

Progress report to the International Cut Flower Growers Association

Development of a Model for Rose Productivity

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The work on this project is continuing in three areas: (1) the effect of root zone oxygen (and related variables) on hydroponic rose production, (2) modeling nutrient uptake by the plant from the root zone and (3) the development of a rose timing tool.

Root zone oxygen

Root zone oxygen is known to be an important element for the proper functioning of plants. It can be provided to the roots by several methods. In growing media with sufficient air porosity, diffusion through the air can supply enough oxygen to the roots. However, roots subjected to water-saturated growing media may use the available oxygen at higher rates than the rate of replenishment by diffusion. Oxygen is also delivered to the roots through the oxygen dissolved in irrigation water. Our recent observations suggest that this can be the most important method for oxygen delivery in hydroponically grown crops and actually determines the ideal irrigation frequency. This is consistent with observations by many growers that hydroponic crops benefit from frequent irrigations during the day even if the total amount of water and fertilizer is far more than needed by the plants. Since frequent over-irrigation is wasteful both from the standpoint of excess energy consumption due to excessive pumping costs (in recirculating systems) as well as due to discharge of pollution into the environment (in non-recirculating systems), we are seeking to develop better methods for the balancing the oxygen requirements of the plant with those for fertilizer and water.

Our current work focuses on maintaining normoxic levels (adequate levels for proper root function) in the growing media of hydroponically grown roses and chrysanthemum. While some of the work reported here is for cut-flower roses, much of the experimentation was done on chrysanthemum so as to get fast results since this crop grows very rapidly (while roses grow relatively slowly).

One of the method discussed in this report is the use of hydrogen peroxide (H_2O_2) in the nutrient solution to maintain higher concentrations of oxygen since some growers have reported benefits from supplying H_2O_2 to their plants. The breakdown of H_2O_2 results in water and oxygen ($2 \text{H}_2\text{O}_2 \rightarrow 2 \text{H}_2\text{O} + \text{O}_2$). Since both endproducts are molecules needed by plant roots, it makes sense that this process could be beneficial to the plant. This report discusses our recent and current work in this area. (We are also working with other methods of increasing oxygen in the root zone, but are not yet ready to report on this).

Materials and Methods

Hydroponic Rose test: Our first test focused on testing the effects of H_2O_2 on rose plants growing in liquid culture with air bubbled into the solution with aquarium pumps. Two roses were grown in nutrient solution in this way without substrate. To impose oxygen deficiency,

each of the roses' air bubblers were removed and their nutrient solutions were left stagnant. Then one of the roses' nutrient solutions was treated with ~20 ppm of H₂O₂ for 3 weeks.

Chrysanthemum test: Chrysanthemum plants (variety 'Olympia', supplied by Yoder Brothers) were used in this part of the research to carry out a set of rapid experiments whose results will later be tested on roses.

A preliminary test was designed to subject plants to various concentrations of H₂O₂ to see what the effect might be so as to allow us to design experiments with treatments that make sense. We used 35ppm as the basis for our test since various growers had found this to be a reasonable level. Five concentrations levels, Control=0X, 1X, 2X, 4X, and 8X, were tried on plants growing in liquid culture in nutrient solution. The visual observation results from this led us to use these levels in all subsequent work.

An experiment was run to investigate the effect of these concentration levels on biomass accumulation. 'Olympia' mums were grown in UCMix in 1 gallon containers at one plant per pot. The treatments were as indicated above. At the end of the experiment the shoot and root fresh weights were determined and compared using statistical analyses. Visual observations were also recorded.

Results and Discussion

Hydroponic Rose plants: The hydroponically grown rose which was treated with H₂O₂ showed extensive interveinal chlorosis in the new leaves. After three weeks of imposed treatment we decided to see if this could be alleviated with an application of chelated iron. As a result the chlorotic leaves became darker green and looked healthy, suggesting that the H₂O₂ treatments may be responsible for iron deficiency if the conventional rates are used.

Chrysanthemum: The 35ppm treatment (1X) did not result in more shoot or root growth in chrysanthemum growing in substrate (Table 1). At the same time it also did not result in significantly lesser growth.

Table 1. Stem and root fresh weights (grams) among the H ₂ O ₂ treatments. Different letters after mean values indicate that means in each of the columns are significantly different (Tukey means separation test; 10 observations).		
Treatment	Mean Shoot Fresh wt	Mean Root Fresh Weight
Control	42.2 a	21.8 a
1X	41.5 a	21.0 a
2X	41.0 a	19.0 ab
4X	38.6 a	15.1 bc
8X	32.5 b	12.5 c

The 8X treatment on the other hand resulted in significantly lower shoot biomass. The root

weights from 0X, 1X, and 2X treatments were not different from each other. The plants treated at 4X and 8X did have significantly less root biomass than the plants in the control or 1X treatment.

At the same time, it is probably not just coincidence that the means for both shoot and root biomass appear to decline with applied concentration of H₂O₂, suggesting that even the lowest concentrations H₂O₂ had a negative impact. This can be tested with greater sample sizes and statistical analyses that specifically test for trends. Future test will be designed with this in mind.

Conclusions

While considerably more work needs to be done, some preliminary conclusions can be drawn.

Overall the plants that were grown in liquid culture in nutrient solution were affected more drastically by the introduction of hydrogen peroxide than those grown in UC Mix. This could be explained by the fact that H₂O₂ acts as an oxidant with the substrate acting as buffer.

A sanitation effect may also explain why growers are finding a benefit while we are not seeing this. It may be that growers have latent, near-negligible levels of root zone pathogens that are inhibited or destroyed through the sanitation effect of the H₂O₂, thus compensating for losses in biomass.

At the same time we may be observing the negative effects of the interaction between pH and iron availability. Thus it is as yet too early to draw conclusions as to the suitability of hydrogen peroxide as a supplement in hydroponic production. However, it does seem clear that its ability to supply oxygen is not a significant factor.

Another difference between growing crops in a growing media and nutrient solution is pH fluctuation. In a growing media there is much more of a buffer for pH, and its fluctuations will not be as drastic. The pH in nutrient solutions can fluctuate much more in shorter periods of time, and it is known that pH affects plants' ability to absorb iron. Since we did not anticipate this results we did not initially track substrate pH (all ongoing experiments with H₂O₂ track pH).

Modeling Rose Nutrition

The previous progress report reflects the latest results that we can report at this time on the facet related to nutrient uptake.

Rose Timing Tool

The Rose Timing Tool consists of software that uses the developmental submodel of the rose crop model to calculate pinch dates in relation to harvest dates. This assumes that one set of heat unit parameters per variety is adequate to calculate timing information throughout the year.

In earlier work we noticed that the number of heat units required to reach developmental

events in roses differed in winter and summer. For example for Fire and Ice 775 heat units were required in the winter and 640 in the summer. Since the heat unit equation takes temperature into account these differences must be due to an effect other than it simply being warmer in the summer than winter (that effect is indeed captured by the heat-unit model). We suspect that this may be an artifact of how we measure crop temperature. In our data collection (and in the way data are collected in production greenhouses) temperature sensors were placed within the leaf canopy level to measure canopy air temperature. It is possible that higher light levels increase the temperature of developing shoot tissues to a greater degree than air temperature. Thus, we are currently testing the hypothesis is that light has an effect on development by raising the temperature of flower shoots more than it raises canopy air temperature.

Thus we are currently conducting an experiment to determine whether or not light itself may be responsible for decreasing the length of a crop cycle; or if light affects cycle length through its effect on shoot temperature. In this experiment plants are grown under 3 light treatments: control (ambient light only), +80 (ambient light plus $80 \mu\text{mol m}^{-2} \text{s}^{-1}$ of supplemental light from HPS lamps), +240 (ambient light plus $240 \mu\text{mol m}^{-2} \text{s}^{-1}$ supplemental light from HPS lamps). Four temperature sensors are used for each light treatment: canopy level air temperature, flower shoot level air temperature, shoot tip temperature, leaf temperature (leaf near the shoot tip). The number of heat units required to reach each developmental stage will be calculated using each of these temperature sensors. In addition, the experiment will determine the influence of supplemental light on flower stem yield, flower stem quality, and the number of blind shoots.

This experiment is on-going and it is as yet too early to report results.