GREENHOUSE IRRIGATION AND FERTILIZATION OVERVIEW

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INTRODUCTION

Greenhouse irrigation is just one of many systems which the grower uses to control growth, development, and timing of crop production. Overall control relies on the interaction of all systems: watering, fertilization, heating, cooling, ventilation, humidity control, lighting, and carbon dioxide supplementation. Water cycles throughout the plant and its environment, and plays an important role in total environmental control.

It is important to understand the impact water has not only on plant growth, but also on plant environment. Plants evaporate water from their leaves in order to keep cool under the constant heat of the sun. Often, the best approach to greenhouse temperature control is to encourage the plant's own evaporative cooling system. Once water evaporates, it adds to the humidity of the air. The lighter moist air rises through heavier dry air, helping to create natural air currents which moves hot air away from the plants, and fresh, carbon dioxide-rich air to the plants. Another water cycle occurs beneath the soil. Water added through irrigation reaches roots, which absorb the water needed to meet the needs of leaf evaporation. This water also carries nutrients to the plant roots much faster than roots are able to grow toward new nutrient supplies, offering a distinct advantage over field crop root uptake strategies. The type of potting media must be selected with this water movement in mind.

This paper discusses the common methods of greenhouse irrigation and fertilization. An overview of the benefits and costs of each system as well as general operational guidance is provided. Finally, an integrated approach to water and nutrient management is presented. This approach is based on current research of greenhouse irrigation systems. Only recently have researchers focused on the importance of precise water and nutrient control for optimal greenhouse crop production. In the future, as crop nutrient requirements are determined with increasing precision, growers using all types of irrigation systems will be able to tailor fertilizer applications to better meet crop needs.

IRRIGATION SYSTEMS

No matter what irrigation system is used, the goal is the same: apply the proper amount of water to each plant. The proper amount is defined by the amount of water the plant uses in the process of evapotranspiration (ET). ET can be predicted for a given plant based on several key environmental factors: light, temperature, humidity, and wind. However, each plant responds to the environment in a slightly different way to give a different water requirement. General guidelines can be found in most horticultural production manuals. For example, poinsettia uses 7 to 9 quarts over the 15 weeks of the crop. This range is relatively narrow since poinsettias are grown at a specific controlled temperature and predominately at one time of year (to meet the Christmas rush). The low side of the limit would be for a season with mostly cloudy conditions, and the high side for when most sunny conditions occur. Once you know how much water the plant needs, you can calculate how much water is needed at each irrigation by knowing how many times you will irrigate over the growing period. This is largely determined by the type of irrigation system used.

Hand watering has inexpensive up-front equipment but expensive labor costs. Often, uniformity is difficult to maintain. However, training operators in a few simple concepts will greatly improve the effectiveness of this system. This method can be adapted for both flats and potted plants. It is best to operate under low flow rates (2-4 gallons per minute) and to apply a know amount (by amount of time in one location with a know flow rate) directly to each pot or bedding flat. One simple method is to determine how many ounces of water it takes to fill a pot, and leave space at the top of the pot for only that much volume. Then, filling the pot with water will provide the precise amount of water needed. Plants with well established root systems should be watered thoroughly and allowed to dry between waterings. As long as water quality is acceptable, there is no need for leaching.

Sprinkler/mist systems use stationary nozzles to distribute water across the growing area. These systems are best used for flats, but can be used for potted plants with a loss of efficiency due to water falling between pots. Though complete uniformity is rarely attained, proper placement of sprinklers can provide more consistent, uniform watering than hand systems, particularly when nozzles are cleaned and maintained. The goal is the same as discussed with hand watering: allow media to dry before returning to water thoroughly. Systems can be fully automated. Equipment costs can be significant.

Watering booms are simply sprinklers or mist heads placed on moveable central units, either mounted on carts or on overhead framework. Again, uniformity depends on proper nozzle placement and maintenance. Lower initial costs compared to stationary systems are offset by increased maintenance. These systems can also be controlled by computer for increased flexibility and control.

Drip irrigation can be used for hanging baskets and potted plants. Precise amounts of water are applied through low-flow emitters in each pot. Filtration is often required to minimize clogging. Again, water amounts should be determined to completely wet media without leaching. Because water is applied directly to the soil, foliage is kept dry, reducing the chance of several diseases.

Ebb-flood systems water plants from below by periodically filling a trough-like bench to a shallow depth and letting water wick into the potting soil. Irrigation water is used again and again in a closed system. As with the drip system, some diseases which need moist foliage to thrive are minimized. Up-front costs can be high, but the system is easily maintained. Management details are still being refined with this relatively new technique.

FERTILIZATION SYSTEMS

Nutrients must be supplied to plant roots in sufficient supply to meet crop nutrient demands at the proper time. In well watered greenhouse soils, nutrients dissolved within both soil and irrigation waters are mixed and transported to plant roots with the irrigation water. Several methods are commonly used to provide plants with nutrients in greenhouse systems.

Solid fertilizers can be added directly to potting soils at the time they are mixed. Because greenhouse potting soils are often otherwise sterile, the nutrients can be selected and added to meet specific plant needs. The slow-release fertilizers are distributed throughout the media during mixing. As water dissolves the nutrients, they become available to the plant. Depending on the plant and soil media type, all or part of the plant needs can be met in this way.

Liquid fertilizers can be added to the irrigation water in a process known as *fertigation*. Fertigation can be used to meet all or part of the crop demand. One common method of adding nutrients to water is by a *proportioner*. A concentrated pre-mixed recipe of nutrients are pumped or sucked into the irrigation stream at a rate proportional to the rate of irrigation flow. This assures that the concentration of nutrients in the irrigation water remains constant regardless of the irrigation rate. A second method of applying nutrients is by *fertilizer injector*. The injector pumps a set amount of one or more concentrated nutrient solutions into the irrigation stream at a rate determined by the grower. Quantities of individual nutrients and relative proportions of different nutrients can be customized to meet plant demands of different crops at different growth stages. These systems can be controlled by computer for added flexibility.

INTEGRATED WATER AND NUTRIENT MANAGEMENT

Because greenhouse irrigation systems commonly apply water and nutrients together, they must be managed together. Separate calculations can be done for each nutrient individually, or only for several key nutrients. Requirements of N and K are typically the most critical followed by P, Ca, and Mg. Micronutrients should be maintained at a constant level.

1. Determine the amount of water to be applied during each irrigation.
   This can be determined by dividing the total lifetime plant water requirement by the number of irrigations anticipated, or by an ET calculated for the specific environmental conditions and crops used. Soil moisture sensors can help determine how frequently to return for irrigation. Some recent environmental control computers include ET calculations which can be used to control watering timing and amount.

2. Determine the amount of nutrient needed by the plant with each irrigation.
   First, find the total nutrient requirement over life of plant. Then subtract the amount of nutrient in the soil, as determined by exact fertilizer additions or soil media test. Finally, divide the total nutrients to be added in the irrigation water by the number of irrigation/ fertilizer additions expected.

3. Calculate proper concentration for each watering.
   The concentration of nutrients added in each watering is calculated by dividing the amount of nutrient by the amount of water. This gives a weight of nutrients to be added to a volume of water.

As long as leaching is minimized, this method will provide the precise amount of fertilizer needed by the plant, matched to the amount of water needed by the plant. This method is an improvement over the common practice of leaching 10-20% of the pot volume with each irrigation using high, preset levels of nutrient concentrations. By accounting for water and nutrients together, over or under fertilizing can be avoided. Precise control of nutrient additions eliminates the need for leaching. Since nutrients are not washed from the pot, lower concentrations can be used while still meeting the nutrient needs of the plant.