Sustainable Nutrient Research, Innovation, & Education

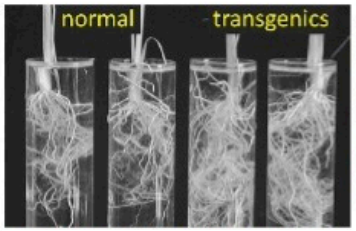
STEINBECK INNOVATION

CONCEPT: Society cannot achieve food security without a sustainable fertilizer system, one that assures reliable and affordable long-term access to essential fertilizer nutrients (nitrogen, N; phosphorus, P) while safeguarding the environment from the effects of nutrient pollution. Attaining such nutrient sustainability requires a *systems approach* that increases nutrient-use efficiency by crops while also establishing diverse nutrient-recycling pathways across the entire food chain. Collaborating on economic and social dimensions with regional stakeholders and relying on extensive involvement of students at multiple levels, our project will join the Steinbeck Cluster to pursue both fronts in establishing nutrient sustainability approaches for profitable and environmentally friendly smart farms in the Salinas Valley. Specifically, we will develop, test, and deploy *next-generation, nutrient-efficient crops* coupled to diverse and effective *alternative fertilizers* and couple our efforts to active measures for technology transfer and dissemination.

ASU Arizona State University — University of Arizona

OBJECTIVES:

1. Engineer and assess nutrient-efficient varieties of crops that maintain high yield on reduced fertilizer inputs. *PIs: Gaxiola, Sanchez*
   - Develop & refine crop varieties using Gaxiola's PP transporter approach. Targets can include lettuce, tomatoes, celery, artichokes, garlic, broccoli, and grapes. Propagate seed for greenhouse testing and eventual field assessment.
   - Screen existing crop varieties for natural variation in PP-transporter function. Propagate seed for greenhouse testing and eventual field assessment.
2. Engineer and assess methods of nutrient recovery using chemical and biological processes that capture nutrients at multiple nodes of the food system. *PIs: Rittman, Westerhoff, Sommerfeld, Hu*
   - Develop biotic and abiotic reactor systems coupled to ion exchange nutrient recapture with bioenergy co-product. Produce proof-of-concept apparatus to use crop waste, food waste, and animal waste as feedstock.
   - Test field-scale algae-based nutrient recapture systems with bioenergy co-product using feedlot and row crop runoff.
3. Assess, at the greenhouse and farm-field scales, the operation of a "closed-loop" crop/fertilizer systems in which nutrient-efficient crops are grown with recycled "alternative" fertilizers. *PIs: Gaxiola, Sanchez, J. Elser, Hall*
   - Determine effectiveness of "alternative fertilizers" (from #2) in yield of nutrient-efficient crops (from #1) at plot scale.
   - Determine biogeochemical efficiency of coupled nutrient efficient (fertilizer/crop) system at plot scale, including impacts on water quality.
4. Examine the economic viability and wider social and environmental benefits of nutrient-efficient crops and alternative fertilizers, and explore strategies to advance sustainable "alternative fertilizer" systems. *PIs: Aggarwal, Rahman*
   - Design and implement relevant surveys to understand current barriers to and potential for adoption and marketing of nutrient-efficient crops and alternative fertilizers.
   - Assess on-farm economic viability of new crops and alternative fertilizers for different production systems and production scales.
5. Develop and implement K-12 education strategies related to nutrient sustainability. *PI: M. Elser*
   - Design standards-based modules focused on agricultural sustainability for high school science curriculum.
   - Design and advise implementation of program of high school research and entrepreneurship internships related to nutrient sustainability.



Effects of PP transporter enhancement on root production in lowland rice. Photo: R. Gaxiola.


Effects of PP transporter enhancement (top row) on yield and N fertilizer response (right to left) in romaine lettuce. Normal plants on bottom. Photo: R. Gaxiola.


Effects of PP transporter enhancement on A. *Arabidopsis*, (PP-enhanced on left) B. lowland rice (PP-enhanced on right), C. lettuce (PP-enhanced on right), and D. tomato (PP-enhanced on right). Photos: R. Gaxiola.


Ion exchange apparatus for chemical recapture of N and P from concentrated organic waste streams.


Large-scale algal culture facility for biological N and P recapture and bioenergy co-production from dilute waste streams at the Laboratory for Algae Research and Biotechnology, ASU Polytechnic.

FOR FURTHER READING:

Childers, D.L., J. Corman, M. Edwards, and J.J. Elser. 2011. Sustainability challenges of phosphorus and food: Solutions from closing the human phosphorus cycle. Bioscience 61: 117-124.

Elser, J.J., and E. Bennett. 2011. Phosphorus: a broken biogeochemical cycle. Nature 478: 29-31.

Gaxiola, R., M. Edwards, and J.J. Elser. 2011. A transgenic approach to enhance phosphorus use efficiency in crops as part of a comprehensive strategy for sustainable agriculture. Chemosphere 84: 840-845.

Rittmann, B.E., P. Westerhoff, and M. Edwards. 2011. Capturing the lost phosphorus. Chemosphere 84: 846-853.

WEB RESOURCES OF INTEREST:

ASU Global Institute of Sustainability: sustainability.asu.edu
ASU Laboratory for Algae Research and Biotechnology: larb.asu.edu
ASU Swette Center for Environmental Biotechnology: http://tinyurl.com/83tpdmw
ASU Sustainable P Initiative: sustainablep.asu.edu
Elser in Foreign Policy: tinyurl.com/7emypcj
Elser on NPR Marketplace: http://www.marketplace.org/topics/business/end-phosphorus
Elser at Arizona Science Center: http://vimeo.com/13160504
Rittmann in The Atlantic: tinyurl.com/84zfso3

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