

# BioEnsure: Novel Microbial Seed Treatments for Crop Stress Tolerance and Yield Enhancement





# All Plants are Symbiotic with Microorganisms



Plants in nature are symbiotic with bacteria, mycorrhizae, viruses, invertebrates and fungal endophytes

Microbes can Enhance Crop Production Through

- 1) Nutrition
- 2) Biotic Stress Tolerance
- 3) Growth & Development
- 4) Abiotic Stress Tolerance\*\*
- 5) Soil Health
- 6) Farmer Health



Plants provide 3 symbiotic habitats:  
Phylosphere  
Endosphere  
Rhizosphere



# How do Plants Adapt to Abiotic Stress?



Mt Everest – Moss at 6480m



Deserts



High Energy Explosives



Geothermal Soils



Heavy Metals



Coastal Beaches



CO2 Sink Holes



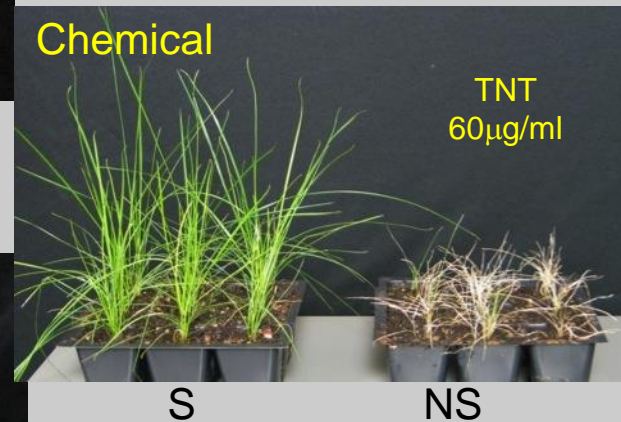
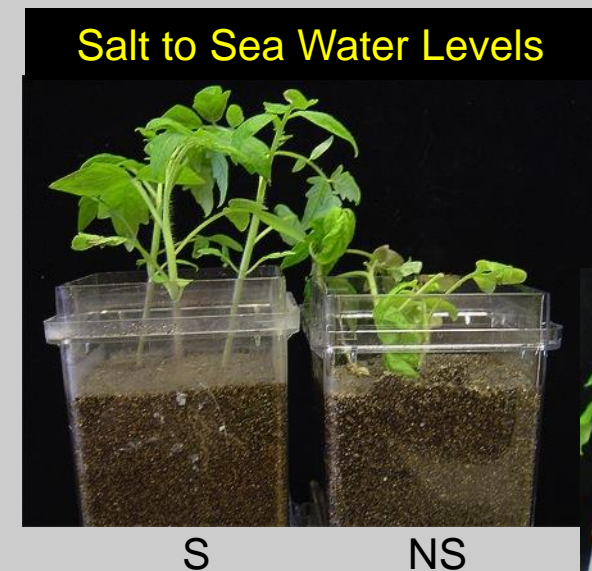
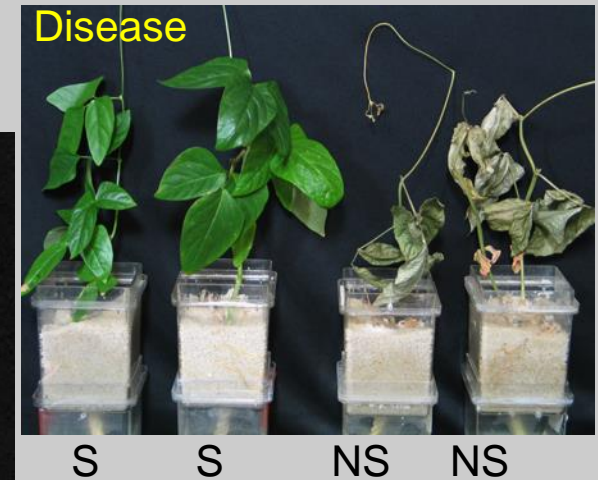
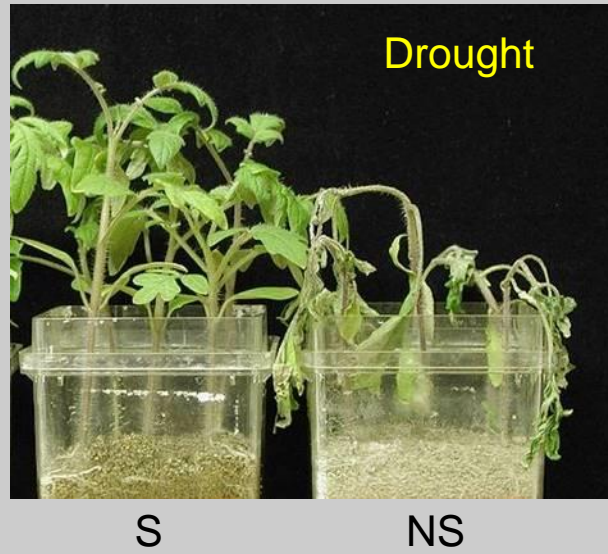
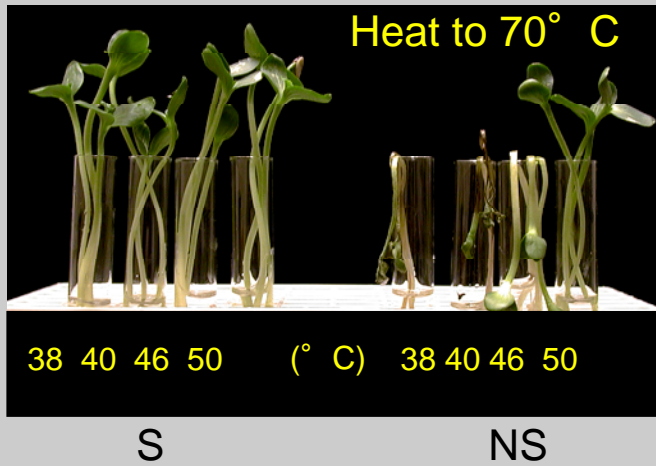
Steppe



Serpentine Soils



# Plant Adaptation via Symbiosis



Redman et al. 2002, Science  
Marquez et al. 2007, Science  
Redman et al. 2011, PLoS  
Kim et al. in preparation  
Redman et al. in preparation

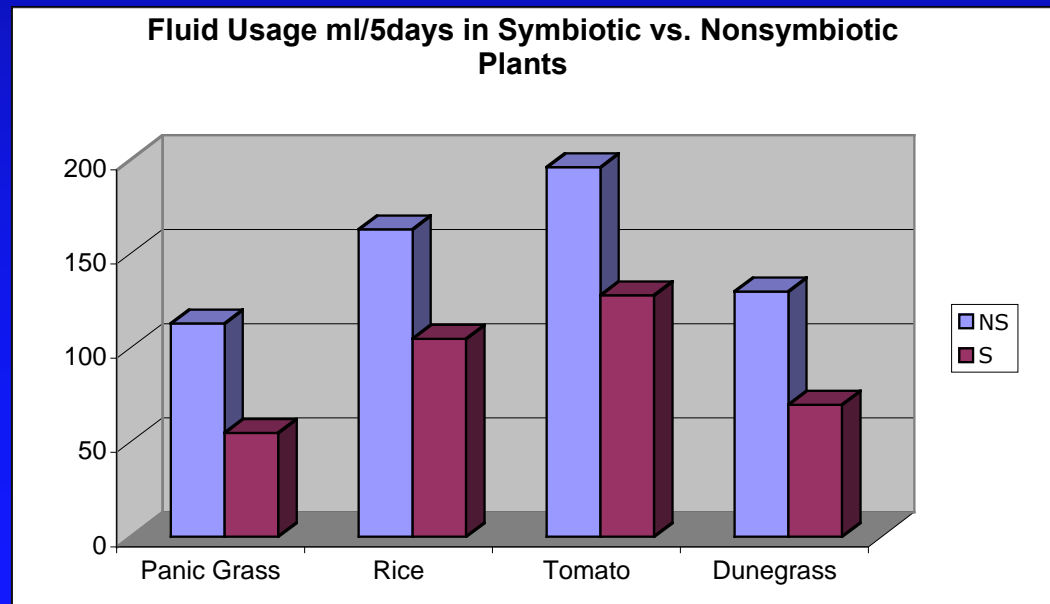
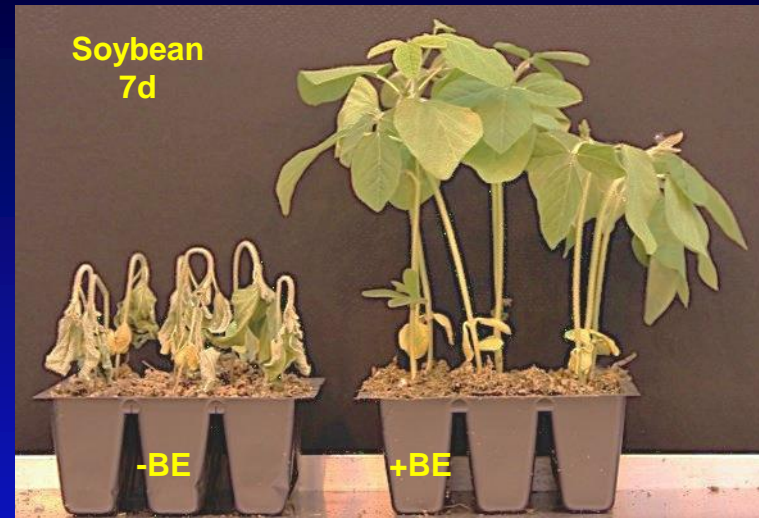
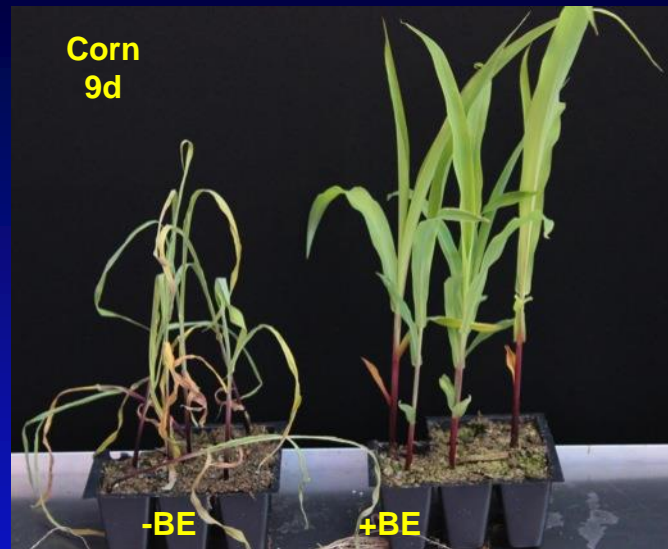


Established in 2008 and expanded in 2012

**Dedicated to improving agricultural sustainability and farmers profitability by developing novel technologies to mitigate the impacts of climate variability.**



# BioEnsure® Conferred Drought Tolerance



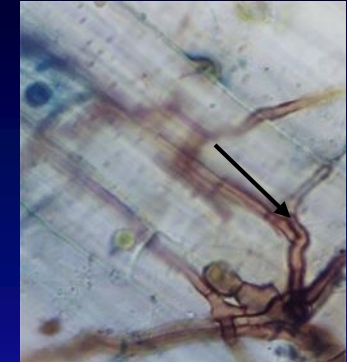
# AST's Development of BioEnsure®



Optimize Formulations



Assess Commercial Potential



Fungal Isolation



Field Test

## Products

Developed – corn, rice, wheat

In progress – soybean, Barley, cotton, vegetables, sugar cane, turf, canola, sugarbeet, millet, sorghum, alfalfa, sunflower

## Regulatory

U.S.- approved in 30 U.S. states and registered as organic by OMRI  
International – Australia, Kenya, Argentina, India

Production - Developed novel & scalable, solid-phase fermentation systems to meet demands for full market penetration in the US.

Shelf Life (ongoing studies) - Product alone >24 months, product on seeds > 16 months

Formulations - Liquid & powder for different applications

Application - Compatible with all existing seed treatment equipment and common chemicals

Field Testing – U.S., India, Kenya, Argentina, South Africa

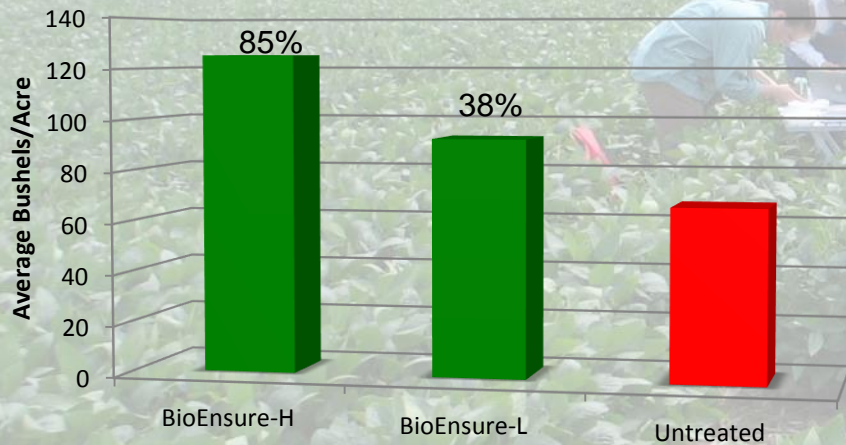




# BioEnsure<sup>®</sup> – Corn Field Test Summary

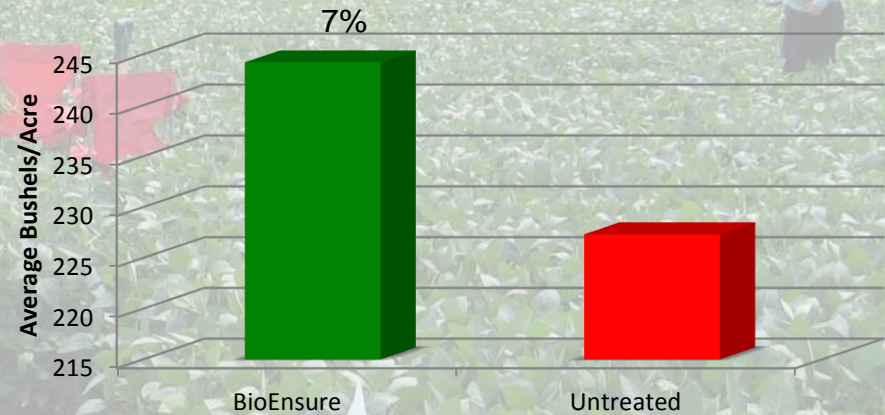


## 2012 (severe drought)



A randomized design with 25 plots (20'x20') established by AST at one location in MI. Four corn varieties were tested with 2 BioEnsure treatments and there were 10 reps/treatment with N=30/treatment).  
BioEnsure = 30-85% yield increase above untreated plants (T test, p<0.01).

## 2013 & 2014 (low stress)



Cumulative results from hundreds of test plots (20'x20' – 50 acres) established by independent cooperators in several soil types across CA, MI, IN, NE, SD. BioEnsure<sup>®</sup> increased yield an average of 7% across all locations and hybrids and a range of 5-20% (T test, p<0.01).

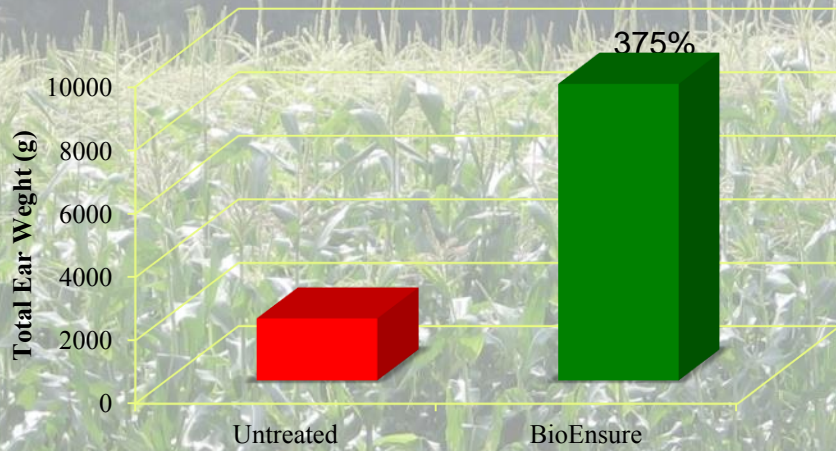
Similar Results with rice, wheat, barley, cotton and millet



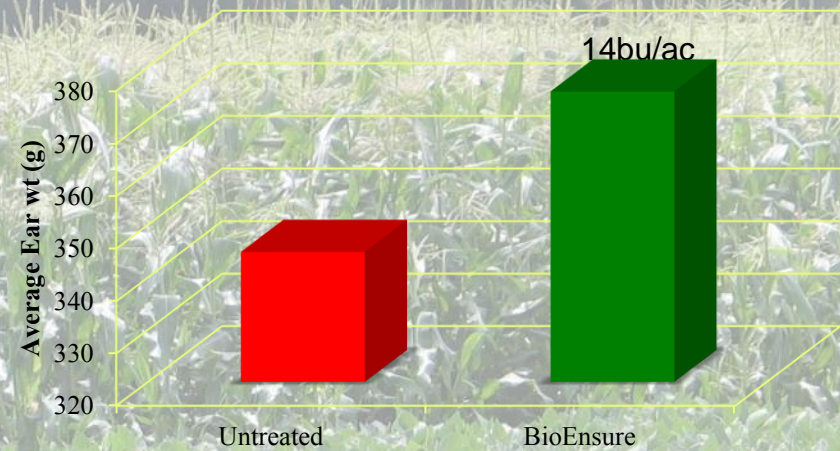


# 2015 BioEnsure<sup>®</sup> Corn Yield Increase in 5 locations

## 2015 (extreme drought)



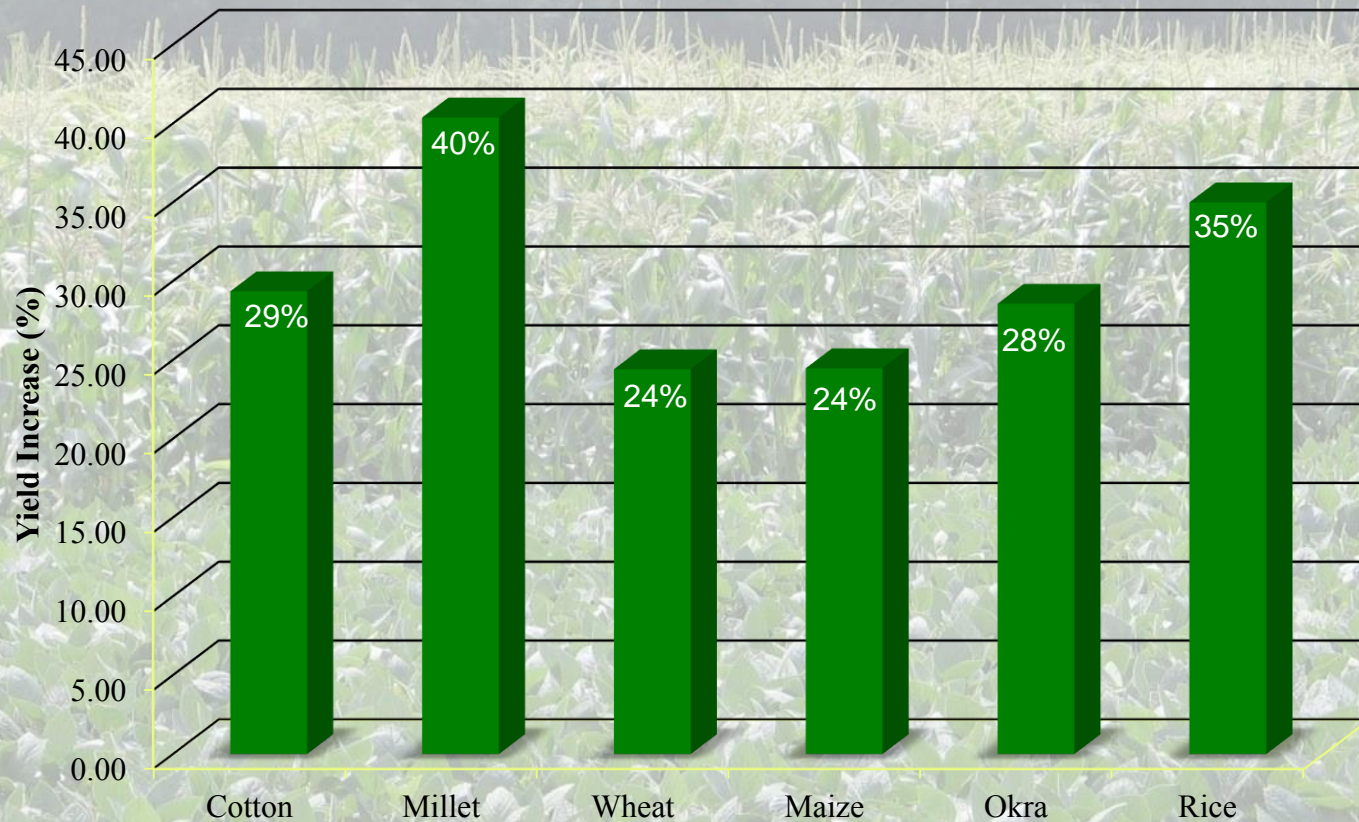
## 2015 (low stress)



Cumulative results from six test plots (100' x 60') established by independent cooperator in CA, IN, IA, WI, WA. BioEnsure<sup>®</sup> increased yield an average of 14% across replicates with a range of 6.7-28bu/ac.



# BioEnsure<sup>®</sup> Field Testing in India 2014 & 2015



White numbers indicate average yield increase among replications



# AST's Approach to Sustainable Food Security

**Microbial consortia** to confer enhanced benefits to plants:

- Abiotic stress tolerance
- Biotic stress protection
- Improved nutrition
- Improved seedling growth & development
- Increased yields

**Improving** soil health

**Breeding** a new generation of plants for enhanced symbiotic communication

**Real Time Diagnostics** of gene expression for predictive management

