Non-Confidential Description - PSU No. PSSHE-24
"Trojan Horse" targeted delivery system for crop species *

Keywords:

Phytosiderophores, *Avena Sativa*, iron uptake, iron deficiency, agriculture, GMO, genetically modified organism, crop, crops, crop yield, plant growth, plant health, companion planting, agrochemical runoff,

Inventors:

George T. Davis, Mark G. Stocksdale

Background

Grasses, including the cereal grains, represent the world's most economically important plants. They provide more than 2/3rds of the nutrition in human diets worldwide and occupy almost 40% of global cropland. Iron is vital for normal plant growth and development. Most grasses have evolved a method of sequestering and transporting iron, designated Strategy II, which includes the synthesis and secretion of phytosiderophores that chelate iron and move it to the root where the entire complex is taken in through a transmembrane porter.

The bioavailability of iron is limited by its tendency to form insoluble oxyhydroxide polymers. This is especially problematic in alkaline soils which constitute ~30% of the world's arable soils. Consequently, iron is the third most rate limiting nutrient under field conditions, next to nitrogen and phosphorus.

Projections indicate that for yields to keep pace with the expected increase in demand, the application of agrochemicals must be increased with the resultant detrimental impact on the environment, including chemical pollution and aquatic and marine eutrophication. For example, it is predicted that another three-fold increase in the rate of nitrogen fertilizer application is necessary to sustain the next doubling of global food production. However, it is estimated that current fertilization practices result in less than ½ of the applied nitrogen either being retained in the field or being taken up by the target crop.

There is a clear need for development of systems that will allow reducing current rates of fertilizer applications at the same time increasing plant's ability to retrieve maximum nutrition from the environment.

Invention Description

Phytosiderophore conjugates provide a means of targeting effector molecules to a specific plant group or species. Phytosiderophore transporters may provide a convenient portal through which to deliver a Fe^{+3}-phytosiderophore-effector molecule complexes to a target through either foliar delivery or through the rhizosphere via liquid or granular application or in a time-release manner at the time of planting.

Our invention relates to a transporter protein and variations thereof from *Avena sativa* responsible for absorption of avenic acid-iron complex (and engineered avenic acid analogs) from the soil, to improve plant health and regulate plant growth. We can demonstrate the proof of concept by the generation of "designer" avenic acid analogs conjugated with nutrients, growth regulators, herbicides, fertilizers and the like that may be taken up by the graminaceous

Contact: **Lidia Sobkow, PhD**
Technology Licensing Officer
The Pennsylvania State University

Phone: (814) 863-6336
Fax: (814) 865-3591
E-mail: lks5393@psu.edu

phytosiderophore transport mechanism in plants. Those analogs can be targeted to plants engineered to express the transporter gene. This system also allows generation of a transgenic plants that can take upFe^{+3}/avenic acid and engineered effector analogs and growth effector conjugates by the transgenic plants.

Because there may be some species specificity with regard to plant-phytosiderophore interactions, this technology will have application in delivering biologically active molecules such as nutrients, growth regulators, and herbicides to specific targets. Uptake of the conjugate will be limited to the cognate target species and genetically modified transformants, while excluding or attenuating interactions with non-target species and reducing the impact on the environment.

Advantages/Applications

- Provide environmentally friendly alternatives to current agricultural practices
- Enhance effectiveness of current practices
- "Trojan Horse" system to deliver growth effectors with specificity to a target at the exclusion of non-target species using the iron uptake system exclusive to grasses.
- Invention can be used both in Avena and other grasses which naturally include this uptake system and in other plants that have been engineered to have the same.
- Expand the range of transformed plants (eg., soybean) to promote more vigorous growth and reduce iron deficiency chlorosis in alkaline soils
- The invention allows for the development of companion planting strategies in which *Avena* can serve as a nurse crop to supplement transformants under iron-limiting (i.e. alkaline) conditions
- Allows for plant specificity with regard to application of agrochemicals and growth regulators, thus reducing runoff and consequent environmental impact associated with less selective targeting of fertilizers, pesticides, etc. Allows generation of transgenic plants thus introducing enhanced nutrient/mineral uptake in plant that lack those pathways

IP status

Provisional application filed in April 2016

We are looking for industrial partners to further development of this invention. We are interested in either licensing opportunity or industry sponsored research collaboration.

*Note: This invention was created at and is owned by Bloomsburg University. It is managed by Penn State under agreement.

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