Extension Education Methods

Survey of Container Nursery Irrigation Practices in Georgia

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Summary. A 2001 survey of 102 nurseries that were members of the Georgia Green Industry Association was conducted to assess irrigation practices of container ornamental nurseries. Mean nursery size was 64 acres (26 ha) and mean annual revenue was about $3 million. About 50% of the irrigation water was from wells and the other 50% came from surface sources, such as collection basins. Irrigation in smaller containers, including #1, #3, and #5, was applied primarily by overhead methods, while larger containers (#7, #15, #25) made extensive use of direct application methods, such as drip or spray stakes. Frequency of irrigation in the summer growing months was about three times that of the winter season. Georgia nurseries use irrigation practices suggested in Southern Nursery Association best management practices, including collection of runoff water (48%), cyclic irrigation (44%), watering in the morning (92%), and grass strips between the production beds and drainage areas (60%).

Container ornamental nursery production is one of the fastest growing segments of American agriculture. Container nurseries produce a wide array of shrubs, ground covers, herbaceous perennials, and trees used in residential and commercial landscapes. The state of Georgia has four of the top 100 container nurseries (Georgia Green Industry Association, personal communications) in the U.S. and the state supplies plant material throughout the U.S.

Production systems for container nurseries differ from row-crop agriculture. Container nurseries grow in various sized containers filled with artificial substrates, whereas traditional agriculture crops are produced in ground. Container nurseries also are dependent on frequent supplemental irrigation. While use of irrigation in agriculture crops has increased, crops in the soil are not as dependent on supplemental irrigation. However, irrigation practices and the amount of irrigation water used are better documented for row crops than for container nursery crops.

The production of container ornamentals in the U.S. has evolved during a period of generous availability of irrigation water. Severe drought conditions in many regions of the U.S. in recent years has raised issues such as water availability, efficiency of use, and value derived from this natural resource. The nursery industry in the southeastern U.S. has responded, in part, by developing a set of best management practices (BMPs) to guide production practices (Yeager et al., 1997). To our knowledge, only one previous study, in Alabama, has documented the status of voluntary adoption of the Southern Nursery Association (Atlanta) (SNA) BMPs by the nursery industry (Fain et al., 2000).

The objectives of this study were to evaluate 1) irrigation practices of container nurseries and the value of product grown, 2) adoption of industry BMPs, 3) application methods for irrigation water, and 4) practices adopted by container nurseries to reduce water use and improve quality of water leaving the nursery.

Materials and methods

A 2001 survey was conducted of 102 container ornamental nurseries in Georgia that were members of the Georgia Green Industry Association (Epworth, Ga.). The survey instrument was mailed to all nurseries in April 2001 and a second mailing to nonrespondents during May 2001. Completed surveys were received from 26 firms, for a 26% response rate, a sufficiently high rate to make generalizations about the Georgia container nursery industry. Also, three of the four nurseries that rate in the top 100 in the U.S., according to annual sales revenue, responded to the survey. Data were tabulated and analysis of response conducted using PROC FREQ, PROC MEANS, PROC GLM (SAS, 1999).

Results and discussion

Water use and application. Mean reported annual gross revenue for respondent nurseries was about $3 million, with a range of $20,000 to $27 million (Table 1). The mean size of nurseries was 64 acres (25.9 ha) but ranged from 0.5 acres (0.20 ha) to 450 acres (182.1 ha) of production area. This suggests that the survey respondents represent the full range of nursery sizes (area and revenue) in Georgia. Median annual revenue per acre of production bed was $56,000 ($138,374/ha).

The efficiency of use of water applied to container nurseries is influenced by factors such as container density and method of application (Beeson and Knox, 1991). Mean container density, at final spacing, ranged from about

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Table 1. Annual revenue and size of Georgia container nurseries.

Variable	Respondents (no.)	Mean ± SE
Annual gross revenue ($1,000)	20	3012 ± 1528
Size (acres)[z]	24	64 ± 21
Revenue ($1,000/acre)[y]	20	56 ± 9

[z]1 acre = 0.4 ha.
[y]$1,000/acre = $2,471/ha.

Table 2. Description of container nursery product mix by container size, production area, and density of containers.

Container	Diam [inches (cm)]	Respondents (no.)	Mean production[z] (acres)	Mean density[y] (containers/acre)
<#1	---	10	3.8	151,707
#1	6 (15.2)	17	11.3	55,898
#3	8 (20.3)	18	20.6	13,067
#5	10 (25.4)	6	10.5	9,595
#7	14 (35.6)	11	8.8	4,877
#15	17 (43.2)	9	11.3	3,722
#25	23 (58.4)	3	9.2	1,742

[z]1.0 acre = 0.40 ha.
[y]1,000 containers/acre = 2,471 containers/ha.

56,000/production acre (138,374/ha) for #1s, to about 1740/acre (4300/ha) for #25s (Table 2). These densities translate into container spacings that are comparable to industry standards, such as 12 inches (30.5 cm) on-center for #1s and 24 inches (61 cm) on-center for #3s, the two most common container sizes used in Georgia and other states in the southeastern U.S.

The #3 container spacing (Table 2) indicates that each plant requires about 4 ft^2 (0.37 m^2) of nursery surface while the container occupies about 64 inch^2 (412.9 cm^2) of nursery area. This implies that the maximum interception efficiency of water applied by overhead irrigation would be about 11% for #3 containers and 25% for #1 containers. Containers represent a very small percentage of the required production bed area, therefore the efficiency of water use would be greatly influenced by the method of application.

Container nursery producers in Georgia were asked to indicate the percentage of production, by container size, that was irrigated by overhead/broadcast methods versus directed or drip/spray methods (Table 3). Essentially all of the smaller containers (liners, #1, #3, and #5) are irrigated by overhead methods. Directed application of irrigation water (drip/spray) was practiced with the larger containers. Directed application was used in #7 containers (49%), #15 (85%), and #25 (75%). The use of directed irrigation is highest with containers of lowest density. The use of directed irrigation with larger containers is a desirable practice since the larger containers intercept the lowest percentage of applied overhead irrigation. However, the industry primarily used overhead application methods for #1, #3, and #5 containers, the largest segment of the product mix and production bed area.

The rates of irrigation applications are described in Table 4. Nurseries apply about 1 acre-inch (102.8 m^3) of water by overhead irrigation per irrigation event for #1 and #3 containers, while about 0.5 acre-inch (51.4 m^3) is applied per irrigation event for #5, #7, and #15 containers. The average amount of irrigation applied via overhead sprinklers ranged from 0.3 to 1.3 inches (7.6 to 33.0 mm) per application in Alabama nurseries (Fare et al., 1992).

The amount of water applied by directed irrigation (drip/spray) increased with container size and was reported in gallons per application, verus acre-inches for overhead. The mean level of directed irrigation applied per irrigation event to each #3, #7, #15, and #25 container was 0.4, 1.1, 1.5, and 1.7 gal (1.51, 4.16, 5.68, and 6.44 L), respectively. The frequency of irrigation varied, although not significantly, among container sizes.

The summer irrigation frequency was about three times that of the winter season (Table 5). The mean weekly application frequency was 3.2 in the winter season and 9.0

Table 3. Method of water application for Georgia container nurseries.

Container	Diam [inches (cm)]	Application method: Overhead (%)	Application method: Drip/spray (%)
<#1	---	92	8
#1	6 (15.2)	100	0
#3	8 (20.3)	94	6
#5	10 (25.4)	100	0
#7	14 (35.6)	51	49
#15	17 (43.2)	15	85
#25	23 (58.4)	25	75

Table 4. Quantity of water applied by the overhead and drip/spray methods for each container size by Georgia container nurseries.

Container	Overhead (acre-inches)[z] Mean ± SE	Min	Max	Drip/spray (gal/container)[y] Mean ± SE	Min	Max
<#1	0.34 ± 0.09	0.20	0.50	---	---	---
#1	1.03 ± 0.46	0.20	5.50	---	---	---
#3	1.17 ± 0.50	0.25	5.50	0.38 ± 0.12 a[x]	0.25	0.50
#5	0.48 ± 0.06	0.33	0.60	---	---	---
#7	0.55 ± 0.05	0.50	0.60	1.07 ± 0.07 ab	1.00	1.20
#15	0.50	---	---	1.54 ± 0.20 b	1.00	2.00
#25	---	---	---	1.73 ± 0.27 b	1.20	2.00

[z]1.00 acre-inch = 102.8 m^3.
[y]1.00 gal = 3.785 L.
[x]Means, within a column, followed by different letters, differ ($P < 0.05$).

Table 5. Weekly frequency of irrigation events during the growing season (March to September) and winter season (October to February) for Georgia container nurseries.

Container	Growing season Mean ± SE	Min	Max	Winter season Mean ± SE	Min	Max
<#1						
	8.2 ± 1.1	3.0	14.0	2.7 ± 0.6	1.0	7.0
#1	7.9 ± 0.7	4.0	14.0	2.7 ± 0.5	1.0	7.0
#3	7.8 ± 0.9	3.0	14.0	2.9 ± 0.6	1.0	7.0
#5	8.2 ± 1.0	6.0	10.0	2.5 ± 0.5	1.0	3.0
#7	10.1 ± 1.8	6.0	21.0	3.8 ± 0.8	1.0	8.0
#15	9.2 ± 2.1	2.0	21.0	3.5 ± 0.9	1.0	8.0
#25	11.6 ± 2.7	6.0	21.0	4.0 ± 1.4	1.0	8.0

in the growing season. There was substantial range in frequency of application among nurseries. The wide range in frequency of irrigation events could be due in part to variation in the use of cyclic irrigation (Table 6). With cyclic irrigation, there is a higher frequency of irrigation events but a smaller amount of water applied with each event. Information on amount of water applied (Table 4) and frequency of irrigation events (Table 5) could be used to 1) compute peak irrigation demand, and hence irrigation system specifications for nurseries, 2) irrigation capacity or well size and pumping requirements, and 3) estimate total annual irrigation water applied in nurseries.

BEST MANAGEMENT PRACTICES. The status of voluntary adoption of the SNA BMPs by Georgia nurseries was assessed (Table 6). Forty eight percent of the nurseries collect runoff irrigation water in a basin (Table 6). For nurseries that collect runoff water, the mean percentage of nursery area that drains into a basin is 71%. A substantial amount of nursery area runoff for Georgia container nurseries is being collected in basins. This compares to Florida, where 15% of the ornamental nurseries collect 75% or more of their water (Vasquez and Nesheim, 2000).

All respondent nurseries use well water (100%) for irrigation purposes and respondents estimated that about

Table 6. Irrigation management practices for Georgia container nurseries.

Practice	Response (%)
Collect irrigation water in basin/pond	48
If you collect runoff water in a basin/pond, the percentage of nursery area that drains into basin	71
Use well water	100
Percentage of irrigation water from a well	50
If you collect runoff water	44
If you do not collect runoff water	58
Practice cyclic irrigation	44
If you use cyclic irrigation, percentage of nursery irrigated by this method	77
Water early in morning	92
If you water early in morning, percentage of nursery that can be watered in morning	75
Grass strips/erosion filters between production beds and drainage area	60
If you have grass strips/erosion filters, percentage of production bed runoff that is filtered	79
Treat recycled water before use	17
Acid injector used to control pH of irrigation water	16

Table 7. Monitoring of key water factors by Georgia container nurseries.

Factor	Not applicable	Never	Yearly	Quarterly	Monthly	Weekly
Irrigation water alkalinity	8.3	25.0	45.8	12.5	8.3	0.0
Runoff water quality	13.0	47.8	21.7	8.7	8.7	0.0
Water quality in collection basins	18.2	40.9	31.8	0.0	9.1	0.0

Table 8. Nursery practices used by Georgia container nurseries to conserve water.

Practice	Response (%)
Recycle water	17
Water only when needed and minimize duration	17
Drip irrigation	15
Water in morning	13
Minimize predetermined irrigation frequency and use rain sensors and account for cloudy days	13
Cyclic irrigation	8
Arrangement of containers (spacing, group by size, avoid pot-bound plants)	8
Type of media including wetting agent	6
Repair leaks in timely manner	3

50% of total water use comes from a well (Table 6). The estimated percentage of irrigation water from a well was higher (58%) for nurseries that did not collect runoff water than for nurseries collecting runoff water (44%). The results demonstrate that about half of the irrigation water used by Georgia container nurseries comes from ground water while the other half is surface sources such as recaptured irrigation water or rain water. The use of recycled water can help nurseries reduce the need for potable water.

Forty-four percent of the respondent nurseries practice cyclic irrigation (Table 6). Cyclic irrigation is when a plant's water allotment is divided into a series of application events throughout the day. For nurseries using cyclic irrigation, 77% of the nursery was irrigated using the cyclic irrigation method.

Ninety-two percent of the respondent nurseries (Table 6) water early in the morning and 75% of the nursery production area could be watered during this period. Overhead irrigation is most efficient when applied before 10:00 AM due to less wind and lower evaporative demands (Yeager et al., 1997).

The use of grass/riparian strips is recommended in the SNA BMPs as a method to improve quality of runoff water (Yeager et al., 1997). Grass strips can reduce sediment transfer to collection basins or streams, calcium that may reach the collection basin from the use of lime rock beds, and nitrate or phosphorus fertilizers from leaving the nursery. Sixty percent of the respondent nurseries use grass strips/erosion filters between production beds and drainage areas (Table 6). The mean production area that drains through these strips for respondent nurseries using grass strips was 80% of production bed area.

Although 48% of respondent nurseries recycle water, only 17% of the respondent nurseries treat the recycle water before use (Table 6). The primary treatment of water is for pH control. Sixteen percent of the respondent container nurseries used acid injection to control pH of irrigation water.

An important factor in consistent production of high quality nursery plants is the establishment of quality control procedures (Garber and Ruter, 1993). Monitoring key variables is an important aspect of a quality control program. Georgia nurseries were asked the frequency of monitoring for three important water factors (Table 7). The respondents were allowed to choose among several frequencies of measurement, weekly, monthly, quarterly, annual, never, or does not apply. Almost half (45.8%) of the respondent nurseries monitored water alkalinity once a year, while 25% of the nurseries never checked water alkalinity. About 48% of the respondent nurseries (Table 7) never checked the quality of runoff water, while 21.7% checked once per year. Unfortunately, the once-a-year measurement would not allow a nursery to determine a baseline or levels of peak nutrient loss. The monitoring of water quality in collection basins was comparable to the monitoring of runoff water quality (Table 7). About 41% of the respondents did not check water quality in basins. Since this water is recycled, a large number of nurseries are incorporating an unknown quantity of nutrients into their production system. Almost 32% of respondents checked water quality in basins on an annual basis. Based on the results in this survey, more of Georgia's nurseries should be monitoring key water variables and they should do it on a more frequent basis, than is the current practice.

NURSERY PRACTICES TO CONSERVE WATER AND IMPROVE WATER QUALITY. Two environmental challenges for container nurseries are conservation of water and the quality of runoff water leaving the nursery. Georgia container nurseries were asked to list the two most important practices they took to conserve water (Table 8). Responses to the open-end questions were analyzed, categories of response developed, and frequency of response analyzed. The most frequently listed practices to conserve water, in descending order, are listed in Table 8. The practices included recycling water (17%), irrigating when needed and for the minimum required time (17%), use of drip irrigation in lieu of overhead irrigation (15%), water in the morning hours to minimize loss of water due to evaporation (13%), water based on plant requirement and not based on preset frequency (13%), use of cyclic irrigation (8%), arrangement of containers, such as grouping by size (8%), altering growing media, including wetting agents (6%), and timely repair of

Table 9. Nursery practices used by Georgia container nurseries to protect stream and ground water quality.

Practice	Response (%)
Capture runoff water in basins for irrigation	33
Grass strips and wetlands to filter water	21
Control release fertilizers	18
Minimize and careful use of chemicals through IPM	18
Monitor amount of water applied/duration of irrigation	10

irrigation system leaks (3%). The most frequently listed practices by respondent Georgia container nurseries to conserve water generally followed recommendations of the SNA Association BMPs (Yeager et al., 1997). The diverse list of practices and relatively even distribution of response, indicates that respondent Georgia nurseries are not relying on a single solution to water conservation but rather are employing a diverse set of practices. This should help ensure successful efforts by the Georgia industry to conserve water.

Georgia nurseries were asked to list the two most important practices they used to protect stream and ground water quality (Table 9). The five categories of practices identified by respondents, in descending order, were capture runoff water in basins for irrigation (33%), grass strips and wetlands (21%), use of control release fertilizers in lieu of liquid fertilizer (18%), reduced use of chemicals through integrated pest management (18%), and monitor duration of irrigation more closely (10%) to avoid excess application of irrigation water. The five categories identified are effective means to improve the quality of water leaving the nursery. As with water conservation, the respondent nurseries are using a diverse set of practices to improve the quality of runoff water.

Summary and conclusion

The long standing assumption that water will always be available in generous supply is probably invalid. Most states in the U.S., particularly southeastern and northeastern states, have recently experienced significant water shortages. The implication for container nurseries, and other ornamental producers, is that the industry must learn to better manage this precious natural resource. To accomplish this, the nursery industry will need more and better information on how much water is currently used to grow crops, how the water is managed, and how much water is required to grow crops. These are difficult questions that the industry will have to address. In many states good data is not available. The issue of how much water is required by container nursery crops is outside the scope of this study and requires additional research, such as that conducted by Beeson (2001).

This survey of Georgia nurseries provides baseline data for the first two issues, how much water is used by container nurseries and how efficiently is the water used. Similar studies could be conducted in other states to determine water use and adoption of BMPs for water management. This information would provide guidance for industry water conservation efforts and university research and extension programs. For instance, we identified a low level of monitoring of key water attributes in Georgia container nurseries. This suggests that future extension training activities for nurseries should include identification of key water quality variables and how to measure. Monitoring of key production variables is critical to production of consistent quality plants. As production systems are changed to better manage water resources, monitoring of water quality attributes will be increasingly important. The information in this study could be used by growers in other states to determine their relative water use, application methods, and procedures to reduce water use and improve runoff water quality. A greater water use than Georgia would suggest an analysis of Georgia practices to determine the feasibility of reduced water applications.

During the course of this study, it became apparent that the information provided on quantity of water applied were estimates made by nursery operators. Very little quantitative monitoring of water use is occurring. Georgia is probably not unique in this respect. As a necessary first step to better manage water resources, the container nursery industry should consider quantitative measurement of water applied. This should be done by application method and container size, where feasible. It will be difficult for the container nursery industry to document progress in reducing water use in the absence of baseline data on amount of water applied. Quantitative measurement would help document the necessary quantity of water required, an important element in dealing with water regulators.

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