Mechanisms of Boron Toxicity in Crop Plants

Principle Investigator

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Executive Summary

This project addresses critical aspects of direct relevance to the Salinity Drainage Program, specifically, this project will provide key information to help determine the impacts of boron on the long-term consequences of using drainage water for irrigation, and will provide the information needed to better understand and manage the problem of boron toxicity in saline soils and irrigation.

Boron toxicity is a problem threatening significant areas of production in California and limiting the reuse of drainage waters. Research into the management of B has been plagued by results that are inconsistent, contradictory and difficult to interpret. In our opinion the primary reason we struggle with B management is because, ***'we do not know why B is toxic to plants and we do not know how to measure crop B and its relationship to the occurrence and impact of B toxicity.'*** Without this most fundamental of information, producers, extensionists and researchers cannot hope to understand or manage boron in saline impacted environments. This lack of information directly compromises our ability to select for improved cultivars, manage the use of high B irrigation water or manage crops under high B environments. This grant explicitly attempts to identify the mechanism of B toxicity, and to develop the sampling strategies and standards necessary for field research and crop management. This research is expected to provide the fundamental basis for subsequent attempts to manage excess B in water and soils.

The working hypothesis for this project is that the determination of the specific physiological basis for B toxicity and identification of the tissues, stages of crop phenology that are most sensitive to B toxicity will provide the needed information to intelligently manage B in the environment. Knowledge of why B is toxic, and which tissues and stages of growth are most susceptible to high B will provide the information needed to manage B, select or breed for B tolerance and generally interpret the wealth of contradictory information that already exists.

We will approach this task with a combination of laboratory and field based research. We have developed an innovative but highly logical hypothesis that B toxicity occurs by

disrupting normal growth and reproduction through its negative effects on cell walls. Phase 1 of this project will test this hypothesis and will be conducted in the laboratory to ensure that we have the needed control to be able to measure and interpret the response of plant cells to toxic levels of B. While we recognize the inherent value of field based trials in managing complex environments, these trials have generally failed to provide clearly interpretable results in the past. The conduct of a focused lab trial will provide the information needed to enhance the effectiveness of subsequent field trials.

In the second phase of this project, field trials will be conducted that draw upon the results of phase 1 to help define the specific tissue tests, plant sampling and interpretation protocols required to manage B toxicity in field situations.

Through the identification of the primary mechanism and site of B toxicity, and through determination of optimal sampling strategies, this project will provide the means to monitor plant response to B which is essential if we are to effectively determine the impact of different management or breeding strategies on plant growth and crop productivity. The principles developed in this research are expected to be relevant and instructive for all species.

The overall objective of the project is to understand the physiological basis of B toxicity in plants and to determine the optimal sampling strategy to monitor plant B levels. This information can then be used to guide crop selection and optimize production management (including irrigation). This information will allow us to better manage the use of water high in B.