Fungal Endophytes that Confer Tolerance for Plant Growth on Saline Soil

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Introduction

Plants survive environmental variability and stress by means of physiological and biochemical adaptation. Symbiotic fungi associated with plants as asymptomatic endophytes appear to play a vital role to increase plant adaptation to environmental stress. Class 2 fungal endophytes colonize roots and shoots and confer habitat-adapted stress tolerance. Current research aims to characterize a suite of class 2 endophytes for ability to confer tolerance to salt and drought.

Methods

Plants were collected from salinized natural and human-impacted sites in Saskatchewan. Class 2 endophytes were isolated from surface-sterilized roots and shoots. Strains were identified to genus by spore morphology. Tomato variety Rutgers seeds were colonized with endophyte spores (control plants were mock inoculated with ultra-pure water) and grown in double-decker Magenta boxes for 21 d, with the lower chamber containing Hoagland's solution. Consumption by colonized and control plants was measured. Replicate plants were salt stressed for 10 d with 18 g/L or 30 g/L NaCl in Hoagland's, or drought stressed by growing without Hoagland's for 10 d. Plants were recovered from stress with reverse osmosis water for 2 d. Root and shoot fresh and dry biomass were measured.

Results

Compared to control, endophyte colonized plants had 20-60 % higher root and 10-20 % higher shoot biomass for both salt stress experiments. For drought, endophyte colonized plants had 30-40 % higher root and 10-20 % higher shoot biomass. Endophyte colonized plants had 10-25 % better water use efficiency in the absence or salt or drought stress. Endophyte mediated growth enhancement is a promising non-GMO strategy for improving crop growth in dry or saline soils.

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Abstract

Soil salinization is a critical abiotic stress that affects plant growth and yield. Some fungi grow symbiotically *in planta* as endophytes. Class 2 fungal endophytes promote plant growth under abiotic stresses. Strains of class 2 endophytes isolated from highly saline sites in Saskatchewan were used to colonize tomato seeds. Seedlings were grown in double-decker Magenta boxes to precisely control water quantity and salinity under salt and drought stress. Endophyte-colonized plants had higher root (20-60 %) and shoot biomass (10-20 %) in salt stress (300 mM or 500 mM NaCl) treatments than non-colonized plants, indicating a fitness benefit due to endophyte colonization. Another experiment compared the effect of 10 days without water (drought stress). Endophyte-colonized plants had 30-40 % increased root and 10-20 % increased shoot biomass in compared to control plants. It also consistent with 10-25 % better water use efficiency due to colonization. Class 2 endophytes isolated from plants naturally growing on saline soils have high potential to improve agriculture on saline soil.

Introduction

- Drought, salinity, and nutrient imbalance (including toxicities and deficiencies) the major environmental stresses for plants growth and development.
- Soil salinity is the high salt deposition in soil leading to decrease soil porosity and poor soil aeration. This results a lower water potential zone in the soil, making it difficult for plants to uptake both water and mineral nutrients.
- Endophytes are symbiotic fungi which live within plant tissues and are variously associated with roots, stems and leaves.
- Class 2 endophytes have capability to confer habitat adapted stress (salt, temperature, and pH) tolerance to plants.
- Common plants physiological responses to salt, heat and drought stress involve increasing the levels of cellular osmolytes and reactive oxygen species (ROS) generation.

Research Questions

- Do class 2 endophytes increase fitness benefits under abiotic stress (salt and drought)?
- Do class 2 endophytes increase water use efficiency in plants?
- Do endophytes work on different levels of NaCl (300-500mM) stress?

Methods

- Plants were collected from salinized natural and human-impacted sites in Saskatchewan.
- Endophytes are isolated from the plants. These were named after their sites of collection.
- Endophytes growing from both roots and shoots of plants are expected to be class 2 endophytes.
- Class 2 endophytics, HZ613, 419.03, and 405.06 are used for tomato (variety Rutgers) plants colonization.
- Plants colonized with FcRed1 (class 2 endophytes from our colleagues) and no-colonized plants are used as positive and negative control respectively.

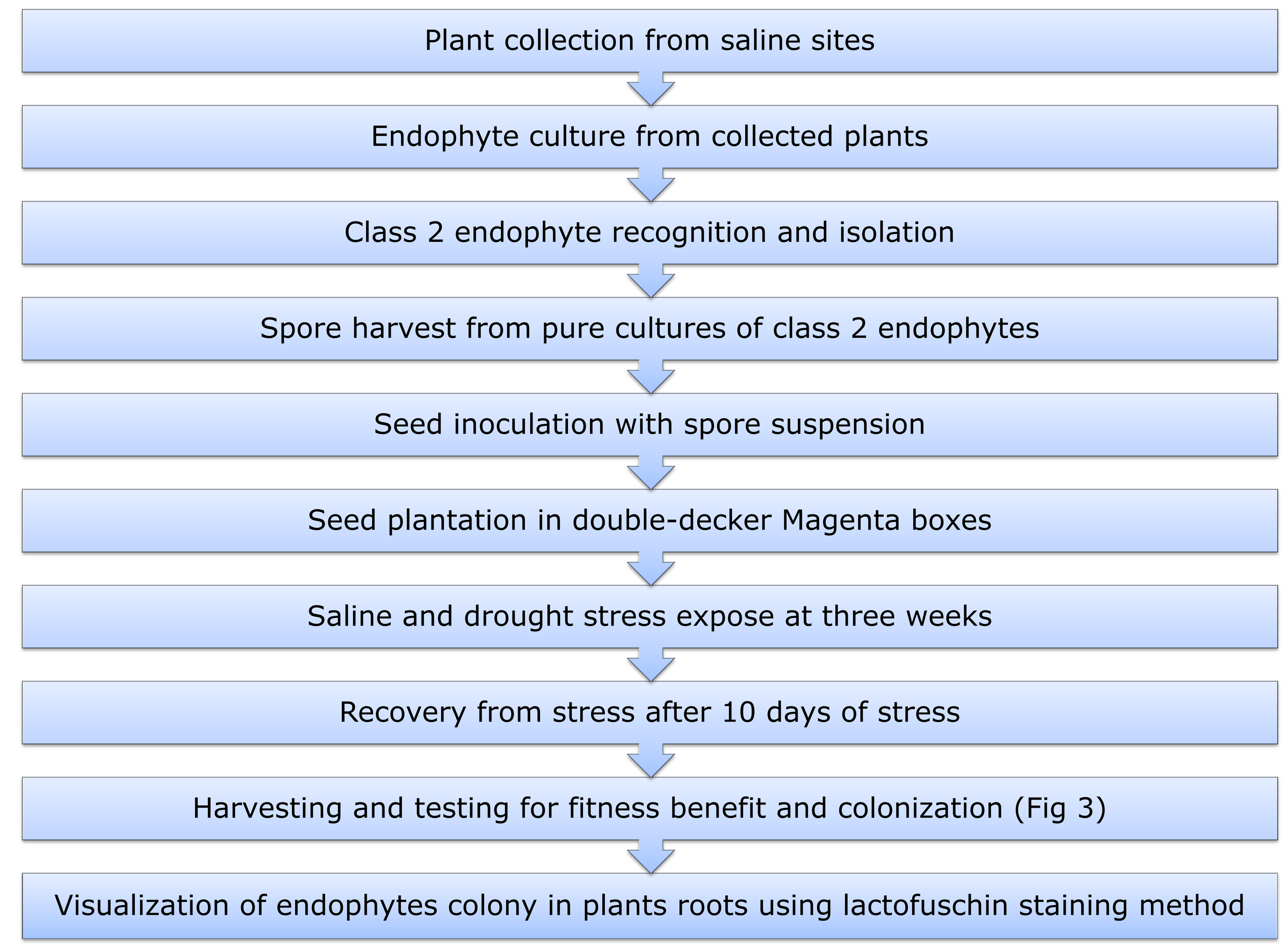

Fig 1. Diagram showing procedure of abiotic stress experiment

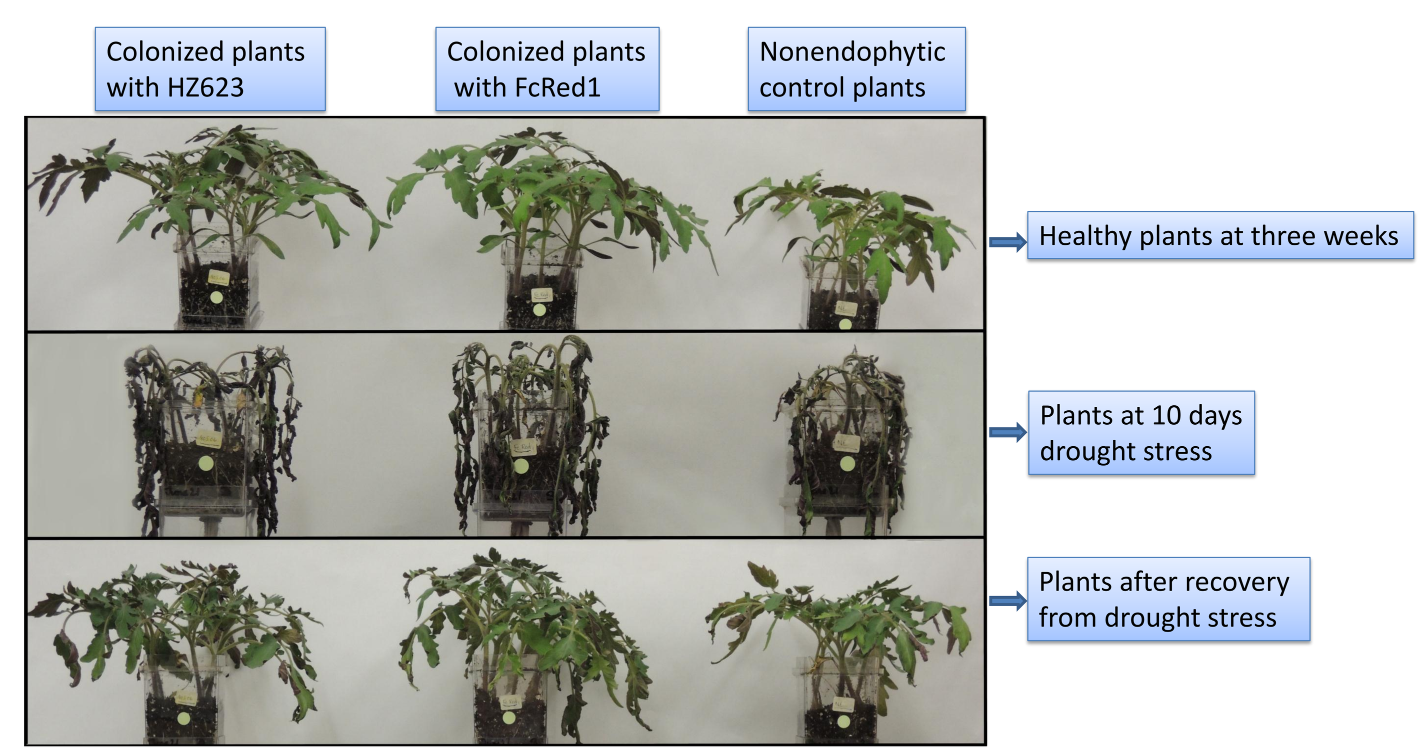

Fig 2. Different stages of plants at drought stress

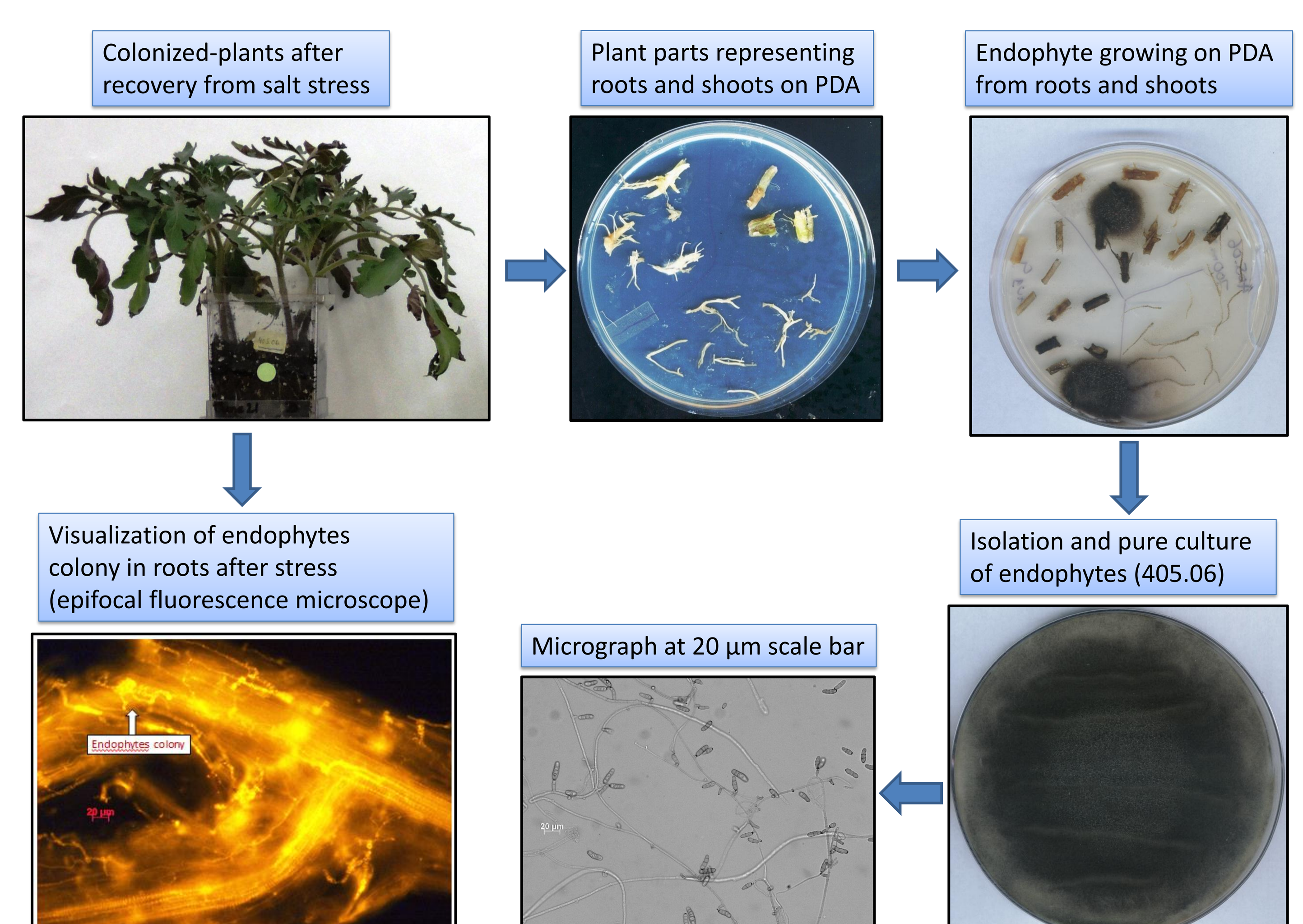

Fig 2. Procedure for colonization test and reacquisition of endophyte

Preliminary Results

- Endophyte-colonized plants had higher root (20-60%) and shoot biomass (10-20%) in salt stress (300 mM or 500 mM NaCl) treatments than non-colonized plants (Fig 4 and Fig 5).
- Endophyte-colonized plants had 30-40% increased root and 10-20% increased shoot biomass compared to control plants in drought stress (Fig 6).
- Endophyte-colonized plants had 10-25% better water use efficiency compared to no-colonized plants (Fig 7).

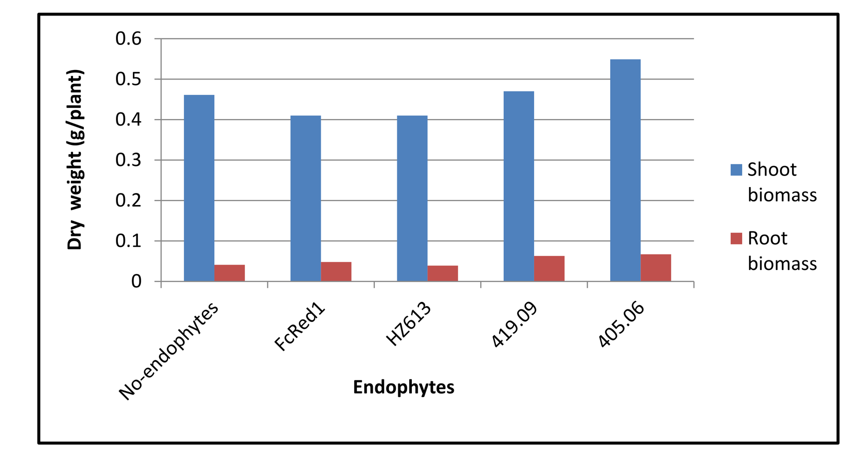

Fig 4. Biomass (g/plant) comparing endophytic and nonendophytic plants (10 days, 300 mM NaCl stress)

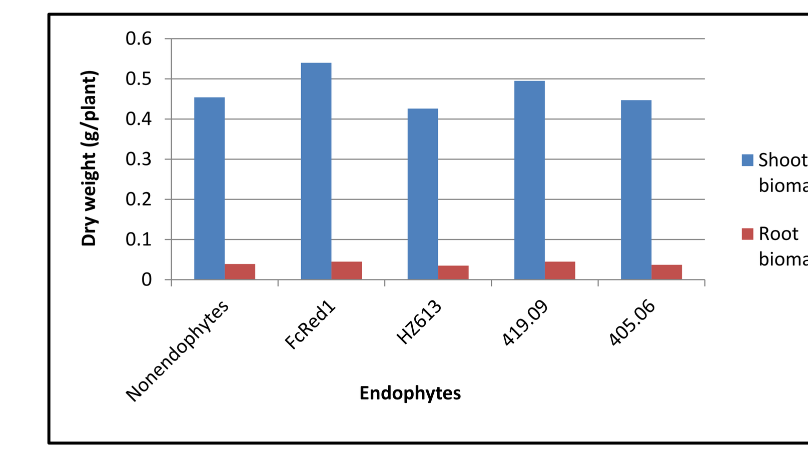

Fig 5. Biomass (g/plant) comparing endophytic and nonendophytic plants (10 days, 500 mM NaCl stress)

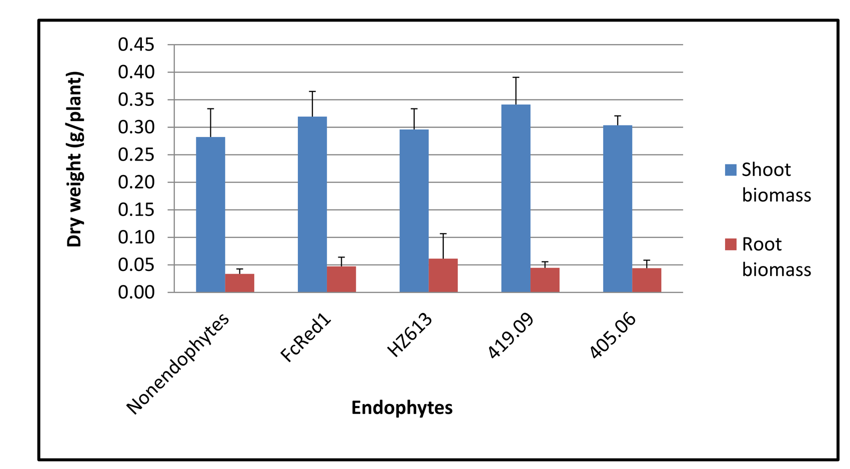

Fig 6. Biomass (g/plant) comparing endophytic and nonendophytic plants after 10 days drought stress

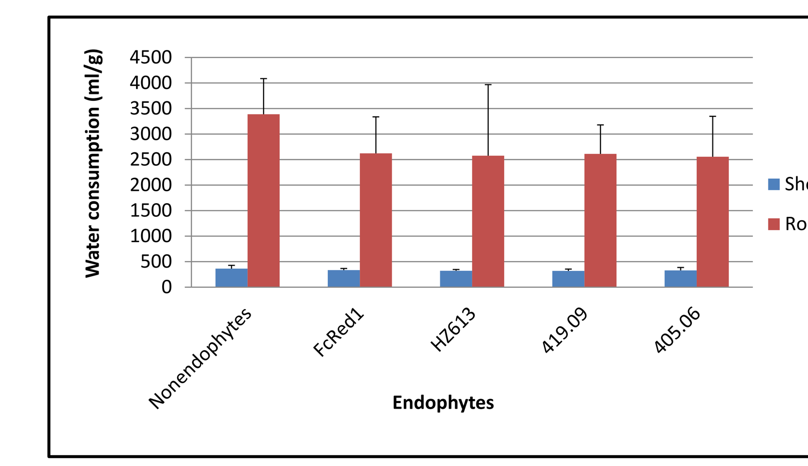

Fig 7. Water use efficiency (mL/g) comparing endophytic and nonendophytic plants in 21 days

Conclusion & Future Direction

- Preliminary results indicate endophyte efficacy in improving water consumption and fitness benefits of colonized plants.
- Future questions
  - How do colonized plants respond to other levels of NaCl salinity?
  - How do colonized plants respond to other soil salts like $MgSO_4$, Na_2SO_4?
  - Are increased osmolyte concentration and decreased ROS concentration responsible for fitness benefits in colonized plants?

Reference

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Acknowledgment

Guosheng Liu for technical help; Dominic Olver for image editing and cooperation; Dr. Zakia Boubakir and Huimin Zhang for cooperation; University of Saskatchewan.