Recycling used Nutrient Solution for Greenhouse Tomato

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Recycled nutrient solution, or reuse of solution after it has once been used to water plants, is the preferred legislative solution to prevent groundwater pollution from intensive agricultural production. There are several potential problems that may arise due to using recycled nutrient solutions to produce vegetable crops. Accumulation or deficiency of elements in nutrient solutions could ultimately have deleterious effects on plant growth, product quality, and the dietary value of vegetables. We examined the composition of a nutrient solution as it was continuously recycled to a greenhouse tomato crop, in comparison to solutions that were used to water plants only once.

Irrigation

Crops were grown in spring and summer for two years in a greenhouse using rockwool as the root medium. Rock-wool is an inert substrate that looks like fiberglass insulation. It provides no nutrients and little exchange capacity. Plants take up a similar amount of water if grown in other media such as soil or peat, but it is harder to measure the amount used in these other media. Watering occurred several times a day. The frequency of watering was based on the integrated sunlight for the day. Plants were always watered at dawn. They were watered up to an additional 7 times depending on the sunlight for the day. As the plants increased in size, the duration of watering was increased so that a relatively constant fraction of water was in excess and leaked from the slabs.

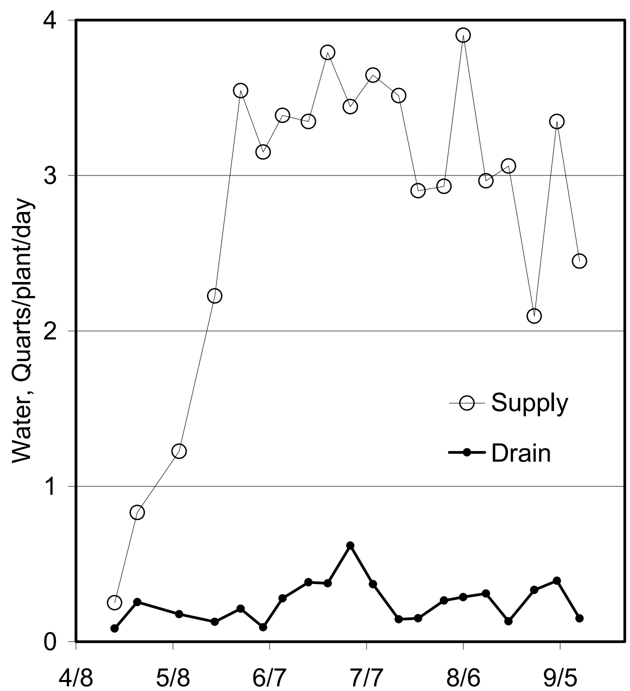
Greenhouse tomato plants use a lot of water. The amount of water required per day changes as the plants grow, and it also varies day-to-day according to sunlight. New transplants need less than 2 ounces per plant per day. However on sunny days during fruit production, plants may need up to 3 quarts of water per plant per day. Growers need to monitor plants closely during vegetative growth and fruit set, and increase the water supply as needed. Figure 1 shows there was a large daily variation in water use due to sunlight, and a more gradual trend as plants grow and develop over the season. When grown in soil, this daily variation may not be important, because over a period of a week, sunlight does not vary as much as from day to day. However, if plants are grown in a well drained medium, or in a small volume per plant, one should account for this daily variation in water uptake with sunlight. Plants during fruit production may need water several times a day to prevent drying of the root medium. Changes in water status in the root zone can crack the skin of tomato fruit and result in other disorders. Thus, it is best to control irrigation automatically, with the use of time clocks or electronic controllers. To insure that all plants receive enough water, irrigate so that 10 to 20% of the water supply drains after each watering.

Fertilization

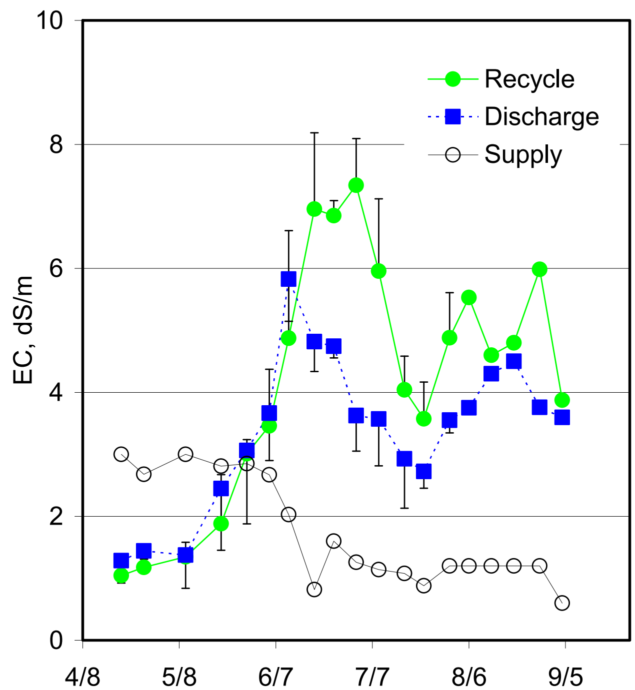
A successful nutrition program for greenhouse tomato includes the following:
Knowing the EC of the nutrient solution and the concentration of each nutrient in the fertilizer.
Measuring EC and pH of the media or drain solution, and responding in a timely manner.

Tomatoes need continuous fertilization unless they are grown in a large volume of soil. Otherwise, vegetative growth ceases and fruit lose their taste. Over a season, I calculate a single tomato plant takes up 0.7 ounce of nitrogen (N) and 0.9 ounce of potassium (K). Tomatoes require high N, K, and calcium (Ca), but low phosphorus (P). A single complete nutrient mix of 20-10-20 N-P2O5-K2O can be used to grow tomatoes. However, most growers use a complete nutrient mix with low N and high K, and supplement with calcium nitrate to provide most of the N. I have used a complete nutrient mix of 4-18-38 N-P2O5-K2O at a 1:1 ratio with calcium nitrate and a 2:1 ratio with magnesium sulfate, or a 3-15-26 mix at a 1.5:1 ratio with calcium nitrate.

Volumes of water per tomato plant taken up and drained per day, averaged over each week.



Electric conductivity of nutrient solution and supplied to tomato plants, and drained from recycled or discharged drainage systems.



I injected nutrients into the water supply using proportioners. Once or twice a week, the conductivity and concentrations of nitrate and potassium were measured in the solutions supplied to the plants and the solution in the rock-wool slabs. There was a rapid rise in uptake of nitrogen that closely followed the same time course as the rise in uptake of water. However, nitrogen uptake increased more rapidly than water uptake during early fruit growth of tomato plants. When nitrate was injected at a concentration of 100 ppm N, the concentration in the root medium fell to a low level in early and mid May, despite the rapid increase in the volume of water supplied per plant. Raising the nitrate supply to 200 ppm N eventually restored the appropriate level in the root zone. This depletion of nitrogen corresponded to the time when the roots had thoroughly penetrated the entire volume of root medium. A high concentration of N is recommended for seedling tomatoes in early spring to avoid this sudden depletion of nutrients. Water use continued to increase into early fruit ripening, while the demand for nitrogen was constant. Thus, a nitrate concentration of about 130 ppm N in the water supply matched the uptake of nitrogen by tomato plants during fruit production. The uptake of nitrogen generally declined to about half the maximum rate by the end of the season. Nitrate at 100 ppm was sufficient after the plants were topped, because N uptake decreased more rapidly than water uptake.

Potassium uptake increased more slowly than nitrogen uptake in the spring, and reached a plateau about one month after the start of fruit production. Although potassium uptake increased faster than water uptake in May, it was not depleted in the root medium when the concentration in supply solution was increased to 220 ppm. A constant concentration of K in water of about 150 ppm was sufficient for the plants until this time. Potassium uptake continued to increase with water use for a month after fruit began to ripen. A potassium concentration of around 180 ppm in the water supply matched the uptake of potassium by tomato plants during fruit production. Thus uptake of potassium rose more slowly than nitrogen uptake during development of the crop in the spring. Potassium uptake declined slightly later in the season, as shown by the increasing concentration in the root medium.

The difference in composition of recycled compared to discharged solution developed gradually over more than one month of recycling. Typically, the transition from vegetative to fruit growth, which coincides with the beginning of the warm season, resulted in over-supply of nitrate, potassium and other nutrients. It took a longer time to return the solution to an optimal composition with recycled compared to discharged solution. There was little effect on composition of plants, despite the large but temporary differences in composition of nutrient solution.

In part, the change in nutrient uptake from spring to summer is due to a transition from cool to warm temperature. As hot weather arrives, plants require more water, but they do not need more nutrients. This is one reason why the concentration of nutrients can be decreased in summer. If the concentration is not decreased, then nutrients will accumulate in the root medium, and the EC will rise. If no adjustment is made to the nutrient solution, and it is recycled to the plants, this accumulation of nutrients may be enough to damage the plants or reduce fruit size.

Further reading.

Gent, M.P.N. 2003. Greenhouse Tomato Cultivar Trials in Connecticut 1999-2002. Connecticut Agric. Experiment Station Bulletin 990. 16 pp. www.caes.state.ct.us/Bulletins/2003/b990.pdf