Understanding salinity and nitrogen interactions to improve floriculture efficiencies

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1 INTRODUCTION

Water quality and quantity will be limited by needs of a growing human population. Under these circumstances, saline wastewaters may become a valuable resource for the irrigation of selected floriculture crops. Historically, the floriculture industry has been a significant user of water resources. This is especially true where many economically important crops are salt sensitive and require quality water for irrigation. In recent years, however, population growth has also increased demand for fresh water in many regions of California (Parsons, 2000). Additionally, a majority of cut flower growers are located in coastal areas where ground waters are becoming more saline. Many growers in these areas are also opting to sell their land and relocate to areas further inland as coastal real estate values are increasing, but inland agricultural soils typically contain higher concentrations of salts. As competition for quality water continues, the use of wastewaters for irrigation may be a desirable option for many salt tolerant floriculture crops.

The greenhouse and nursery industries are also facing increasing real and potential restrictions on the release of effluents (primarily nitrogen compounds) aimed at improving the quality of local water resources. Specifically, the discharge of effluents from greenhouse and nursery operations has become a critical issue with regard to contamination of rivers, streams, aquifers, and tidal pools since effluents typically contain high concentrations of nitrate salts.

There is a need for a greater number of options for irrigation with wastewaters. In an attempt to address water consumption and water quality issues, this study was designed to determine how saline waters with a range of nitrogen concentrations can be effectively utilized to: (1) produce commercial stock (*Matthiola incana*) with waters thought previously unsuitable due to salinity levels, and (2) evaluate if recirculated closed-system irrigation can reduce nitrogen waste loads into the environment.

2 MATERIALS AND METHODS

Treatments—A 4 × 4 factorial design with partial replication was used to assess the effects of salinity and nitrogen on the production of cut flowers. Seeds were sown in each of twenty-three outdoor volumetric lysimeters at the George E. Brown, Jr., Salinity Laboratory in Riverside, CA. Four rows with 25 wells were planted with two seeds each. Four salinity treatments with target electrical conductivity (EC) levels of 2, 5, 8, and 11 dS m^{-1} were combined with four nitrogen treatments of 35, 50, 75, and 100 ppm. A compliment of other

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macro- and micro-nutrients were also added to the irrigation water that ultimately was intended to simulate irrigation water typical of the Coachella valley of California. One lysimeter was left unplanted to estimate evaporation.

An empirical model developed by Lieth et al. (1995) was implemented to evaluate the growth response of each combination of salinity and nitrogen treatments. The three-phase model is represented by an initial size parameter (α), an estimation of the intrinsic growth rate of the exponential phase (β), a transitional phase between the first two phases (t_l), the length of the linear exponential phase (ε), and the final intrinsic saturation rate (γ), expressed

as: $$F(t) = \begin{cases} \alpha - 1 + e\beta^{(t-t_0)} & \ldots for\ t_0 \le t \le t_1 \\ \alpha - 1 + \left(1 + (t - t_1)\right) e^{\beta(t_1 - t_0)} & \ldots for\ t_1 < t \le t_1 + \varepsilon \\ \alpha - 1 + \left(1 + \beta\varepsilon + \frac{\beta}{\gamma}\left(1 - e^{-\gamma(t - t_1 - \varepsilon)}\right)\right) e^{\beta(t_1 - t_0)} & \ldots for\ t > t_1 + \varepsilon \end{cases}$$

Graphically, the function depicts the relation of the parameters to the curve shape (Figure 1).

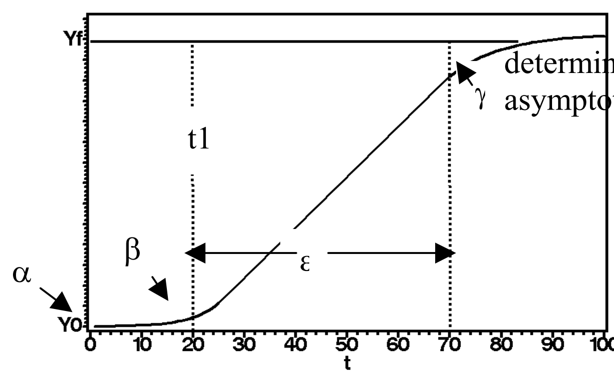

Figure 1. Graphical depiction of sigmoid growth pattern model (from Lieth et al., 1995)

The model was bound for values of $\alpha > 0$ for since a negative initial height was not observed. Two treatments were bound for $\varepsilon > 13$ (EC = 5, N = 100 and EC = 11 and N = 50), since the other 14 of the sixteen possible non-linear fittings produced values of $\varepsilon > 13$ without constraints and these treatments did not converge without this constraint. A value of $\varepsilon < 13$ is physiologically unlikely

3 RESULTS AND DISCUSSION

The model successfully fitted the plant height data over time for all sixteen nitrogen and salinity treatment combinations. Effects of salinity on α and t_2 (ε+t_1) were not significant. Nitrogen treatments had no significant effect on any of the model parameters and the effect of salinity was greatest when irrigation water salinity was 11 dS m^{-1} (Figure 2).

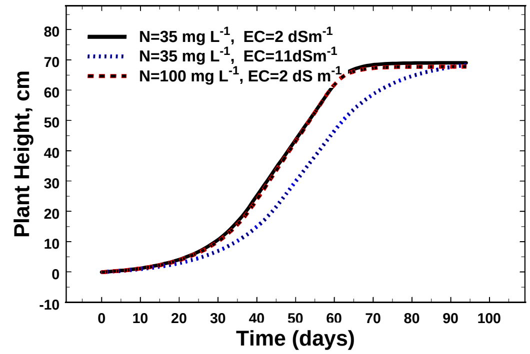

Figure 2. *Matthiola* plant height development modeled as a function of time for different nitrogen and salinity treatments. Salinity delays initiation of linear growth phase (t1) and decreases the length of the linear phase (ε) by 20%. Decreasing N applications by 67% had no measurable effect on final plant height at any salinity, however, the time to reach the final height was delayed by salinity.

Correlations between model parameters and measured electrical conductivity were significant forβ, t_l, ε, and γ (Figure 3).

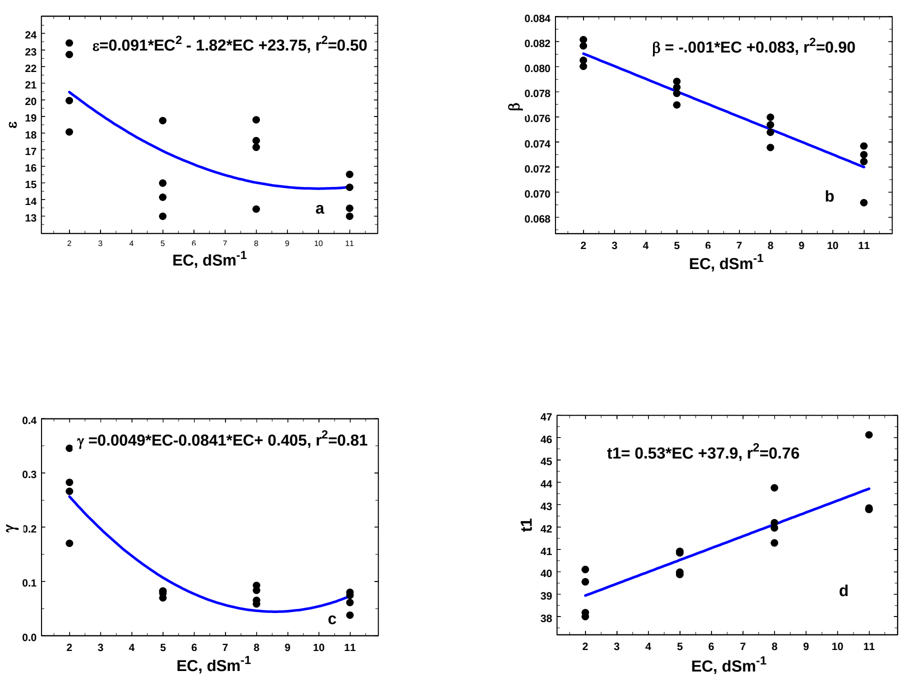

Figure 3. Effect of increasing salinity (EC, dS m^{-1}), on model parameters: ε (a), β (b), and γ (c) decrease with increasing salinity and t1 (d) increases with increasing salinity.

A very strong change in β with EC indicates a decrease in the intrinsic exponential growth rate due to salinity stress. This coupled with the decrease in γ results in a shorter ε or linear phase growth. Flower quality was not affected despite a significant difference in growth phases. Salinized plants required greater time to reach final height. Nitrogen applications of 35 mg L^{-1} did not result in significantly different parameter estimates or final plant heights when compared with concentrations up to 100 mg N L^{-1}.

Nitrogen consumption from solution per unit evapotranspiration increased with salinity and nitrogen concentration in solution. An increase of 25 to 33% in NUE (nitrogen uptake per mm of evapotranspiration) was observed from low to high salinity regardless of the initial N content in the system (Figure 4).

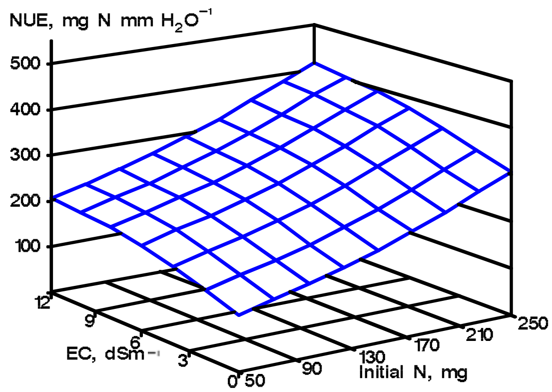

Figure 4. Predicted surface of Nitrogen Use Efficiency (NUE), defined as nitrogen uptake per unit evapotranspiration (mm H_2O), as a function of increasing salinity (EC, dS m^{-1}) and initial mass of nitrogen in a closed irrigation system.

4 CONCLUSIONS

Production of *Matthiola incana* flowers can be achieved while minimizing nitrogen inputs and maximizing the salinity of the irrigation water. The use of a three-phase growth curve analysis allows for flexibility in predicting the effect of altering the nitrogen concentrations and salinity of irrigation waters used in closed-loop irrigation systems. This type of model is also more suitable for use in simulations where inputs (light, heat, day-night temperature differentials) differ from one environment to the next when expressed in thermal units. Significant reductions in N input can be realized with no loss of crop quality in the closed system. The closed system of production can significantly reduce off-site nitrogen loading and maximize the use of otherwise regarded poor quality waters. These are environmentally desirable features that can improve the water resource-use efficiencies of floriculture production.

5 REFERENCES

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Parsons, L. R. 2000. Water management and water relations of horticultural crops: introduction to the colloquium. Introduction to Water Management and Water Relations of Horticultural Crops. HortScience 35:1035-1036