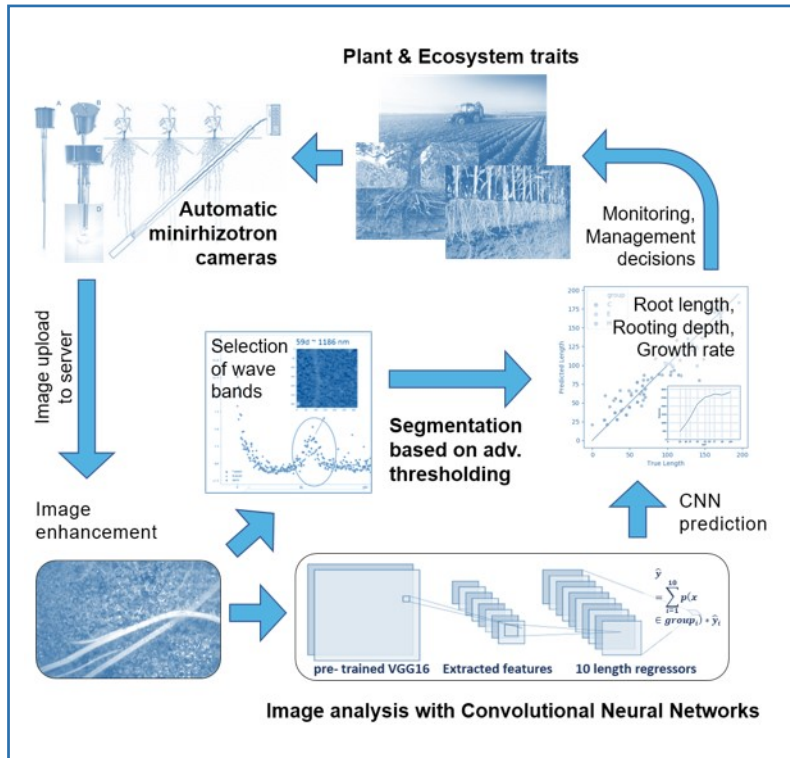Enabling next level research on roots – automatising MiniRhizotron image acquisition and analysis (NextMR-IAA)

NextMR-IAA aims: **1) automated, modular, stand-alone Minirhizotron (MR) image acquisition system** & accompanying **2) image-processing pipelines**

Current status of progress

1. Automatic, research-grade MR camera system with Ultra HD camera module operational
2. Automatic, cost-effective MR camera system for use in agronomy / horticultural industry prototyped
3. Wavebands beyond VIS for advanced root segmentation and soil moisture determination identified via hyperspectral imaging
4. Convolutional neural network-based, automatic total root length measurement in noisy rhizosphere images (with low error rate, reduced training input) achieved

**1. How would your technology scale up to become an industrial product/system?**

- VSI will **scale-up** the **"Research-grade UHD RGB MR camera"** (TRL6-7) to TRL9 **until mid 2021** using **NextMR-IAA** knowledge; additional VSI **R&D expenditures** will be used to bring the **multispectral imaging module** and advanced features such as **super-resolution images** to TRL9

- **Considerable additional source funding** and **additional partnering** (see below) must be used to **scale-up** the **"MR camera for farming applications"** (TRL4-5) and the related **"CNN-based software pipeline"** (TRL4) to TRL9. For TRL7, e.g., large-scale field test & case studies must clearly demonstrate sign. advantages of "rooting information" for plant & ecosystem management to industry; server infrastructure and consumer UI should be developed in a participatory approach with users. An integrated business model, based on MR camera hardware sales/leasing and image analysing services, must be developed—enabling integration of additional data ("Ecosystem-of-Things"). The NextMR-IAA spin-off would initially target markets in the Euro-Mediterranean Area, North America & China as business contacts exist

2. With who you would need to partner for this to happen, meaning potentially enlarging your actual consortium?

- **Computer scientists,** and **Agriculture automation companies** (incl. Suppliers of Irrigation / Fertilisation systems; e.g. Netafim, ISR)

- **Software engineers**

- **Experimental agricultural station** operators (e.g. AGES, AT; ARO, ISR), **crop breeding companies** (e.g. KWS, GER), urban **garden departments** (e.g. MA42, City of Vienna, AT) and / or **turf grass industry** (e.g. STRABAG, AT)

3. What applications will you demonstrate with value for science, industry and society?

- **Science:** The next generation MR system will facilitate information on root system development and turnover — particular enhancing the scientific understanding of plant functioning and ecosystem C dynamics by improving image quality (RGB, and wave bands beyond VIS spectra) and temporal resolution of MR camera systems

- **Agronomy:** The automated, cost-efficient MR camera system in combination with automated analysis of rooting depth and density will enable farmers to base irrigation and fertilization on root system development, increasing resource use efficiencies and allowing to reduce e.g. water infiltration / nitrate leaching below the rooting zone. In addition, the technology has the potential to detect root diseases and parasites before above ground signs become visible

- **Plant breeders (Case study):** Integrating the automated root system monitoring tool into plant breeders toolbox will facilitate genotype selection for target environments – improving yield and yield stability
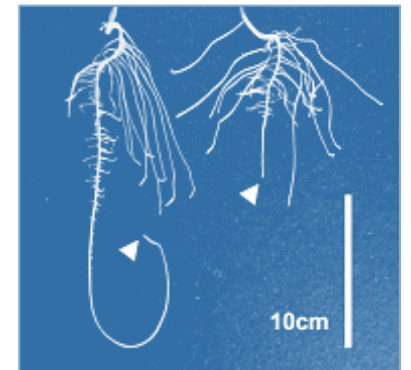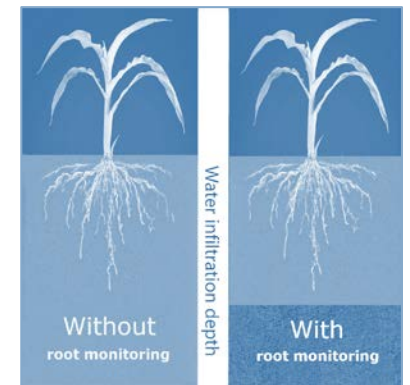
3. What applications will you demonstrate ... *continued*

- **Turf grass industry / Urban forestry (Case studies):** Monitoring turf root / tree root establishment and maintenance procedures (sport grounds / roadside trees) will provide evidence-based answers to liability questions

- **Society:** Benefits for society are in particular better estimations of global (soil) C budgets and more sustainable agricultural production systems (particular improving water and N,P-fertilizer use efficiencies, reducing groundwater pollution)

5. Would you apply for other complementary funding source for helping you to go to market? 4. How would you plan to contact potential investors in your technology?

- **"Research-grade" MR system:** No. Development of the automatic MR system (and in a 2nd phase the advanced imaging module) to TRL9 can be funded by VSI R&D expenditures

- **"Applied" MR camera and software pipeline:** Yes. For this long-term, "high-risk – high-gain" R&D&I project, comple-mentary funding sources are key, i.e seed funding by international and national public R&D funds (e.g. FFG, Austria), philanthropic donations, and finally "impact" investment funding (e.g. Bridges, Israel) to scale up (faster). Spin-offs related to BGU benefit from established business relations (Cyber focus); contacts to incubators in AT are established