

Title: Development of mathematical models for use in management of irrigation, fertilization and run-off in greenhouses.

Period covered: From: 10/2004 To: 09/2005

PI: Heiner Lieth, Ornamental Crop Modeling Laboratory,
Plant Sciences Department, University of California, Davis, CA

Progress and Outcome

1. What major problem or issue is being resolved and how are you resolving it?

Management of irrigation and fertilization are two of the most important aspects of greenhouse crop production. While significant regulatory pressures have been put in place in recent years, growers still use luxuriant amounts of water and fertilizer so as to maximize productivity. The resulting run-off is polluting the environment. Many regional water quality districts and state governments are now restricting this discharge. As a result growers are in a situation where they need to comply with regulations but are unable to do so for lack of information and technology.

The goal for growers is to recirculate all their effluent. When they use just fresh water, it is a matter of adding specific amounts of each nutrient and no special sanitation methods are required. When they use any amount of effluent in this, they need to know how much of each nutrient is already present and they need to filter and sanitize the solution. With the current level of technology, there are salts in this water which will continue to accumulate as the water is reused over and over again. Thus at some point, the effluent becomes too toxic in one or more unusable nutrient (e.g. sodium) so that it becomes unusable.

Our approach to the problem is to develop tools that can be used to simulate greenhouse production in relation to irrigation and fertilization strategy. In greenhouse production many crops can be produced hydroponically, so that recirculation is feasible. The problem is that the chemical constituents of the recirculating irrigation solution need to be adjusted dynamically so as to provide optimal nutrition for the plants at all times. Since there are no sensors and control systems that allow for dynamic control, we seek to develop models that allow calculation of the composition of the captured run-off, so that it can be augmented with the needed fertilizers to re-create optimal irrigation solution. This requires a number of models that will combine to form the desired simulation model.

2. How serious is the problem. Why does it matter?

The problem has become critical across the nation. Many states have mandated complete recirculation without realizing that this is impossible for growers. Science-based information for adjusting their fertilizer injection systems.

3. How does it relate to the National Program and the National Program Component(s)?

This project is under Natural Resources and Sustainable Agricultural Systems, National Program 201, Water Quality and Management. Component - Water Quality Protection and Management (Excess Nutrients).

4. What were the most significant accomplishments this past year?

This project is a collaborative project of several researchers was assembled last year to work on this area. During the past year this group has made significant progress in a number of areas.

In previous years we built a rose crop model that includes the major

physiological processes (photosynthesis, respiration, growth, etc). Our focus has been to work with this model to make it responsive to the various environmental factors that are important (e.g. light, CO₂ concentration, temperature, water status, nutrient status, salinity, etc). The following areas have been the key areas of progress over the past year:

A. Last year we began investigating the role of oxygen in the root zone and this work is continuing. We are still developing the information needed to build a model that describes how oxygen concentration drives such variables as nutrient uptake and water uptake. Unfortunately we have had some set-backs in this area: in our research we have been unable to identify a critical oxygen pressure, which had been the core of our modelling approach. Thus we are currently reformulating this approach and restarting our experimental work in this area.

None-the-less, since growers are getting frequent updates on our findings, we have succeeded in making them aware of the importance of oxygen diffusion and dissolved oxygen concentration in the root zone. Thus many have altered their practices somewhat to attempt to avoid suboptimal oxygen concentrations.

B. Previously our rose shoot simulation model was expanded to include nutrient uptake model. We are currently in the midst of experiments to model additional nutrients to allow us to deal with both primary and secondary nutrients in our model.

As we develop models for various facets of greenhouse crop production, we are also developing specific grower tools based on these models. This work was to start this past year, but we were not able to make progress in this area.

5. Describe the major accomplishments over the life of the project, including their predicted or actual impact.

We have made some advances in our understanding of optimization of water, nutrient and oxygen in irrigation solution, especially with regard to recirculation. Information has been presented to growers and some growers are modifying their practices as a result of the research results. The impact of the work is substantial as the resulting information will be important for all growers producing crops in protected cultivation.

6. What do you expect to accomplish, year by year over the next 3 years?

The key goal is still to develop models that describe the extraction of key nutrients by rose plants from the soil solution. While we have made some progress in this area, the same goal still remains. Over the next three years we envision adding the effect of all other major nutrients into the model (which is work we have recently begun). We also envision developing software tools that growers can use in managing their irrigation and fertilization practices.

7. What science and/or technologies have been transferred and to whom? When is the science and/or technology likely to become available to the end user (industry farmer, other associate)? What are the constraints, if known, to the adoption and durability of the technology products.

Dissemination of information from this work has been made directly to greenhouse flower growers at meetings. I have given talks nationally and internationally which included results from this work. We are also planning a software tool to help grower make decisions. This software will be a very useful extension tool as it packages the highly-technical information in a way that growers to use it.

8. List the most important publications in the popular press (no abstracts) and presentations to nonscientific organizations and articles written about your work (NOTE: this does not replace peer-reviewed publications which are

listed below).

No popular press articles related to this project were yet written.

9. Scientific Publications:

Oki, L.R. and J.H. Lieth, 2004. Effect of Changes in Substrate Salinity on the Elongation of *Rosa hybrida* L. 'Kardinal' Stems. *Scientia Horticulturae* 101:103-11

Kim, S.H., K.A. Shackel, J.H. Lieth, 2004. Bending alters water balance and reduces photosynthesis of rose shoots. *J. Amer. Soc. Hort. Sci.* 129:896-901

Lieth, J.H., R. Flannery and N. Mattson, 2004. Development of a model for rose productivity. *International Cut Flower Growers Bulletin*