Evaluating rootzone stresses and the role of the root system on rose crop productivity and fertilizer-water use efficiency:

Leachate chemical quality and cumulative biomass and flower yields

Raúl I. Cabrera
Texas A&M University
Research and Extension Center
17360 Coit Road, Dallas, Texas 75252

Now at Rutgers University
Cabrera@aesop.rutgers.edu

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ICFG-HILL, P.O. Box 99, Haslett, MI 48840
ICFG.HILL@yahoo.com

Since the last report we collected data for two additional flowering cycles. But before we get into the biomass and flower yield data, let's examine the leachates collected from representative one-half root sections receiving the different stressing solutions described in the previous report. In addition to being interested in the leachates' chemical quality (namely EC and pH), determination of their volume allowed us to adjust our irrigation events and volumes as to approximate the targeted leaching fractions of 25% across all treatments.

It should be noted here that it took some inspiration to figure out how to collect leachates without moving or disturbing the split root systems. In the past we used to just lift the pots and place a leach tray beneath them, but the combination of relatively large canopies, its supporting net (to hold flower stems up) and the split root system made it basically impossible to follow the same approach. Fortunately the plants were placed atop benches fitted with heavy duty, aluminum mesh surfaces, which allowed free drainage (Fig. 1) and the placement of leach trays suspended underneath the selected containers (one-half root sections). Each suspended leach tray was slanted and a drainage hole made on the lowest corner, which dripped to a 2-quart plastic container located beneath it.

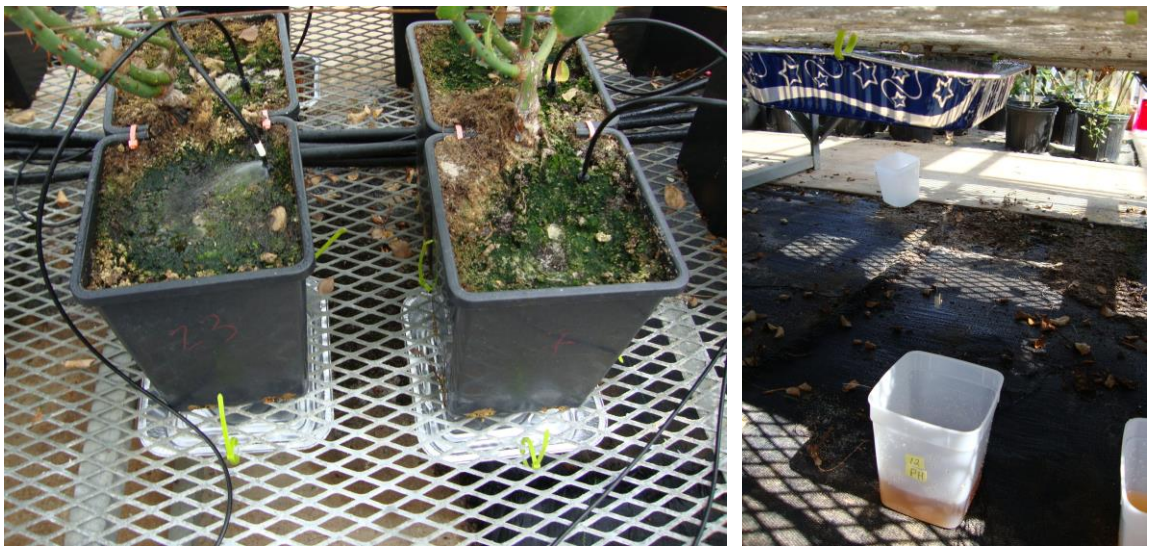

Figure 1. Aluminum trays suspended beneath pots were used to collect leachates from selected rose root half-sections (split root system) fertigated with differential nutrient solutions.

Regarding the EC of the leachates, which denotes their overall salinity, we expected to have the highest values in those root halves receiving the NaCl stress, whose starting solution EC was 4.7 dS/m, compared to 1.7 dS/m for the control solution. Interestingly, while the leachate EC from the NaCl treatment was high, averaging 7.0 dS/m, it was the high-urea solution treatment that produced the highest leachate EC values, averaging 8.1 dS/m (Fig. 2A), and contrasting the average value of 5.3 dS/m observed across the rest of the treatments, including the control. How could the urea treatment produce such high leachate EC values when its initial solution EC was basically the same as the control solution (1.8 dS/m)? In its native form urea is a non-polar

molecule, meaning it does not contribute to the electrical balance of a solution. However, once it dissociates (breaks down), thanks to the effect of the ubiquitous urease enzyme found in soil/substrate microorganisms, it produces two NH_3 molecules (plus one CO_2 molecule) which do contribute to the soil solution EC as they turn into NH_4+ ions, or as they are later converted to NO_3- (Marschner, 1995). Nevertheless, we estimated that even if all of the urea was to rapidly dissociate in solution and remain as NH_4+ or be nitrified (converted) to NO_3- ions, it would raise the base nutrient solution EC by 0.7 dS/m, to yield a final value of 2.5 dS/m, way below that of 4.7 dS/m observed in the NaCl solution. These observations lead us to believe that a rather high accumulation of NH_4+ and/or NO_3- ions occurred in the soil solution of the root halves exposed to the high urea treatment, contributing to the high EC values observed in the leachates. This contention is based on our previous research on the N nutrition of roses, where it has been demonstrated that the plants have a tight control over N uptake (Cabrera et al., 1995, 1996), and that the non-absorbed N molecules thereby can significantly contribute to the EC of the leachates (Cabrera, 2000; Cabrera et al., 1993). We are planning on analyzing the total and ionic N content of refrigerated leachate samples to confirm this hypothesis.

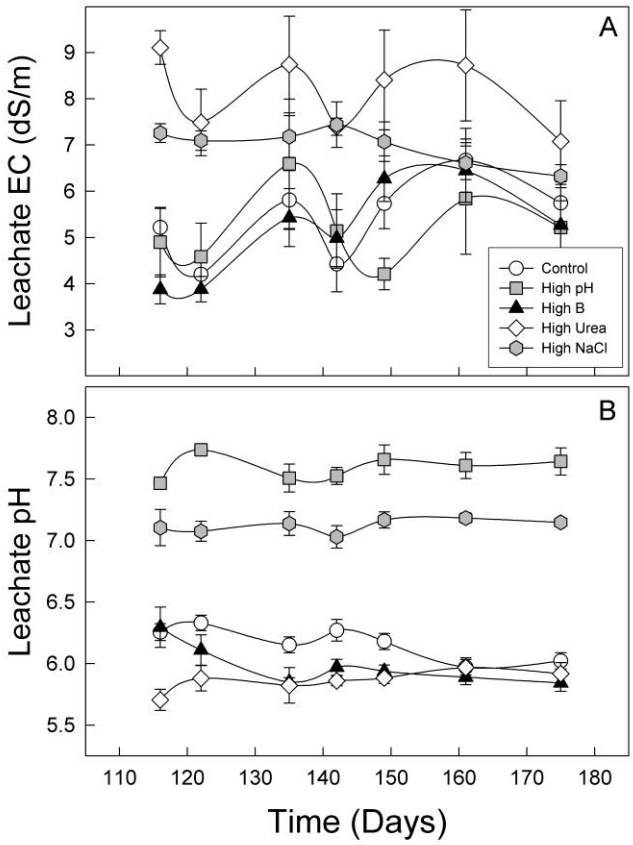

Figure 2. Electrical conductivity (A) and pH (B) in leachates collected from 'Revival' roses (on 'Natal Briar') growing on a split-root system fertigated with differential nutrient solutions.

With respect to leachate pH, the highest values were, expectedly, found for those collected from the root halves receiving the high pH (alkalinity) solutions, averaging 7.6 (Fig. 2B). Interestingly, these were closely followed by those collected from the root sections receiving the high salinity (NaCl) solutions, at 7.1, contrasting the average value of 6.0 observed for the rest of the treatments. It does appear that the addition of 30 m*M* NaCl to the base solution influences not only its overall EC, but significantly changes the chemical dynamics in the rhizosphere (soil solution) as to elicit significant increases in its pH. No doubt that this additional effect will have undesirable effects on the plants besides the actual salinity stress that was originally intended for this treatment.

The total cumulative biomass and flower yields and quality, after five flushes of growth and flowering, are shown in Table 1. While the data after three flower flushes (see our previous report) did not show substantial differences among treatments, the trends predicted from it are confirmed after five flushes. Compared to the control plants, the stressing nutrient solutions high pH, high boron and high NaCl, even when affecting only one-half of the root system, had negative impacts on harvested dry weights and flowers. These yield reductions ranged from 6 to 21 % for total plant biomass (for high B and high NaCl, respectively), and 8 to 17 % for harvested flowers (also for high B and high NaCl, respectively). The biomass and flower reductions observed for the plants receiving the high pH solution were in between these ranges. Conversely, the plants with one-half of their roots subjected to the high-urea treatment had biomass and flower yields that were 13 and 10% higher, respectively, than those values observed in the control plants (Table 1). This is a rather interesting observation, considering the above mentioned fact that the leachates from the high-urea treatment showed the highest EC values, even above those for the high NaCl treatment!

Table 1. Growth, flower productivity and quality in rose plants ('Revival' on 'Natal Briar') growing on a split-root system fertigated with differential nutrient solutions. Cumulative data after five flower flushes. Means of 8 plants/treatment, except the last (bottom 4) treatments which are means of 2 plants (observational treatments only).

Treatments		**Total DW-g**	**Harvested Stems**	**Stem Length**	**Stem DW**	**Leaf Chlorophyll**
Pot 1	**Pot 2**	(g/plant)	(per plant)	(cm)	(g/stem)	(SPAD)
Control	**Control**	163	41	31.3	4.1	43.3
Control	**pH**	147 (-10)	36 (-12)	29.8	4.2	40.9
Control	**Boron**	153 (- 6)	38 (- 8)	30.3	4.4	43.3
Control	**Urea**	185 (+13)	45 (+10)	29.8	4.2	44.0
Control	**NaCl**	129 (-21)	34 (-17)	26.8	3.6	41.0
Additional observational treatments						
NaCl	**High pH**	123 (-25)	30 (-27)	26.8	4.0	44.4
Urea	**High pH**	168 (+ 3)	44 (+ 8)	28.0	3.8	43.4
Urea	**High B**	155 (- 5)	42 (+ 3)	27.1	3.9	44.1
NaCl	**High B**	121 (-26)	33 (-20)	25.8	3.0	38.4

NOTE: The numbers shown in parentheses denote the % change of that variable and treatment with respect to the plants receiving the control solution on both root halves.

Leaf chlorophyll concentrations in the harvested shoots were equally high, averaging 43.5, for the plants exposed to the control, high urea and high B treatments, whereas they averaged 41 for the high pH and high NaCl treatments. These treatment differences were more visible in the non-harvested leaves, including scorching and necrosis symptoms, which were more severe in plants subjected to the partial high pH and high NaCl solutions. These results are being analyzed and will be highlighted in the next report.

In our experiments we always include guard or border plants that surround our treatment plants (a standard practice recommended for collection of data deemed sound for statistical analyses). For observational purposes we decided to subject some of these border/guard plants to a combination of two stress solutions (one per root half; see treatments on bottom of Table 1). The worst biomass and flower yield performance was confirmed to occur in the plants receiving the high NaCl salinity coupled with high pH (alkalinity) and high B, causing reductions of 20-27% compared to control plants. This observation lends more support to the susceptibility or rose plants, at least those grafted on 'Natal Briar', to salinity stress (Cabrera and Perdomo, 2003; Cabrera et al., 2009) and its compounding and worsening effect when coupled to other stresses.

Interestingly, the coupling of high pH and high B solutions (in one-half of the roots) with high urea (in the other one-half) produced biomass and flower yields that were comparable or higher than those observed in the control plants! Unfortunately we did not collect leachates from these "extra" observational treatments to get a better insight as to what might be happening. Nevertheless, it is suspected that the addition of urea in one-half of the root systems improved the chemical dynamics in those sections as to promote the uptake of optimum N levels and/or NO_3- to NH_4+ ratios that were conducive to counteract the negative effects of high NaCl and high B on the other root half-section, and sustain overall plant biomass and flower yields. Previous research has shown that plant productivity in most agronomic and horticultural crops, including greenhouse roses, are maximized when approaching an optimum NO_3- to NH_4+ ratio in the soil (solution), which is around 3:1 (Cabrera et al., 1996; Marschner, 1995).

For the next report we'll have information on whole plant quality, biomass and partitioning among organs, and tissue nutrient concentrations.

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