Research on the Micro-climate of Grapes in Tokaj-Hegyalja Hills

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Abstract: *The micro-climate of grape is affected by clouds and wind. The influence of these factors is always lessened because clouds hinder both radiant exposure and outgoing long-wave radiation. The turbulence caused by the wind mix colder and warmer layers of air near the surface. The rate of heat-surplus or deficiency in the cultivated area of the grape plantation in comparison with non-cultivated area at different stages of growth is very important. The number of hours covered in the given part of the day and weather conditions are also of main importance.*

Key words: *grape, microclimate, Tokaj-Hegyalja*

Research on the **horizontal thermo-gradients** gives us information about temperature conditions between the plantation and its surroundings and different heat-usage between them. Horizontal gradients at 10 cm in air layers near the surface are reported later.

Windy and cloudy macro-weather has got a great effect on changes in horizontal gradients. In this case gradients are small, insignificant. However we can come to conclusions concerning the temperature conditions of the two cultivation methods.

Considering the two methods of grape cultivation, heat surplus can be detected only around noon. This does not reach $1,0^oC$ so it is not significant. Positive and negative thermo-gradients are more or less the same in grape –plantations. There is difference only in the period of time, when in cordon-cultivation the period of negative horizontal gradients is up to 6hours.This is the time when the plantation takes up heat from its surroundings. Whereas in ridge-cultivation this takes 9hours.We must emphasize that these microclimatic conditions are only for overcast and windy weather. Microclimatic measurements take place on the area between the rows of grapes.

So far we have examined the phytoclimate of grape in cloudy and windy circumstances. Now we are presenting the microclimatic conditions of a cloudless day with little wind on the 15^{th} of May, 2000.The length of bunches is 1-4 cm, the average length of sprouts is 20-25 cm with 5-6 leaves on each bud. The width of leaves is up to 3-7 cm.

Data of air temperature at the height of 10 and 150 cm are presented below. Measurements started at 8.00 a.m. on the 15^{th} and lasted till 9.00 p.m. Then, they continued from 2.00 p.m. to 8.00 a.m. on the 16^{th} on the territory between the rows.

Concerning the average figures of air temperature examined at the height of 15ocm there are not big differences. It can be explained with the stronger motion of air. At this height we cannot talk about active area, as the average length of bunches is 20cm.

Comparing the results taken in the instrument shelter with the non-cultivated area, we can come to the conclusion that rise and cool-down of temperature is quicker in the cultivated and non-cultivated area as well. Differences at 10cm height in layers near the surface are bigger. Temperature conditions of cordon-cultivated plantations are more favorable here. Due to bright and shiny circumstances, distinctions between the plantation and its surroundings are growing and they are bigger than in overcast, windy weather.

In the followings we are examining the differences between cultivation methods and non-cultivated area at the heights of 10 and 150 cm with help of **horizontal thermo-gradients**.

Concerning both lower and upper regions, divergences are not big except for one or two cases. However it is interesting to note that there is heat-surplus in the upper region from11am to 4pm, which is bigger at11am and 1pm in ridge-cultivated plantations, but in other cases results are the same. In the upper sphere there is heat-deficiency till 11.00 a.m., which continues from 4.00 p.m. to 4.00 a.m.

The lower part of the plantation is warmer than its surroundings from 9.00 a.m. and it has heat-surplus. This lasts during sunshine and while the speed of wind is under 1,0m/sec. In this case the

extent of heat surplus is bigger than 1,0 ^{o}C, moreover in wire-based cordon-cultivated plantations it exceeds 2,0 ^{o}C. After 4.00 p.m. the speed of wind is getting quicker, exceeding 2,0 m/sec, which is resulted in the gradual disappearance of heat-surplus and after 6.00 p.m. plantations of both cultivation methods take up heat from their surroundings.

If we compare micro-meteorological conditions in overcast and windy weather versus bright weather with a little wind, we can immediately come to the conclusion that differences are growing near the surface in bright weather. It is especially true for the time of heating up, when the plantation has got overwhelming heat surplus in comparison with its surroundings. In bright weather without wind, divergences of temperature will surely be multiplied. Consequently, **in the period of sprouting there is heat-surplus in grape plantations**. The rate of heat-surplus depends on the method of cultivation at a certain extent, if the plants of cordon-cultivation are not shadowed in the area between the rows.

There can be heat-surplus even in cloudy and windy weather with some sunshine. Measurements prove that the type of climate in plantations varies according to different weather conditions. During the night there is heat-deficiency in both forms of cultivation with the same values.

The results show that the extent of heat surplus is regulated by weather conditions and, in this case, agro-technology. Obviously there are other determining factors, such as extension or height of plants.

According to our experiments we can get a picture about the vertical heat exchange of the day and night **with the help of vertical thermo-gradients**. If the lower layer of the plantation is warmer than the upper one, in other words, the temperature falls upwards, **this gradient is positive**. Otherwise if it falls downwards, it is **negative**. Vertical gradients in both methods and in non-cultivated area at the height of 10 and 150 cm are given below.

Temperature data show that **heat-surplus** is accompanied by **positive heat exchange** in the plantation in both forms of cultivation, namely lower layers are warmer. In non-cultivated areas, differences of vertical thermo-gradients show great divergences only around noon, whereas the biggest positive thermo-gradients can be measured in cordon-cultivated plantations. Concerning ridge-cultivation, the divergences between lower and upper parts are smaller, as stakes provide support against wind at the height of 150 cm. Turbulent movements at this layer are slowed down more than in cordon-cultivated plantations. Protection against the wind results in heat surplus.

In cordon-cultivated plantations there are not any stakes at this layer, therefore stronger air currents decrease temperature. Temperature conditions between the two cultivation methods and the surroundings of plantations are shown in the following chart.

The period of time and average value of vertical and horizontal gradients are very different. Horizontal gradients show that the period if positive gradients of upper layers in ridge-cultivated grape plantations is two hours less than in cordon-cultivation, in spite of the fact that the average horizontal thermo-gradients is slightly bigger in the case of ridge-cultivated plantations. The cause of this has already been mentioned earlier. At the height of 150 cm there is heat-surplus.

Although the period of positive gradients at this layer is less than that of negative ones, positive gradients of daylight over-compensate negative ones. In lower layers the average number of hours of the negative gradients is the same, with only one extra hour of the negative gradients in the case of ridge-cultivation.

The layer of air in lower parts gives us another picture about conditions of temperature usage. Average positive thermo-gradients in cordon-cultivated plantations are bigger, which means that the air layer of cordon stock shows warmer conditions. At higher layers the divergence between the time period of positive and negative thermo-gradients in the two methods of cultivation was 1-2 hours, at lower stratum the period of positive gradients in the case of cordon cultivation was twice as big.

According to vertical gradients, rise in the temperature of the day is much more intensive in bright, shiny weather than the cool-down at night. Concerning the two methods, rising is quicker in cordon – cultivation, while cool-down at night is also the most intensive in this method. The difference however is insignificant.

Research done at night informs us that the air of cordon-cultivated areas cools down more. We must note that the cool-down at night can also be detected in the period of cropping and ripening. Ridge-cultivation provides protection against radiation at night.

In this section we are examining the difference of heat balance of plantations in overcast and windy weather and in bright one with only a little wind. The positive period of thermo-gradients in the same phenological phase, in cloudy and windy weather, is 2 hours in ridge-cultivation, 3 hours in cordon-

cultivation. If the weather is bright with a bit of wind, this period can be 14-15 hours. The average number of hours of positive thermo-gradient is 0,5 in both forms of cultivations in overcast and windy conditions, but when it is bright with a bit of wind this number is 0,9 or 1,1. To get even more punctual picture about microclimatic conditions, it could have been useful to take measurements of the plantation in more kinds of macroclimatic situations, for example in bright or cloudy weather without any wind.

If we manage to examine these weather conditions from microclimatic perspective in the plantations throughout a lot of measurements on each type of weather, and we also get knowledge about climatic conditions of positive and negative gradients and the best cultivation method for it, we will be able to tell the state of heat balance in certain conditions of the given cultivation method without any measurement. We need a lot of years of examination in different climatic conditions to be able to state the probability and occurrence of phytoclimatic phenomena.

Here we are studying the state of **vertical gradients**. Divergences between lower and higher layers are called gradients. If the temperature falls upwards the gradient is **positive**, otherwise it is **negative**. According to the experiment the positive heat exchange adequate to the type of radiant exposure lasts for 12 hours in the non-cultivated area with a gradient of 1,03. Positive heat exchange during outgoing longwave radiation at night is reduced to 14 hours, whereas the negative one is up to 6 hours. During measurements isotherm occurred on both cultivated and non-cultivated areas.

Experiments on heat exchange show us that temperature conditions of the air layer near the surface are more extreme than that of the surroundings. Examining the average of vertical positive thermo-gradients we can state that this figure is 0,4 degrees bigger on average in plantations of cordon-cultivation than in ridge-cultivation. Around noon, at the time of strong radiant exposure there are distinctions exceeding one degree between the two forms of cultivation. Considering the extent of negative thermo-gradients there is no difference between the two methods. The value of negative gradients is in connection with the different heat-usage of the methods. Factors determining the extent of heat balance are not the same in the methods, but there are also distinctions between cultivated and non-cultivated areas.

The cultivated area receiving radiation gets smaller amount of solar radiation than the non-cultivated surface, though there is heat accumulation in the lower layers of all forms of cultivation. It can be attributed to the less motion of air in lower layers. This is not the same in the two methods and also changes in progress with the growth of the grape.

In the section below we are presenting the data of examination on the behavior of air temperature gradients in cultivated and non-cultivated areas during flowering. First we are going to deal with the **horizontal thermo-gradients**. These particulars are presented in the upper right-hand side corner of our charts.

Concerning the sign of horizontal thermo-gradients of all the three years we can state the same as we have already mentioned in respect of air temperature conditions. We have to emphasize the phenomenon that positive gradients are **bigger** in cordon-cultivated plantations, whereas negative ones are **smaller**.

On the basis of changes in the extensions of gradients it means that the plantation of cordon-cultivation **gets warmer quicker**, so it has bigger heat-surplus and smaller heat-defection. In ridge-cultivation it takes more time to warm up because of bigger shading, consequently it will gain less heat-surplus and more heat-defection. Another important factor is that heat surplus of blooming grapes can be stated only under favorable macroclimatic conditions. By looking at the charts it will soon turn out that heat surplus disappears in overcast weather without sunshine.

Thus, studying horizontal thermo-gradients in the period of blooming can be very important in grape production, as they explore characteristic features that determine and describe certain types of climate. Therefore we have to take measurements in all kinds of weather conditions in order to get punctual analysis of the main characteristic qualities.

From now on we are representing the research on the decrease and increase in temperature between the two methods and the lower and higher parts of non-cultivated area. These conditions are presented with the vertical gradient between 10 and 150 cm. The vertical gradient of temperature in the plantation and non-cultivated parts is **positive** in most of the day. This means that there is positive heat exchange during the current type of radiant exposure in the plantation. The only exception was the day 17th of June, 2000, when the heat exchange was negative in the late afternoon hours in both forms of methods and on the cultivation free area as well.

The extent of positive heat exchange is much reflected in the changes of macroclimate. In 2000, for instance, the temperature was the lowest during the time of blooming of all the three years. This was the time when the smallest vertical thermo-gradients evolved. The value of vertical gradients doubled in 2001 and 2002. Consequently there is heat-surplus in the blooming plantation in bright weather without any wind, which is accompanied by **positive heat exchange**.

Positive vertical thermo-gradients are bigger in cordon-cultivated plantations that in ridge-cultivation, as the height of plantations are not the same. The biggest positive gradient develops around noon in both methods. The value of vertical gradient in cordon-cultivated plantations fluctuates **between wider limits**, in ridge-cultivation the positive gradients are smaller and **less extreme**. If we compare vertical and horizontal gradients it will turn out that heat deficiency is not always accompanied by negative heat exchange.

Therefore positive heat exchange can evolve even when there is heat-deficiency in lower air layers. This condition was true for the period between 4.00-7.00 p.m. on the 8th of June, 2000. In the respect of the two methods we can see that there is heat-deficiency during daylight in ridge-cultivated plantations, but heat exchange is positive. In cordon-cultivation there is heat-surplus with positive vertical thermo-gradient. As a consequence, vertical heat exchanges of the two methods have the same signs, although they differ in size and value. They have opposite signs concerning the temperature conditions between the plantation and its surroundings. The period of time during which there is heat-surplus or deficiency and positive or negative heat-exchange in the time of blooming and other phenological phases has got practical importance.

The period of positive heat-exchange during blooming is determined mainly by the temperature conditions of measurements. The effect of agro-technology from the gradients' point of view can be seen in the fact that they are smaller in ridge-cultivated areas and bigger in cordon-cultivated plantations. The method of cultivation has got greater influence on the heat-surplus or deficiency than the period of time. Especially in cordon-cultivation there is bigger heat-surplus and smaller heat-deficiency in the air layers near the surface.

Literature

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Výskum mikroklímy viníc v Tokajských vrchoch

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Zhrnutie: *V príspevku sa zaoberáme vplyvom vertikálneho a horizontálneho tepelného gradientu na mikroklímu, ktorá má vplyv na pestovanie viniča v Tokajských vrchoch (Tokaj-Hegyalja) v severovýchodnom Maďarsku. Mikroklímu viníc ovplyvňuje najmä oblačnosť a veterné pomery. Vplyv týchto faktorov sa vždy znižuje, pretože oblačnosť zadržuje dlhovlnné žiarenie. Turbulenciu vzduchu spôsobuje striedanie teplých a studených vzduchových hmôt vzduchu nad povrchom. Veľmi dôležitá je miera nadbytku alebo nedostatku tepla v obhospodarovaných oblastiach pestovania viniča v porovnaní s inými oblasťami v rôznych fázach rastu. Počet hodín slnečného žiarenia resp. zamračeného počasia počas dňa sú taktiež dôležité.*

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