Université Mohammed V-Agdal

Faculté des Sciences – Rabat

Effet de démasclage sur l'impédance électrique des feuilles de chêne liège

Abdelillah Hakam, Mariange Magne Takam, Mustapha Chokairi

Abstract

This study examined the effect of bark stripping on the electrical impedance parameters of cork oak young leaves between 40Hz and 100 kHz. This was a new application of the electrical impedances spectroscopy (EIS) in plant science. Various stripping coefficients (CD) were applied on the trees. Bark stripping is expected to affect water metabolism of leaves and therefore changes in the EIS parameters are expected as well. Single-DCE (ZARC) model was used as equivalent circuit for leaves. Several electrophysiological parameters of this model were compared with moisture content (MC) of the leaves. Intracellular resistance (R_i), extracellular resistance (R_e) and relaxation time (τ) of the leaves increased during 14 days after stripping while the distributed coefficient (Ψ) and MC decreased. Significant correlation between EIS parameters, MC and trees treatments were found.

Keywords: *Quercus suber* L., Electrical impedance, Equivalent circuit, Single DCE, Leaves, Bark-stripping, Bark-stripping coefficient**.**

Material and method

EIS of leaves was performed in summer 2009 (before and after bark-stripping period). There were five sampling dates, i.e., onJuly 7, (few hours before stripping), July 14, (seven days after stripping), July 22, (fourteen days after stripping), 7 august (thirty days after stripping), August 27, (fifty days after stripping). From each tree and at each sampling date, one short shoot was sampled each time from branches located in the central crows of the tree. The leaves were placed in the plastic bags immediately after sampling and transported to the laboratory. The leaves were oriented vertically when running the impedance measurements. Impedance spectra were measured with an Ag/AgCl-cell connected to a Hewlett-Packard 3330 LCZ meter. The Ag/AgCl electrodes were kept in contact with the samples using a conductive paste (3M red Dot Foam Monitoring Electrode 2237-3, of the type commonly used for electrocardiograms) to maintain minimum electrode tissue interface polarization. Further, the device was calibrated by using OPEN/SHORT circuit correction to eliminate the effect of electrodes- paste interface. The real (Z_r) and imaginary (Z_i) values of impedance were then measured within a frequency range of 40 Hz to 100 kHz. The input voltage of the signal was 30 mV (rms). The section of the conductive part of electrodes was 0.78 cm^2 corresponding to a disk of 1cm of as diameter. From each short shoot, 3 young leaves were selected and numbered L_1 to L_3. L_1, L_2 and L_3 were respectively the first, the second and the third leaf formed on the short shoot. The three leaves were tested and a leaf thickness was measured with a digital Mitutoyo Calipers 0.01 mm. All the tested leaves had an area of more than 0.78 cm^2 and with naked eye; they presented no sign of aging.

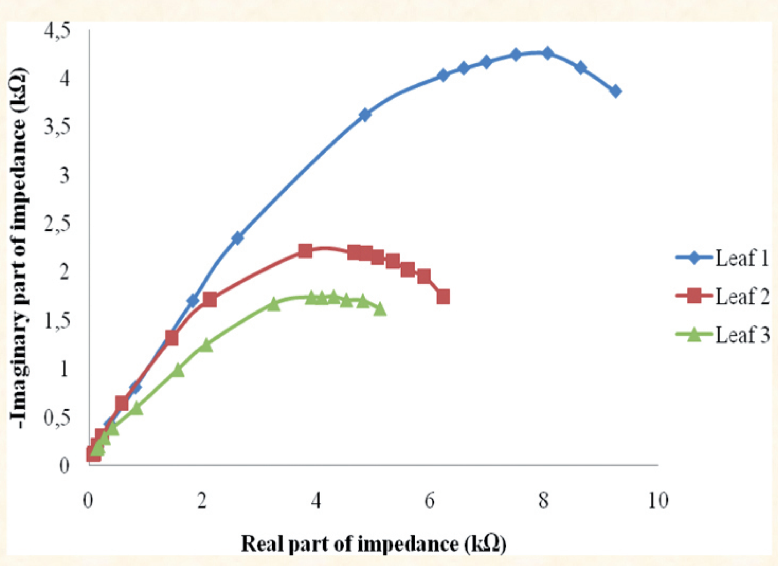
Modelling of leaves impedance

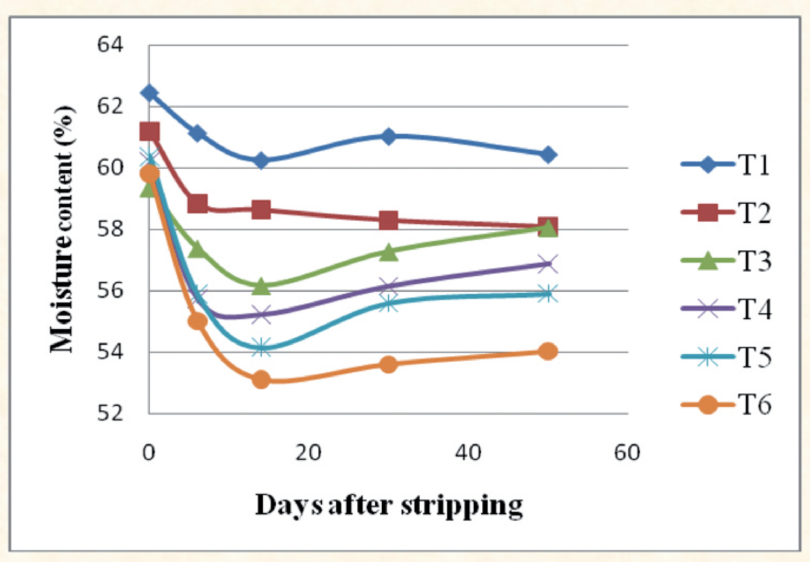
Impedance analysis in plants is performed using mainly two types of equivalent circuits i.e., lumped (Harker 1994) and distributed models (Repo et al.; 1994; 2000; Stout 1988; Mancuso 1999; Mizukami 2007). In this study, the mathematical model ZARC illustrated by the circuit diagram in fig.1 was fitted to the data. The ZARC comprises includes a distributed circuit element (DCE) in series with a resistor (R_∞). The DCE element comprises includes a Constant Phase Element (CPE) in parallel with a resistor (R).

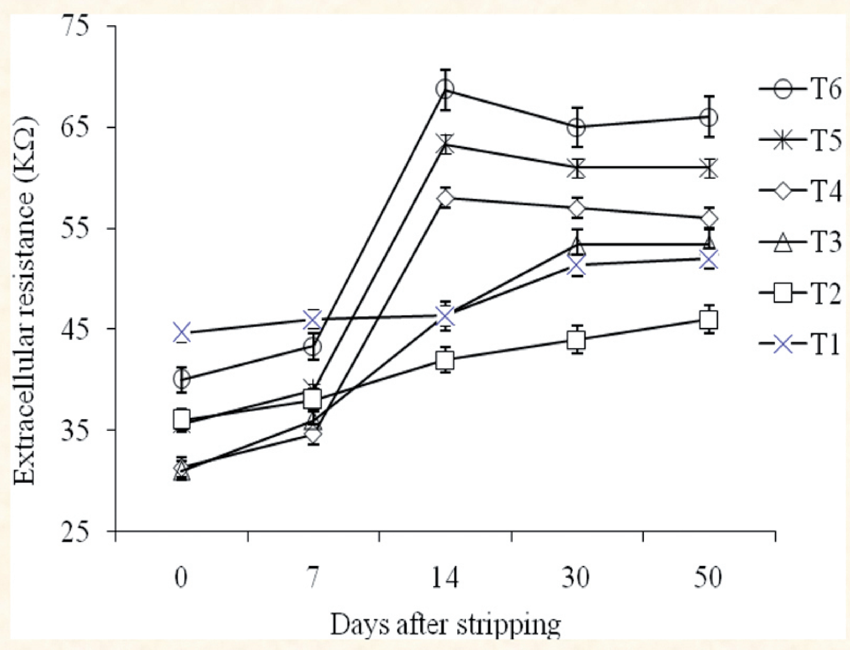
Results

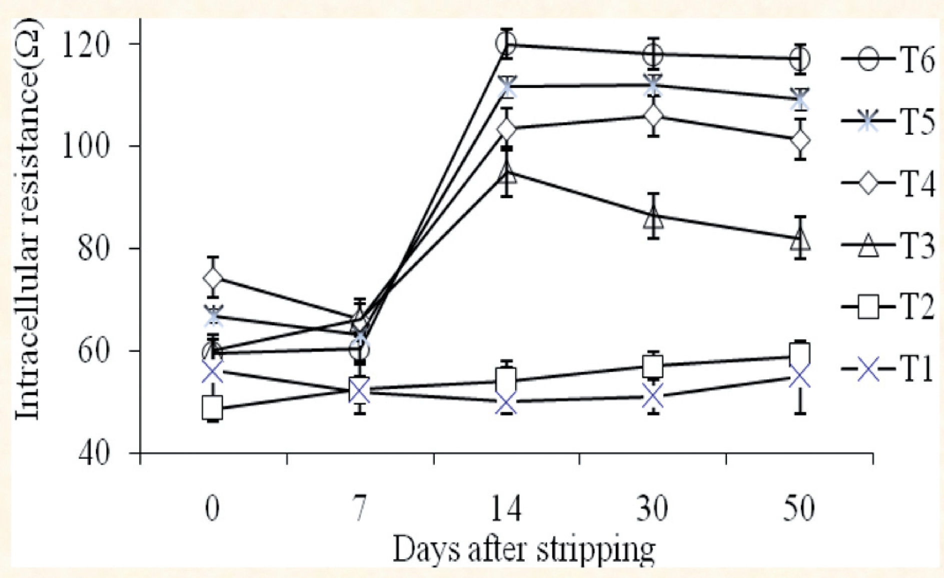
The graph representing in complex plane between 40 Hz to 100 kHz for three young leaves from the same branch of the tree number 4 are presented. The impedance spectrum of every leaf had a single arc in the form of parabola where the top corresponds to the frequency value characteristic of material f_c and the intersection of the parabola with the x axis gives R_∞ and the Re . The radius of the arc increased with increase in leaf maturity.

All resistance increased during the study. The R_i was 60Ω at the beginning of July (before bark stripping) and rose up to 105Ω in August. The extracellular resistances typically were the lowest (35kΩ) at the bark stripping date and then increased, τ inreased slightly from 1.33ms to 1.81ms after bark-stripping; i.e. the characteristic frequency *fc* decreased from 120 to 88Hz. Comparatively to intracellular resistance we noticed a slight increase R_e already seven days after bark-stripping, however, 14 days after stripping, there was a strongly difference between the variations of intra and extracellular resistance (98% and 75% respectively). The exponent Ψ increased during experiments (from 0.63 to 0.78). Leaves MC was the highest for all treatements at beginning of the study and then tapered off.CD had a significant effect on all EIS parameters and MC (P<0.01). There was good correlation between MC and all EIS parameters except for Ψ. Our results also demonstrated the importance of sampling date on EIS parameters and, especially on the intracellular resistance.









Conclusion

In conclusion, this was the first time that EIS was applied to study the effect of bark stripping on the dehydration stress of the *Quercus Suber* L. leaves. Impedance parameters were significantly sensible to physiological variations in the leaves that were associated with stresses caused by bark stripping. Intra and extracellular resistance increase as moisture content decreases and increase as bark stripping coefficient increase. According to this technique, the trees seemed to balance their hydric gap 21 days after stripping. However, bark stripping occurred during the summer when trees were already subjected to other environmental stresses; consequently, there were a great number of variables over which we had no control. Further research is needed to evaluate the so called speed of balance hydric gap with an aim to define specific bark stripping coefficient for each tree depending on the tree characteristics.

Equipe Sciences du Bois, Faculté des Sciences, 4, Avenue Ibn Battouta, BP 1014-Rabat. Maroc