Fertilization guidelines for Subirrigation of Six Bedding Plant Species

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As water becomes an increasingly precious commodity, greenhouse growers turn to closed subirrigation systems, which can not only conserve water, labor and fertilizer, but also can produce more uniform crops compared to overhead or drip irrigation. Subirrigation requires a different fertilization program than more traditional irrigation systems. Because excess nutrients are not removed by leaching, the electrical conductivity of the growing medium (EC, a measure of the amount of salts in the growing medium) of subirrigated plants often increases during production. Therefore, fertilizer guidelines for subirrigation systems commonly use lower fertilizer concentrations than overhead irrigation systems.

More and more, researchers and extension specialists give fertilizer recommendations based on the EC of the growing medium, instead of recommendations based on fertilizer concentrations. This is because fertilizer recommendations based on the EC of the growing medium give a better indication of the nutrient availability to the plant, as well as the potential for salt stress which can damage the roots and leaves. Growing medium-based guidelines also have the advantage that they are less dependent on environmental conditions.

In the past, we have reported fertilizer guidelines for subirrigated pansy, petunia, and begonia (see GMPRO February, 2001; Greenhouse Grower, March 2001). In this issue, we bring you results of our continuing research on bedding plants and subirrigation.

Plant Materials and Nutrient Solutions

Plug seedlings of alyssum ‘New Carpet of Snow’, celosia ‘Gloria Scarlet’, dianthus ‘Telstar Crimson’, gomphrena ‘Gnome White’, stock ‘Special Mix’, and zinnia ‘Dreamland Mix’ were transplanted into cell packs filled with a soilless growing medium with an initial pH and EC of 5.7 and 2.1 mS/cm (determined with the saturated media extract method).

We watered the plants with a specially-formulated nutrient solution in which all necessary nutrients were dissolved. The advantage of using such solution is that we know and can vary the exact concentration of each nutrient in it and we can add all the necessary macro- and microelements required for plant growth. This nutrient solution is not unlike the solution which exists in a regular well-watered growing medium, minus the solid particles and the air. We used five nutrient solutions with EC of 0.4, 0.7, 1.1, 2.0, and 3.7 mS/cm (26, 52, 105, 210, and 420 ppm N, respectively).

Measurements

We used the aboveground plant parts (shoots) to measure the effects of nutrient solution concentration on plant growth. One of the most accurate indicators of plant growth is dry weight, which is measured by weighing plants after drying them in an oven. Shoot dry weight tells us how much “substance” or weight (cell components, cell walls, etc.) the plant has accumulated and thus, how is it affected by the treatments. We measured the amounts of macro- and microelements in the leaf tissue, which is indicative of the actual nutritional status of the plant. Also, we measured the chlorophyll content in the leaves. Chlorophyll is the main pigment responsible for light harvesting in the photosynthetic process, and its synthesis is dependent on the supply of magnesium and other mineral elements. Low chlorophyll content would mean low capacity for photosynthesis and growth.

We also measured indicators of plant appearance, such as height, flower size and number of flowers. Because the growth characteristics of the species differed, we collected slightly different data from each species. Leachate EC and pH were measured using the pour-through method.

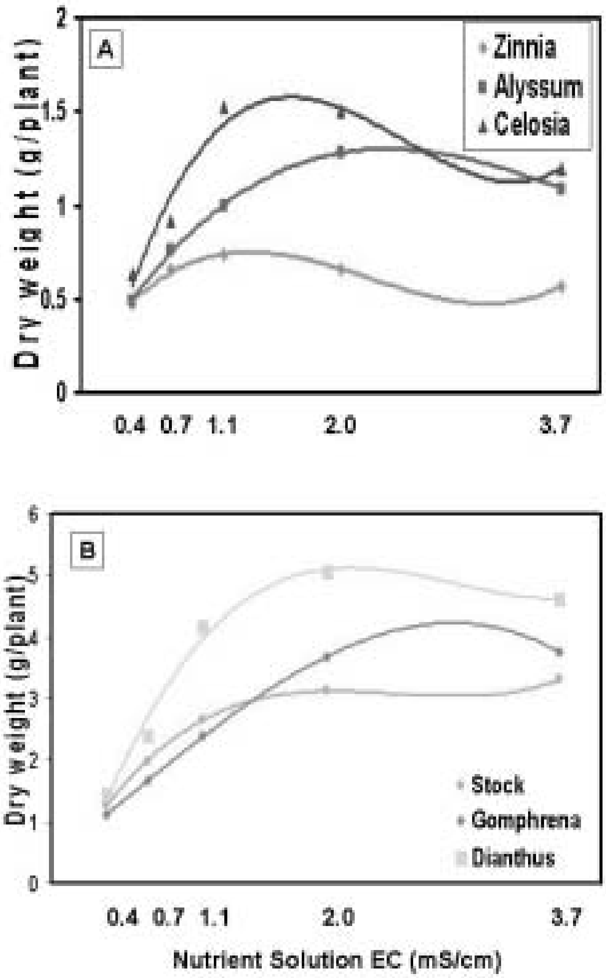

FIG. 1. Effect of nutrient solution concentration on dry weight of (A) alyssum, celosia and zinnia, and (B) dianthus, stock, and gomphrena. Note the different Y-axis scales in A and B.

Plant Growth

Alyssum grew best when fertilized with a nutrient solution with an EC of 2.0 mS/cm (Table 1). Both higher and lower fertilizer EC reduced growth, and this was especially noticeable with fertilizer ECs of 0.4 and 0.7 mS/cm (Fig. 1A). Celosia grew best when fertilized with a nutrient solution with an EC of 1.1 and 2.0 mS/cm (Fig. 1A), and dianthus grew best when fertilized with a nutrient solution with an EC of 2.0 mS/cm (Fig. 1B). In dianthus, low nutrient solution EC (0.4 and 0.7 mS/cm) decreased plant growth greatly compared to higher EC. The number of flowers of dianthus increased with increasing fertilizer concentration, which was probably due to an increase in the overall size of the plants, since both the number of flowers and dry weight were higher with increasing fertilizer concentrations. Gomphrena and stock preferred high fertilizer concentrations and grew best when fertilized with a nutrient solution with an EC of 2.0 and 3.7 mS/cm (Fig. 1B), while an EC of 1.1 mS/cm (stock) and 2.0 mS/cm (gomphrena and stock) produced the tallest plants. Gomphrena had the most flowers when plants were fertilized with an EC of 2.0 or 3.7 mS/cm. As with dianthus, the increase in the number of gomphrena flowers with increasing fertilizer concentration was probably due to an increase in the overall size of the plants, since number of flowers and dry weight were higher with increasing fertilizer concentrations.

Zinnia grew best when fertilized with an EC of 1.1 mS/cm. However, in general zinnia growth was less responsive to different nutrient solution concentrations than the other species. Flower size in zinnia decreased with increasing nutrient concentrations, while the number of flowers was not affected by the nutrient concentration (data not shown).

The chlorophyll concentrations in the leaves of the plants generally increased with increasing fertilizer concentrations, especially as the EC of the fertilizer was increased from 0.4 to 1.1 mS/cm. Further increases in fertilizer concentration had little effect on the chlorophyll levels in the levels. This suggests that the poor growth of these plants at low fertilizer concentrations may be related to a lack of chlorophyll, which in turn would reduce photosynthesis and growth.

Nutrient Concentrations in the Tissue

Tissue concentrations of macronutrients (N, P, K, S, Ca, Mg, and Fe) in dianthus shoots increased with increasing concentration of the nutrient solution. The concentration of many of the nutrients (N, P, K, S, Ca, and Mg) increased gradually with increasing nutrient solution EC from 0.4 to 2.0 mS/cm, with little or no further increase in tissue concentration with higher EC. Boron tissue concentrations did not increase rapidly until EC was increased from 2.0 to 3.7 mS/cm, while the Fe concentration was highest with EC of 1.1 mS/cm. Shoot concentrations of Mo and Zn decreased with increasing nutrient solution concentration. Compared to variety of other annual bedding plants, the nutrient concentrations in dianthus tissue suggest that there were no major deficiencies.

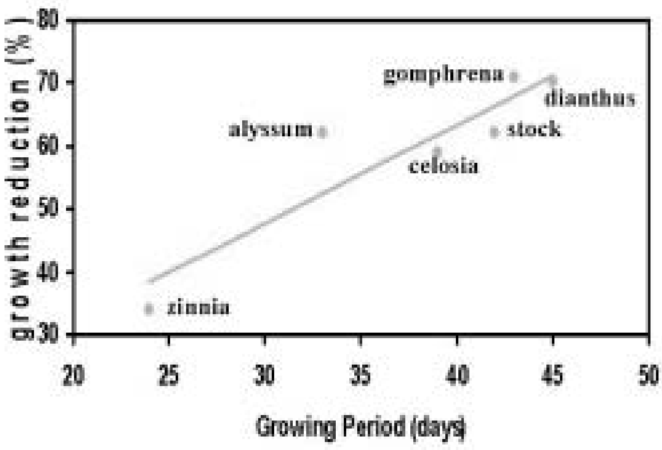

FIG. 2. Effect of growing period duration on growth reduction of six bedding plants. Growth reduction calculations were based on the dry weight of plants grown with an EC = 0.4 mS/cm (which resulted in the lowest dry weight in all species) and the maximum dry weight (which occurred at different concentrations for the different species).

Growing Period Duration and Dry Weight Reduction

To see how sensitive the different species were to low fertilizer concentrations, we calculated a 'growth reduction percentage', which we defined as the dry weight at the lowest fertilizer concentration divided by the dry weight at the optimal fertilizer concentration. So the growth reduction is an indicator of how well the different species could grow at less than optimal fertilizer concentrations. This reduction was different for the various species (Figure 2). In zinnia, this growth reduction was only 34, indicating that zinnia grew reasonably well well low fertilizer concentrations. The growth reduction in the other five species was 58 to 71%, showing that they were more sensitive to low fertilizer than zinnia. The unresponsiveness of zinnia to low nutrient solution concentrations may have been related to its short growing period. The relative difference in dry weight between the treatments with the lowest and the highest dry weight of the different species was closely related to the duration of the growing period. The shorter the growing period, the less sensitive the plants were to low fertilizer concentrations. This may be due to the presence of a starter fertilizer in the growing medium, which may have supported plant growth during the early part of the experiment, thus delaying the effects of low concentrations of the nutrient solution. These results suggest that using the appropriate fertilizer concentrations is much more important for crops with a long growing period than for crops than are finished in only a few weeks.

Growing Medium pH and Leachate EC

The growing medium pH ranged from approximately 6.5 with a fertilizer EC of 0.4 mS/cm to 5.5 with an EC of 3.7 mS/cm. This is close to the recommended pH range for the growing medium of floricultural crops (5.4 to 6.3). Thus, it is unlikely that the results from our research were affected greatly by the pH of the growing medium, especially since no micronutrient deficiencies were observed and micronutrient concentrations in the shoot tissue generally were adequate. In general, the pH of the leachate was affected little by increasing the nutrient solution concentration from an EC of 0.4 to 1.1 mS/cm, but increased rapidly when the nutrient solution concentration was increased further (to 2.0 and 3.7 mS/cm).

Summary

Plant growth of alyssum was maximized when the EC of the growing medium was approximately 2.0-2.5 mS/cm. A leachate EC of 1.1 to 2.5 mS/cm was optimal for celosia. Dianthus appeared to prefer higher leachate EC levels and grew best when the final leachate EC was approximately 3.7 mS/cm. Gomphrena and stock grew well with high leachate EC; maximum growth was seen with a leachate EC of 2.3 to 6.5 mS/cm. This indicates that gomphrena and stock can tolerate, but don=t require higher leachate EC levels than many other bedding plant species. Dianthus also was very tolerant of high EC levels. Even at a leachate EC of 12.5 mS/cm, there was little effect on growth.

Optimal fertilizer concentrations were species-dependent and ranged from 105 ppm N for zinnia to 210 - 420 ppm N for gomphrena and stock. None of the species showed drastic reductions in growth at high fertilizer concentrations or leachate EC levels, indicating that salt build-up in the growing medium as the results of subirrigation is not a serious threat to these species.

One thing to keep in mind when you use subirrigation, is that high fertilizer concentrations and regular watering make it easy for the roots to take up all the required water and nutrients. Because the water and nutrients are readily available to the roots, there is a risk that the plants may not develop vigorous root systems. In other research, we have seen that high fertilizer concentrations result in a lot of leaves and flowers, but small root systems. When this occurs, there is a risk that the plants may not do well after they are placed in the landscape, because the roots are not vigorous enough to take up all the water and nutrients under the more adverse conditions that plants are exposed to after they leave the greenhouse. So, it is crucial to keep a close eye on the roots throughout production. Decreasing the fertilizer concentration or watering less often will encourage more root growth.

Table 1. Nutrient solution concentrations which produced highest dry weight, chlorophyll content, number of flowers, and flower size in six bedding plants.

Plant Species and Cultivar	Nutrient Solution EC (mS/cm) that produced the highest			
	Dry Weight	Chlorophyll Content	Number of Flowers	Flower Diameter
Alyssum ‘New Carpet of Snow’	2.0	-	-	-
Celosia ‘Gloria Scarlet’	1.1 and 2.0	3.7	-	-
Dianthus ‘Telstar Crimson’	2.0	3.7	2.0 and 3.7	-
Gomphrena ‘Gnome White’	2.0 and 3.7	3.7	2.0 and 3.7	-
Stock ‘Special Mix’	2.0 and 3.7	3.7	-	-
Zinnia ‘Dreamland Mix’	1.1	3.7	-	0.7