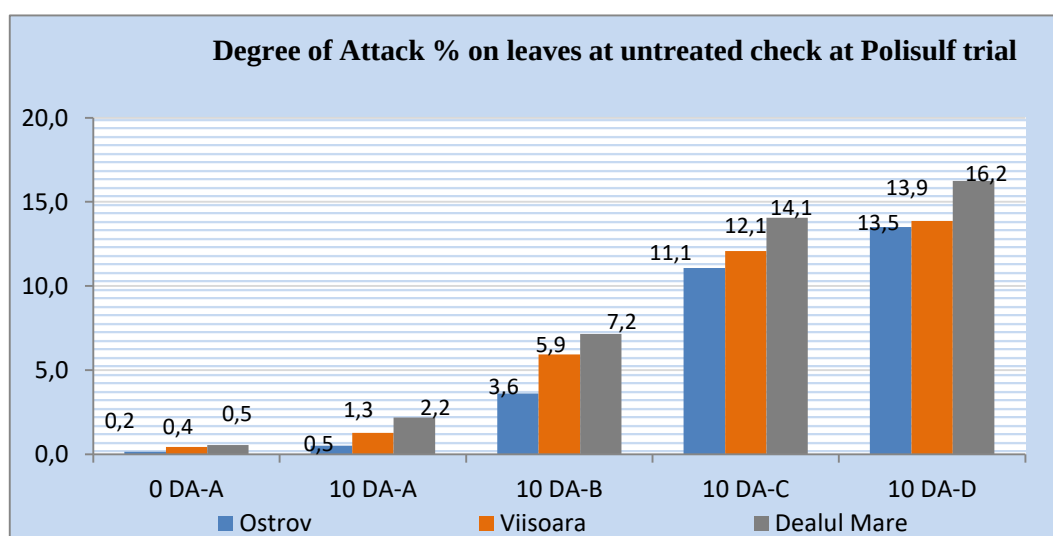


Fig. 1.

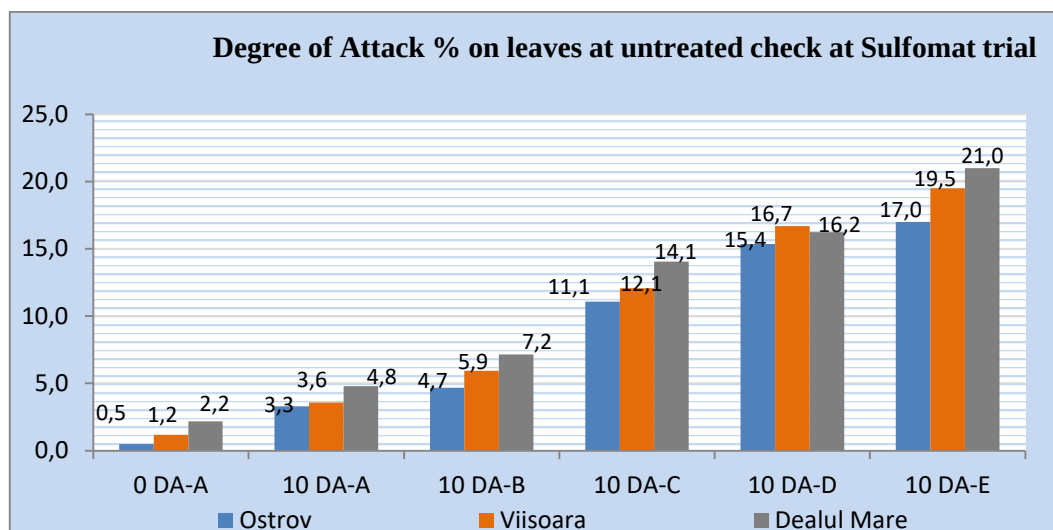


Fig. 2.

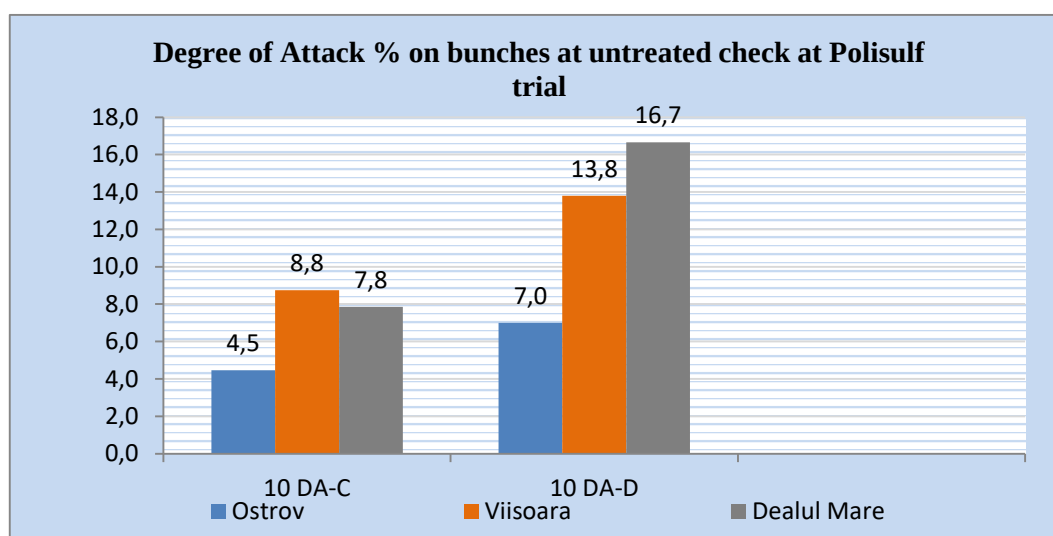


Fig. 3.

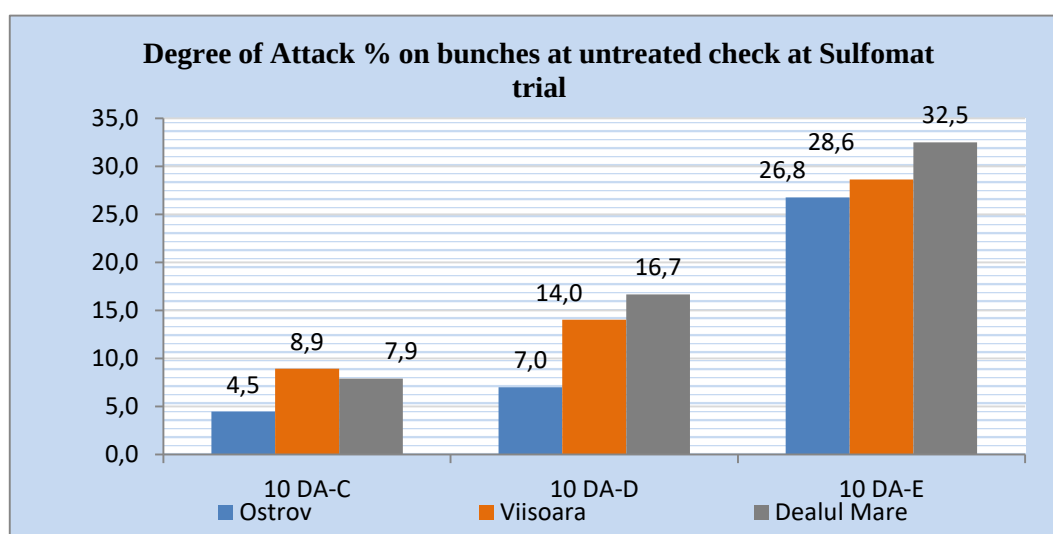


Fig. 4.

4. DISCUSSION

As one can see, the degree of attack had an upward evolution and increased at every assessments at untreated checks, due to weather conditions and lack of treatments. So, at Polisulf trial, the degree of attack on leaves reached from 0.2% to 13.5 % (Ostrov), from 0.4 % to 13.9 % (Vișoara) and from 0.5% to 16.2% (Dealul Mare).

At Sulfomat trial, which was carried out on a longer – term, the infestations was stronger, so that the degree of attack increased from 0.5 % to 17.0 % (Ostrov), from 1.2% to 19.5 % (Vișoara) and from 2.2 % to 21.0 % (Dealul Mare). The highest value, the most intensive infestation with powdery mildew was recorded at Dealul Mare, where vineyard has a Southeastern exposition, is grown at a higher altitude (370m) and there is a large amount of pathogenic inoculum in the area. Also, the amount of rain fall was poor than never before.

On bunches, powdery mildew degree of attack increased from 4.5% to 7 % in Polisulf trial at Ostrov, from 8.8% to 13.8% at Vișoara and from 7.8% to 16.7% at Dealul Mare. The highest degree of attack was recorded at Dealul Mare trial. In Sulfomat trial it had a similar evolution: from 4.5% to 26.8% at Ostrov, from 8.9% to 28.6 at Vișoara and from 7.9 to 32.5% at Dealul Mare. As in Polisulf trial, there was Dealul Mare the location with the highest degree of attack at untreated check.

Location	Ostrov		Vișoara		Dealul Mare	
Days after treatment	Sulfomat 80 PU	Kumulus DF	Sulfomat 80 PU	Kumulus DF	Sulfomat 80 PU	Kumulus DF
10 DA-A	57.8	60.5	54.7	56.3	58.8	55.3
P value*	F TEST				0.750	
10DA-B	70.6	71.8	62.4	66.8	65.8	64.2
P value*	F TEST				0.935	
10DA-C	82.6	83.8	80.6	82.8	74.5	72.3
P value*	F TEST				0.609	
10DA-D	84.4	85.6	82.4	84.6	81.6	79.4
P value*	F TEST				0.316	

Table 5. Efficacy % of Polisulf in control of powdery mildew on leaves

Location	Ostrov		Vișoara		Dealul Mare	
Days after treatment	Sulfomat 80 PU	Kumulus DF	Sulfomat 80 PU	Kumulus DF	Sulfomat 80 PU	Kumulus DF
10 DA-A	42.0	44.5	39.6	41.8	40.2	42.5
P value*	F TEST				0.885	
10 DA-B	66.0	67.3	65.9	67.5	63.5	64.3
P value*	F TEST				0.768	
10 DA-C	77.4	78.8	76.3	77.5	74.6	75.8
P value*	F TEST				0.935	
10 DA-D	86.5	88.8	87.1	92.1	76.9	83.7
P value*	F TEST				0.706	
10DA-E	86.7	89.4	87.7	90.5	81.2	88.3
P value*	F TEST				0.179	

Legenda: *P-value is the probability of obtaining the observed results of a test, assuming that the null hypothesis is correct;

Table 6. Efficacy % of Sulfomat 80 PU in control of powdery mildew on leaves

As you can see, the lack of treatments at untreated checks has led to a high level of powdery mildew infection in all trials.

According to F Test, if the P-value is greater than 0.05, that indicates that there is weak evidence against the conjecture, so the investor must validate the null hypothesis, so that there are not significant differences between the variance of the two groups (Pomohaci, C. M. & Vâșcă-Zamfir D., 2017).

In our situation, at Polisulf trials, when α (probability) = 0.05, as it is shown, the P-value is always > 0.05, this means there is no differences between samples, we accept the nule hypothesis, Polisulf and Kumulus DF has almost the same efficacy to control powdery mildew on vines.

As far as it concerns the Sulfomat 80 PU trials, when α = 0.05, as one can see, the P-value is always > 0,05, this means there is no differences between samples, the effectiveness of the two products (Sulfomat 80 PU and Kumulus DF) is almost similar, the tested product performed very well, just like the standard reference. In order to illustrate more clearly the importance of application of the sulphur based-on products during growing season on vineyards in Romania, we can check out table 7 and table 8, where is shown the level of effectiveness of Polisulf and Sulfomat 80 PU at every moment of the assessments done after treatments. The symptoms of powdery mildew on leaves and bunches can be seen on figures 5 - 8.

Location	Ostrov		Vișoara		Dealul Mare	
Days after treatment	Sulfomat 80 PU	Kumulus DF	Sulfomat 80 PU	Kumulus DF	Sulfomat 80 PU	Kumulus DF
10DA-C	66.60	67.54	65.45	69.01	71.62	70.76
P value*	F TEST 0.388					
10DA-D	76.56	74.25	79.03	81.94	78.60	74.06
P value*	F TEST 0.158					

Table 7. Efficacy % of Polisulf in control of powdery mildew on bunches

Location	Ostrov		Vișoara		Dealul Mare	
Days after treatment	Sulfomat 80 PU	Kumulus DF	Sulfomat 80 PU	Kumulus DF	Sulfomat 80 PU	Kumulus DF
10 DA-C	69.76	67.54	68.23	69.91	65.53	69.10
P value*	F TEST 0.480					
10 DA-D	70.04	67.15	77.42	82.24	78.34	73.27
P value*	F TEST 0.528					
10DA-E	80.20	79.63	82.22	84.69	86.64	88.37
P value*	F TEST 0.774					

Table 8. Efficacy % of Sulfomat 80 PU in control of powdery mildew on bunches

As F Test proved, P value is always higher than 0.05, this means that we have to validate the null hypothesis, so that there are not significant differences between the variance of the two groups.



Fig. 5. Powdery mildew attack on bunch (Viisoara)



Fig. 6. Powdery mildew attack on bunch (Ostrov)



Fig. 7. Powdery mildew attack on leaf (Dealul Mare)



Fig. 8. Powdery mildew attack on bunch (Ostrov)

5. CONCLUSIONS

It's a certified thing that there are problems with powdery mildew in vineyards of Southern Romania. Depending on climatic conditions, this disease may occur from the early stages of vines development so that this disease have to be controlled in order not to cause serious damages on leaves, bunches and consequently on the process of winemaking. There is a must for vines growers to control this disease.

The sulphur – based on products Polisulf and Sulfomat provided good effectiveness to control *U. necator* in vines, almost equal to standard product Kumulus DF. Being applied at very right stage, they can assure a good protection in vineyards against powdery mildew.

REFERENCES

1. Braun, U., Cook, R.T.A., Inman, A.J. & Shin, H.-D., 2002. The taxonomy of the powdery mildew fungi. In: The Powdery Mildews (Belanger, R.R., Bushnell, W.R., Dik, A.J. and Carver, T.L.W., eds), pp. 13–55. St. Paul, MN: APS Press.
2. Brewer, M.T. & Milgroom, M.G., 2010. Phylogeography and population structure of the grape powdery mildew fungus, *Erysiphe necator*, from diverse *Vitis* species. BMC Evol. Biol. 10, 268.
3. Carroll, J.E. & Wilcox, W.F., 2003. Effects of humidity on the development of grapevine powdery mildew. Phytopathology, 93, 1137–1144.
4. Chellemi, D.O., Marois, J.J., 1992. Influence of leaf removal, fungicide applications and fruit maturity on incidence and severity of grape powdery mildew”. Am. J. Enol. Vitic. 43, 53–57.

5. Gadoury, D.M., Seem, R.C., Magarey, P.A., Emmett, R. & Magarey, R., 1997. Effects of environment and fungicides on epidemics of grape powdery mildew: considerations for practical model development and disease management. *Vitic. Enol. Sci.* 52, 225–229.
6. Gheorghies, C. & Geamăn, I., 2003. Bolile plantelor horticole, Editura Universitas Co. București, pag. 248 – 251.
7. Cordero-Bueso G., Arroyo T., Serrano A et al., 2011. Influence of the farming system and vine variety on yeast communities associated with grape berries. *Int J Food Microbiol* 2011; 145:132–9.
8. Forsyth, W., 1802. “A treatise on the culture and management of fruit trees”. London: Nichols and Son.
9. Fry, W. E., 1982. Principles of plant disease management. Departament of Plant Pathology, Cornell University, Ithaca, New York. Academic Press. 277 pag.
10. Jalobă, D. & Grădila, M., 2019. Powdery mildew control by unpollutant methods in apple orchards with sulphur based on products”, *Romanian Journal for Plant Protection*, Vol. XII, 2019 ISSN 2248 – 129X; ISSN-L 2248 – 129X.
11. Ough, C.S., Berg, H.W., 1979. Powdery mildew sensory effect on wine. *Am. J. Enol. Vitic.* 30, 321.
12. Pearson, R.C. and Gadoury, D.M., 1992. Grape powdery mildew. In: *Plant Diseases of International Importance*, Vol. III. Diseases of Fruit Crops (Kumar, J., Chaube, H.S., Singh, U.S. and Mukhopadhyay, A.N., eds), pp. 129–146. Englewood Cliffs, NJ: Prentice Hall.
13. Schweinitz, L.D., 1834. *Transactions of the American Philosophical Society*, N.S. IV, 141-316.
14. Tudorel Baicu & Tatiana Eugenia Șesan, 1996. *Fitopatologie agricolă*. Editura Ceres, București.
15. Tweedy, B.G., 1969. Elemental sulfur. In “*Fungicides and Advanced treatise*.” Volume 2 D.C. Torgeson (ed.), Academic Press, New York and London, pag. 119 – 145.
16. (**2017) Even with effective synthetic alternatives Sulfur remains a relevant tool for controlling powdery mildew <<https://www.farmprogress.com/grapes/even-effective-synthetic-alternatives-sulfur-remains-relevant-tool-controlling-powdery-mildew>>
17. (*2018) Un secol într-un pahar: suprafața cultivată cu viță-de-vie a crescut de 2,5 ori în ultimii 100 de ani. România, în top 10 european la producția de vin <<https://www.zf.ro/romania100/un-secol-intr-un-pahar-suprafata-cultivata-cu-vita-de-vie-a-crescut-de-2-5-ori-in-ultimii-100-de-ani-romania-in-top-10-european-la-productia-de-vin-17230247>>