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Plant stem electrical properties associated with stress conditions in plants

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Abstract (300 word limit)

Statement of the Problem: The analysis of the electrophysiological activity of plants permits a real-time information of the plant status (e.g. light availability and water stress). However, even though it is clear that the role of the electrical signals in plant is crucial, especially in processes involving the propagation of rapid signals, a systematic approach for the interpretation of the electrical patterns is still missing.

Methodology & Theoretical Orientation: this presentation aims to elucidate long term electrical analysis related to plant stress. For example, the analysis of the physiological status of each plant has been used to correlate different water stress intensities with specific electrical patterns. Here we present a methodology based on a continuous monitoring of several plants in vivo, in a non-destructive way, for a long period through a new set-up that consists of a multi-electrodes system able to detect the electrical signals on several plants (or in different zones of the same plant).

Findings: the electrical properties measurement has been utilized to monitor several parameters (i.e. water stress) of each plant and to evaluate if it was possible to establish when the plant was facing the stress, the timing of the recovery and eventually to differentiate the intensity of the stress (i.e. mild, high or no stress). The comparison between the physiological parameters of the plants and the electrical measurements has highlighted the possibility to use such electrical signal to obtain information on the plant status.

Conclusion & Significance: multi-electrodes approach can be easily applied for monitoring a few plants as "biosensor" to estimate the status of a more numerous group of plants subjected to similar conditions. The set-up could provide a useful tool for monitoring water conditions in plants and has several potential applications for sensor and automatic system in greenhouse or field.

Image



Figure1:pictures of the shielded cables of the multi-electrode system while recording the electrical activity of tobacco plants (Top), below from left to right respectively an enlarged detail of one or more pairs of electrodes inserted in an olive tree, black cabbage and tobacco.

Related recent publications (minimum 5)

Nadler, A. et at. (2008). Detecting water stress in trees using stem electrical conductivity measurements. Soil Science Society of America Journal, 72(4), 1014-1024.

Souza, G. M et al. (2017). Plant "electrome" can be pushed toward a self-organized critical state by external cues: Evidences from a study with soybean seedlings subject to different environmental conditions. Plant signaling & behavior, 12(3), e1290040.

Wang, Zhong-Yi, et al. (2009) "Monitoring system for electrical signals in plants in the greenhouse and its applications." biosystems engineering 103.1: 1-11.

De Toledo, G. R., et al.. (2019). Plant electrome: the electrical dimension of plant life. Theoretical and Experimental Plant Physiology, 31(1), 21-46

Gurovich, L. A., & Hermosilla, P. (2009). Electric signalling in fruit trees in response to water applications and light–darkness conditions. Journal of plant physiology, 166(3), 290-300

Biography (150 word limit)

Biography

I got my PhD in Agro-biotecnology for tropical production in Florence studying the mechanisms involved in the early stages of the chemical and electrical response to gravity in root tips. It also involved the investigation of biomaterials inspired by plant (biomimetic) and their potential application for soil exploration. I did my post-doc in Japan at the University of Kitakyushu focusing on the effect of light through the use of LEDs technologies for plant researches. I'm currently doing a Marie Sklodowska-Curie individual fellowships project in collaboration with the University of Wageningen (The Netherland). The project aim is to develop automated hydroponic systems that use high frequency pulsing-light and intermittent/alternate nutrient supply to optimize resources and plant acclimation. The main research involve the interpretation of the electrical activity of plant to develop automated hydroponic cultivation system driven by the plant "itself" able to optimize/control the supply of light, water and nutrients.

Publications

1. Taiti, C., Costa, C., Migliori, C. A., Comparini, D., Figorilli, S., & Mancuso, S. (2019). Correlation Between Volatile Compounds and Spiciness in Domesticated and Wild Fresh Chili Peppers. Food and Bioprocess Technology, 1-15.
2. Caparrotta, S., Comparini, D., Marone, E., Kimmenfield, R., Luzzietti, L., Taiti, C., & Mancuso, S. (2019). Correlation between VOC fingerprinting and antimicrobial activity of several essential oils extracted by plant resins against A. tumefaciens and P. savastanoi. Flavour and Fragrance Journal, 34(5), 377-387.
3. Taiti, C., Costa, C., Figorilli, S., Billi, M., Caparrotta, S., Comparini, D., & Mancuso, S. (2018). Volatome analysis approach for the taxonomic classification of tree exudate collection using Proton Transfer Reaction Time of Flight Mass Spectrometry. Flavour and fragrance journal, 33(3), 245-262.
4. Comparini, D., Nguyen, H. T., Ueda, K., Moritaka, K., Kihara, T., & Kawano, T. (2018). Effect of different light spectra on the pigmentation of stored elephant garlic. Journal of the Science of Food and Agriculture, 98(7), 2598-2606
5. Hara, A., Takaichi, H., Murata, Y., Sakata, R., Hara, Y., Iwase, J., Comparini, D., Suzuki, T. and Kawano, T. (2016). Optical evaluation of the shading properties of climbing fern Lygodium japonicum used as thermal buffering green wall plant. Advances in Horticultural Science, 30(2), 59-67.
6. Comparini D., Kihara T., and Kawano T. (2016). Uses of X-ray 3D-Computed-Tomography to monitor the development of garlic shooting inside the intact cloves. Environmental Control in Biology, 54 (1), 39-44.
7. Lin C., Hara A., Comparini D., Bouteau F., Kawano T. (2015). Zinc-dependent protection of tobacco and rice cells from Aluminum-induced superoxide-mediated cytotoxicity. Frontiers in Plant Science, vol. 6, art. 1079.
8. Nagasawa K., Iwase J.,Comparini D., Kawano T. (2015). Empirical and simulative evaluations of white fluorescence-type light emitting diodes as algal growing light sources based on the photosynthetic oxygen evolution by Synechocystis spp. PCC6803. Environmental Control in Biology 53(3):169-173.
9. J. Iwase, Sato Y., Comparini D., Masi E., Mancuso S., Kawano T. (2015). Non-invasive acoustic sensing of belowground wooden tissues: possible application to spatial mapping of soil usage by tree roots. Environmental Control in Biology 53 (3):175-179.
10. Iwase J., Sato Y., Comparini D., Masi E., Mancuso S., Kawano T. Non-invasive Acoustic Sensing of Tuberous Roots of Sweet Potato (Ipomoea batatas) Growing Belowground. Adv. Hort. Science. (2015).
11. Comparini, D., Uezu, K., Kawano, T. (2015). Monitoring of Sonochemically Released Carbon Dioxide from a Methanol-Water System. Solvent Extraction Research and Development, Jpn. Vol. 22(2), 215-221.
12. Masi, E., Ciszak, M., Comparini, D., Monetti, E., Pandolfi, C., Azzarello, E., ... & Mancuso, S. (2015). The electrical network of maize root apex is gravity dependent. Scientific reports, 5.
13. Taiti, C., Costa, C., Menesatti, P., Comparini, D., Bazihizina, N., Azzarello, E., ... & Mancuso, S. (2015). Class-modeling approach to PTR-TOF MS data: a peppers case study. Journal of the Science of Food and Agriculture, 95(8), 1757-1763.
14. Mugnai S., Pandolfi C., Masi E., Azzarello E., Monetti E., Comparini D., Voigt B., Volkmann D., Mancuso S. (2014) Oxidative Stress and NO Signalling in the Root Apex as an Early Response to Changes in Gravity Conditions. BioMed Research International. http://dx.doi.org/10.1155/2014/834134.
15. Furlan, S., Comparini, D., Ciszak, M., Beccai, L., Mancuso, S., & Mazzolai, B. (2012). Origin of polar order in dense suspensions of phototactic micro-swimmers. PloS one, 7(6), e38895-e38895.
16. Ciszak, M., Comparini, D., Mazzolai, B., Baluska, F., Arecchi, F. T., Vicsek, T., & Mancuso, S. (2012). Swarming behavior in plant roots. PLoS One, 7(1), e29759.
17. Biondi, E. G., Tatti, E., Comparini, D., Giuntini, E., Mocali, S., Giovannetti, L., ... & Viti, C. (2009). Metabolic capacity of Sinorhizobium (Ensifer) meliloti strains as determined by phenotype microarray analysis. Applied and environmental microbiology, 75(16), 5396-5404.

Research work presented at conference:

JSABEES conference (Japanese Society of Agricultural, Biological and Environmental Engineers and Scientists). Okinawa, Japan, 11/2015. Speaker: "Possible acoustic monitoring of below-ground plant growth and development". Comparini D., Iwase J., Sato Y., Masi E., Mancuso S., Kawano T.
JSABEES conference (Japanese Society of Agricultural, Biological and Environmental Engineers and Scientists). Miyazaki, Japan, 9/2015. Speaker "Scoring tomato fruit maturation based on measurements of frequency-modulated sound propagation and solar-light reflectance by intact fruits". Comparini D., Iwase J., Murata Y., Hara A., Takaichi H., Kawano T.
Invited speaker at International Symposium on Plant Signaling and Behavior. 29 June - 2 July, 2015, Paris, France. "Acoustic sensing of belowground plant growth and monitoring of fruit ripening". Comparini D., Iwase J, Masi E., Mancuso S., Sato Y., Kawano T.
JSABEES conference (Japanese Society of Agricultural, Biological and Environmental Engineers and Scientists). Kumamoto, Japan, 11/2014. Speaker: "Controls of plant growth and development under HB-LEDs: cases of vegetable growth, pigmentation, photosynthesis, and storage". D. Comparini, T. Kihara, and T.Kawano. Best Presentation Awarded.
Annual Meeting of the Society of Plant Signaling and Behavior, Vancouver, British Columbia, Canada; 07/2013. Speaker "Go green, stay green under green light". Comparini D., Yamamoto Y., Moritaka K., Hieu N. H. T., Kihara T., Masago H., Mancuso S., Kawano T.

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Note

Hope you will find this topic interesting, I would like to join as speaker to perform an oral presentation. I'm aware this is a short notice but It would be great for me to receive a reply If my presentation is accepted before February 29 to be able to register in time for the conference. Thank you in advance.