

AUG. 23, 2007

Contact: *A.V. LeBude, Horticultural Science, 828.684.3562*
T.E. Bilderback, Horticultural Science, 919.515.1201
North Carolina Cooperative Extension
College of Agriculture and Life Sciences
North Carolina State University
or contact your county N.C. Cooperative Extension Center

Managing Drought on Nursery Crops

Drought has always caused nursery crop producers great concern. If irrigation water becomes limiting, growers producing nursery crops in containers may lose their entire crop. Newly planted field-grown crops also sustain heavy losses if they are not irrigated frequently during the first year of production. Although established field-grown nursery stock will survive if not irrigated during periods of drought, they will not grow under these conditions. Adequate moisture during field production will produce field-grown shade trees of marketable size in three to five years. Poorly irrigated plants will take longer to reach marketable size, thus lengthening the time cost of production.

Container Production

The initial design and planning of irrigation directly affects a container nursery's flexibility and adaptability in providing adequate water to crops during drought. Most container nursery growers who have experienced droughty conditions expanded their irrigation resources by drilling wells, constructing ponds, and recapturing and recycling irrigation runoff. To prepare for droughty conditions when designing a nursery, growers must determine how much water they will need when irrigating during the growing season. Once the water supply is in place, choosing a delivery system is most important, followed by making sure the water is delivered accurately, efficiently and in the correct amount for the crops being grown.

Strategically designed natural landform structures are the primary source of irrigation water at most container nurseries. Wells are often used to recharge (dilute and freshen) and re-supply water in these structures. Many nurseries have always captured and recycled irrigation runoff to have adequate irrigation supplies. This practice has been adopted widely as the benefits of recycling water and an increased environmental awareness have been embraced by nursery professionals.

The single best management practice for reducing run-off, decreasing nutrients in the water supply, capturing pesticide residues and disease organisms (all of which may be present in recycled water) is to filter the return water through grass strips and other vegetated areas such as constructed wetlands or secondary impoundments. Pond aerators may also help oxygenate surface waters and enhance breakdown of impurities by aquatic microflora. Many nurseries have also begun water treatment procedures such as chlorination and extensive filtration before reapplying water.

Most nursery crops grown in 1- to 5-gallon containers are irrigated by overhead-impact sprinkler irrigation. Each sprinkler nozzle may require up to 15 gallons per hour for proper performance. Professionals who design irrigation systems for container nurseries suggest that no less than 1-acre inch (approximately 27,000 gallons) of irrigation storage per acre of nursery stock per day be used in

planning for water supplies. Another recommendation used for planning water supply is 5- to 10-acre feet of irrigation water per acre of nursery stock per year. If container stock were irrigated 163 days a year at the rate of 1-acre inch per day, approximately 4.5 million gallons per acre would be required. This is equivalent to 13-acre feet of water per acre of nursery stock.

In reality, most growers apply water to an area of containers for a specific time, such as 1 hour. The actual volume of water applied to an area is highly variable depending on design and compatibility of nozzles used, percent of overlap between nozzles, volume and pressure loss over the length of irrigation lines, nozzle orifice wear, plus evaporative and environmental conditions such as wind. It is often suggested that 1-gallon containers (7.5-inch top diameter) must receive 1 pint of water (0.125 gallon) with each irrigation. If 27,000 gallons of water (1-acre inch) are applied over an acre of 1-gallon container nursery stock, 0.19 gallon will enter the pot (plant-canopy interference not considered).

Two best management practices to irrigate efficiently are to make sure all irrigation is applied uniformly over the growing area and that the correct amount of water is applied for the desired crops. To measure uniformity, place plastic bags within empty pots throughout a block or zone before an irrigation cycle; collect the water applied and measure the amounts in each container. If the volume collected among containers is highly variable, risers and nozzle orifices should be inspected. Risers should be straightened so that they are perpendicular to the ground and nozzle orifices should be replaced if they appear irregular in shape or larger than new orifice openings. If wind frequently interferes with water distribution, producers should consider creating a windbreak.

Determine the correct amount of water to use while irrigating by measuring the leaching fraction from containers. A leaching fraction is the amount of water applied to a plant during irrigation divided by the amount that drains from the container after irrigation (volume of leachate/total volume irrigation entering the container*100=percent leachate or leaching fraction). To measure the amount of water applied during irrigation, simply put a plastic bag in an empty pot and leave it in the irrigation zone. To collect the amount of water that drains from a plant's container after irrigation, place another plastic bag in an empty pot. This time, however, nestle a container plant inside the plastic-bag-lined-container. Do this for a number of crops in differently sized containers. After the last irrigation cycle of the day, compare the amount of water collected in the bag placed in the empty pots to the amount of water collected in the bags below various crops. The amount of water in bags under crops should be approximately 10 to 20% of the amount collected in the empty container. If it is considerably more under some crops, plants may be receiving more irrigation than necessary. This is a good way to determine if plants are over-irrigated and it provides a good method to conserve water by monitoring irrigation during the production period.

Leaching fractions can be affected by the architecture of the plant's canopy. For example, canopy architecture can gather, repel or have little effect on the amount of water entering containers. In recent research at NC State University, overhead-irrigated container-grown 1 gallon camellias gathered 240% more water than an empty 1 gallon container, while crops such as cotoneaster had little effect on the amount of water entering containers. The canopy of the camellia acted as a funnel by collecting water and directing it into the container, whereas, the canopy of the cotoneaster probably repelled as much water as it directed into the container. Knowing these characteristics about the crops you grow can assist in putting the right plants together in an irrigation zone and help conserve water by irrigating only as long as needed.

If water is applied uniformly, less irrigation will be required. Plants can be removed from containers and the degree of uniform wetness in the container can be observed. If the irrigation was adequate, there will be no dry spots in the container root zone and it will be obvious that water has moved through the entire depth of the container profile.

Increasing irrigation efficiency is the best water-conservation practice that growers who are facing a water shortage or want to reduce water runoff can adopt. Correcting water-distribution problems is an important step in water conservation. Uniformity of distribution and maintaining a 10-20%

leaching fraction are very important, because some growers irrigate until the driest plants are watered adequately. This practice is very inefficient.

Irrigation Conservation Techniques for Container and Field Production

Low-Pressure/Low-Volume Irrigation System. In recent years, nurseries have adopted several water-conservation practices. Low-pressure/low-volume irrigation systems, which use drip emitters or spray-stakes, are being used for both field-production of nursery crops and large-container (5, 25, 50, 100, 200 gallons and larger) crop production. These emitters often require only 10 to 20 pounds per square inch (psi) pressure and 0.5 to 15 gallons per hour of water. Where there are long distribution lines or uneven terrain, pressure-compensated emitters are available to ensure even distribution of water.

Drip irrigation increases both the growth rate of field-grown trees and the number of roots harvested within the dug root ball. This is also true of trees grown with drip irrigation in areas where rainfall is considered adequate for production of field stock. Drip irrigation provides a consistent, direct application of water to the root zone during production. Another advantage of low-volume/low-pressure systems is direct injection of fertilizers within the irrigation water. Applying nutrients directly to the root zone increases nutrient use efficiency because nutrient application is more closely controlled by the grower. When nutrients are applied in granular form as a top-dress, there is always the possibility of losing nutrients in the run-off after periods of heavy rains.

Emitter and spray-stake orifices are much smaller than overhead-sprinkler, irrigation-nozzle orifices and can very easily become clogged unless the water is free from sediment. Good sources include clean well water, municipal water or water that is adequately filtered. Clean water may only need a small screen filter (200 mesh) to ensure that small particle impurities will not plug orifices. Most surface or pond water must be filtered by using a sand media filtration system to avoid clogging emitters. The initial cost of sand media filtration may be \$3,000 or higher. However, advantages of water conservation, efficiency of water distribution, potential to apply nutrients directly to plants, and enhanced growth quickly provide a greater return than the cost. Overhead forms of water application to field production, for example, large center pivot guns, deliver enormous amounts of water inefficiently. Most of the water is delivered between rows. During periods of drought, the wasted water becomes more valuable because water tables, pond levels and stream flow may be reduced. By applying low pressure/low volume irrigation, growers conserve water by applying it more consistently and efficiently, which is reflected in the consistent growth of crops.

Pot-In-Pot Production. Pot-in-Pot production utilizes a socket pot that is left in the ground; a pot containing a plant is placed into the socket pot. This is a combination between traditional container production and field production. This system is almost exclusively irrigated by drip, trickle or spray-stake irrigation.

Cycled Irrigation. Cyclic irrigation is the best management practice that applies the necessary daily amount of irrigation in more than one application with timed intervals between applications. For example, if 0.6 inches of water are required per day within an irrigation zone, 0.2 inches will be applied three separate times with approximately 1 hour between irrigation cycles. Cyclic irrigation requires automated irrigation controllers, which schedule irrigation between nursery container blocks throughout the day. After all blocks are irrigated once, the rotation begins again. Growers using cyclic irrigation to water container-grown crops have reported that the quantity of total irrigation applied was reduced by approximately 25% through the growing season. This represents a savings in both water and energy consumption.

Many nurseries have adopted cyclic irrigation over a daily, single irrigation cycle because of water and nutrient conservation. A single irrigation cycle commonly distributes water over a growing block for an hour, and in most nurseries 0.5 to 1 inch of water is applied. Similar to a downpour, water applied continuously to a container can move through the substrate quickly collecting nutrients in the leachate.

As a result very little lateral wetting of the substrate occurs, while a large portion of the water as well as the nutrients are lost through the bottom of the container. If the nursery is near surface water such as streams or rivers, and runoff from production areas flow into these surface waters, there is potential to impact water quality. For other locations, particularly in areas with sandy soils and shallow aquifers, high volumes of irrigation can leach nutrients.

In contrast, during the first application of water in a cycled irrigation management practice, the foliage canopy as well as the surface medium are moistened but not saturated. Because a third of the water is applied, water moves laterally and downward into the substrate slowly. More water moves into small pore spaces between substrate particles and provides greater wetting and moisture retention as compared to one long irrigation application. The second irrigation cycle continues moving the wetting front (the arc of water moving downward and laterally from the surface of the container) slowly down the container column. Ideally, the third irrigation cycle pushes the wetting front to the bottom of the container.

Much less leaching and irrigation runoff results from cycled irrigation. In drought situations, EC tends to increase, particularly with recycled irrigation supplies. Although the Virginia Tech PourThru extraction method has specific protocols, growers can simply pick up pots about 30 minutes after irrigation and collect the leachate that drips from pots to measure EC and pH. This is an important management practice during drought periods because EC can change from a desirable range of 0.5 to 1.5 mmhos/cm to 2.5 to 5.0 mmhos/cm in a matter of days. If this happens and you have the water, use it to leach elevated salts out of containers. Otherwise, you are close to losing crops. It would be wise to send an irrigation water sample to an analytical lab to find out if elevated levels of salts are also in the water supply. Unfortunately there may be chlorides and bicarbonates which can antagonize growth of some crops.

Water Content of Substrates

Pine bark is the predominant component in potting substrates used in southeastern U.S. nurseries. Because it is difficult to create saturated conditions in pine bark potting media, conditions such as poor drainage, inadequate air space and excessive diseases caused by waterlogging of root zones are usually avoided. As a result, pine bark substrates require frequent irrigation and have very high unavailable water content. Screened pine bark used alone as a potting substrate has a water-holding capacity of approximately 65% water (by volume), but only approximately 32% of the container capacity will be available for plant use. During drought, a 4-to-1 ratio blend of pine bark and sand would provide more favorable water relationships, since the water-holding capacities are equal and approximately 41% of the water held is available to plants. The mixture of pine bark and sand also wets faster and more uniformly during irrigation, since the infiltration rate (movement downward) of water is slowed and better lateral wetting occurs. The trade-off is that this substrate weighs over twice as much as pine bark alone, and some plants may not grow as rapidly if water is never limited because much of the air space in the pot is replaced by sand particles. A 10% addition of peat moss increases water retention even more than sand, but does have the potential of becoming waterlogged under frequent rainfall or irrigation.

Horticultural wetting agents are effective in providing more water retention in potting substrates without creating waterlogged conditions. These characteristics can be very useful for enhancing root growth and establishment of newly potted liners. However, one application of a wetting agent may lose effectiveness before the end of the growing season. In most cases, newly potted plants are well established in containers by that time, and reapplication is not necessary.

Synthetic hydrogels have been shown to enhance growth of established plants in containers in very coarse substrates such as pine bark. They appear to have little effect on newly potted plants. The water absorption of hydrogels is affected by fertilizers and compounds in organic potting substrates, but they still retain significant quantities of moisture that are available as established plants extend roots into and adjacent to the cubes in the potting mix. In effect, they act as miniature oases for roots. However, since they must be incorporated to be effective, the need for these materials must be anticipated prior to drought for them to be of benefit.

Grouping of Plants for Efficient Irrigation

Grouping plants to apply irrigation more uniformly can be based on container size, substrate, plant type, plant water requirements, plant leaf type, and plant canopy architecture. Because small containers will be saturated before large container plants receive enough water, most container growers group differently-sized containers into separate irrigation zones. Likewise, plants growing in very different potting media should not be grouped under the same irrigation regimes. Plants brought in from other nurseries also may be in different mixes and require separate watering. Nursery crops such as azaleas, rhododendrons and camellias are often grown in mixes containing peat moss and may require less frequent irrigation.

If a large number of cultivars of one type of plant, such as junipers or hollies, are grown, like-size containers of these should be grouped under the same irrigation zone. More difficulty is experienced in determining how to group different types of plants for most efficient irrigation. Various published lists for landscape plants do indicate which plants will tolerate similar conditions such as dry, moist or wet locations. These groupings can be used to segregate plants in nurseries for similar irrigation needs.

Some nursery studies have also compared plant water-usage needs. Generally plants with a thick waxy cuticle or thick fleshy leaves can be grouped together and watered less frequently than plants with thin leaves. Deciduous plants usually require more water than broadleaved evergreens during the growing season but less when they are dormant. In general, junipers and conifers require less frequent irrigation than do broadleaved evergreens. Depending on winter protection provided, most container plants require occasional irrigation during winter months.

The group of plants that may need irrigation most frequently during active growth is bedding plants because they grow rapidly and are usually grown in small containers. Perennials are often grouped with bedding plants, but are often overwatered because many have very different water requirements and grow at different rates.

Plant canopy architecture, as mentioned above, can act as a funnel and direct more irrigation water into the container compared to an architecture that acts as an umbrella and repels irrigation water. By grouping these plants separately and measuring leaching fractions bi-weekly or at least monthly, growers can supply irrigation volumes based on the demand of the plant and the actual amount of water being collected in containers.

Last-Resort Drought Decisions

If the point is reached that watering must be restricted or entirely eliminated on portions of the nursery, several alternative decision-making processes are available.

Selection of plants that can tolerate less frequent irrigation. Where daily irrigation is a standard practice, choosing plants that will receive irrigation every other day will cut water consumption in those areas in half. Junipers or crops grown under shade, such as rhododendrons, probably will grow well under every-other-day (or even less frequent) irrigation cycles.

Prioritizing nursery crops by their profitability potential. Every nursery has some crops that are profitable and others that are marginal or that lose money. Crops that make money should be irrigated to maximize profits, and marginal crops or loss leaders should not be irrigated.

Considering the restocking cost of crops. Propagation and stock material for some crops may be difficult to obtain. If cuttings and liners are expensive, such as patented, trademarked or otherwise specially designated cultivars, irrigation of these crops should be continued; but discontinued for plants that are readily available in the trade by obtaining new cuttings. This assumes, of course, that economic margins and production costs for patented plants are inherently higher than for industry standards. Eliminating containers using the above criteria may require moving blocks of plants in or out of irrigation zones according to their assigned fate.

Analyzing inventory related to crops and size availability. Several sizes of the same cultivar of plant may be included in the inventory. Eliminating one or two sizes of plants is a consideration. Liners, quarts, and 1-gallon plants are worth less than larger container sizes, and if blocks are spread out, they may be irrigated in a less efficient manner. Most nursery crops can be propagated in fall and winter months, so loss of liners may be only a six-month setback rather than a full growing season.

Summary

Planning before a drought is the best way to avoid losses as well as increase efficiency and profits. Discuss drought management plans with your staff and your local county extension agents. Deciding on action plans for use during a drought is sometimes best done when there is no drought or immediate stress on the one making the decisions. Best Management Practices regarding irrigation sources, filtration, container growing media, and irrigation distribution should become part of daily nursery crop production.

Prepared by

*A.V. LeBude, Assistant Professor and Nursery Extension Specialist,
North Carolina Cooperative Extension Service, North Carolina State University*

*T. E. Bilderback, Professor and Nursery Extension Specialist,
North Carolina Cooperative Extension Service, North Carolina State University*

*This publication has been issued in print by the North Carolina Cooperative Extension Service
as publication number AG-519-6 (December 2007).*

*This file is one in a series of electronically available drought information publications produced
with support from the U.S. Department of Agriculture, Extension Service, under special project number
93-EFRA-1-0013. The Drought Disaster Recovery Project was a joint effort of the Extension Services
in Delaware, Georgia, North Carolina, South Carolina, and Virginia.*

Published by

**NORTH CAROLINA COOPERATIVE EXTENSION SERVICE
North Carolina State University, Raleigh, North Carolina**

Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. Employment and program opportunities are offered to all people regardless of race, color, national origin, sex, age, or disability. North Carolina State University, North Carolina A&T State University, U.S. Department of Agriculture, and local governments cooperating.

Electronic Publication Number DRO-18
(December 2007)