Optimizing rose crop fertilization and irrigation over hourly, daily and seasonal time scales:

Cyclical ion and water uptake over different time scales

Raúl I. Cabrera and Alma R. Solís-Pérez
Texas A&M University
Research and Extension Center
17360 Coit Road, Dallas, Texas 75252

Dr. Cabrera is now at Rutgers University
Cabrera@aesop.rutgers.edu

Report Date: December 31, 2008 (2009-09 Midterm Report)
Funded by the Joseph H. Hill Memorial Foundation, Inc.
ICFG-HILL, P.O. Box 99, Haslett, MI 48840
ICFG.HILL@yahoo.com

Since our last report we conducted another hydroponic study to confirm the seasonal, and more particularly the daily (hourly, over 24-h intervals), water and nutrient uptake patterns that we and others have reported in the past (Cabrera, 2003; Cabrera *et al.*, 1995; Mattson and Lieth, 2005). The most significant finding in our last experiment was that the uptake of water and nutrient by 'Happy Hour' roses over the course of an individual flowering cycle, and over two daily (24-h) cycles were not influenced by the rootstock (scion grafted on 'Manetti' and 'Natal Briar'). It should be noted that the data from that experiment was collected during the summer months, when average daily temperatures and solar radiation are higher compared to the fall and spring months.

In this experiment, conducted in the fall (Oct.- Nov.), we employed plants of the cultivar 'Erin' grafted on *R*. 'Manetti', utilizing the recirculating hydroponic system described in previous reports. As in previous studies, we confirmed the cyclical water and nutrient uptake patterns that are associated with flower shoot development (Figure 1). The patterns of shoot elongation observed in this flowering flush (Fig. 1A) were slightly different than in previous ones, a phenomenon largely attributed to a widely fluctuating solar radiation (Fig. 1B), as well as temperature and relative humidity (data not shown) over this period. The significant changes in these environmental variables effectively produced two early peaks in shoot elongation rate plus a final, maximum one that was fairly delayed in relation to its expected occurrence (predicted to happen between days 24-25). Nevertheless, water uptake (Fig. 1B) still followed a pattern that closely followed shoot elongation and therefore leaf unfolding (i.e. increases in leaf area). Nutrient (total ion) uptake, which declined right after harvest of the flowers from the previous flush, remained depressed until about day 20 – when the first peak in shoot elongation rate was being observed. Thereafter ion uptake rate continued to increase, albeit it showed a temporary reduction in its slope between the second and third (maximum) shoot elongation peaks. Maximum water and ion uptake rates were observed at the end of the flowering cycle, preceding harvest.

Notice that there were a total of four changes in the nutrient solutions (modified 0.25X Hoagland formulation) during this experimental cycle, and that for the first two solution changes there was a steady and relatively sharp increase in their electrical conductivity (EC from about 1.4 to 1.7 dS m^{-1}; Fig. 1C), coinciding with the period between the previous flower harvest, bud break and the onset of the maximum shoot elongation rates of this cycle. Compare these against the last two solution changes, when overall EC's were lower, and although they also tended to increase over time, they did it at a lower slope (rate of change). Altogether these observations with those of ion uptake (Figs. 1C and 1D) should point to growers employing intensive fertigation, semi-hydroponic and hydroponic systems that when producing roses in synchronized flushes (like for Valentine's) they could safely and effectively lower their fertilization rates – i.e. nutrient solution concentrations – between the synchronizing hard pinch and the period when maximum shoot elongation rates are observed. This would have benefits like minimizing nutrient use and leaching/discharge, thus saving fertilization costs and minimizing environmental impact, and perhaps also minimizing the osmotic (fertilizer salt) stress to the plants and potentially maximizing final shoot length.

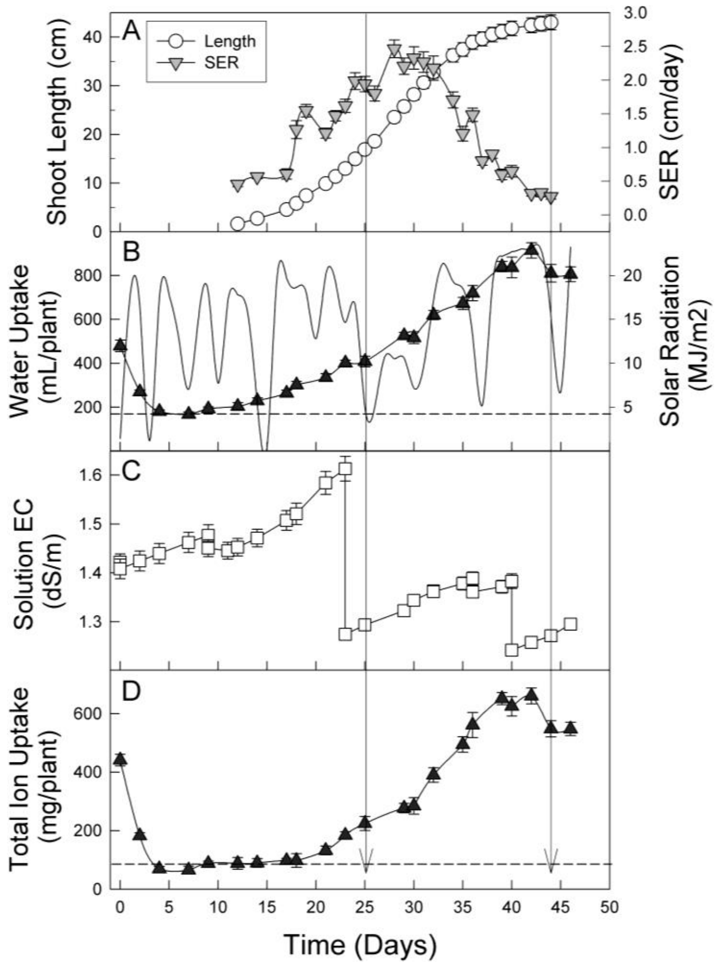

Figure 1. Shoot length and elongation rates (A); water uptake and growing degree-days (B); nutrient solution EC (C) and total ion (salt) uptake (D) over an entire growth & flowering cycle of hydroponically-grown 'Erin' roses grafted on the rootstock *R. manetti*. Data points are means± S.E. of nine plants. The arrows denote the days when diurnal patterns of water and nutrient uptake were evaluated (see text and Figure 2).

Within this flowering cycle we also evaluated the diurnal (hourly) patterns of water and nutrient uptake. The first 24-hour cycle (Day 25; Fig. 2) was originally chosen to be within the period when the flower shoots were elongating (growing) at their fastest rate, and when whole plant nutrient uptake was also around its lowest point during this flowering flush. The second 24-hour cycle (Day 44; Fig. 2) corresponds to a day just before flower harvest. As previously reported, and expected, and regardless of the phenological stage of the crop, daily water uptake (transpiration) peaked at mid-day, between noon and 1pm (Fig. 2), corresponding to the period of maximum evapotranspirative demand, and was minimal during the dark night hours. The higher leaf area and plant biomass present in the plants just before harvest explains the higher hourly transpiration rates observed at Day 44 compared to Day 25.

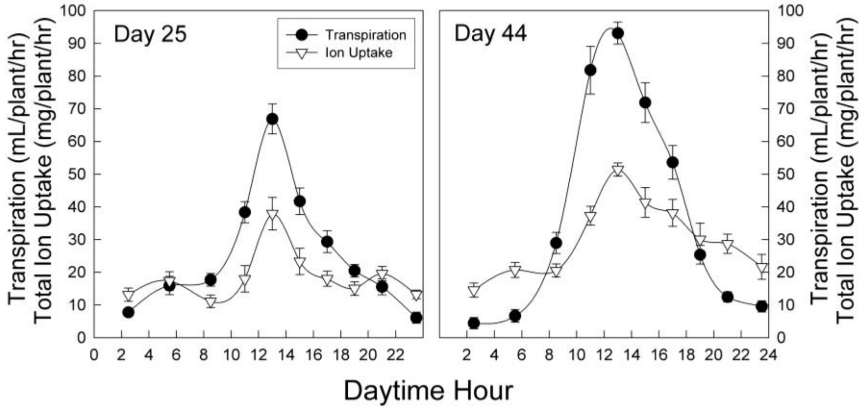

Figure 2. Hourly patterns of water and total ion (salt) uptake for two days in the growth & flowering cycle of hydroponically-grown 'Erin' roses grafted on the rootstock *R. manetti*. Data points are means± S.E. of nine plants.

With respect to total ion (fertilizer salt) uptake, the average hourly rates were significantly lower during Day 25 compared to the day preceding harvest (Day 44). While the peak hourly nutrient uptake also coincided with maximum water uptake between 12pm and 1pm, it was noticed that nutrient uptake rates in the afternoon hours remained at higher levels than those seen during the night and morning hours. A quick evaluation of the areas under the ion uptake curves (Fig. 2) suggests that a larger fraction of total daily ion uptake occurs in the afternoon hours (from about 2pm to 8pm) compared to the morning hours (from about 8am to 2pm). This is very interesting as over a decade ago we observed that 'Royalty' roses growing on *R.* 'Manetti' showed maximum nitrate-nitrogen uptake rates in the afternoon to early evening hours (Cabrera et al., 1996). We are currently trying to actually measure diurnal (hourly over 24-h periods) nitrate and potassium uptake rates to confirm these observations. For our next report we are also calculating the actual fractions (percentages) of total water and nutrient uptake that occur over discrete periods throughout the day, and for all the 24-h cycles that we have run so far (including three cultivars and two rootstocks).

REFERENCES

Cabrera, R.I. 2003. Mineral Nutrition. In: A. Roberts, S. Gudin and T. Debener (Eds.), Encyclopedia of Rose Science, pp. 573-580. Academic Press. London, UK.

Cabrera, R.I., R. Evans and J. Paul. 1995. Cyclic nitrogen uptake by greenhouse roses. Sci. Hort. 63: 57-66

Cabrera, R.I., R.Y. Evans and J.L. Paul. 1996. Enhancement of short-term nitrogen uptake by greenhouse roses under intermittent N-deprivation. Plant and Soil 179: 73-79.

Mattson, N.S. and J.H. Lieth. 2005. Modeling macronutrient uptake of hydroponically-grown cut flower roses. 4th Int. Symposium on Rose Research and Cultivation. Program and Book of Abstracts, pg. 5.