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# Powdery mildew infection dependent on weather factors in vineyards near Keszthely in 2008

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***Summary:*** Weather conditions are extremely influential on grapevine productivity and quality. High temperature and humidity makes favorable conditions for powdery mildew infection respectively. The meteorological data around Keszthely, Hungary show the vegetative period is dryer and warmer than it was closely hundred years ago. We examined the development of powdery mildew infection on two varieties *Vitis vinifera* L. cv Italian Riesling and cv Merlot in relation with meteorological data. No primer infections were appeared in the vineyard. The year of 2008 was quite ideal for the accumulation of *Erysiphe necator* in the experimental vineyard. Although the dry summer can lower the infection, but if the high temperature is coupling with rainfall, the possibilities of powdery mildew infection is going to grow higher during the upcoming years.

***Key words:*** oriental fruit moth, plum moth, sex pheromone trap, selectivity

## Introduction

Hungary is situated on the border of the oceanic, of the dry continental, and of the Mediterranean climate regions. Because these regions are constantly changing all the time Hungary is going to be influenced harder by one of them.

The metabolisms of grapevines are strictly connected to the environment; it receives the build up substrates, the essential energy for the vigor. The physiologically efficient elements are giving the ecological environment of the grapevines, and the physiologically inefficient elements are giving the inactive elements. The most important ecological factors constitute the life conditions of the grape plant (lights, heat, water, oxygen, carbon-dioxide, mineral materials) (*Kozma,* 1991). In general we can separate these factors to three main group: climatic factors, edafic factors, and biological factors.

The relations of the qualitative and quantitative factors are the restrictive agent of the vegetation in a plantation. If the ecological circumstances are ideal for the grapevines, its metabolism is undisturbed, it grows well, and the quality of the yield is excellent. If the circumstances are unfavorable, or some of the factors are in low level the development is going to be weak, so this way the quality of the yield is going to be worse (*Kozma,* 1991).

Because of the effect of global warming the harmful organisms of plants are multiplicative, so the stress factors for the grapevines as well. For the survival of the grape plant it has to adapt to the changed circumstances. From the point of view of grape growing it is important to know that because the global warming the number of extreme weather elements increased. The warm weather accelerates the possibility of an infection in a plantation, because the air is warmer and humid, which conduct ideal circumstances for the pathogens. During the life of a grapevine the extreme weather and the high amount of pathogens is an important stress factor (*Hajdu & Botos,* 2005).

The extreme climate change could cause surprising changes, to what grapevine has to adapt to survive.

*Szász* (2005) estimated the metrological data since1870, according to this data he established the following: The average of the temperature in Hungary raised 0,6–07 °C in the last hundred years. The trend was decreasing in the first quarter of the 1900s, after this period warming up was observed. The warmest period – according to the yearly averages- was between 1965–1975 therefore these winters were moderate, so the length of the vegetation extended significantly. The most powerful warming up can be experienced nowadays according to the 30 year averages. Significant differences of the temperature could not be established during the summer-time. In the yearly summation of the precipitation a variable decreasing can be experienced during the 130 years. In the first part of the 20th century, the decreasing of the precipitation was average 40 mm/100 years. The decreasing of the precipitation in the area of Hungary is uneven, in the southern part it is intensive, in the northern skirts significant decreasing could not be observed. The decreasing only seen in the transitional seasons, during the summer the length of the dry periods are extending.

According to Bartholy and his associates results (In the 0,5–4°C global warm up region) in a yearly period the level of the clouds could decrease a few percent probably, the warming up of the temperature is going to be conformal to the global warming. In case of 1–1,5 °C warming up the decreasing of the precipitation is possible. If the warming up is higher than this, it will be more or less higher. The guessing in case of 3 °C of global warming is quiet indefinite higher precipitation. It is hard to forecast but almost certain that the yearly averages in Hungary are going to change in the upcoming decade. The climate in Hungary is going to be warmer and drier. The winters are going to be warmer, with a bit more precipitation, so the possibility of a flood is higher. The summers are going to be warmer as well, and the precipitation is going to be less, so the chance of drought going to be higher too. With the 0,5°C average higher temperature on the hemisphere raises the possibility of drought months 60%. In the last tierce of the 20th century it was observed that the physical intensity of the rainfall raised, so if this tendency stays like this the water usage of the plants, and the physical soil system will suffer irreversible damages.

According to *Szalai* (2004) it is a fact, that proclivity to drought in Europe is increasing in the Mediterranean region, and the climate of Hungary is very similar to the southern neighbors. The possibility of drought in the area of Hungary shows cumulative tendency. Also in the last decade the appearance of drought, increased intensely.

## Materials and methods

The meteorological data of Keszthely is available for 130 years, by the virtue of this data the changing of the regional climate is traceable. Thanks to these data Kocsis established that the precipitation was the lowest in 2000 (393 mm), and the highest was 1937 (1098 mm). In the region of Keszthely the annual average total precipitation was 678+134 mm (variation). In case of precipitation it is an often used index the climate normal. According to this it is certain that the average of the precipitation yearly is getting lower from the last part of the 20th century. According to this data the period of 1901–1930 had the highest average of precipitation, and the driest period of this survey was from 1971–2000.

In Hungary every 4 or 5 days there is at least 0,1 mm average rainfall (*Szász,* 1994). Most of the ploughed field crops are suffering after 5–10 days dry heat, and they afflict irreversible damages (*Szász,* 1994). This type of 10–14 days of dry periods occurs every year in the region of Keszthely. After 1968 these type of periods were 3–5 times a year, during the period of 1977–1985 these occasions are decreased to 1–3 times. After 2000 the number was increased minor, but it was not unique. According to the survey we have to face at least one 15 days of dry weather or two times of 10–14 days period, but the possibility of extreme circumstances could occur as well (*Kocsis & Anda,* 2006). If the data is separated to seasons it is observed that the rainfall during the spring season is linearly decreasing and the maximums are disappearing during fall.

As a conclusion the consequence of global climate change appears in the difference between the seasons in the case of Keszthely region, but a small amount of difference appears in the yearly and in the monthly data as well. The decreasing of the spring precipitation could have a critical influence on the agriculture production, because in the case of spring planted, and fall planted crops, this low precipitation can cause shortfall in the yield. In case of Keszthely the statistically certifiable warm is smaller, than it was detected at the other weather centrals in the Dunántúl region. On the touristic side the warming up has a positive effect, but it has an unfavorable effect on the evaporation of the Lake Balaton and transpiration of the field crops (*Kocsis,* 2008).

To use this for the plant protection treatments we have to fully aware of the ideal weather factors for the fungus *Erysiphe necator*. We can separate to two groups the climate factors which have influence on the fungal infection (favorable and unfavorable).

These factors are in order temperature, humidity, and light (*Yarwood,* 1957) the effect of rainfall and dewfall is unfavorable. The pathogen of powdery-mildew demands high temperature, even so its conidia can germinate on 4–5 °C, although the intensity of these processes is much slower. This development increases with the temperature; the highest is on 25–28 °C. On this temperature the conidia germinates in 1,5 hours, and from the time of the infection till the appearance of the conidia it only needs 5 days (*Barra,* 1961). The temperature higher than 30 °C is unfavorable, and 34–35 °C can cause the death of the fungus (*Delp,* 1953). The time of the required incubation is shown on *Table 1*.

***Table 1:*** The incubation time of powdery mildew

| Average temperature [°C] | Incubation time [nap] |
|---|---|
| 12 | 17 |
| 18 | 12 |
| 20 | 8 |
| 24—25 | 7 |

In optimal temperature 25–28 °C, with high humidity 87–92% is favorable for the growth rate of the fungus (*Brebion,* 1951). Temperature lower than this and the lower level of humidity, is a moderate limiter factor, because the transpiration of the plant balances the humidity and the ectophyton fungi living on the surface are relieved from this circumstance. The effect of rainfall is negative, because the drop are washing of the conidia from the surface, and the bigger osmotic potential the water uptake of the conidia rises, which can cause the rive up of the cells.

On the covered parts of the vines and especially in the shady parts, the growth rate of the fungus is much higher, although the daily 8–12 hours sunlight increases the germination capability of the fungus. It is possible that this effect is caused by the plant indirectly. The sunlight has a positive effect on the vines and it increases the viability of the fungus as well (*Yarwood,* 1936; 1957).

The direct sunlight thought 3-4 hours causes the lost of the germination capability of the conidia (*Blumer,* 1933).

Long lasting warm temperature and the moderate humid weather facilitate the fast spread of the disease. The possibility of the infection is higher, especially when these years are following each other. The cold winters has a large of influence on these so called epidemic years. If the winter is moderate and the temperature doesn't goes below -15°C the wintering of the fungus is fine, which is a good condition for a possible epidemic. If there is frost and the temperature goes constantly below -15 °C during the nights, the hyphas of the fungus freezes, and the chance of the wintering decreases, or it can be even stop (*Lehoczky,* 1968).

The appearance of the disease is largely influenced the type and the dominancy of the primer infection. The initiated infection by the conidia of the flag shoots is usually focal nature, while ascospores cause even contamination after overwintering in the form of chasmothecium (*Jailloux* et al., 1998).

These circumstances are delaying the epidemic. Generally the ideal circumstances for the downy mildew are restricting the appearance of powdery mildew, a vice-versa.

The experimental field was located in the field of University of Pannonia Faculty of Georgikon. According the review of the literature sources, the spraying database, and the weather data of the field, the time of the possible primer infection was crucial to determinate the time of the spraying. In January 2008 cane samples were collected from the field. The basic infection was observed from these samples later on *(Figure 1.)*.

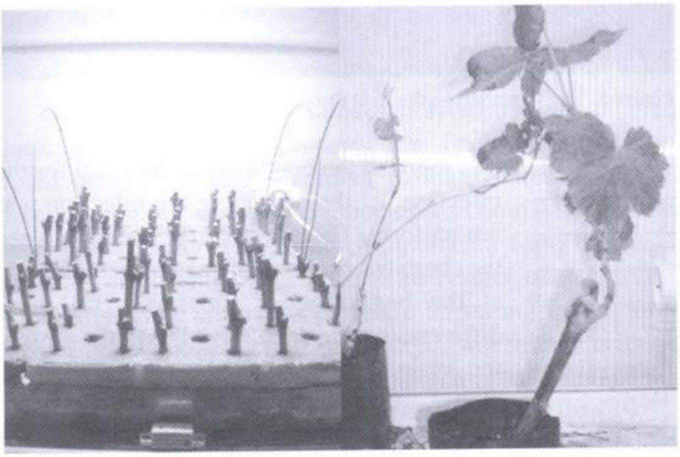

***Figure 1.*** The survey of basic infections on the cuttings (Taksonyi).

On the experimental field, in 2008 was a general survey. The most important was the status of the vines in each plot. Two different varieties (Italian riesling, Merlot) were marked for the experiments. The marked rows have different age, and they are on separated plots. During the previous survey the count of the envies and the health status of each vine were observed.

According to the survey the experimental plot consists of 4 rows of the Riesling and four rows of the Merlot.

On the first experimental plot is the Italian riesling variety middle high cordon *(Figure 2)*. In four rows 92 post space, 397 vines, 5 vines in each space. There are 63 missing vines, and the plot is 16 years old.

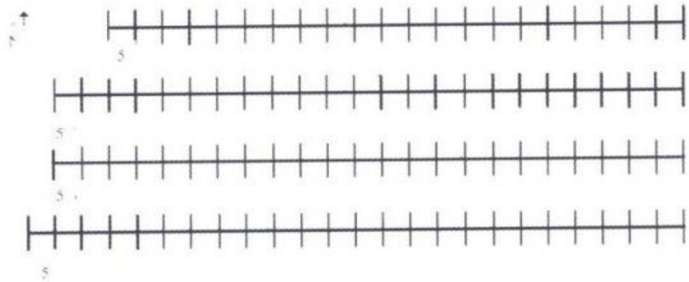

***Figure 2.*** The experimental plot of the variety Italian riesling

The second experimental plot was a middle high Merlot. In the marked row there are 36 post space 226 vines, 6–8 vines per space. The plot is 13 years old, and only 1 vine is missing.

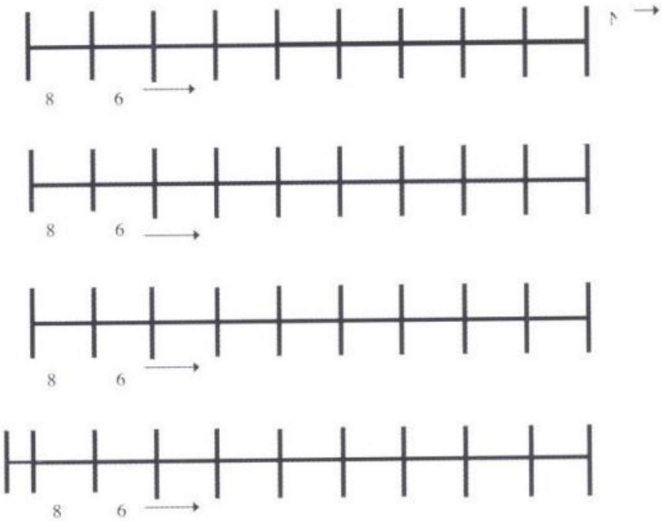


***Figure 3.*** The experimental plot of the variety Merlot.

The general conditions of the vines compared to literature sources were satisfying. The health statement of the vines on the experimental plot was adequate, so the plot was ideal for the experiments.

Because of the previous treatments and the variable usage of the QoI fungicides it was presumable that on the field resistant pathogens will be appear. The different techniques applied in the surrounding plots are confirming this hypothesis. Because from the surrounding plots a lot of inoculums could invade in the previous years.

***Figure 4.*** The condition of the Italian riesling and Merlot plots in March (Taksonyi).

## Results

The weather results of 2008 confirmed the warming period of the last decade. In the summer of 2006–2007 the temperature was high and the precipitation were low, the summer of 2008 in Keszthely the precipitation was quiet high compared to the years before. The distribution of the rainfall was evenly. Besides the precipitation the temperature was high and the level of the humidity was up to 80%, which could be the principle of a powdery-mildew infection.

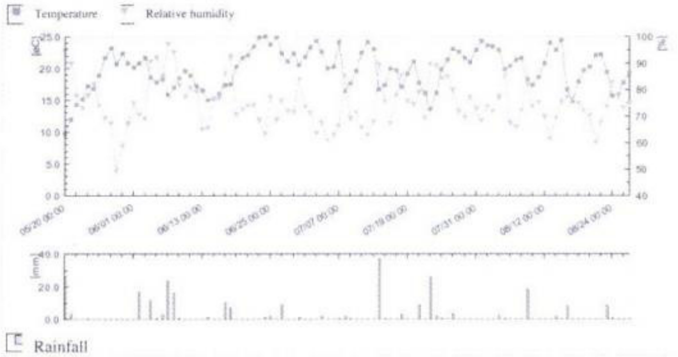


***Figure 5.*** The weather data from 2008

Besides observation of the weather parameters, another experiment was conducted on the field. The basic goals of the experiment started in May 2008, the survey of QoI-fugicides resistant powdery mildew types, the proof of there presence. On the experimental plot such survey never happened before this time. Two main varieties were observed.

At the design of the spraying experiments it was the main consideration, that the appeared or existing stems are resistant or sensitive to the QoI fungicides. During the experiments, the available sortiment of QoI fungicides in the grape growing practice were used. From the simple strobilurin agents to the products and the applied protection programs were experimented. In two plots and four experimental groups were the observations made *(Table 2)*.

The spraying experiments were started 31 May, 2008; the time between the treatments was 7–10 days, adapted to the weather. There were 6 treatments in the vegetation of 2008. Before every treatment and after the last treatment the data of the leaf and cluster infections were recorded.

Against the expectation, no primer infections were appeared in the vineyard. This happened because the low rate of infection from the previous years, and because of the plant protection technology practices before the experiment was conducted in the plot. The source of the powdery mildew infection was not the older woody parts (trunk, arm, cane), the inoculums were rather invaded from a different area. The year of 2008 was quite ideal for the accumulation of *Erysiphe necator* in Cserszegtomaj. This process was assisted by the weather conditions of the year. While the year 2006, 2007 were quiet dry, in 2008 the amount precipitation was not a lot, but it was quiet moderate *(Figure 5.)*. Besides that the temperature was high, so the conditions were ideal for the infection. At the beginning the infection was not uniform. There were differences between the chemical agents in the experimental group at the beginning of the trial. But these differences were decreased during the term of the vegetation because the pressure of the highly infected plots. The symptoms were uniformed at the end of the vegetation in the experimental plots. Compared to the weather data of the last 130 years, the year of 2008 doesn't confirms the tendency, because there were no 12–14 days of dry period. The only dry part was the end of May, when 11 days without of precipitation were monitored on the field. After this there were only 4–7 days without any precipitation. Besides of these data the temperature was high, so the cycle of the powdery mildew infection was accelerated. This mend the time of the cycle was shorter and the generations were switched faster in the plot. The generations were overlapped each other so the resistant individuals could multiplicate in safety. This was quite traceable during the year *(Figure 6)*.

***Figure 5.*** The symptoms in the field (Taksonyi).

***Table 2.*** The sortiment of the used agents Cserszegtomaj 2008.

| | | | | | |
|---|---|---|---|---|---|
| I. | | Strobilurin agents | Dose: | Vines/ space | Marks |
| | a | Piraclostrobin | 8ml | 33/7 | I./pir |
| | b | Azoxistrobin | 12 ml | 31/7 | I./az |
| | c | Trifloxistrobin | 3g | 32/7 | I./tri |
| II. | | | | | |
| | | Strobilurin agents supplied with agent against *P. viticola* | | | |
| | a | Piraclostrobin+metiram | 20g | 28/7 | II./pm |
| | b | Azoxistrobin+folpet | 20ml | 30/7 | II./af |
| | c | Trifloxistrobin+cimoxanil | 5g | 23/7 | II./tc |
| | d | cimoxanil+famoxadon | 4g | 29/6 | II./cf |
| III. | | Strobilurin agents supplied with agents against E. necator | | | |
| | a | (Piraclostrobin+metiram)+sulphur | 20+40g | 29/7 | III./pmk |
| | b | (Trifloxistrobin+cimoxanil)+ sulphur | 5+40g | 35/7 | III./tck |
| | c | (Azoxistrobin+folpet)+penkonazol | 20+3 ml | 33/7 | III./afp |
| | | | | | |
| IV. | | Applied technology | | | |
| | a | BASF | | 26/7 | IV. |
| | b | BAYER | | 31/7 | IV. |
| | c | SYNGENTA | | 30/7 | IV. |
| | | | | | |
| Kontroll | | | untreated | | 15/3 |

***Table 3.*** An example of the rate of infection

| | I. | | II. | | III. | | Pathogen | Date |
|---|---|---|---|---|---|---|---|---|
| Piraklostrobin | levél | fürt | levél | fürt | levél | fürt | | |
| | 0/50 | 0/20 | 0/50 | 0/20 | 0/50 | 0/20 | E. necator | 2008.05.30 |
| | 0/50 | 0/20 | 0/50 | 0/20 | 0/50 | 0/20 | E. necator | 2008.06.13 |
| | 15/50 | 9/20 | 23/50 | 10/20 | 11/50 | 7/20 | E. necator | 2008.06.24 |
| | 35/50 | 19/20 | 40/50 | 17/20 | 18/50 | 19/20 | E. necator | 2008.07.16 |
| | 35/50 | 20/20 | 30/50 | 20/20 | 31/50 | 20/20 | E. necator | 2008.07.26 |
| | 42/50 | 20/20 | 36/50 | 20/20 | 40/50 | 20/20 | E. necator | 2008.08.03 |
| | 50/50 | 20/20 | 47/50 | 20/20 | 49/50 | 20/20 | E. necator | 2008.08.18 |

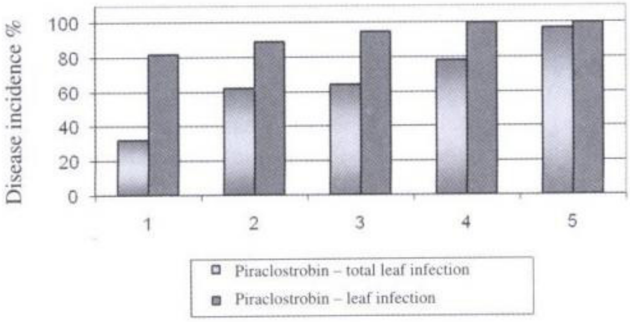


***Figure 6.:*** The change of average infection on the leaves during the vegetation (Cserszegtomaj, 2008).

## Conclusions

The warming of the climate in Hungary will change basically the pathogens progress cycle. The rates of infection could be high or low according to the differences of the precipitation in each year. The pathogens could winter in the buds not even in mycelia or chasmothecia form, but it is possible in chasmothecia form. The results of successful wintering of the chasmothecium are appearing in a primer type of infection, in contrast of a focused infection which can cause by the anamorph type of the fungus. The spread of the ascospores are depending on the temperature higher than 10 °C, precipitation more than 2,5–10 mm, 12–14 hours of leaf humidity. In those plots where the rate of infection was high in the previous years, the possibility of this type of infection is much higher. The higher average temperature winters favors the wintering of the pathogen, so the infection caused by the earlier spring period will be more aggressive than usual. Although the dry summer can lower the infection, but if the high temperature is coupling with rainfall, the possibilities of powdery mildew infection is going to grow higher during the upcoming years. We must not forget the simple organisms can adopt to extreme circumstances than developed ones. So they tolerate faster the stress caused by their environment. The results of this adaptation are appearing on the expenses of the growers, paid for plant protection.

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