
# Plant Production

The majority of ornamental plants grown in the United States are produced in container nursery or greenhouse operations. Plants are grown in containers primarily for production efficiency and for ease of shipping to retailers. These operations are classified as intensive agricultural systems because they use a combination of expensive resources (labor, water, fertilizers, etc.) to produce plants in large numbers on small acreages.

A nursery is often defined by its method of production (container or field), its market (landscapers, wholesale, retail), the crops grown (trees, perennials, etc.), or the sizes of plants sold (liners, bedding plants, balled and burlapped, etc.). The types and diversity of crops and plant sizes have a great impact on the ability to market plant material to the appropriate target audience and realize economic sustainability.

According to the most recent FNGLA sponsored economic impact study, the University of Florida found that increasing costs of production is one of the top four issues facing the horticulture and landscape industry, along with water use restrictions, low prices for products and services, and government regulations. These emerging constraints mean the ornamental horticulture industry needs to rely heavily on research-based best management practices to devise integrated sustainable production methods without reducing plant quality and profitability.

## Nursery Production

As one of the largest agricultural industries in the state, plant nurseries represent a major component of the economy of Florida. A profitable nursery business requires a sizable investment of money in labor and equipment, plus good management. It also requires growers to become familiar with production practices in use within the geographical area and take steps to sustainably manage resources.

### *Types of Production*

The two basic types of nursery production are field and container. Field stock is either direct seeded or transplanted from seedlings in the ground and then lifted bareroot for use as nursery liners, rootstock, windbreaks or conservation plantings. Balled and burlapped (B&B) plants are also field grown. ***Container stock*** is propagated from seed, rooted cuttings or field grown seedlings and grown to marketable size in containers. Most woody landscape plants are container grown.

## Propagation Nurseries

Propagation nurseries reproduce plants by seedlings, cuttings, grafting, or tissue culture. They supply plants that will be placed in the field or containers for growing on to a marketable landscape size.

## Field Nurseries

Field nurseries grow woody trees and shrubs in the ground; they are most commonly harvested by balled and burlapped (B&B) methods. Pot-in-pot production is an intermediate production system grouped with field production that combines inground production with the marketing flexibility of container production. This method alleviates some of the problems associated with container production, such as blowover and moisture loss. Pot-in-pot startup costs are high for irrigation and drainage systems, plus the inground pot that holds the plant production pot. Yet, overwintering costs are negligible compared to container production because root balls are protected by surrounding soil that moderates temperature extremes. Consequently, overall return for pot-in-pot systems has been reported to be at or greater than conventional field B&B or container production systems.

### Container Production

The *advantages* of container production include:

- achieving high plant densities in production beds;
- planting at times independent of the weather;
- eliminating some operations, like root pruning;
- lowering transportation costs because of lightweight media;
- experiencing less root loss when transplanting;
- greater chance of survival than with field grown trees;
- more efficient use of production and sales areas;
- year-round sales; and
- development of attractive sales packages.

The *disadvantages* include:

- small containers need frequent watering;
- nutrients deplete rapidly;
- plants require winter protection;
- plants easily become root bound;
- wind can knock over trees;
- containers are costly; and
- temperature extremes stress roots.

## Container Nurseries

Container producers (Figure 12-1) grow plants in pots of varying types and sizes, normally above ground. While the plants are immediately ready for use, the level of management is significantly higher than for field production. The majority of plants produced in Florida are grown in containers; thus, the focus of this chapter will be primarily on container production systems.

photo by gale albritton

Figure 12-1. Container production of landscape ornamentals.

There is a distinction made between potted stock, container grown stock, and containerized stock in the nursery trade. ***Potted stock*** refers to seedlings, rooted cuttings, or recently grafted plants that are grown for a period of time in small pots before they are planted in larger containers or lined out in the field. ***Container grown stock*** is grown in the container from a seedling, rooted cutting, or graft to a salable size in a relatively small volume of growth medium. ***Containerized stock*** is a field grown plant that is dug and put into a container to be sold.

### Shade Structures

Most container plants are grown in full sun; however, some plant species require shade for optimum growth. ***Shadehouses*** are outdoor structures used in nursery production that provide extra shade and temperature control for plants needing lower levels of light, acclimatization before sale for interiorscape use, hardening after rooting, or for stem cuttings that perform well in outdoor propagation environments. The simplest and most inexpensive shade structure is composed of shadecloth supported on galvanized steel (Figure 12-2) or wooden poles.

Fabric shadecloth screens out varying amounts of sunlight. It can be purchased in different densities to reduce light levels from between 30% to 90%. Shadecloth may be woven or knitted. Woven fabric has a distinct grid of horizontal and vertical lines, is more plastic looking than knitted and will unravel if a hole occurs. Knitted fabric appears more clothlike and has threads running in various directions; it will not unravel if cut or if a hole occurs, and also weighs less than woven fabric. Woven shadecloth is only available in black, but knitted shadecloth can be purchased in metallic or white colors that help reflect radiant heat and further reduce temperatures in the shade structure.

Shadehouses are usually open on the sides; however, some growers place shadecloth or ground cloth fabric part way or completely up the sides to provide extra protection from wind blowing mist off target, to reduce cold air entry on the north and west sides, or to keep weed seed, insects or disease organisms from blowing into the production area.

photo by gale albritton

Figure 12-2. Shadehouse propagation and production of rooted liners.

***Computer monitoring and control systems*** (Figure 12-13) can be used to provide constant regulation and close control of the greenhouse environment. These systems are expensive, but they are accurate and offer the greatest range of use. All pieces of automated equipment can be controlled together in a synchronized fashion. This precise control results in lower energy costs and greater productivity of plant materials.

## Production Considerations

The design of growing areas is strongly influenced by factors such as irrigation and drainage, materials handling, cultural and maintenance requirements of the plants, size of the containers, and costs involved. Layout of the site must be efficient if the nursery is to be productive as well as competitive.

The most desirable location for greenhouse placement is influenced by land characteristics (elevation, topography, and drainage). Climatic factors such as temperature and wind influence crop planning and production schedules. To enhance crop performance, greenhouses are generally oriented north-south for maximum light interception inside the greenhouse and minimum shading effects of structural components within the roof.

In addition, accessibility to needed commercial services should be considered along with the availability of shipping facilities and proximity to main roads. The supply of utilities (electricity, water and fuel) must be considered, and communications between buildings or growing areas must be planned to achieve optimal business operations.

### *Planning and Crop Selection*

Planning a schedule of operations from plant selection to harvest is essential to business success. The process begins with a strategic plan that identifies market potential and client needs (Figure 12-14).

Nursery and greenhouse managers should consider growing plants for which there is an expanding market, that are well suited to the

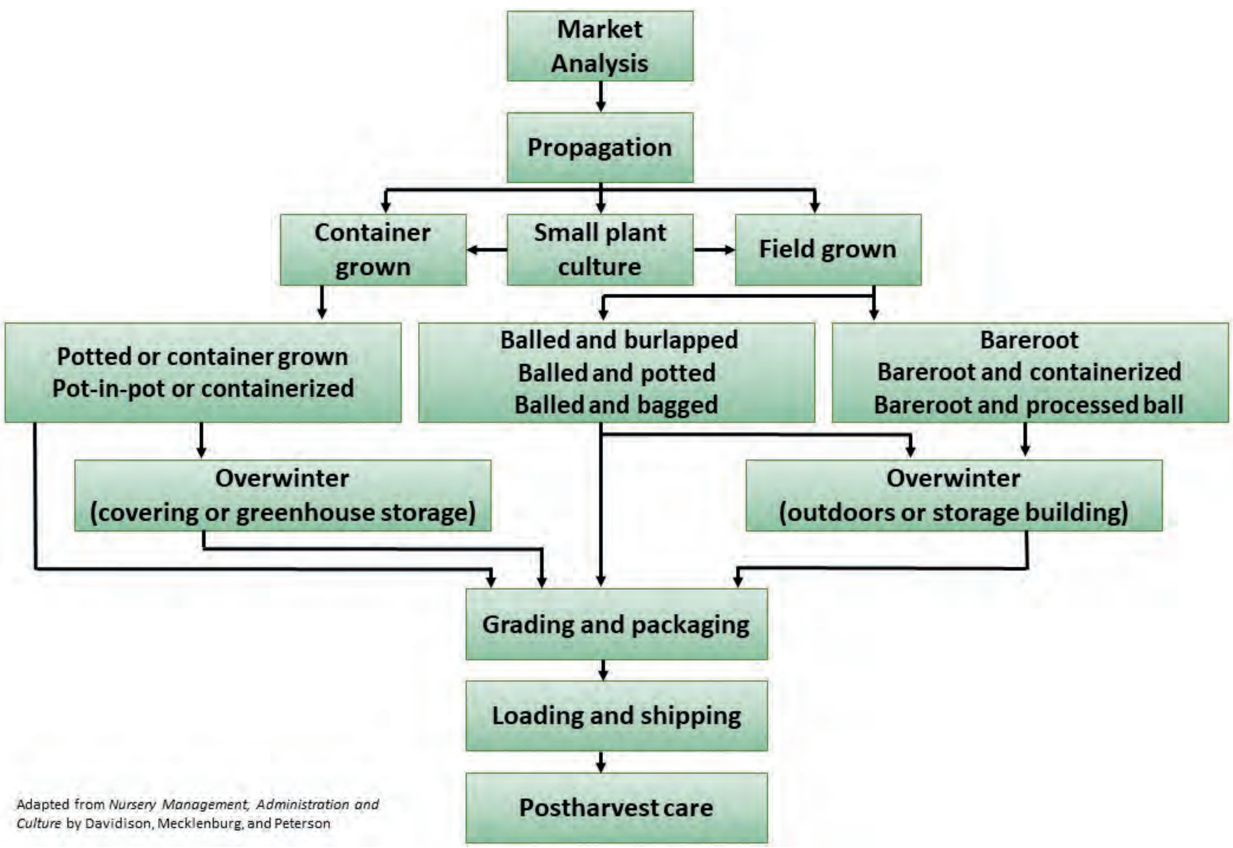


Figure 12-14. Diagram of nursery production processes for container and field grown culture.

production site, and that fit grower expertise. Observing what is popularly grown in the market area and discussing possibilities with other growers provides valuable information to help make decisions on production species and quantities. Local landscape contractors and designers, as well as visits to recent landscape projects, are also good sources of market information.

Additionally, it is helpful to analyze the demand for unique plants and services in the market area that are currently not being met. Growers should be aware of current and future preferences for plant sizes, foliage and flower colors, textures, forms and densities to successfully meet market demands. Careful projection of sales volume possibilities from the chosen niche market and assurance that the necessary resources and technical expertise are in place to support production efforts improve chances for success.

Shorter rotation time is one of the major advantages of container production, leading to faster turnover of invested capital. The actual space requirement varies with the market objective, the climate, various cultural practices, and spatial arrangements.

**Considerations for Planning Container Grown Crops**

- Planting schedule, including kinds and numbers of plants, container sizes, and planting dates.
- Total area required for each crop and all-weather surfaces for access to the plants.
- Types and quantity of growing media and fertilizer program.
- Building space, equipment, tools, irrigation system.
- Winter protection structures required.
- Labor for planting, moving and cultural practices.

*(Adapted from Nursery Management, Administration and Culture)*

## Site Preparation and Growing Surfaces

Growing areas and roadways should be well organized for efficient use of machinery and year-round operation. Roadways should be constructed to carry heavily loaded trailer trucks with wide turns for easy maneuverability. A good site for growing nursery crops in containers should be well drained in order to carry off large amounts of water in a short time during rainstorms or from overhead irrigation.

The production area should be carefully graded, smoothed, and compacted, so the center of the bed has a 2% crown above the edges intended for a bed that is 100 feet wide. Grading will prevent the accumulation of water around containers, which may cause root rot and plant damage. Some growers create a swale by sloping to the center of the bed (Figure 12-15); this technique avoids water collection on bed edges and may facilitate better use of equipment and other production activities.

The growing surface for container production should be covered. Materials used for a particular location usually depend upon cost and availability. Although ***black plastic film*** is the least expensive, it will disintegrate and must be replaced after each crop. Another more expensive solution is to put down six inches of ***crushed stone*** (½ to ¾ inch diameter) over a fabric weed barrier and place the containers on the stone. This method has all

photo by gale allbritton

Figure 12-15. Nursery production beds covered with ground cloth. The center swale facilitates drainage and improves access.

the advantages of woven plastic fabric, plus the additional benefit of being more permanent. One disadvantage is that potting soil falls into the stone, which encourages weed growth. A different alternative is woven black plastic fabric (***ground cloth***), which is more expensive than black plastic, but more durable and allows for better drainage; it can also be purchased with lines to assist in precise plant placement. As another option, ground cloth can be placed on top of crushed stone when covering more impervious soils (such as clay), but this adds additional expense for materials and labor.

## Cultural Considerations

Initially, nursery or greenhouse businesses may find it more convenient and profitable to purchase plants for lining out (potting and growing on) than to produce them. Purchasing seedlings or rooted cuttings (liners) for the first few years allows for concentration on growing quality plants at a profit and avoids the risks involved in propagation.

The quality of production stock is determined by the quality of the young liner plants. For that reason, select only vigorously growing seedlings, well-rooted cuttings, or properly knitted grafts for transplanting; unhealthy and poorly developed plants from propagation should be rogued (selected and discarded). Keep in mind that when a plant dies or is stunted, it continues to take up space that is irrigated, fertilized, and weeded, making all the other plants more expensive.

Although all crops require regular attention to moisture, nutrition, and pest control, each type of plant has slightly different cultural conditions. Transplanting requirements, spacing, appropriate pruning, soil type, pH needs, and length of time to reach marketable size are all variable factors that must be managed for successful production in profitable businesses.

### Container Selection

There are several factors to keep in mind when deciding what containers to use in plant production. Cost, design features that control root growth, durability, shipping capacity, availability, how the container affects growing media moisture content and temperature, plus how the container suits the particular needs of the nursery should all be considered. At the retail level, containers not only hold plants and soil, they have become a visual part of marketing, so this feature must also be considered (Figure 12-16).

Round, black ***plastic pots*** are the industry standard, but they can cause root development that leads to circling roots and plants with poorly formed root systems. However, there are other kinds of containers designed for enhanced root growth. For example, plants grown in copper treated plastic containers tend to be less root bound and have higher transplant survival rates.

photo by nursery supplies

Figure 12-16. Assorted nursery containers.

***Fiber pots***, made from recycled paper, are biodegradable and can even be composted. The main problem with fiber pots is the potential to degrade too quickly; but it has been found that incorporating copper into fiber pots can increase longevity and keep roots cooler in the summer.

The use of ***bottomless pots***, which allow for ***air root pruning***, is another way to prevent root circling. Air root pruning employs a similar mechanism to copper treated pots. Root tips that come in contact with air are killed and the root system branches out within the root ball. Repeated air root pruning stimulates lateral branching and results in a fibrous root system as opposed to a strong taproot system. In this case, the benefit is more rapid establishment after transplanting into the landscape.

While plastic containers revolutionized plant production, environmental concerns have increased over plastic products, both in how they are made and how they become part of the waste stream. The key challenge for container manufacturers is to find materials that will contain soil and plants as they move through production and marketing systems, yet breakdown after they are used, usually in composting systems.

It is important to note that many container producers have already evolved from using virgin plastic to using recycled materials. This process at least recovers the plastic already in use in the horticulture industry, plus absorbs some of the consumer waste stream. Utilizing new technology and alternatives to plastic products is a positive step toward sustainable production and the next phase in the evolution of the nursery industry.

## Scheduling

The primary objective of production scheduling is to plan for efficient growth of high quality plants for the most profit. Because container grown plants represent a greater capital investment than field grown plants, it becomes essential to reduce costs by producing the plant in as short a time period as possible.

Container production research has shown that larger containers promote greater rates of plant growth. If the goal is to produce 3-gallon sized plants, liner plants should be planted directly into a 3-gallon container rather than planting in a 1-gallon and then transplanting into a 3-gallon container (Figure 12-17). If the market goal is a 10-gallon container, the liner should be transplanted to a 3-gallon and later to a 10-gallon container. Larger containers will require less frequent irrigation and fertilization once the plants are established, but will require more production space. The additional cost of the space needs to be balanced against the additional rate of growth and the savings in transplanting costs. A crop succession plan, including space requirements, should be worked out in advance of planting so that costly underestimates or overestimates will not be made and plants need not be moved great distances.

Figure 12-17. Liners planted directly into a 3-gallon container.

## Spacing

Figure 12-18. Spacing of one-gallon young plants in the nursery.

Container grown plants should be spaced so that the leaf tips of adjacent plants are just touching. This spacing procedure results in compact growth of good quality and production space that is used efficiently. Spacing too closely results in spindly growth and loss of lower foliage.

Applying this spacing guide (Figure 12-18), most transplants can be placed pot-tight or rim-to-rim for the first few months and possibly the first year of growth, depending on the species. This production technique shades and protects newly established roots in pots from hot summer sun until the top growth develops a canopy over the pot rim. At the beginning of the second year, containers are usually spaced as far apart as the crown diameter of plants.

## Media

Most of the peat moss, bark and other organic constituents used in soilless growing media have ***hydrophobic*** or water repelling characteristics. When excessively dry, these materials have a tendency to be difficult to wet and therefore require careful attention during irrigation. In some instances, a ***wetting agent*** may be required to provide adequate absorption. The key to avoiding problems associated with wetting media is not potting plants in excessively dry media or allowing the medium to dry out between irrigations. These problems may become more acute in the presence of soluble salts.

Since media selection and management are critical components of successful plant production, more detailed information on this topic can be found in the *Plant, Soil and Water Relationships* chapter.

## Irrigation

Irrigation of nursery and greenhouse crops is one of the most critical of all production practices; and yet, it is frequently overlooked and taken for granted. Potting mixes in containers dry quickly and are therefore more dependent upon a supply of water. Since the size of the plant root zone is restricted by the container, water available to the plant can be used rapidly, making daily applications typical in nursery and greenhouse settings.

### Overhead Irrigation

An overhead irrigation system requires large amounts of water to overcome rapid drying of relatively small root volumes in containers; it also produces uneven water distribution patterns, which can slow plant growth, encourage disease and contribute to runoff. When spacing is factored in, as little as 20% to 25% of the water applied overhead may enter containers because of deflection from plant canopies and loss between the containers. This means that about 75% to 80% of irrigation water does not get into the container and becomes runoff or evaporates in spite of the fact that irrigation event scheduling is done properly, plants are grouped by sizes and water requirements, and water is applied only when needed in the right amounts.

| Comparison of Water Systems for Container Nursery Stock | | | |
|---|---|---|---|
| | ***Overhead irrigation*** | ***Drip or trickle irrigation*** | ***Subirrigation*** |
| ***Installation cost per acre*** | moderate | moderate to high | high |
| ***Maintenance*** | low | high | moderate to high |
| ***Durability*** | excellent | low | good to excellent |
| ***Labor*** | low | moderate to high | moderate |
| ***Water distribution*** | fair | fair to good* | good* |
| ***Water use efficiency*** | poor, very wasteful | good | good** |
| ***Pump required*** | large, high pressure | small, low pressure | medium, moderate pressure*** |
| ***Wind effect on distribution*** | serious | none | none |

**if ground or bench is level and water quality is good*
***if recycled*
****dependent on area covered*

*Source: Adapted from National Sustainable Agriculture Information Service*

Figure 12-19. Comparison of features in irrigation systems commonly used in nursery and greenhouse production.

There are good reasons why ***overhead irrigation systems*** are commonly used in the container nursery industry (Figure 12-19). This system is reliable and has relatively low maintenance; it can also provide frost protection and be used for chemical injection. However, unless runoff water can be recycled, the biggest drawback is very inefficient water usage, particularly if roads and walkways are irrigated and plants are spaced large distances apart.

The efficiency of overhead sprinkler irrigation systems can be significantly increased by good system design and an impermeable surface for runoff collection and water recycling. Water recycling ponds (Figure 12-20) are common in many nurseries. However, runoff collection is often costly and requires additional land. In some cases, the conversion to microirrigation may be more appropriate.


photo by gale allbritton

Figure 12-20. Water recycling pond used for irrigation in a nursery setting.

## Microirrigation

Since microirrigation systems supply water and chemicals mixed with irrigation water (***chemigation***) directly to the container medium, there are no losses between containers. Workers can also continue maintenance activities while plants are being irrigated. The biggest disadvantage to a microirrigation (drip or trickle) system, besides the initial cost, is the labor required to keep smaller pipes and emitters clean. Depending on the crop, overhead irrigation may also still be needed to relieve heat stress during high temperature months.

Except for production of greenhouse specialty crops (Figure 12-21), microirrigation has been labor and cost prohibitive for production in smaller (1-gallon or less) containers because of the higher cost of installation and maintenance when compared to overhead irrigation. Consequently, it has been mainly used in the nursery to produce larger plants (5-gallon or greater). A well-designed and managed microirrigation system can have an efficiency of 90% to 95%, meaning that less than 10% of applied water is wasted.

Water may also be applied to greenhouse crops using ***subirrigation*** or capillary mats on specialized benches. However, in areas where soluble salts are a problem, mats do not provide for leaching, thereby increasing the risk of salt injury.

photo by gale allbritton

Figure 12-21. Drip irrigation system in greenhouse foliage crops.

## Irrigation Frequency and Amount

Frequency of irrigation is largely determined by existing environmental conditions. During active growing periods, growers must irrigate container plants at least once a day and often two to three times. This frequency of irrigation means that growers must consider the physical characteristics of growing media (for example, water holding capacity and drainage) very carefully, particularly where soluble salts are a problem. Often, nutritional problems, such as magnesium and micronutrient deficiencies, arise as the result of excess leaching. In these cases, special attention must be given to media amendments and nutritional regimes to provide for optimum plant growth.

The amount of irrigation water to apply in container production is perhaps more important than how and when to irrigate. A general rule of thumb is to apply 10% to 15% more water than the container will hold. This facilitates leaching at each irrigation interval and reduces the potential for accumulation of soluble salts. Of course, the rate of irrigation must be low enough to allow the water to percolate through the growing media as opposed to overflowing the top of the container, a particular caution if hand watering. This is especially important when using soluble fertilizers in irrigation water to liquid feed plants.

## Water Quality

Water quality can have a huge impact on plant growth, especially in soilless plant production systems where intensive management of water and nutrients is required. Irrigation water quality impacts nutrient levels and availability as well as other chemical characteristics of the soilless media substrate. Poor quality water applied with overhead irrigation can damage foliage, change media pH, or result in unsightly foliar residues or stains. Use of poor quality water in irrigation systems can clog mist nozzles and microirrigation emitters. Irrigation,

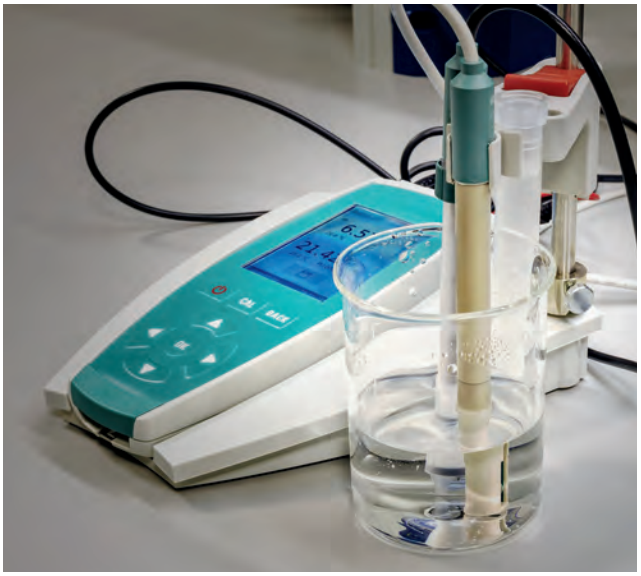

Figure 12-22. Water quality testing equipment.

**Water Quality Standards for the Production of Greenhouse and Nursery Crops**

| *Quality* | *Electrical conductivity EC X $10^{-3}$ (millimhos)* | *Total soluble salts (ppm)* | *Sodium content (% Salts as Na)* | *SAR* | *pH* |
|---|---|---|---|---|---|
| Excellent | 0.25 | 175 | 20 | 3 | 6.5 |
| Good | 0.25 - 0.75 | 175 - 525 | 20 - 40 | 3 - 5 | 6.5 - 6.8 |
| Permissible | 0.75 - 2.0 | 525 - 1400 | 40 - 60 | 5 - 10 | 6.8 - 7.0 |
| Doubtful | 2.0 - 3.0 | 1400 - 2100 | 60 - 80 | 10 - 15 | 7.0 - 8.0 |
| Unsuitable | >3.0 | >2100 | >80 | >15 | >8.0 |
| *Source: Information obtained from Greenhouse Management Handbook by Texas A&M AgriLife Extension Service* | | | | | |

Figure 12-23. Guidelines for interpretation of irrigation water quality in greenhouse and nursery crop production.

fertilization, pesticide efficacy, and efficiency of production are more easily managed when using good quality water. Therefore, water testing before and during production cycles is recommended (Figure 12-22).

A standard test that measures the majority of critical water quality factors is acceptable for most plants, including bedding plants, potted flowering crops, trees and shrubs. Water testing should be regularly repeated since the quality of water from the same source will vary over time. For example, drought can reduce the volume of stored water, which may result in an increased concentration of minerals.

Factors that influence water quality are electrical conductivity, alkalinity, calcium and magnesium, sodium, chloride and pH. Substances present in irrigation water can also impact irrigation equipment by causing corrosion of parts or clogging of emitters.

Remember, a water quality test can help identify and diagnose problems. Understanding how the information conveyed in a water quality report affects plant production decisions is a first step in the proper management of irrigation practices and in making any required maintenance adjustments. The table in Figure 12-23 presents guidelines on the interpretation of selected irrigation water quality standards. The *Plant, Soil and Water Relationships* chapter provides more detailed information about the chemical properties of container media as influenced by water and fertilizer.

### Water Treatment

Although cultural management techniques may be used to deal with some water quality problems, certain situations require more drastic action. Growers in coastal regions, on islands, or in areas where saltwater intrusion has occurred may use water treated through a process known as ***reverse osmosis*** (RO) to remove potentially harmful salts (Figure 12-24). RO water is cheaper than distilled or deionized water and the overall quality is the same.

Unfortunately, the use of RO water does not solve all the problems associated with soluble salts. In fact, it can create some very unique situations that are, in many respects, more difficult to correct. For example, growers generally take for granted the micronutrients present in irrigation water. When certain

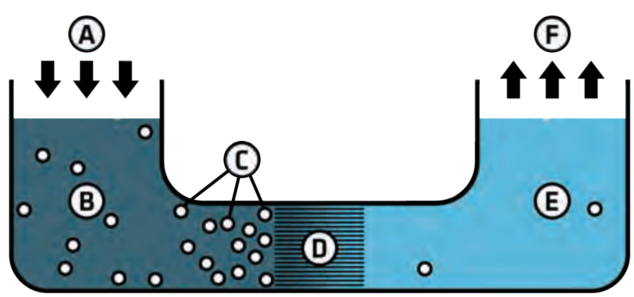


photo by colby fisher, wikimedia

Figure 12-24. Reverse osmosis (RO) is a water purification technology that uses a semipermeable membrane to remove ions, molecules and larger particles from drinking water. Water desalination is accomplished using reverse osmosis. The system applies pressure (A) to saltwater (B). Salts (C) cannot pass through the semipermeable membrane (D) and are filtered out of the solution. This results in potable water (E) that is moved into the distribution system (F).