Tytuł projektu

Podstawa plastyczności fenotypowej systemu korzeniowego *Arabidopsis thaliana* na zmienne pole elektromagnetyczne: dowody na udział auksyny i sygnalizacji wapniowej

Project title

The basis of phenotypic plasticity of *Arabidopsis thaliana* root system to the variable electromagnetic field: evidences for the involvement of auxin and calcium signalling

Dyscyplina /Area of science

Nauki biologiczne

PROJECT DESCRIPTION

Project goals

the aims of the project is explanation of the processes underlying the *Arabidopsis thaliana*'s response to electromagnetic fields by giving more holistic insight into the mechanism of auxin - and calcium regulated root growth and development under action of two very different MF values (strong and below geomagnetic fields)

Outline

The ability of the root system architecture to respond to (electro)magnetic field (MF) is a key adaptative behaviour allowing plants to cope with environmental conditions. An effect of MF on germinating seed (magnetotropism) was already reported. Since then many scientific papers present plethora of influence of varied MF intensities on plant growth and development, including agricultural use of MF as a preconditioning factor of seed germination. The weak or strong values of MF are used in various experimental research proving that particular MF intensity causes different effect on plant cells, leading for example to promotion or reduction in seed vitality, germination, cell division and cell elongation, which is part of the growth process. Moreover, a dependence of the amplitude of electromagnetic field on biological effects, especially in low-frequency fields, is observed.

Already one of the first report on MF effects on plants postulated an auxin-like effect of the MF on germinating seeds. Considering the well documented important role of auxin in root growth and development, the studies on the auxin-regulated root-growth response to specified MF value can be an appropriate model to evaluate the responses of plant exposed to MF. Apart from auxin, calcium ions (Ca^{2+}) are considered as the most crucial messengers of plant response to internal and external stimuli. Gravitropism is a good example of apparent interplay between auxin and Ca^{2+}. The changes in cytoplasmic free Ca^{2+} are observed under MF treatment, particularly in low MF conditions. The existing

data highlights also the importance of Ca^{2+} in auxin transport, where polar auxin transport (PAT) was found to be highly dependent on Ca^{2+} availability. Moreover, it was observed that specific calcium sensors (kinases, kalmodulin) can participate in auxin signaling i.a. through various phosphorylation events on auxin efflux carriers (PIN proteins) influencing intercellular auxin concentration.

Plant growth is accomplished by tightly regulated cell division and cell expansion. It is known that auxins stimulate elongation by a process postulated to require acidification of the cell wall by a K^+-dependent H^+-pumping ATPase. On the other hand, out of several elements of a complex signaling cascade linking cellular Ca^{2+} to cell-cycle regulation, the calcium-dependent, calmodulin independent protein kinases (CDPKs/CPKs) have been proposed as active signal mediators.

This PhD project will be conduct in close cooperation with prof. Massimo Maffei from Department of Life Sciences and Systems Biology, University of Turin, Italy, where below geomagnetic field studies will be carried out.

Work plan

1. Observation of the effects of treatment of germinating seeds of wild type *Arabidopsis thaliana* Colombia-0 ecotype (Col-0) with two values of MF: 7 mT (strong MF) and 40 nanoT (below geomagnetic field; GMF) with control the GMF value (50 microT), on length, morphology and anatomy of seedling roots.

2. Answer the question of whether the observed differences in roots length are the consequence of reduced/increased rate of cell division or cell growth expressed as cell elongation

3. Investigation of mechanism of *Arabidopsis* root response to MF:

- examination of auxin involvement in MF response by analysis of endogenous auxin levels, expression level of *PIN* genes, *AUX 1* gene and *ABP1* and their immunolocalization in WT and transgenic *Arabidopsis thaliana* plants;
- examination of Ca^{2+} ions involvement in MF response by measurement of intracellular level in Ca^{2+} in MF treated and control roots of *Arabidopsis* seedling and analysis of gene expression level of chosen Ca^{2+} regulated kinases (CIPK, CDPK) and calmodulins

Literature

Maffei ME (2018) Plant responses to electromagnetic field. In: Biological and Medical Aspects of Electromagnetic Fields, Fourth Edition, Greenebaum B and Barnes F (ed.)
Maffei ME (2014) Magnetic field effects on plant growth, development, and evolution.

Front Plant Sci. 2014; 5: 445.
Pazur A, Rassadina V (2009) Transient effect of weak electromagnetic fields on calcium ion concentration in *Arabidopsis thaliana.* BMC Plant Biol. 9: 47.
Volkov A (2012) Plant electrophysiology – signalling and responses. Springer
Toyota M, Furuichi T, Tatsumi H, Sokabe M (2008) Critical consideration on the relationship between auxin transport and calcium transients in gravity perception of Arabidopsis seedlings. Plant Signal Behav. 3(8): 521–524.

Required initial knowledge and skills of the PhD candidate

- ➔ Interest in processes occurring in plant cells under the influence of environmental factors,
- ➔ Knowledge about plant physiology, biochemistry and molecular biology,
- ➔ Understanding of basic physics,
- ➔ Skills and attitudes: creativity, analytical thinking, perseverance,
- ➔ Eager to learn and work hard,

Zgłaszający projekt/ Author of the project	
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