MECHANISMS OF DROUGHT TOLERANCE IN MESOXEROPHYTIC OAKS

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ABSTRACT

At the 70th celebration of the Institute this paper review the overall progress in the knowledge achievement in the area of tree physiology and forest ecophysiology in our country, significantly exemplified by results regarding the mesoxerophytic oaks (*Quercus cerris L.* si *Q. frainetto ten.*) and the stand ecophysiology of such ecosystems of great importance for the low altitude area in Romania, under likely climate change impact. It is shown the main research items approached over last 40 years, as well as the main authors involved. As well the results of the research carried out over very recent years are shown (stomatal conductance, photosynthesis, dark respiration, transpiration, mineral nutrition, ecophysiological correlation, etc). The main finding is an outlining of the importance of the tree physiology and forest ecophysiology in the enhancement of the efficacy of managerial act in sustainable management of such ecosystems.
Keywords: research, tree physiology, tradition, oaks, drought, gas exchange, water potential

THE HISTORY OF TREE PHYSIOLOGY AND FOREST ECOPHYSIOLOGY IN ROMANIA.

Early physiological research on forest trees occurred isolated in universities and forestry faculties, within dendrology and botanic, well before the ‘60, but that is the time when organized tree physiological research starts in Romania. Those times, the hydric processes related to soils were mostly approached, in terms of soil physical properties related to water retention and available water for seedlings, trees and stands. For first time water consumption of stands were approached, via leaf transpiration and leaves biomass on trees. Simple indicators were used to characterize the hydric processes in trees (like foliar transpiration, transpiration productivity, wilting point of the soil). Trees and stands water relations were focused with the occasion of large studies of decline of forests occurred in the middle of 19th century in Romania. Amongst the people involved with such research it is worthwhile to mention the most prevalent persons like I. Moraru, Constantin C. Georgescu, I. Popescu Zeletin, Eugen Pîrvu, S. Papadopol, Gh. Marcu, I. Catrina, A. Popa, C. Huluta. Over the '70 -'80 the decline process of forests was approached by deeper physiological research and understanding of hydric proces-ses within large research scheme composed by foresters, teachers and biologists (I. Catrina, D. Parascan, M. Ianculescu, Mihaela Pauca Comanescu, A. Alexe). Later on multiple approaches and extensive research on physiologic potential of forest trees were focused for different species, but mainly on oaks (photosynthesis and solar conversion energy capacity, dark respiration, foliar pigments) by I. Catrina, A. Popa, A. Atanasiu, D. Parascan, A. Alexe.

Mineral nutrition based on total form of element in the leaf of trees was approached for almost all important forest species (by I. Catrina, A. Popa, A. Alexe, T. Ivanschi & A. Costea, V. Bolea). Recently, over last decade of 20^{th} century, new approaches on leaf level were approached by use of gas analyzers and water potential (by V. Blujdea and Mihaela Pauca-Comanescu) or by integration of water relation and mineral nutrition at leaf level by soluble forms of nutrients. Simple and complex indicators are used to characterize the drought tolerance and water use efficiency in forest trees, mostly in oaks.

Water availability in the soils

Mesoxerophitic oaks lay mainly in small altitude areas of West and South of Romania on soils with an important share of argil developed under continental climate. Such a climate is unbalanced from point of view of precipitation fall over the vegetative season, which is poor in water and it is characterized by high evapotranspiration. Under such circumstances, limited soil water availability and high evapotranspiration potential should be controlled by stomatal opening and by other specific morphological or behavioral trees adaptation. Soil water availability decreases all along the vegetative season from exceeding or optimal available in springtime toward extreme shortage in mid and late summer. For a particular site, (Vlad Tepes forests, *Querceto frainetto-cerris* communities, 50 years natural stand, 30 km South of Bucharest) we present the evolution of the percent of water content over 1999, in a "brun roscat", red brown soil (luvic phaeozems, according FAO/UNESCO Soil Clasification). The percent of water and hydro-physical soil indictors (wilting point and full water capacity) are presented against dry matter of soil (Figure 1).

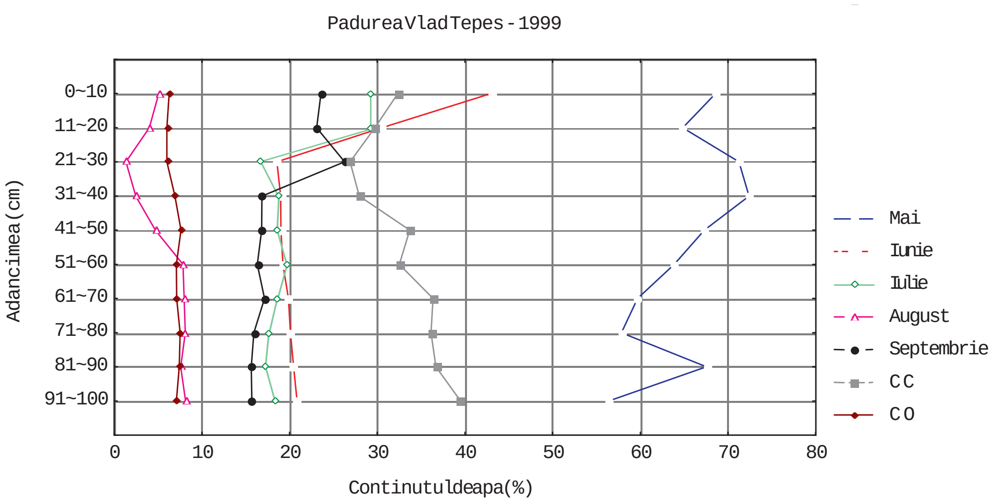

Figure 1. Monthly humidity and hydro-physical properties of the soil (%) in a specific type of soil for a mesoxerophytic oak based ecosystem

Maximum available water content of this particular soil ranges between 17 - 35 %, as it is increasing while go deeper to 1 m depth. While in spring time the water is in excess for at least upper part of the soil, it becomes unavailable also in the upper part of the soil in the last part of the vegetative season, as being 1-4 % less than witling point.

LEAF GAS EXCHANGE MEASUREMENTS

Leaf gas exchange measurements were done in *Quercus cerris* and *Q. frainetto* using an infrared gas analyzer ADC, equipped with a broad chamber LCA-4 of 6.25 cm^2. A wooden tower allowed crown access at 12 m height and 4 trees were pair approached. All environmental factors relevant for gas exchange were recorded (Tair, PAR, water vapor pressure in the air, air CO_2 reference) and some parameters were calculated (Tleaf, water vapor pressure deficit in the air - VPD). Gas exchange parameters were recorded on every two hours basis (actual rate of photosynthesis, leaf transpiration, stomatal conductance, internal CO_2 concentration). The purpose of the approach was to make obvious different behaviors between the two species of oaks. For that, the boundary line analysis, plotting stomatal conductance against environmental relevant factors, was used (g_s against PAR, VPD and air temperature), under the condition that sufficient number of measurements was taken. Boundary line analysis suggests opening of sto-mata at sensibly similar air temperature of 12^{o}C in both species, but there is an obviously different optimal temperature for gas exchange in *Q. cerris*

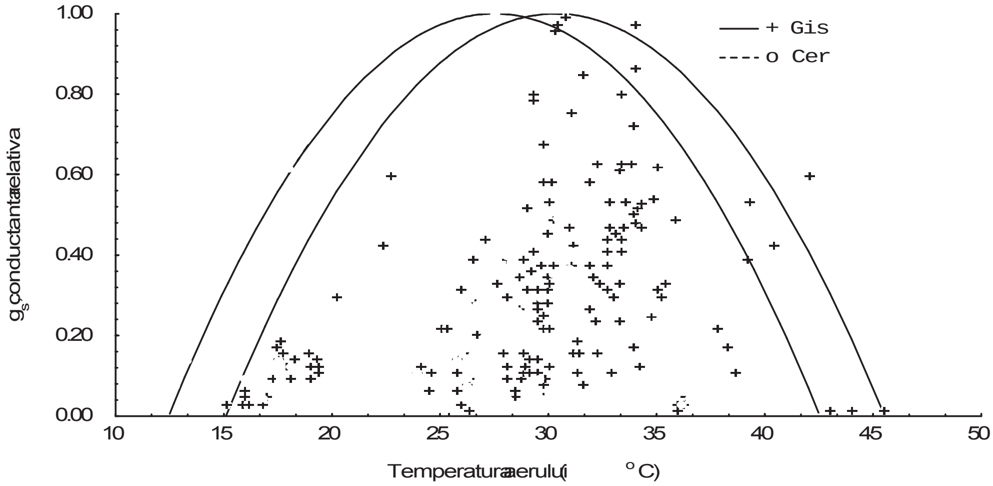

Figure 2. Response of stomatal opening against air temperature

($t_{optimum}$ = 27.5°C) compared to *Q. frainetto* ($t_{optimum}$= 30.2°C); meanwhile full stomatal closure is happening at air temperature of 40°C in both species (Figure 2).

According the photosynthetically active radiation (PAR) the fully stomatal opening

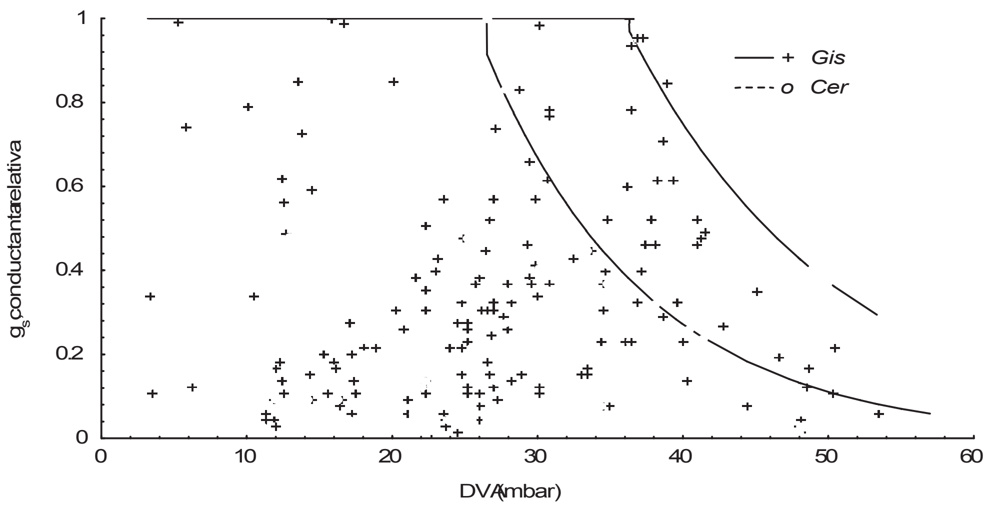

Figure 3. Response of stomatal opening against vapor pressure deficit in the air

realizes at similar values of 220 - 250 µmol $m^{-2}s^{-1}$, in both species. High evapotranspiration potential is reflected in air deficit of water vapor, against which the stomatal opening is analyzed in the figure 3.

The thresholds of stomatal closure generated by VPD are different in both species; in Q. cerris the stomatal closure starts at 2.65 kPa while in *Q. frainetto* at 3.62 kPa.

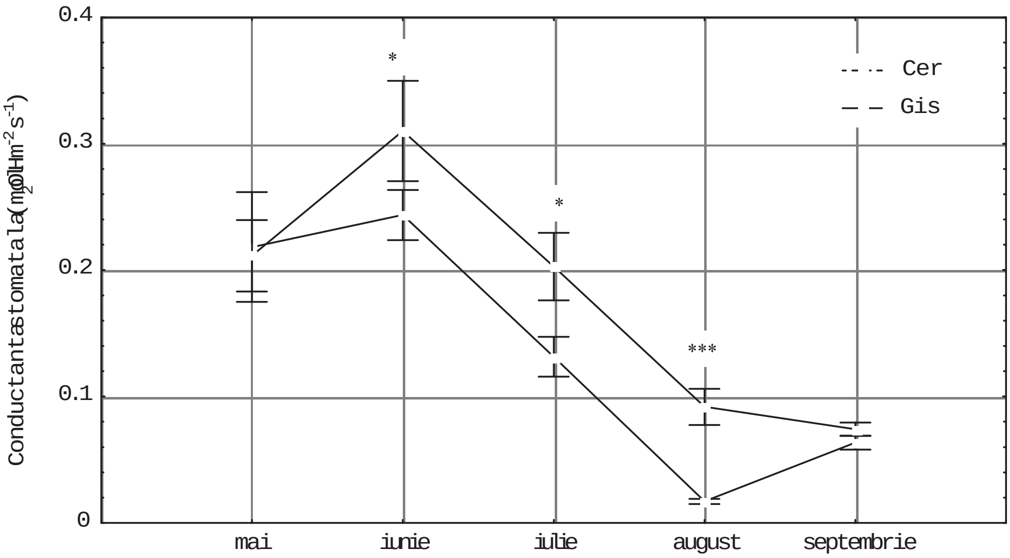

Figure 4. Seasonal trend of stomatal conductance in *Q. cerris* (Cer) and *Q. frainetto* (Gis)

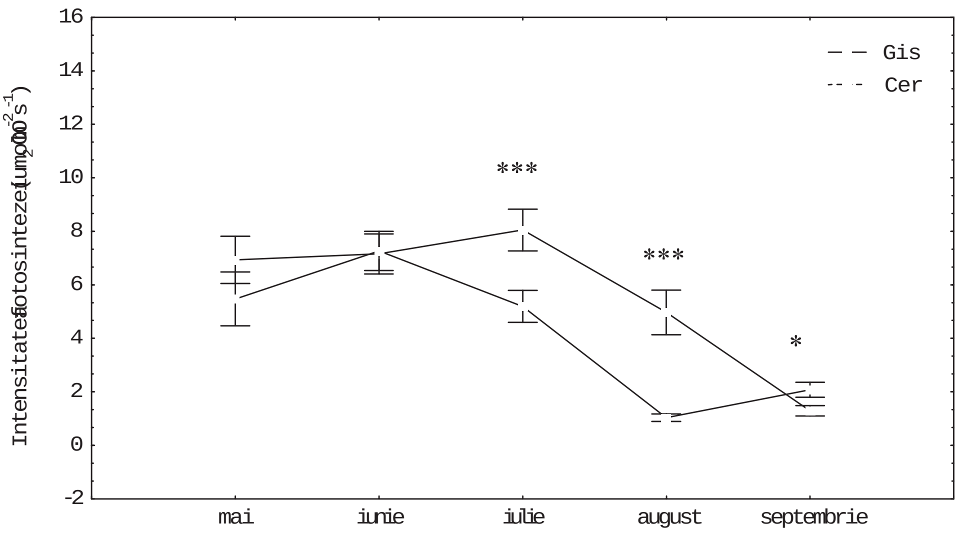

Figure 5. Seasonal trend of net assimilation in *Q. cerris* (Cer) and *Q. frainetto* (Gis)

Dynamic of gas exchange over the vegetative season is analyzed by trend of stomatal conductance (Figure 4), actual assimilation rate (Figure 5), dark respiration (Figure 6) and individual leaf transpiration (Figure 7).

Gas exchange process consists in several fluxes driven by relevant and associated forces. Stomatal flux is driven by water vapor deficit in the atmosphere while stomatal opening allow outside oriented flux to occur while leaves tissues should maintain adequately watered. The decreasing soil water availability and increasing of evapotranspi-

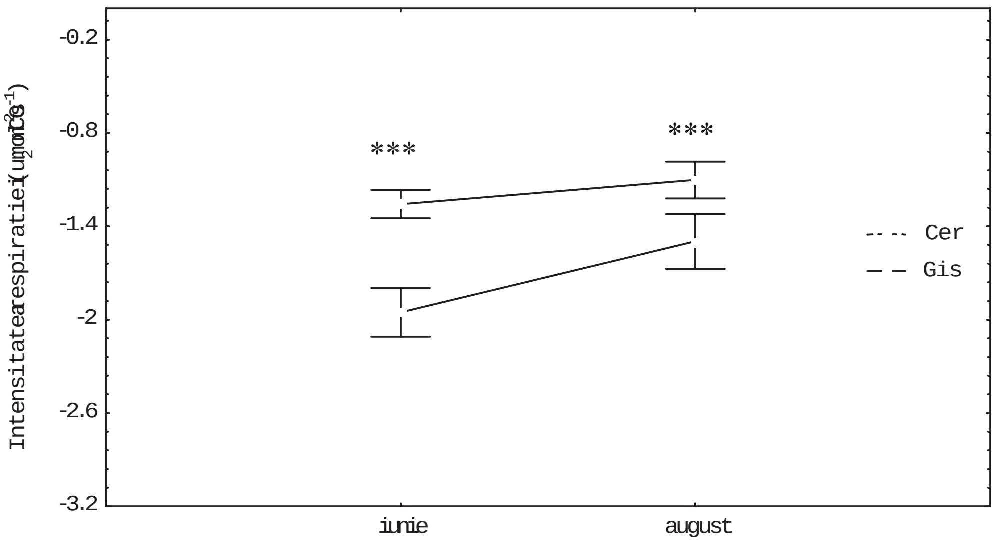

Figure 6. Seasonal trend of foliar dark respiration in *Q. cerris* (Cer) and *Q. frainetto* (Gis)

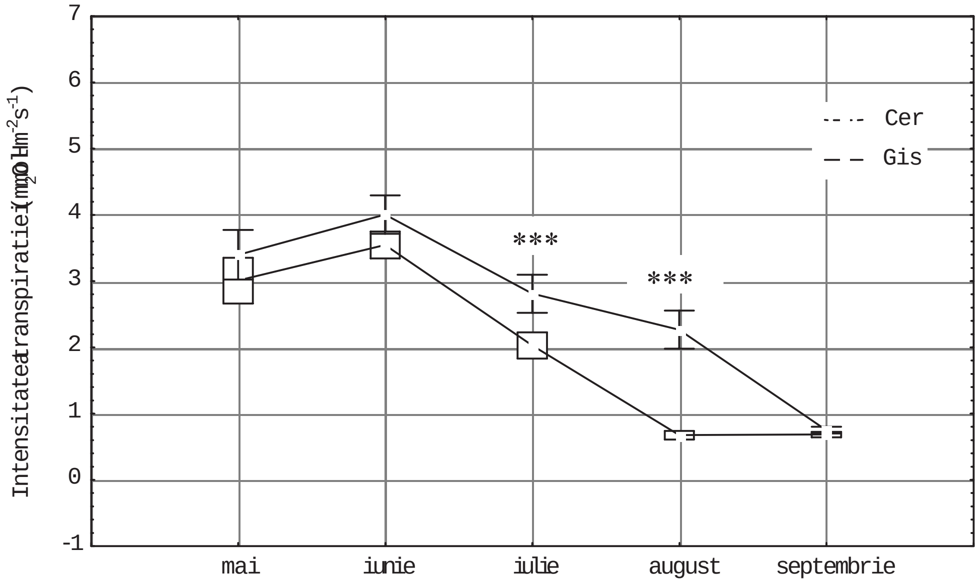

Figure 7. Seasonal trend of foliar dark respiration in *Q. cerris* (Cer) and *Q. frainetto* (Gis)

ration potential over the season generate reduction of intensity of gas exchange and improvement of efficient mechanisms for water use, what explains the general shape of above-mentioned processes.

Hydric status of leaves tissues is similar under normal environmental conditions in terms of water availability. The leaf tissues water potential, vary from - 0.3 MPa early in the morning to - 2.0 MPa at the midday for *Q. cerris* and *Q. rubra* under well watered

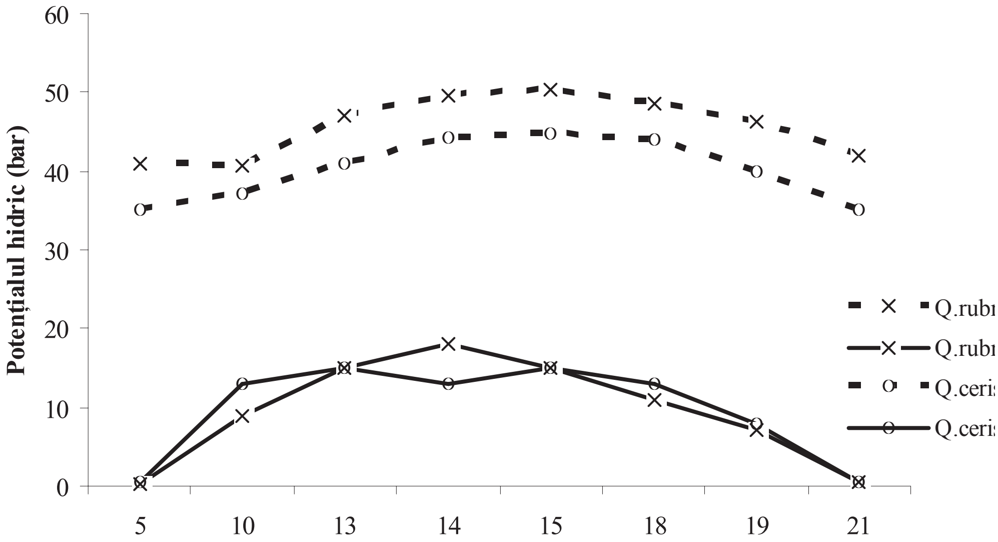

Figure 8. Diurnal course of the water potentials in the leaves of *Q. cerris* and *Q. rubra* under dry - uscat (dotted) and wet-umed (full) conditions

conditions (soil at full water capacity). Under shortage of water with the soil at water content at wilting point or less the leaf water potential goes down to -4.0 MPa in *Q. cerris* leaves and -5.0 MPa in *Q. rubra* leaves (Figure 8).

Discussions and conclusions

The most efficient tools for the assessment of the tolerance of forest trees to drought are foliar associated, which includes gas exchange control, adjustable chemical tools, early senescence, biomass size control, next to other multiple morphological adaptations. Among these tools nevertheless the stomatal opening is the most flexible in terms of time reactivity and efficiency. The low levels of water potential in leaves tissues reflect high tolerance to water supply and to high atmospheric water deficit in the way to continue with assimilation of CO_2 under such extreme conditions. Watered tissues ensure a certain stomatal opening that allows assimilation, the two opposite fluxes being synergistic. In case of reduction of stomatal opening mainly outward water vapor flux is affected at the passage through stomata compared with inward CO_2 flux, as generally shown by ratio between Assimilation (CO_2)/Transpiration (H_2O). The efficiency of passage of the two gases through stomata is well described by A/gs and A/ci. Watered status of leaves tissue contributes to the passive/active movement of stomata, but also it allows a certain dynamic of the CO_2 solubilization and supply to sites for carboxilation. *Q. frainetto* is utilized better the warm and dry spans of the vegetative season, while Q. cerris does better use efficiency in colder and wet periods since it close stomata over dry periods.

Sustainable management of mesoxerophytic oaks' based forests

These oaks are of high significant interest for the forestry of low altitude area of Romania, but also in Balkans, as offering stable ecosystems and multiple benefits for local environment and society. Ecophysiological research helps to understand the processes occurring in such ecosystems and for further improvement of the management approaches in the way to cope with currently climate change and maintaining productive capacity. In such ecosystems, based on mesoxerofitic oaks, *Q. cerris* and *Q. frainetto* behave complementary what enhances the system stability, so promoting the balance between these two species is a valid option for sustainable management under likely but also uncertain climate change. In certain extreme environment should be remind that *Q. cerris* is actively resistant to water vapor deficit in the air, that allow it to contributes to speci-fic stands structure, whatever the way: by preservation of natural composition or to attain such a target by intensive management approach.

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