Starter Fertilizer and Plant Water–Use Can Modify Fertilizer Requirements

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Nature of Work: Subirrigation systems have become more popular in recent years due to zero runoff and increased efficiency in fertilizer and water use (1). As leaching from the growing medium is practically absent in subirrigation, starter fertilizer can remain in the growing medium for a longer period and affect fertilizer requirements by supplying a substantial amount of nutrients to plants. A change in plant water use can also affect fertilizer requirements of subirrigated plants. To assure that the appropriate amount of nutrients is applied, plants consuming a relatively large amount of water to produce one gram of dry matter (or low water use efficiency, WUE) should be fertilized with a lower concentration of fertilizer than plants which use water more efficiently. The required N concentration in the fertilizer for optimum tissue N (N_{FERT}, in ppm or mg/L) can be calculated as the desired tissue N concentration (in mg/g) times the WUE (in g/L).

As light intensity affects WUE due to its effect on growth and transpiration in plants, changes in light intensity can affect optimum fertilizer concentration of plants. Surprisingly, there is only one research report on the effect of WUE on optimum fertilizer concentrations of subirrigated plants (2). We hypothesized that a change in light intensity would affect WUE and thus the optimal fertilizer concentration of subirrigated plants.

Plug seedlings of Wax begonia ‘Cocktail vodka’ were obtained from a commercial grower and transplanted into 4 inch containers filled with soilless growth medium (Fafard 2P mix), with or without (leached with tap water) starter fertilizer. The average electrical conductivity (EC) of these media was 2.1 and 0.9 mS/cm, respectively. After transplantation, seedlings were placed on 4' x 8' ebb and flow benches, and subirrigated with fertilizer solutions made from Peter’s 20 10 20 Peat Lite Special. Two groups of plants (with and without starter fertilizer), consisting of 30 plants each, were grown under three different light intensities (63, 35 and 0 percent shade resulting with an average photosynthetic photon flux of 4.4, 6.2 and 9.8 mol/m^2/day, respectively) and subirrigated with one of the four fertilizer concentrations (0, 50, 130, or 210 ppm N, corresponding ECs of 0.15, 0.33 , 0.86 and 1.4 mS/cm, respectively). Shoot dry weight, leaf area, flower number, N_{FERT}, and WUE of plants were measured at the end of the experiment. To determine water use efficiency, net photosynthesis and dark respiration (P_n and R_d, expressed in mol/s) were measured using a whole plant gas exchange system (3). Water lost in evapotranspiration (ET) was measured as the difference in the weight of the pots before and after the gas exchange measurements. Growth rate (GR) was calculated as follows:

$$GR = (P_n \times t_{light} - R_d \times t_{dark}) \times 0.0036 \times 12 / f_c,$$

where t_{light} and t_{dark} are the durations of light and dark period (in hours), the factor 0.0036 converts mol/s to mol/h, 12 converts moles of carbon to grams of carbon, and f_c = carbon content of the plants (in g/g, converts g of C to g of dry matter). Water use efficiency (grams of dry matter per liter of water lost in ET, expressed in g/L) was calculated as WUE = GR/ET.

The treatments were organized in a split-split plot design with three replications. Data were subjected to ANOVA and regression analysis with $P < 0.05$ considered to be statistically significant. To describe the effect of increasing light intensity (light) and fertilizer concentration (ppm) on the plants, we fitted the following polynomial regression with an interaction term:

$$Y = \beta_0 + \beta_1 \times ppm + \beta_2 \times light + \beta_3 \times ppm^2 + \beta_4 \times light^2 + \beta_5 \times ppm \times light,$$

where Y is the dependent variable of interest and $\beta_1 \ldots \beta_5$ are regression coefficients. The fitted polynomial regression was reduced further by backward selection ($P < 0.05$).

Results and Discussion: When the growing medium contained a starter fertilizer, shoot dry weight did not respond to increasing fertilizer concentration, but without a starter fertilizer, dry weight responded quadratically with increasing fertilizer concentration (Fig. 1A). Maximum growth was obtained with fertilizer concentrations of 130 to 210 ppm, independent of light intensity. Leaf area and number of flowers per plant responded similarly (data not shown).

There was an interactive effect of light intensity and fertilizer concentration on WUE and N_{FERT} of plants (Fig. 1B). Water use efficiency and N_{FERT} were higher for plants grown at 9.9 mol/m^2/day than for those at 6.2 or 4.4 mol/m^2/day, especially at high fertilizer concentrations. Treatment effects on WUE and N_{fert} suggest that plants at high light intensity should be grown with higher fertilizer concentrations. However, this was not confirmed by the treatment effects on dry weight or leaf area of the plants. Those data indicated that the optimal fertilizer concentration was the same at all light intensities (130 - 210 ppm N in a growing medium without starter fertilizer). The absence of an interactive effect of fertilizer EC and light intensity on dry weight or leaf area indicates that the fertilizer concentration does not need to be adjusted based on light intensity. Based on our findings, begonias should be fertilized with 130 - 210 ppm N (equivalent to an EC of 1.2 mS/cm) if the growing medium does not contain a starter fertilizer, while low concentrations (about 50 ppm N) can be used for media with a starter fertilizer.

Significance to Industry: Quality of bedding plants greatly depends on the supplied fertilizer concentration. Subirrigated wax begonias can be produced with very little fertilizer if the growing medium contains a starter fertilizer. This would also reduce potential toxic effects of excess fertilizer, which could reduce plant quality and result in a monetary loss. If the growing medium does not contain a starter fertilizer, concentrations of 130-210 ppm should be used. These concentrations do not need to be adjusted based on light intensity.

Literature cited:

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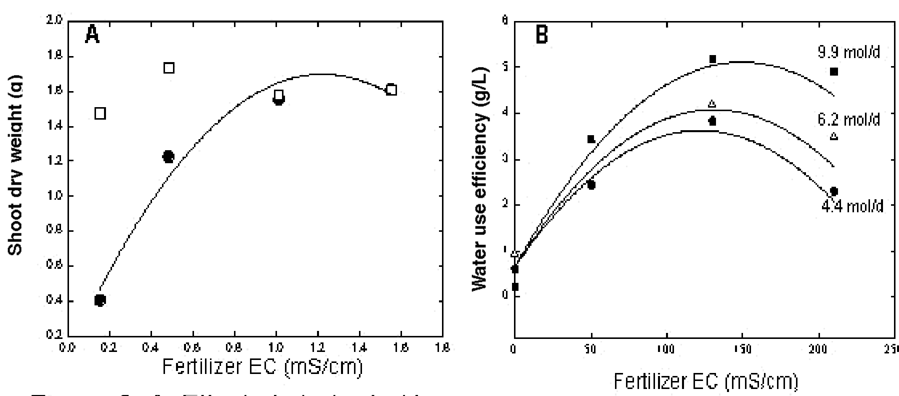

Figure 1. A. Effect of starter fertilizer a
tion on shoot dry weight of subirrigated wax begonias at the end of experiment, '•' indicates without starter fertilizer and '^' indicates with starter fertilizer. B. Effect of light intensity and fertilizer concentration on water use efficiency of wax begonias at the end of the experiment. The lines indicate a significant quadratic effects.