Progress report to the International Cut Flower Growers Association
Development of a model for rose productivity
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Introduction

Two aspects of the rose productivity model have been getting the most attention during the fall of 2001. The first of these is the characterization of stem elongation patterns to identify specific developmental events in relation to growth phases. The second is a study of the effects of substrate salinity on stem elongation rates. Following are summaries of those projects. The information from these projects will be used to develop submodels that would become part of the rose shoot model. Of this work the modeling is funded by the ICFGA funds; the salinity work is funded from other sources (California Association of Nurserymen). Progress is also being made on other facets of the proposed work, but it is as yet too early to report on these. Three scientists have been hired and will be working with me on these.

Our initial work in trying to develop models that describe water use and nutrient uptake we found that there was not much quantitative information on how nutrients affect rose productivity, particular in relation to salinity. This is a fairly important facet of the root zone management, so the model needs to include this. The information that makes up the guidelines for EC in the industry does not include effects on elongation. Since the EC that plants experience is varying substantially with water content and fertilization patterns, it is important to account for this in the model.

Linear Growth Phase Demarcation and Diurnal Patterns in *Rosa hybrida* L. Stem Elongation

Stem elongation is an important facet of rose productivity since cut-flower roses are graded and marketed by stem length. Optimization of stem length in roses requires an understanding of how shoot elongation varies over the course of the day and during development. The pattern is generally such that the stem first grows exponentially, then linearly for several weeks, followed by a slowdown. This project characterized how the linear phase of stem elongation was related to development. The second aspect of this work examined the diurnal patterns of stem elongation in the greenhouse and in a growth chamber.

The length of stems of greenhouse-grown rose plants in containers was measured daily. In addition, the number of unfolded leaves on those shoots was counted and the dates of visible bud and harvest recorded. Elongation rates were calculated from the length data. A Least Significant Difference (LSD) value was determined to calculate the growth rates that would occur during the linear growth phase. The day that stem growth started and ended this phase was used to ascertain the number of leaves that would be unfolded at those times. It was found that when five leaves were unfolded, the stem had entered the linear growth phase in both the summer and fall seasons. In the summer, leaf unfolding was completed before the linear phase ended. In the fall, leaf unfolding was completed one or two days after the linear phase ended.

Stem elongation was also measured on plants in the greenhouse and in a growth chamber using linear displacement position sensors (LDPS) and the elongation rates were calculated. Relative elongation rates (RER) were determined (RER= rate during portion of day/rate during the whole day) to reveal diurnal growth patterns. In the greenhouse, RER was greatest (1.56) just after sunset,
decreasing to about 1.05 at midnight. It then was constant through the remainder of the night. After
sunrise, the rate decreased temporarily to 0.90 in the midmorning before rising to >1.0 from 10:00 AM
to noon. The RER decreased again to 0.78 or less from noon to 2:00 PM before increasing in the
late afternoon. A similar pattern was found on plants in a growth chamber, but fluctuations were
more abrupt as the lights were turned on and off. The late morning peak in RER was also evident.

Despite differences in developmental rate due to seasonality, identifying the occurrence of
the linear growth phase of the stem could be reliably made based on the number of unfolded leaves
present on the stem. Knowledge of the diurnal patterns of rose stem elongation coupled with the
ability to identify when a stem is in a condition of a constant elongation rate may be helpful in
experiments on factors affecting stem growth. A model that includes the effects of water or salinity
stresses, for example, is a useful tool for simulating stem elongation and for determining optimal
irrigation and fertilization practices.

Effect of Changes in Substrate Salinity on the Elongation of Rosa hybrida L. 'Kardinal' Stems

Changes in stem elongation rates of Rosa hybrida L. 'Kardinal' stems were measured using
linear displacement position sensors (LDPS) while plants were exposed to salinized nutrient
solutions for 2 or 12 hours. Greenhouse-grown plants were acclimated in a growth chamber under
constant 25°C and continuous light for at least 36 hours before treatment. While in the growth
chamber, plants were automatically irrigated based on substrate moisture tension with half-strength
Hoagland’s nutrient solution in deionized water (NS). In the two-hour exposure experiment, a
pretreatment irrigation of NS was initiated at 1:00 a.m. and was followed 2 hours later by an
application of deionized water (DI), NS, or NS with NaCl to increase the solution electrical
conductivity (EC) by 1, 2, 4, or 8 dS·m⁻¹ (+1, +2, +4 and +8 respectively). A post-treatment irrigation
with NS followed after 2 more hours.

The shoot elongation rate (SER) of plants treated with DI increased by 0.30 mm/hr from 0.95
mm/hr, then returned to the pretreatment rate after the final irrigation. Treatment with NS resulted
in a growth rate 0.10 mm·hr⁻¹ greater than the pretreatment rate. This was unexpected and is
probably due to a temperature effect caused by irrigating with cold solution. The +1 treatment had
no effect on growth rate, but the more saline treatments resulted in decreases in SER of 0.12, 0.23,
and 0.86 mm·hr⁻¹ respectively. Shoot growth rates of salinized plants returned to or exceeded
pretreatment rates after the final leaching irrigation.

In a 12-hour exposure experiment, the treatment solution was not leached and data was
collected for 12 hours after the treatment. Treatment with +2, +4, and +8 caused immediate, but
temporary reductions in SER. Growth rates then increased and restabilized after 4 to 6 hours.
Stems of the +2 and +4 treated plants regained the pretreatment elongation rates, but +8 treated stems
only partially recovered at 78% of the pretreatment rate.

Applications to the industry

The information obtained from the characterization of stem elongation patterns will be used
in a simulation model of stem elongation with a proposed time resolution of one hour. This may
seem excessive, but the effects of changes in substrate salinity can be rapid and occur in time
intervals that are much shorter (0.1 hours). Greater resolution (shorter time intervals) in the model
may make it too cumbersome and less usable, however. With the simulation model, we will be able
to test the effects of changes in substrate EC on stem lengths at harvest that might occur, for
example, with alterations the nutrient program. A result of these simulations may be a nutrient program that varies during the day to maximize stem lengths without compromising plant nutrition.

Another use for the information obtained from the stem growth patterns study is a grower's tool. The stem elongation pattern was found to be very consistent during the summer and fall seasons. Also discovered were strong relationships that will be used in the development of this tool between the number of unfolded leaves and stem length and between unfolded leaves and the elongation pattern. Using this tool a grower may be able to predict the harvest date and the stem length from observations of development (number of leaves unfolded) and length made on two separate dates. This will enable growers to ascertain crop developmental status when targeting specific harvesting dates and predict flower lengths at harvest.

We are currently developing the above information into a simulation model which will allow us to test various fertilization strategies.

Other relevant work

The scientists and one new graduate student have been added to the Rose modeling project. The student is currently setting up experiments to look at root zone oxygen. This issue is particularly important for hydroponic production as we have found that there seem to be many periods of time where oxygen is not optimal.

Two scientists have been hired on separate funds (Prof Moshe Silberbush, from Israel, and Dr. Wan Soon Kim, from Korea) to work on the modeling of nutrient uptake of roses. Both are currently setting up their research experiments.

Another scientist (Prof Pushpendra Chauhan, from India) will be working on crop productivity and energy issues regarding rose production. The modeling work from this should result in applicable information.

It is as yet too early to report on each of these efforts.