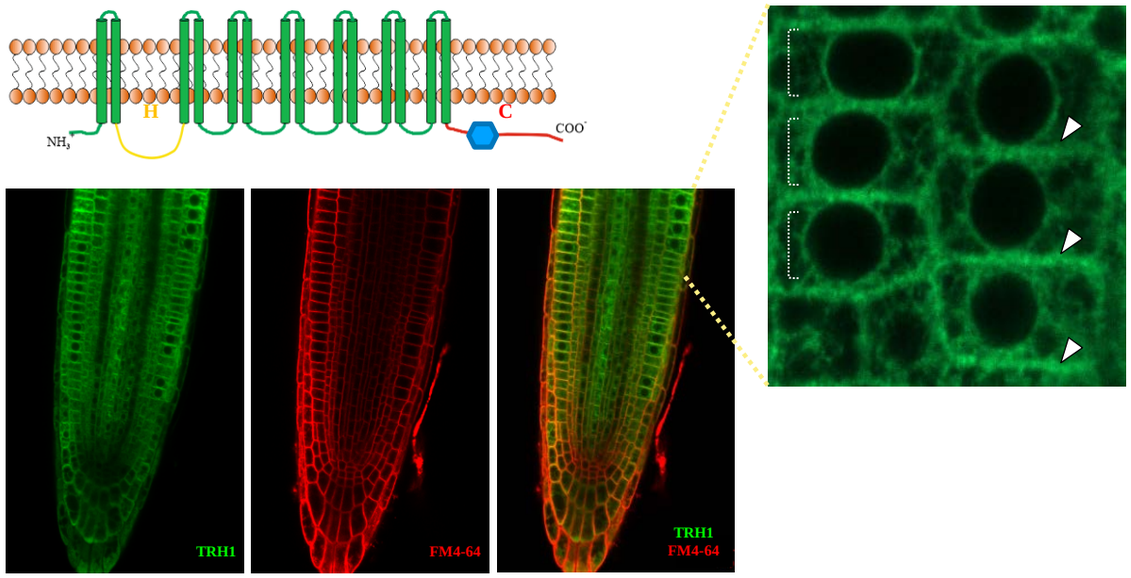
H.F.R.I.
Hellenic Foundation for Research & Innovation

Description of the funded research project

1st Call for H.F.R.I. Research Projects to Support Faculty Members & Researchers and Procure High-Value Research Equipment

Title of the research project: "Root system architecture: the molecular crosstalk between nutrient signaling and auxin homeostasis"



Principal Investigator: Stamatis Rigas

Reader-friendly title: RooTalking

Scientific Area: Agricultural Sciences-Food Science & Technology

Country: Greece

Host Institution: Agricultural University of Athens

Collaborating Institutions:

i. University of Warwick, UK
ii. Swedish University of Agricultural Sciences, Sweden

The PI of RooTalking Research Team

Project webpage:
http://rootalking.aua.gr/

Budget: 170.000€

Duration: 36 months

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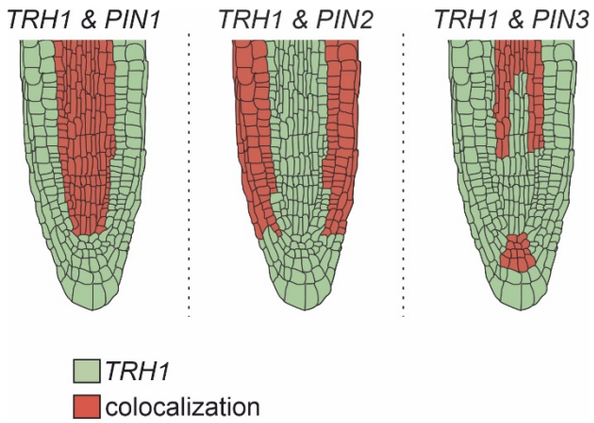
Research Project Synopsis

Potassium (K^+) is an essential **macronutrient** critical for fundamental biological processes in plant cells. The high content of cytoplasmic K^+ highlights the function of active uptake mechanisms. TRH1 belongs to the family of **KT/KUP/HAK K^+ transporters** involved in modulating **root system architecture**. As a transmembrane protein, TRH1 shows basal polar localization at the **plasma membrane** in addition to the localization at **endoplasmic reticulum-like structures** supporting a dynamic subcellular distribution pattern in response to endogenous or exogenous cues. Experimental evidence revealed a defective basipetal auxin transport in *trh1* roots and ectopic localization of PIN1 auxin efflux carrier. Hence, TRH1 maintains **auxin homeostasis** in the root apex to control **root-hair morphogenesis** and **root gravitropism**. These observations support the notion that TRH1 likely promotes a **risk aversion mechanism** to trigger root developmental responses ensuring **root growth plasticity** and **plant adaptation** in changing environments. However, the interplay between K^+ and auxin balance remains unknown as yet. The aim of **RooTalking** is to shed light on the **molecular crosstalk** between **K^+ signaling** and **auxin homeostasis**. To address this aim, **RooTalking** sets four objectives for clarification: **(i)** the functional synergy between TRH1 K^+ transporter and **PIN auxin efflux carriers**; **(ii)** the TRH1-mediated auxin transport mechanism by acting as a K^+/H^+ porter in accordance to the **chemiosmotic theory** of polar auxin transport; **(iii)** the functional role of TRH1 as a **"transceptor"** depending on the **protein phosphorylation** status that affects TRH1 intracellular distribution and **(iv)** the TRH1-dependent **nutrient signal transduction pathways** that modulate root system architecture. **RooTalking** relies on the application of **state-of-the-art** technologies and methods by raising a **collaboration umbrella** and joining hands and resources with well-reputed European research groups. Complementary to the research objectives, **RooTalking** sets as high priority the training of early-stage researchers to cease **brain drain** and advance their future carrier.

Project originality

Our endeavor seeks to identify and thoroughly characterize the function of TRH1 as an **electrochemical potential-driven K^+/H^+ transporter** that is energized by proton (H^+) electrochemical potential differences. It is therefore capable of importing K^+ ions even against a difference in electrochemical potential, which is often the case for K^+. Through this challenging mode of function, TRH1 likely facilitates **polar auxin transport** engaging PIN auxin efflux carriers at the root tip, modulating **root gravitropism** and **root-hair morphogenesis**. On the basis of the spatiotemporal expression of *TRH1* gene, the protein is localized to the cells of the root central cylinder that drive the **acropetal transport of auxin** towards the root tip, and to the peripheral tissues including the epidermis and cortex that define the **basipetal route of auxin transport** towards the hypocotyl. This pattern of TRH1 topology coincides with the auxin polar transport system supported by the PIN auxin efflux carriers. The PIN1 auxin efflux carrier is localized to the central cylinder, constructing an overlapping network with PIN3, which is present at the upper part of the central cylinder towards the hypocotyl and the quiescent center. Taken together, PIN1 and PIN3 map the acropetal route of polar auxin transport, whereas PIN2 constitutes the basipetal route. The scientific innovation of the **RooTalking** project is based on four biological questions raised to elucidate the **molecular crosstalk** between sufficient **nutrient signaling** and **auxin homeostasis**. These working hypotheses will decipher in detail the functional role of the TRH1 system in formation of **root system architecture**.



[1]: The functional synergy between TRH1 K^+ transporter and PIN auxin efflux carriers

[2]: The TRH1-mediated auxin transport mechanism

[3]: The functional role of TRH1 as a “transceptor”

[4]: The TRH1-dependent nutrient signal transduction pathways that modulate root system architecture

Expected results & Research Project Impact

The **RooTalking** project not only promotes **cutting-edge plant scientific research** and **high-class training** but also places the manipulation of **root-system-architecture** in a wider context highly relevant to **biotechnological applications** and **innovation arenas**. The vision driving the **RooTalking** research proposal is to unravel the function of TRH1 to facilitate K^+/H^+ transport, which may act as a H^+-leak system to regulate cellular **pH homeostasis** for **polar auxin transport**. Modulating TRH1 activity could change the auxin-dependent program of root growth to avoid soil layers that are **depleted of K^+** or **highly toxic** due to salinity. This response is important to enable the root to avoid **nutrient deficient** or **toxic** soil patches and explore soil layers with efficient nutrient content. TRH1 could be a **transceptor of risk avoidance** by the root system via **auxin redistribution** in the root cap and thereby providing the root system with **flexible growth** for better **adaptability** and **survival**. **RooTalking** aims to uncover the functional properties of TRH1 regarding the modulation of **auxin homeostasis** and **root plasticity**. This will open new perspectives to understand the mechanisms of plants to avoid adverse environmental conditions. Above all, **RooTalking** provides young researchers the opportunity to work and produce scientific knowledge averting the **brain-drain** that threatens Greek research **human capital** and our **scientific future**.

The importance of this funding

- ✓ **Generate knowledge**
- ✓ **Support basic research activities**
- ✓ **Communicate the achievements of Greek research groups**
- ✓ **Improve the skills and CVs of the research group members**
- ✓ **Develop new collaborative schemes in Greece and abroad**
- ✓ **Cease the brain drain**
- ✓ **Inspire young people to get into the world of research and innovation**
- ✓ **Opening new perspectives to acquire support funds from European centers of excellence**
- ✓ **Promote Green Biotechnology**

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COMMUNICATION

185 Syggrou Ave. & 2 Sardeon St. 2
171 21, N. Smyrni, Greece
+30 210 64 12 410, 420
communication@elidek.gr
www.elidek.gr