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# Florida Nursery Best Management Practices: Past, Present, and Future

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***SUMMARY. Florida nurseries face the challenge of maintaining profitability while protecting the environment and improving the efficiency of water and fertilizer use. Best Management Practices (BMPs) provide guidelines for meeting this challenge. However, increasing nursery participation in the statewide BMP program is crucial as the industry continues to expand and interface with urbanization. BMPs are economically and technologically feasible to implement and address water quality issues.***

Container production began in the 1950's after the nursery industry's beginnings with production of plants in native soils. The earliest reported ornamental plant production in Florida was 1881 at Reasoner's Nursery in Oneco. As the population of Florida increased, demand for plants increased and consequently the number and acreage of nurseries increased (Fig. 1).

There are currently 7,875 nurseries registered with the Division of Plant Inspection (DPI). In the most recent economic study conducted by Hodges and Haydu (2006) of the University of Florida Institute of Food and Agricultural Sciences (UF/IFAS), farm gate value of nursery plants was 2.7 billion dollars with about 59,000 acres of container production and 24,000 acres of field or in-ground production. Many container nurseries are located close to urban markets. Thorp (1995) conducted a survey of sustainable practices used at 113 container nurseries and found that about 50% were within one mile of an urban center. However, this can result in land values exceeding profitable production, problems with some production operations that are not compatible with urbanization, and limited room for expansion. So nurseries that needed larger land areas for expansion have relocated, particularly some from south Florida to south-central Florida. Migration of nurseries to a particular region or locale also stimulates new nurseries to start in that locale.

The diversity of container nurseries both in production and how they market is different that any other facet of agriculture. The sizes and shapes of plants, number of plant species including cultivars, methods of irrigation delivery, fertilizer types and application methods, and number of plants per acre make container production a very complex phenomenon. In addition to production complexities, marketing channels are more diverse than typically found for most agricultural commodities. These include wholesale mass markets; re-wholesale markets, retailers, contractors and developers, landscapers, and restoration and nature markets. Each of these market segments is further fragmented by variations or focus.

Despite market variations and production complexities, the container nursery industry in Florida continues to mature with the leadership of the Florida Nursery, Growers and Landscape Association (FNGLA). Political, regulatory, economic, and educational issues are very import to the industry. FNGLA works cooperatively on many of these issues with the American Nursery and Landscape Association (ANLA), a national nursery association, as well as the Southern Nursery Association (SNA) which represents 16 southern states.

In 1994, industry personnel from the southeast met with regulatory and university personnel to discuss the need for compiling in written form the "best" practices used by the industry. This resulted in the first BMP guide for container nurseries titled *Best Management Practices: Guide for Producing Container-Grown Plants* published by SNA in 1997. As requested by the industry, the guide focused on irrigation and fertilization practices. The BMP guide was promoted in Florida by the Florida Department of Environmental Protection (FDEP) through a series of workshops.

Also in 1994, the Florida legislature passed "nitrate legislation" in response to finding elevated nitrate levels (>10 ppm N) in ground water in several citrus production areas of the state. The legislation provided for a proactive approach for producers to implement management practices that were technologically and economically feasible and would minimize movement of nitrates to ground water. In exchange for implementation and keeping appropriate records the producers would receive a waiver of state-imposed liability for recovery costs if nitrate contamination was subsequently found. FNGLA and UF/IFAS developed cooperatively an interim measure as provided by the legislation. This interim measure for container nurseries was adopted by statutory rule in 2003. Nursery personnel implementing the practices of the interim measure were waived from state-imposed costs for clean-up of nitrate-contaminated ground water. It is important to note that this legislation was applicable to nitrate nitrogen in ground water only. Subsequent legislation (1999) provided the incentives for production agriculture to develop and adopt BMPs applicable to all surface and ground water contaminates.

The initial ornamental plant research and educational efforts conducted under the BMP umbrella in Florida began in the 1980s for the leatherleaf fern industry. Those efforts resulted from the finding of elevated concentrations of nitrates in ground water at a Central Florida fernery. A BMP guide for the leatherleaf fern industry titled *Irrigation and Nutrient Management Practices for Commercial Leatherleaf Fern Production in Florida* is available at http://edis.ifas.ufl.edu. Leatherleaf fern comprises currently about 60% (6,000 acres) of the cut, cultivated greens acreage.

Just as nitrate contamination resulted in the BMP program for leatherleaf fern production, phosphorus discharge to the Everglades resulted in the development of the statewide BMP guide for Florida titled *Water Quality/Quantity Best Management Practices for Florida Container Nurseries*. The initiation of the BMP development process for container nurseries in Florida started in 2003 with SFWMD asking the nursery industry in Broward County for their assistance in achieving 10 ppb discharge from canal 11 to the Everglades. Subsequently, Florida Department of Agriculture and Consumer Services (FDACS) became involved in the process because the Office of Agricultural Water Policy (OAWP) of FDACS is responsible for developing BMPs that are adopted by rule with statutory authority. The BMPs must be economically and technically feasible and developed with grower input. FDACS relies on input of expertise from university personnel to ensure the BMPs are research-based to the extent possible. Also, regulatory personnel of the state are involved in the BMP development process to ensure that BMPs provide the "backbone" for addressing water quality issues.

Industry representatives worked cooperatively with UF/IFAS to develop a BMP guide for Florida (http://floridaagwaterpolicy.com) that was adopted by statutory rule in 2007. UF/IFAS personnel conducted workshops and demonstrations about the use of BMPs. Cost share funds were made available and BMP implementation teams and mobile irrigation lab personnel assisted producers with BMP implementation.

About 600 container nurseries representing 13,560 acres have become BMP users registered with FDACS. Our experience has been that most nurseries not registered with the state as BMP users actually use many of the BMPs. When nursery personnel are asked why they have not formally registered with the state, common reasons include: complacency, skepticism of outside intervention, and general lack of trust of regulatory agencies. Any or all of these could be a reason for not signing on as official BMP practitioners.

Container crops comprise the largest amount of acreage in the state; however, in-ground production is increasing and represents about 30% of the total acreage of nursery plant production. In-ground production typically requires less fertilizer and irrigation than container production. A BMP guide is currently being developed for producers of in-ground trees and shrubs. Caladiums produced in native soils or muck will also be included.

Some benefits for nurseries implementing BMPs are listed below.

- Protection from duplicate regulations at the local level
- Eligibility for USDA Natural Resources Conservation Service and possibly other cost share funds for retrofitting or implementing water-conserving irrigation systems
- Minimizing movement off-site of surface water contaminates such as phosphorus
- A demonstration that the nursery industry can exercise its ability to determine what are the "best" cultural practices and voluntarily use these practices rather than be confronted with mandatory regulations
- Improved production efficiency and reduced production costs
- Waiver of state-imposed liability for surface and ground water cleanup and presumption of compliance with state water quality standards

**Current irrigation practices**

Irrigation water is usually applied with overhead sprinklers if containers are <7 gallons; larger containers are irrigated using microirrigation e.g. drip tube irrigation or micro spray-stake irrigation (Yeager et al., 2006; Garber et al., 2002). The nurseries surveyed by Thorp (1995) had approximately

79% of the acreage with overhead sprinkler irrigation and 12% with low volume microirrigation. Overhead sprinkler irrigation in most regions of Florida is restricted to night-time watering with amount applied approximately 0.3 to 0.6 inches per application. Unlike overhead irrigation, microirrigation is not restricted by amount or time of day. About 3-5 gallons per inch of trunk caliper are applied to 1-3 year-old trees during peak demand with water needs increasing with plant size. Most container crops are irrigated daily due to the limited substrate volume for retaining water. Cyclic irrigation scheduling, which supplies water in several short cycles instead of one long cycle, can improve water retention in containers and is being used by many growers, particularly for microirrigated plants (Schoene et al., 2006). Subjective decision-making based on personal observation and experience is still the key factor used by growers in determining when and for how long to irrigate. For example, from the surveys of 58 nurseries in west-central Florida (Thorp, 1995) it was determined that more than 70% relied on visual observation to determine when to irrigate (Table 1). The primary objective of irrigation decision-making is to apply enough water so as to not reduce plant growth. Minimizing leaching by monitoring container drainage and adjusting irrigation scheduling accordingly is not a primary objective for many growers at this time. Few growers are using BMPs such as ET-based irrigation scheduling, tensiometers, or other system of objective irrigation scheduling.

Besides irrigation scheduling, container spacing can play a major role in irrigation efficiency and runoff. Beeson and Knox (1991) reported that irrigation efficiency was 37% when containers were 'jammed' but only 25% when plants were spaced. Million et al. (2007a) found that spacing containers at planting instead of midseason increased total runoff 9%. Fortunately, most growers place containers adjacent to each other during early stages of production, minimizing the amounts of overhead water that fall un-intercepted between containers. As containers are spaced midseason to allow more sunlight penetration and improve plant quality, the larger canopy can often help capture water that might normally fall between containers. This canopy effect, which depends on plant species, canopy characteristics, and container size and container spacing (Beeson and Yeager, 2003) is not considered by most growers when scheduling irrigation and grouping plants in the nursery. Regardless of the infrastructure specifics for producing container crops, the objective should be to maximize irrigation efficiency and to minimize leaching and associated loss of nutrients. Educating producers and getting them to conduct leaching tests would be an important BMP to conserve water and fertilizer. BMPs used by nurseries with overhead sprinkler and microirrigation in west-central Florida are given in Table 2.

Most research has shown that about 10-40% of overhead irrigation water is captured by containers (Beeson and Knox, 1991; Weatherspoon and Harrell, 1980). Limitations to efficiency include overwatering to compensate for non-uniformity of water delivery or non-uniformity of plant water demand within the irrigation zone (i.e., different container sizes, species, and stage of growth), lack of knowledge about exactly how much water is needed and how the canopy effects irrigation water capture, variable wind conditions, and wide container spacing arrangements. By improving irrigation delivery to more closely match the capturing capabilities of the container-plant, growers could reduce fertilizer leaching. However, reductions in fertilizer leaching through conservative irrigation may be limited in areas with significant rainfall. Leaching of applied nutrients in container production is usually reported to be 10-30% of that applied in CRF (Million et al., 2007a; Million et al., 2007b; Ristvey et al., 2001). Chen et al., (2001) noted that up to 50% of applied fertilizer may leach or runoff.

**Irrigation challenges and BMPs**

Producing plants in containers provide some unique challenges for the grower. The confined volume of substrate, even when the substrate has excellent water-holding properties, provides little buffer against under-watering, and conversely, over-watering. It is not surprising to observe that many growers guard on the side of caution and apply more water than is needed preferring the risk of increased leaching losses rather than the consequences of under-watering. By weighing plants and measuring daily water loss, we know that water uptake is relatively low during early stages of growth and increases as the plant canopy develops. This means that grouping plants within irrigation zones based upon stage of growth and container size is very important if more precise amounts of water are to be applied. Unfortunately, in most nurseries a wide range of crop species, container sizes and stages of growth exist, and although grouping of plants is acknowledged by growers as important, grouping is often based upon space availability and/or labor availability and associated moving costs.

We also know that at any given stage of growth, container evapotranspiration is highly dependent upon the weather, particularly solar radiation. ET-based irrigation scheduling relies on models to help growers adjust irrigation rates according to daily weather (Beeson, 2006; Beeson, 2005; Irmak, 2005; Schuch and Burger, 1997; Beeson, 1997a; Beeson, Jr. 1997b). Other soil moisture-sensing technologies such as suction tensiometers (Bacci et al., 2008) and Time Domain Refractometry (TDR) probes (Bergeron et al., 2004; Charpentier et al., 2004) can be used to trigger irrigation when water content falls below a critical level. These devices require special management expertise and as yet have not been widely adopted. However, they provide an objective method of irrigation scheduling and their use should increase as water conservation demands increase. A simple device which can save growers water and leaching is the automatic rain shut-off sensor. However, its use is limited by the fact that many nurseries do not have automatic irrigation systems to control irrigation (Schoene et al., 2006).

Precise irrigation designed to apply enough water to recharge substrate without excessive leaching requires excellent management (Mathers et al., 2005). This is particularly important with overhead irrigation as irrigation application efficiencies are low. Growers can maximize irrigation efficiency by implementing BMPs listed below.

- Installed and maintained uniform irrigation delivery systems

- Wind breaks planted around perimeter of production areas
- Plants grouped according to water requirements
- Evaporative demand monitored directly by measuring water content or indirectly by using ET models and used to adjust irrigation amount
- Leachate volumes used to adjust irrigation volume
- Plant material moved out of production areas once plants are of marketable size and quality.
- Rain shutoff devices are used
- Rain and irrigation water collected and reused
- Determine water holding capacity of substrate
- Amount of water applied adjusted in relation to water holding capacity of substrate
- Cyclic irrigation used to minimize water and nutrient loss from containers
- Substrate moisture sensors used for initializing irrigation, rather than fixed schedule

**Current fertilizer practices**

Plant nutrients are most often supplied with controlled-release fertilizers (CRF) incorporated at 2-3 lbs of N per cubic yard of substrate prior to potting. Approximately 82% of the nurseries surveyed by Thorp (1995) used CRF. In some situations such as repotting or correcting a deficiency problem, CRF can be placed on the substrate surface although this method may lead to significant fertilizer loss through spillage if containers are over-turned. Due to lower costs and better retention of soluble nutrients, water-soluble granular fertilizers are commonly used for in-ground production. Injection of soluble fertilizers into overhead irrigation water has traditionally been a common method of fertilizing foliage crops watered with overhead irrigation. However, use of controlled-release fertilizers can greatly reduce N leaching in these production systems (Yeager and Henley, 2004).

Many growers monitor substrate nutrition by using the pour-through or suction lysimeter techniques (Yeager, 2003). Published guidelines for electrical conductivity and nutrient concentrations of solutions obtained with these tests are used by producers to determine if nutrition is adequate or excessive. Although tissue testing can be used to confirm deficiencies, the high cost of nutrient analyses prevents its routine use by most growers. The survey conducted by Thorp (1995) indicated that 56% of nurseries surveyed tested the substrate and 18% conducted tissue tests.

**Fertilizer challenges and BMPs**

Supplying adequate nutrients for producing plants in containers also poses some interesting challenges to the grower. Young plants with immature root systems require relatively high concentrations of nutrients to maintain optimal growth despite the fact that the total amount of nutrients taken up is low. As root systems develop, plants are more efficient at taking up nutrients and nutrient uptake is not as sensitive to nutrient release from CRF. During rapid growth stages, fast-growing plants require relatively high amounts of nutrients. Because CRFs must supply in one application enough plant nutrients to support season-long growth of the crop, matching nutrient release with plant requirements is a major challenge for both growers and CRF manufacturers. CRF coating technologies which impart the slow-release properties of these fertilizers has not changed significantly in the past 20 years. The environmental factor primarily affecting nutrient release from most polymer-coated CRFs is temperature which may or may not be related to plant growth. For example, late spring and summer plantings may cause undesirably high release rates during early stages of growth. Furthermore, temperatures in containers can be significantly increased from solar radiation exposure if plants are small and/or containers are widely spaced (Million et al, 2007a; Ingram et al., 1988). This can lead to undesirably fast release rates and leaching losses (Million et al., 2007a). By varying coating thicknesses, manufacturers offer CRFs with different longevities, but with similarly-shaped release curves. Some control over nutrient release patterns has been accomplished by mixing together CRFs with different longevities into one product. For example, a CRF that consists of a combination of 3-4 month product with 8-9 month product can provide quicker nutrient release during early stages of growth than would be possible with 8-9 month product alone. Some CRFs have a significant portion of "imperfectly-coated" product which essentially behaves as soluble fertilizer. This quick release has been a blessing and a curse. It provides for initially high concentrations of nutrients needed for young transplants but amounts may be excessive and lead to excessive leaching early in the growing season (Million et al., 2007a; Huett, 1997), even during initial watering in of transplants (Million et al., 2007b). In this regard, some studies have shown that zeolites, gels, and other active compounds can be used as substrate amendments to retain soluble nutrients within the container (Broschat, 2001; Chen et al., 2000). Successful research in this area, particularly in regards to nitrate retention, could help buffer against rapid loss of nutrients under these circumstances. A working knowledge of plant N requirements, fertilizer release properties, and expected temperatures will provide the best opportunity to apply CRFs most efficiently during container production, especially when combined with precision irrigation scheduling designed to minimize leaching of released nutrients from containers.

Another challenge facing efficient fertilizer usage is the "one size fits all" practice. Because of the wide variability in crop species and container sizes found within a given nursery and the common practice of buying pre-mixed substrate amended with fertilizer, it is not uncommon for nurseries to use the same substrate amended with fertilizer for different types of production. This requires much less management than custom mixing fertilizer into substrates used for different crops. For example, where 3 lb of N per cubic yard may be a judicious rate for a 3-gallon shrub grown for one year, this would likely be excessive for producing a 1-gallon shrub that takes only 4-5 months. As with water, growers tend to guard on the side of caution of applying too much rather than risk an inferior crop from under-fertilization. The added costs of applying additional fertilizer provide a measure of insurance against producing under-fertilized plants of inferior quality and allows for extended growth during times when crops can not be sold. Quality plays a major role in consumer preference for ornamental crops and high fertilizer rates produce dark green, foliage which is desirable for many ornamentals. These factors help to explain why growers are reluctant to reduce application levels to rates found by researchers to produce optimal growth.

Monitoring substrate nutrition is an important BMP for growers to follow. By periodically monitoring substrate nutrition, an objective assessment can be made of how well the fertilizer program is working and provides a valuable insight into the release pattern of the fertilizer used. Adjustments in fertilizer type or application rate made to bring substrate nutrition into recommended ranges can help to maintain optimal plant growth while minimizing the potential for loss of excessively-applied nutrients. Some fertilizer-related BMPs that are important in Florida include:

- Controlled-release fertilizers are used with release patterns that match expected crop requirements
- Fertilization rates and amounts are adjusted for different species and container sizes
- Irrigation runoff is collected and reused if soluble fertilizer is applied in overhead irrigation water
- Substrates are amended with CRF if containers are likely to overturn
- Fertilizer is broadcast on non-spaced containers
- Substrate nutrition is monitored to maintain desirable substrate nutrition levels
- Records are kept to help follow trends and to trouble-shoot unforeseen nutritional problems
- Runoff water is captured and reused to recycle nutrients
- Substrate storage areas are covered to prevent leaching and runoff of nutrients
- Substrate is used immediately (within a week) if amended with fertilizer
- Ratio of $P_2O_5$ to N in fertilizers is1:3 or less

Precision application of both water and fertilizer to match plant requirements provides the best opportunity for conserving nutrient and water resources in the container nursery. Because plants require a significant pool of available N in the substrate to grow well and because rainfall will likely occur, leaching of applied fertilizer nutrients is going to occur regardless of whether irrigation water is precisely applied. Nonetheless, it is essential for monitoring programs to be in place to provide an objective basis for irrigation and fertilization decision-making to maximize conservation of these resources. In this regard, a nursery specializing in fewer crops will have a better chance of implementing these practices which require more management than many growers have been accustomed to providing.

**Water Discharged**

Zero discharge production systems are often used in greenhouses in conjunction with subirrigation. Benches designed to capture runoff and leachates from containers are used with tanks, pumps and plumbing that provides infrastructure needed to recycle water. Irrigation water runoff from outdoor production areas is often recycled but zero discharge from the property is unlikely since storm events often force water to leave the property. Recycling of water from production beds is greatly improved by underlying beds with impervious plastic and providing efficient ditching to channel water efficiently to containment structures.

The volume capacity of a containment structure is generally sized to contain at least 90% of the water applied from an irrigation event. The containment size or volume should also include a buffer zone capable of containing runoff from a 0.5 inch rain prior to the next irrigation event. Entry of runoff into containment structures may be accomplished with pipes or channels with open conveyance. Provisions should be taken within containment structures to minimize erosion of side walls where water enters. Erosion may also result from wave action on side walls. Side wall areas above the high water mark should be firmed and protected with stone, synthetic materials, or natural vegetation.

Drought and excessive rain will result in wide variation in the volume of water contained in the structure. Evaporation amount varies with ambient conditions but generally one inch of evaporation per week can be anticipated. Thus, a month without rain will result in a four to five inch decrease in the amount of water in containment without regards to runoff volume. Count on no more than 50% of irrigation water to be recycled to containment structures. Additionally, the volume contained during a drought is diminished due to lack of runoff from rain on the production surface. Conversely, there should be the capability to discharge water from containment structures due to excessive rain

Storm events can result in movement or a surge of particulates and nutrients transported in runoff. Generally, the first one half inch of a storm event is retained on the nursery and excess discharged. However, the specific amount retained may vary with state and local requirements. The first flush of storm water is usually contained in collection structures and separated from subsequent storm water by the use of retaining walls with overflow capability.

Another approach to retaining storm water is to maximize capacity of the water storage to minimize discharge. This can be important if the nursery depends on storm water for irrigation. Surface runoff resulting from 4 to 5 inches of rain would supply approximately 4 to 5 irrigation events for the container plants (3-gallon or smaller) grown in the production area from which the runoff flowed.

Discharge is best accomplished with open channel conveyance with provisions to minimize erosion. Overflow areas with concrete surfaces and concrete runways or runways with synthetic liners are often used to minimize erosion. Water discharged from the containment structure should be subjected to remediation before being discharged from the property.

Remediation may be accomplished in several ways. Depending on the amount of land available, discharge from one collection structure may flow to another structure or several structures in series before ultimately leaving the property. Discharge from a single containment structure may traverse wetlands or grassed areas for sediment filtering and flocculation. Remediation may also involve biological processing such as provided by nitrate bioreactors and denitrification walls (Schipper et al., 2004).

**Plant Modifications**

The plant palette or diversity of plants produced can change rapidly in response to market demand. Thus it is unlikely, at least short term, that genetics or breeding of plants will result in more efficient us of water and fertilizer. Plant selection within the gene pool could offer potential for plants with enhanced drought tolerance and efficient uptake capabilities. However, the major improvements in water and nutrient use will be achieved by infrastructure or management BMPs.

**Vision for the Future**

There is tremendous potential for container nurseries to become more efficient with water and fertilizer use. Research-based irrigation management strategies currently exist that could be implemented to increase irrigation efficiency and reduce environmental impacts. Many of these have been described in this paper. However, to date, efforts to get producers to adopt in earnest these irrigation management BMPs have not been as successful as we would have liked. We need to investigate further why adoption has been slow and develop strategies to improve this. In regards to nutrient management, adopting precision irrigation management practices will go a long way towards decreasing nutrient losses in the nursery. Although CRFs are used by most growers, we need to develop new CRFs with release patterns that more closely match plant requirements. Unfortunately, developing new nutrient release technologies is costly and exacerbated by the recent rise in oil prices, slow economic growth, and low value of the dollar. Yet the appreciation for the attributes of ornamental plants and the impacts of these plants on our lives are stronger now that at any time in history. Our passion for plants will get stronger if the time-tested model of our European roots continues to grow. Our obligation is to master the environmental challenges of production inherit with a non-agrarian society. The research, teaching, and extension missions of the land-grant universities are vital to meeting these challenges.

We believe that BMPs past, present, and future can be categorically expressed as: 1) BMPs not widely used, 2) BMPs widely used, and 3) BMPs that need to be developed. The inherit pros and cons of these categories will direct the future of BMPs, particularly the impact on BMP research and extension efforts. Some examples to stimulate thought are included below.

**1. BMPs not widely used.** BMPs such as monitoring substrate nutrition, monitoring leachate volume to adjust irrigation volume, use of sensors and irrigation controllers, container adaptations for capturing irrigation water, and effective irrigation delivery for small containers currently have low adoption. In addition, only 8% (23% of acreage) of container nurseries in Florida have signed the notice of intent to implement BMPs. Why the low adoption and commitment despite receiving a waiver of liability and many other benefits? Perhaps this question is worthy of investigation to determine if our communication and educational efforts are on target and appropriate.

**2. BMPs widely used.** BMPs such as covered substrate storage structures and cyclic irrigation on large containers are currently used extensively. To a lesser extent collection basins are used to contain runoff on the property. How effective are these BMPs? Large capital expenditures are required to install collection basins and covered substrate storage areas. But the effectiveness of these BMPs has not been verified with regards to minimizing movement of nutrients in discharge or surface water. Perhaps the effectiveness of BMPs should be documented before building costly infrastructure. Verification may also provide impetus for promoting BMPs to other nurseries. Additionally, cyclic irrigation for overhead sprinkler systems is not costly to adopt but the effectiveness is not known.

**3. BMPS that need to be developed.** New BMPs will likely capitalize on technology or precision agriculture. This might include a CRF with programmable release more in tune with plant nutrient needs, containers that are self cooling so plants have less stress, technologies or plants engineered to indicate water and nutrient stress, repeatable and communicative criteria for categorizing plant water or fertilizer needs, or decision support systems to simulate or trial the use of BMPs in complex production systems without conducting physical experiments. Simulation models would use local weather to help growers with BMP decision-making including irrigation and nutrient scheduling. The simulation of BMP implementation could be linked to economic or profit criteria so the BMPs selected to implement are truly economically and technologically feasible.

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Table 1. Factors used by nursery operators in west-central Florida to aid in the determination of irrigation frequency (Schoene et al., 2006).

| Determination of irrigation frequency | Number of nurseries (%) |
|---|---|
| Indicator plant | 8 |
| Visual observation | 74 |
| Sensor | 12 |
| Fixed | 58 |

Table 2. Best management practices (BMP) adopted by container nurseries in west- central Florida with overhead and microirrigation systems (Schoene et al, 2006).

| Best Management Practice | Number of nurseries (%) |
|---|---|
| Collect irrigation or rain runoff | 35 |
| Know water-holding capacity of substrate | 10 |
| Group plants by irrigation requirements | 77 |
| Group container sizes by irrigation requirements | 72 |
| Use any other grouping for irrigation requirement | 28 |
| Monitor amount of water applied each irrigation | 36 |
| Monitor the application pressure in irrigation | 51 |
| Use automatic rain shutoff | 30 |

Table 3. Summary of current BMP research areas for nursery crops, level of knowledge, gaps.

| BMP research area | Level of knowledge | Gaps |
|---|---|---|
| **Nutrition of nursery crops** | None | Nitrogen volatilization |
| | Very low | When does uptake occur? |
| | Very low | Nutrient needs of plants in native soils |
| | Very low | Variation in nutrition with species |
| | Very low | Substrate temperature impacts |
| | Very low | Economics of change |
| | Very low | Decision support system |
| | Moderate | Nutrient loss from substrates and soils |
| | Moderate | Bio- and phyto-remediation of runoff |
| **Irrigation of nursery crops** | Very low | Non-traditional irrigation systems |
| | Very low | Cyclic irrigation with overhead water |
| | Very low | Economics of change |
| | Very low | Decision support system |
| | Moderate | Water requirements of plants |
| | Moderate | Container capture of overhead water |

Table 4. Questions to and summary of vision statements by key UF/IFAS state and county faculty with active programs in BMPs for nursery crops.

| Question | Answers | Comments |
|---|---|---|
| 1. What is your opinion/vision for the next 5 years on what the industry needs to do to improve irrigation management? | Adopt existing and new management practices. | About 8% of container nurseries (23% of acreage) have signed up for BMP program |
| 2. What is your opinion/vision for the next 5 years on what the industry need to do to improve their fertilizer management? | Fertilization based on plant need. | One rate or fertilizer may not work for all plants. Monitor or test to determine when and how much to apply. |
| 3. What educational programs are needed? (need to be separated for agents, for growers) | Grower – impacts and costs/profits from BMPs. Simulation model of plant production could be used for education/training. | Agents – how to package education based on clientele learning style |
| 4. What are the critical issues on the horizon (5 to 10 years) that may affect the industry? | Energy costs, fertilizer and water regulations, water costs, low percent of applied fertilizer used by plants | |
| 5. Other<br><br>How will we meet BMP goals in the face of diminishing funding? | Provide better documentation of the benefits of adopted BMPs; focus efforts on areas that have the most impact | Promote our successes; involve nurseries in BMP research |

Table 5. Strategic areas of future research involving nursery crops for improving the quality of Florida waters, their respective approaches and estimated chances of success.

| Approach used to improve water quality | Possible areas of research | Estimated relative chance of success | Why? |
|---|---|---|---|
| **Minimize surface discharge or percolation water with nutrients** | Precision application of water and fertilizer to minimize runoff/percolation and associated nutrients | good | Applicable to most nurseries, container or plants in ground |
| | Non-traditional irrigation application techniques e.g. subirrigation | good | Applicable to container and in-ground production |
| | Decision Support Systems | good | Applicable to container and in-ground production |
| | Design, construction and use of recycling systems | fair | High costs for producer |

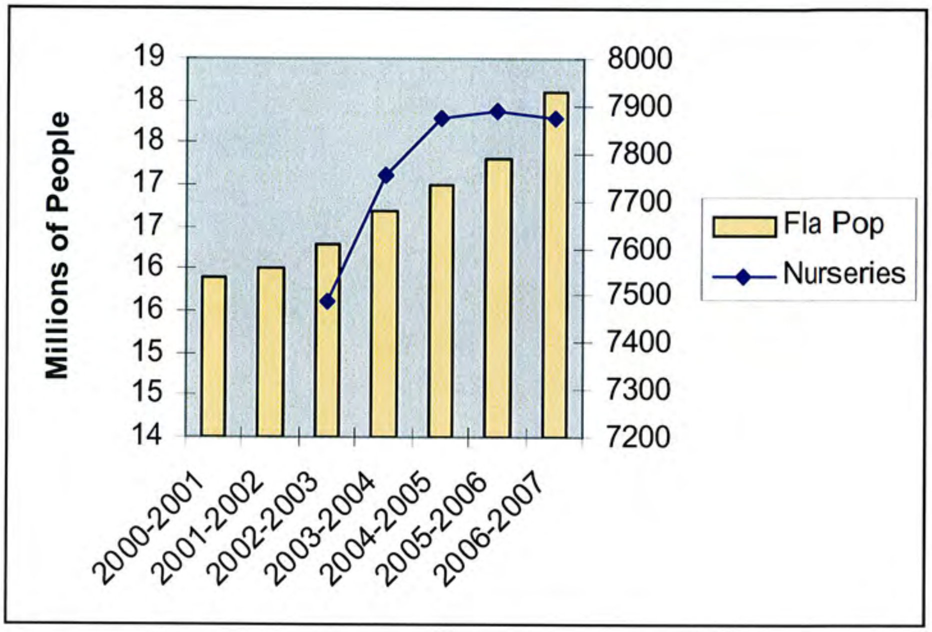


Figure 1. Florida's population growth and increase in number of nurseries.

Source: US Census Bureau and FDACS Annual Reports