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

First flower harvests

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Early this past spring we started the treatments in the main study to characterize the performance of roses growing on a split-pot system that had one half of their roots exposed to various challenging stresses, namely high pH (alkalinity), high salinity, high boron and high nitrogen and ammonium to nitrate ratios. In here we report preliminary results of flower productivity yields and quality on the first three flower flushes.

Results to date

As mentioned in a previous report, we started growing 'Revival' roses (on 'Natal Briar' rootstock) on a split-root system. Basically this means splitting the roots into two adjacent (paired) square Dutch rose pots. The plants were allowed to acclimate to this split root system for a few months, with both "Siamese" containers receiving the same nutrient solution (0.5X Hoagland). In March the plants started to receive differential nutrient solutions in one of their pots (half of the roots), with the other pot continuing to receive the standard (control) 0.5X Hoagland solution (see Table 1 below). For observational purposes, some of the plants used to guard the rose beds (aka, border plants) were subjected to a combination of two stress solutions.

As mentioned before, root containers were individually irrigated with Roberts spitters (one per pot) hooked to the tanks containing the five nutrient solutions (Table 1). Enough solution volumes were applied to each treatment to produce target leaching fractions of ~25%.

Table 1. Solutions, and some of their chemical variables, used in the rose split-root system.

Solutions	EC (dS/m)	pH	Nitrogen (ppm)	Boron (ppm)	NaCl (m*M*)
Control Solution	1.7	6.5	133	≤ 0.6	1.5
+ High pH	1.9	8.1	133	≤ 0.6	1.5
+ High Boron	1.7	6.1	133	1.6 - 1.8	1.5
+ Urea	1.8	6.5	133 (+98 urea)	≤ 0.6	1.5
+ NaCl	4.7	5.8	133	≤ 0.6	31.5

Notes: The tap water used to prepare solutions had pH= 7.64, EC= 0.46 dS/m, B= 0.15 ppm and NaCl= 1.5 m*M*. The EC and pH values shown above are averages of actual readings on final solutions. All solutions had all nutrients at 1/2X Hoagland concentrations, plus the supplemental (stressor) levels of high pH (alkalinity), boron, urea and salt highlighted in the treatment solutions.

The plants have been managed through pruning practices to produce synchronized flushes of growth and flowering. To date we have conducted three (3) harvest events, and the data on cumulative biomass/flower productivity and average quality are presented in Table 2. As in previous studies on nutrient/water management in roses, we have found that it takes 1-2 flower flushes after onset of treatments to begin to see trends or significant differences in flower productivity and/or quality. The first flower flush (data not shown), which happened in late spring, produced the best quality flowers and highest productivities across all treatments. The effect of the stressing nutrient solutions started to be appreciated by the third flower flush. The second and third flowering flushes also coincide with the onset of the highest daily greenhouse temperatures (summer season), which required more frequent irrigation intervals to meet the higher evapotranspiration demands.

Table 2. Biomass, flower productivity and quality in rose plants ('Revival' on 'Natal Briar rootstock) growing on a split-root system fertigated with differential nutrient solutions. Results are the plant sums/averages after three flower harvest cycles.

Treatments		**Total DW**	**Harvested Stems**	**Stem Length**	**Stem DW**	**Leaf Chlorophyll**
Pot 1	**Pot 2**	(g/plant)	(per plant)	(cm)	(g/stem)	(SPAD)
Control	**Control**	118.5	25	34.4	4.8	44.2
Control	**High pH**	114.2	24	33.1	5.0	42.8
Control	**High B**	112.4	25	33.2	5.0	44.1
Control	**Urea**	141.3	28	33.2	5.2	45.1
Control	**NaCl**	110.5	26	31.2	4.2	43.3
NaCl	**High pH**	96.9	21	27.7	4.4	44.9
Urea	**High pH**	131.0	32	29.7	4.3	44.9
Urea	**High B**	104.8	23	28.9	4.6	43.7
NaCl	**High B**	114.9	28	28.1	3.8	42.2

Notes: Values are means of 8 plants per treatment, except the last (bottom 4) treatments, which are means of 2 plants (observational treatments only).

Looking at the cumulative data for the first three harvests, there are no apparent differences in biomass or flower yields, except for the higher values in the plants receiving urea in one-half of their root system. In addition, this treatment also had higher individual stem dry weights and the highest average chlorophyll readings (darker green color). The supplemental nitrogen provided as urea, which breaks down readily into ammonium ($NH4^+$) in soil solution, is likely responsible for this response. Our previous research on the nitrogen nutrition of roses indicates that the application of 25-30% of the total N as ammonium produces the highest biomass and flower yields (Cabrera et al., 1993, 1996). In this case, the urea supplementation treatment to one ½ of the root system provided an ammonium fraction of 42% of the total N, which was also higher by 98 ppm compared to the standard solutions. It is hypothesized that contrary to the expectation of ammonium-toxicity symptoms, the coupling of higher solar radiation conditions in the summer months maximized productivity with the supplemental $NH4^+$-N. The literature and practice do suggest, however, that such scenario could be very different in the winter months, where diminished carbohydrate production (reduced photosynthesis by lower light levels) could not metabolize the excess ammonium and lead to toxicity symptoms (Cabrera, 2000; Cabrera et al., 1993, 1996; Marschner, 1995). We will have to wait for additional flowering cycles to see the longer term effects of such higher N concentrations and ammonium fractions.

It should be noted that although there were no apparent reductions in cumulative biomass and flower yields in the plants receiving high NaCl in one-half of their roots, by the third harvest we appreciated the beginning of classical salt burn damage to the lower (older) leaves (Cabrera and Perdomo, 2003). It appears that rose plants are still fairly sensitive to NaCl salt stress even when it is only partially localized in one ½ sector of the root system, and that the half receiving the standard (non-saline) solution apparently can not offset those global effects on the above-ground tissues. Interestingly the plants receiving high boron concentrations in one half of their roots did not show any apparent B toxicity symptoms. Plants receiving high pH (alkalinity) in half of their roots started to show lighter colored leaves by the third harvest, observation supported by the relatively lower chlorophyll levels recorded, which suggests the likely onset of chlorosis (Reed et al., 1992). A more severe chlorosis is expected in future harvests.

On the observational dual-stress treatments (on bottom of Table 1), the worst biomass and flower yield performance to date was in the plants receiving the combination high NaCl salinity and high pH (alkalinity) in their root systems, which is not surprising. We await to see the plant response to the other dual-stress treatments.

We are collecting leachates from the various treatments, and we'll have information on some of their chemical properties for the next report, when we expect to observe more significant differences between the various treatments in yield and quality. Representative leaves have been collected from all harvests and treatments, and will be subjected to full nutrient analyses to better help elucidate the plant responses.

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