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The environmental factors and their influences on main physiological processes on apple trees

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Abstract The influences of environmental factors on the cultivars are very important in the orchard. In order to obtain good quality crops it is necessary to know the interaction between plants and environmental factors (light, temperature, CO_2 concentration in the air, soil humidity, soil fertility, etc.)

This paper's aim is to study the physiologic reaction (photosynthesis rate, transpiration rate, stomatal conductance of CO_2) of few apple cultivars to environmental factors (temperature, light). Unfavorable environmental conditions (temperature, light, too much or too little) cause the change in the development of physiologic processes.

Fuji and Pinova are the most adapted cultivars for the studied area.

Key words

apple cultivars, environmental factors, physiological processes

The movements of water vapours, O_2 and CO_2 on plants are made through the leaf surface. This is accomplished by opening and closing pores, usually found on the bottom side of the leaf (stomata). Opening and closing of stomata is controlled by specialized cells called **guard cells**. (10).

The photosynthetic activity is conducted both by seasonal and diurnal changes (light intensity fluctuations, leaf temperature, air temperature and humidity) (8, 5).

In same fruit tree species, there is a diurnal variation in photosynthesis activity. Maximum value was recorded in the morning, followed by its reduction. (1, 2, 3).

Under low light levels, the available light is insufficient to support the maximal potential rate of the light-dependent reactions, and thus limits the overall rate of photosynthesis. (4).

At the "light compensation point" the amount of O_2 being taken up for cellular respiration exceeds that produced by photosynthesis.

Increasing the light level, the rate of photosynthesis is increasing too. (6,7).

At a particular light intensity, the so-called "light saturation point", the rate of O_2 evolution levels off. Any further increase in the amount of light striking the leaf does not cause an increase in the rate of photosynthesis the amount of light is said to be 'saturating' for the photosynthetic process. (11). At the light saturation point, increasing the light no longer causes an increase in photosynthesis. (9).

Materials and Methods

Five apple cultivars were taken under study: Fuji, Pinova, Mutsu, Florina, Idared.

Determinations of photosynthesis, transpiration intensity and stomatal conductance were made by using the portable Lcpro system that enables automatic recording of other parameters as well (stomatal conductance, leaf temperature, incident photosynthetic radiation etc). LCpro is designed to carry out precise measurements of photosynthesis and transpiration, by automatically controlling the leaf chamber environment. Lcpro leaf chamber contains a system for analyzing and measuring the CO_2 and H_2O. Measuring of CO_2 is carried out through a miniature infrared gas analyzer. Measuring of H_2O is done by using high quality water vapours sensors. Beside gas exchanges, other relevant parameters are being measured as well; various calculations are also automatically carried out, based on recognized formulae.

All measurements, calculations and experimental programs were stored in files on memory cards.

The results were graphically represented and statistically interpreted using Excel 2007 and NCSS 2007.

Results and Discussions

Sun radiation reaches soil and trees canopy in two forms: direct light and diffuse light. As a result of sun radiation leaf is worming and the process of transpiration is beginning.

Transpiration in fruit trees appears as a result of high temperature. Transpiration is made through all aerial organs, with priority in leaves.

The transpiration process is on the leaves when stomata are open during the passing of CO2 and O2 (photosynthesis process).

This process increased, reaching maximum value at 36-40 ˚C (Figure 1). The highest value of transpiration is reached by Florina and Pinova cultivars. (8,24 µmol/s/m^2 and 7,69 µmol/s/m^2)At the other side is Idared. Temperature bigger than 38˚C cause the closes of stomata for Pinova and Fuji, reducing the transpiration.

Transpiration helps cool the inside of the leaf because the escaping vapor has absorbed heat, the degree of stomatal opening, and the evaporative demand of the atmosphere surrounding the leaf.

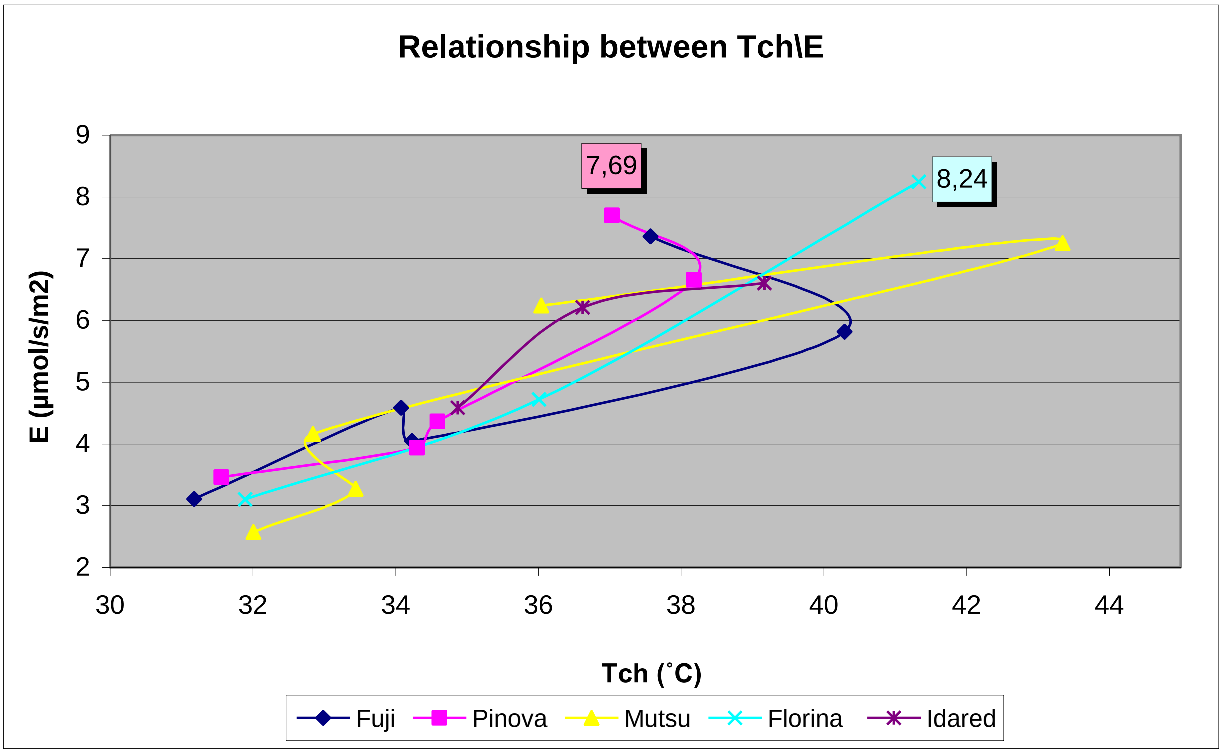

Figure 1. Relationship between temperature and transpiration rate

In the morning, under the sun radiation, the process of photosynthesis is started.

Photosynthesis is a process that converts carbon dioxide into organic compounds, especially sugars, using the energy from sunlight. Photosynthesis uses carbon dioxide and water, releasing oxygen as a waste product.

At the beginning, the quantity of O_2 produced by leaf is lower than the O_2 used for cellular respiration.

At the "light compensation point" the amount of O_2 being taken up for cellular respiration exceeds that produced by photosynthesis. This process of photosynthesis increased, reaching maximum value at 37-39 ˚C. (Figure 2). Any further increase in the amount of temperature striking the leaf does not cause an increase in the rate of photosynthesis. Under experimental condition, Fuji, Pinova showed the higher rate of photosynthesis (17,60 µmol/s/m^2 and 19,77 µmol/s/$m^{2)}$, and Mutsu, Florina the lowest.

Higher temperatures cause the assimilation stop, respiration intensification and fast decrease of reserve substances. In case of fruit-trees, temperature of 39°C, is considered to be maximum limit for normal development of photosynthetic and growth activity.

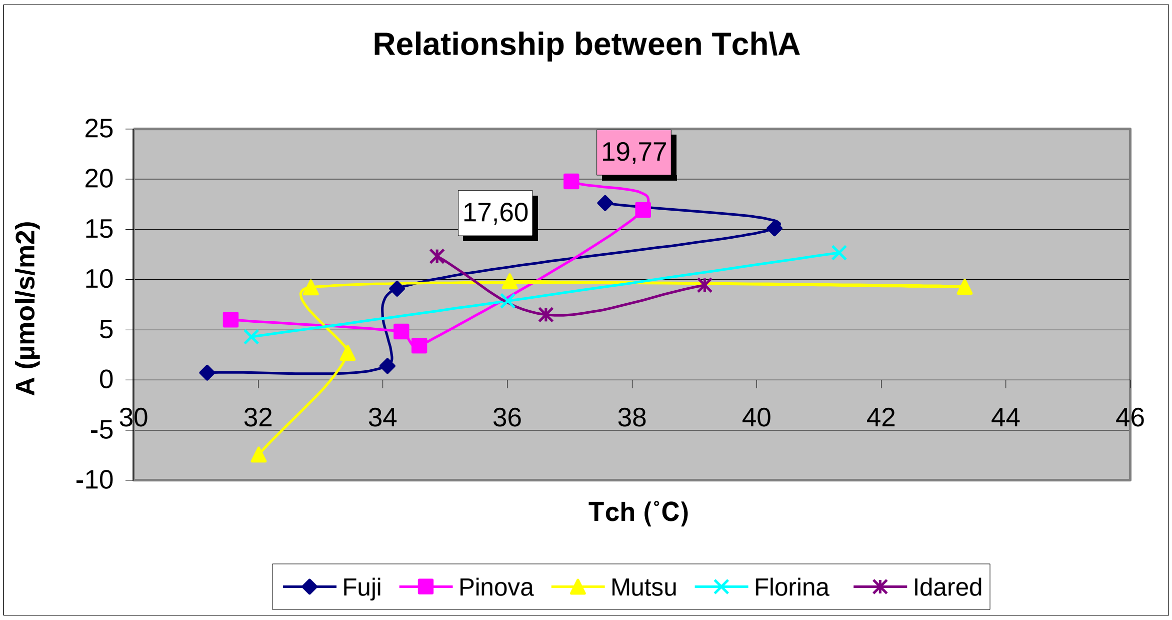

Figure 2. . Influence of temperature on photosynthesis rate

Another factor that was taken under study was stomatal conductance for CO_2. Stomatal conductance for CO_2, expressed in mol/m/s, represents the value expression of stomatal permittivity for carbon dioxide passing through. The study of this parameter offer information on the way how the plant reacts under different conditions of water supply or temperature, to adjust the intensity of transpiration process, so that to reduce water loss.

CO_2 used during photosynthesis first must pass through stomata into internal spaces within the leaf. Then CO_2 diffuses into mesophyll cells where it becomes available for photosynthesis.

Relationships between stomatal conductance and photosynthesis (gs/A) for all cultivars are showed in figure 3.

Under experimental conditions given, Fuji and Pinova showed the biggest permission for CO_2.

If water availability is reduced, stomata close and evaporation decreases, leading to improved water use efficiency. Total CO_2 assimilation (the photosynthesis) also decreases, but the plant conserves water and increases its chances of survival.

When the stomata close, CO_2 levels drop rapidly within the leaf, inhibiting the light-independent reactions. This then causes photosynthesis to stop.

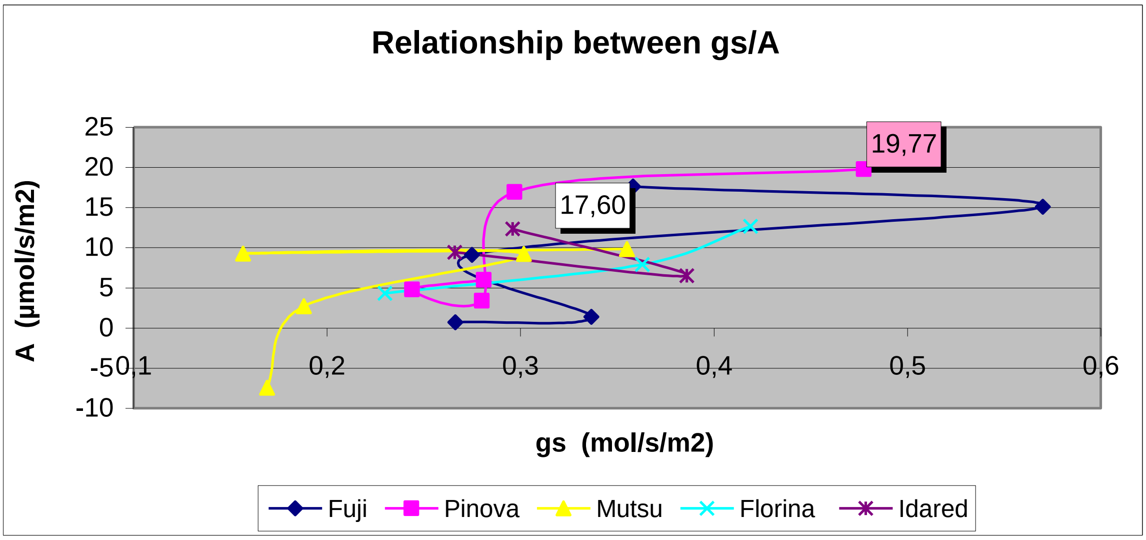

Figure 3. Relation between stomatal conductance and photosynthesis

In figure 4 it is showed the relationship between transpiration and photosynthesis. The rate of transpiration is direct related with the rate of photosynthesis; both are influenced by the aperture of stomata.

Again Fuji and Pinova showed the biggest value for these parameters. (17,60 µmol/s/m^2 and 19,77 µmol/s/m^2).

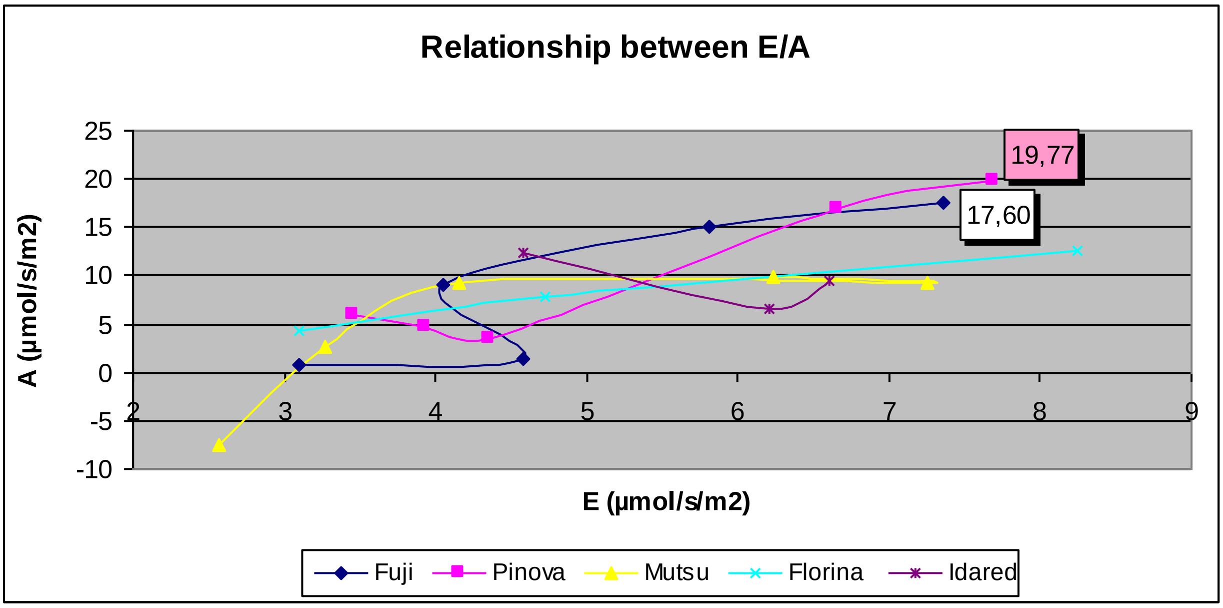

Figure 4. Relation between transpiration rate and photosynthesis rate

All the data were analyzed with NCSS 2007, using Cluster analyse**.**

Cluster analysis or **clustering** is the assignment of a set of observations into subsets (called *clusters*) so that observations in the same cluster are similar in some sense. The purpose of a dendrogram is to display the relationships among distinct units by grouping them into smaller and smaller clusters. In this dendrogram (figure 5) on can see 2 cultivars (Fuji and Pinova) very similar, like behavior, under the experimental conditions. Another similarity is between Idared and Florina.

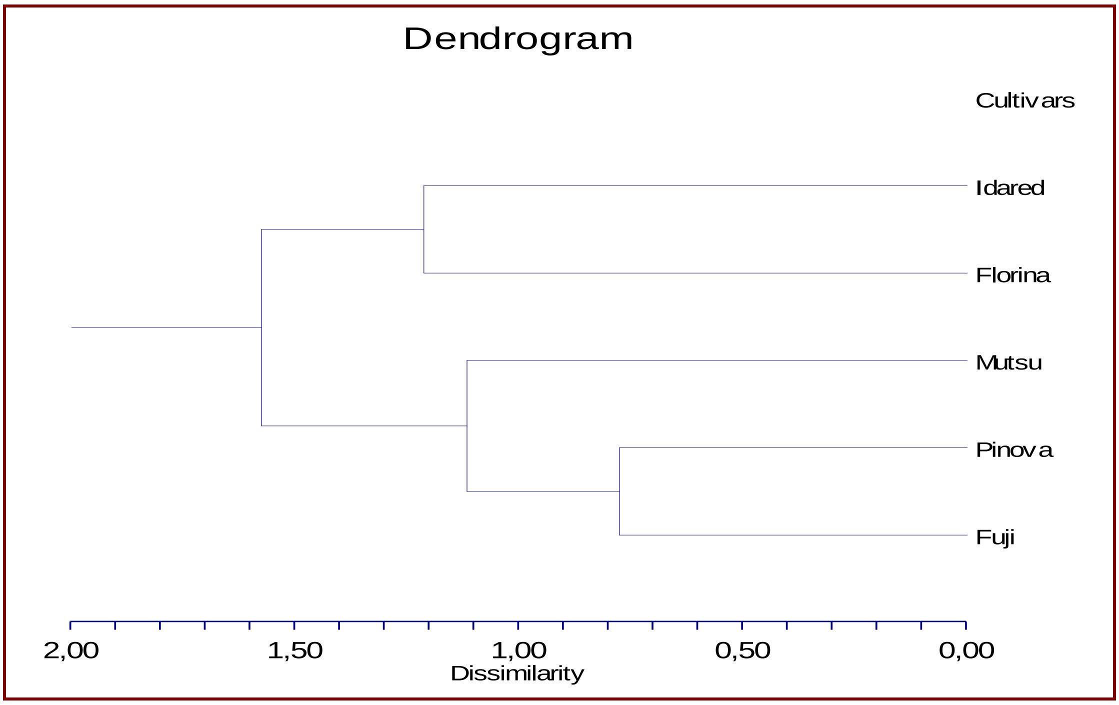

Figure 5. The dendrogram

Conclusions

Photosynthesis is influenced both by environmental factors and internal factors.

Transpiration rate and photosynthetic rate are influenced by closure or aperture of stomata.

Unfavorable environmental conditions (temperature, light, too much or too little) cause the change in the development of physiologic processes.

Fuji and Pinova are the most adapted cultivars for the studied area.

Acknowledgments

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