EGYPT FOOD SECURITY PROJECT

FINAL TECHNICAL REPORT

July 1, 2022

A Binational Fulbright Commission in Egypt Alumni Engagement Activity

Principal Investigator: Dr. Steve Burian, University of Alabama (formerly University of Utah)

Egyptian Consultant: Dr. Ali Shams El-din

U.S. Fulbright Alumni Participants: Dr. Lal Almas, West Texas A&M University; Dr. Mike McFarland, Utah State University and Cache Environmental Laboratories PC

Egyptian Fulbright Alumni Participants: Dr. Mohamed El-sayed, SWERI; Dr. Mohamed Hazman, AGERI

Background

Climate change and freshwater scarcity are driving an urgent food security problem in Egypt. 100% of Egypt's agriculture is irrigated. Water for irrigation is becoming scarcer as the availability of freshwater resources is shrinking and competition among different water use sectors intensifies. Adopting unconventional solutions is needed to enhance water productivity in irrigated agriculture. The Ministry of Agriculture and Land Development report, *Sustainable Agricultural Development Strategy Towards 2030*, presented a suite of water productivity enhancements to realize food security and improved livelihood of rural inhabitants. To be fully implemented, the vision required developing alternative water sources and use of soil amendments as mechanisms to build resilience of agriculture to variations in climate, water availability and quality, soil health, and food demand. One of the most available and feasible water resources is groundwater, which is currently used by farmers, however, several considerations must be carefully understood to avoid the drawbacks on soil health and crop production. One of the most common problems among groundwater aquifers in Egypt is salinity. Thus, this project investigated the limitations to using saline groundwater and the benefit of using soil amendments in concert with saline groundwater to mitigate negative impacts on soil characteristics and plant stress.

Goal and Objectives

The goals of this Fulbright Alumni Activity were to (1) foster *sustainable* scholarly exchange on issues related to food security and water resources management and (2) produce preliminary experimental results regarding the use of saline groundwater in combination with soil amendments to improve the efficiency of production of field and cash crops such as wheat and tomato from agricultural lands reclaimed from the desert in Egypt. The researchers evaluated different, synthesized saline irrigation water (mimicking low to moderate groundwater salinity) and soil amendments on plant crop production and soil properties. The research objective of the project was to evaluate, using lab and field experiments, the effect of irrigation water salinity and soil amendment on soil health, plant response, and productivity of tomato and wheat plants. The results of the original scientific studies were synthesized with the current body of knowledge in the form of peer-reviewed articles. The project results provide insight into the challenges and opportunities with taking saline groundwater and soil amendment solutions to scale in Egypt.

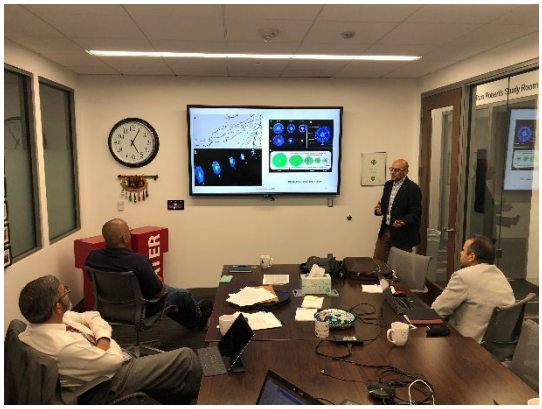
Activities and Methodology

A principal investigator (PI) and an Egyptian consultant designed this Fulbright Alumni Activity to accomplish the goals and objectives. The PI and consultant facilitated the engagement of the four Fulbright Alumni, two from Egypt and two from the United States, in the pursuit of scholarly exchange and scientific study. The project team selected was:

- Principal Investigator: Dr. Steve Burian, University of Alabama
- Egyptian Expert Consultant: Dr. Ali Shams El Din
- Fulbright Alumni:

- Dr. Mohamed El-sayed, Researcher, Soils, Water, and Environmental Research Institute (SWERI), Egypt
- Dr. Mohamed Hazman, Researcher, Agriculture Genetic Engineering Research Institute (AGERI), Egypt
- Dr. Lal Almas, Professor and Associate Dean, West Texas A&M University, USA
- Dr. Mike McFarland, Principal, Cache Environmental Laboratories PC, USA

Originally designed to be a one-year project, challenges associated with the COVID-19 pandemic extended the project to a period of more than three years (2019-2022). To build the research partnership, the four Fulbright Alumni participated in monthly virtual meetings to exchange research ideas and results, brainstorm adaptations, and discuss conclusions and recommendations. The Fulbright Alumni designed the research activities and strengthened the research collaboration during one scholarly exchange visit to the U.S. in September of 2019. An international capstone conference planned for Egypt in the summer of 2022 provides the culminating scholarly exchange and broader impact from the project.



The central part of the project engaged a multi-disciplinary team of Fulbright Alumni in a collaborative research project investigating the feasibility of using saline groundwater in combination with soil amendments to improve crop production in Egypt. The researchers conducted lab and plot-scale experiments in Egypt at the lab and field facilities of AGERI and SWERI to explore critical soil health and plant root response associated with combinations of source water salinity and soil amendment. Tomato and wheat crops were the focus of the controlled experiments performed in settings representing greenhouse and reclaimed land conditions. The researchers investigated drip irrigation using a range of application rates of water defined in consultation with local expert farmers and gardeners. The experiments included testing of biochar as a soil amendment to mitigate the effects of irrigation water salinity.

The study of the effects of saline irrigation and biochar covered two consecutive growing seasons, 2019/2020 and 2020/2021. The study of wheat crops was performed at SWERI's Shandaweel Agricultural Research Station, Sohag, Egypt. The study of tomato crops was performed at AGERI's experiment station in Cairo. The experiment at both locations used two water treatments, i.e., freshwater (307.2 ppm) and saline water (3000 ppm (NaCl + MgCl2)) representing groundwater in Egypt delivered by drip irrigation. The investigation at both sites tested the hypothesis of whether the application of biochar (cob corn) at a rate of 4.8 tons/ha to fertile soil (Nile Valley, Giza, Egypt) would ameliorate the negative effects of saline irrigation regime (3000 ppm) on wheat and tomato crop and soil.

Results and Findings

Results from the first season of experiments provided preliminary assessment of the crop yield for different levels of irrigation water salinity and use of biochar. The important findings from the experiment were (a) both tomato and wheat crop productivity were reduced from use of saline irrigation water and (b) the addition of biochar mitigated the impact of the saline groundwater, nearly restoring the crop productivity achieved with fresh water irrigation.

The results of the wheat experiments at SWERI revealed that saline water reduced the grain yield ratio by 8.5%, 11.0%, and 9.7% compared to non-saline water during seasons 2019/2020 and 2020/2021 and over seasons, respectively. Combined over seasons, the biochar addition enhanced the grain yield by 5.6% and 13.8% compared to non-biochar addition under fresh and saline irrigation water conditions, respectively. Thus, the results indicated and led to a preliminary recommendation that saline groundwater is a viable source of irrigation water and that biochar seemed to alleviate salinity stress on wheat production and in reclaimed soils of Egypt.

The results of two seasons of tomato experiments at AGERI showed that saline irrigation significantly reduced tomato crop yield by an average reduction ratio of 51%, and biochar addition could not compensate such reduction. Furthermore, biochar did not reduce accumulated Na+ in fruits or roots. Tomato fruits produced from biochar-added soil were lower in TSS levels (41.7% reduction ratio) yet larger in diameter by approximately 1.5-fold increase. Interestingly, biochar addition into soil greatly promotes the length of stem-borne lateral roots and elevates the expression of LeNR (encodes nitrate reductase enzyme) in leaves yet under fresh irrigation regime. For soil properties, biochar application enhanced the soil properties under either saline or fresh water irrigation conditions. Collectively, it is assumed that biochar application to fertile soil in Nile Valley of Egypt could not alleviate tomato fruits yield reduction affected by applied saline irrigation regime.

Broadly, the project supported the development of five U.S. graduate students/scholars. Three peer-reviewed journal articles were published, one conference paper was published, and three posters and four platform presentations were made at research conferences. In the fall of 2020 a virtual science dialog facilitated the exchange and discussion of key issues between Egyptian and U.S. experts and policy makers. Experimental outcomes elucidated the benefits and consequences of irrigation water salinity with and without soil amendment on soil health and production of tomato and wheat plants. Final results and discussion of future directions will take place at the capstone conference in Cairo, Egypt during the summer of 2022.

Farm Field Study Tour in the United States, September 2019

Experiments at SWERI, Sohag, Egypt, 2019-2021

Experiments at AGERI, Cairo, Egypt, 2019-2021