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ENH1210

Field Production of Palms[1]

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Palms are important landscape ornamentals and are increasingly used as components of interiorscapes within malls and office buildings. Field production is the most practical means of producing large palm specimens, and it has several advantages over container production. Yield per acre can be maximized compared to many other woody ornamentals because of the columnar growth habit of most palms and their ability to survive transplanting with a minimal root ball. When dug and tied properly, many more palms can be loaded into a standard shipping container than could similarly sized trees. Palms also offer great versatility in the method of field harvesting.

Market Considerations

Field-grown palms can be produced for many different markets. These include the following:

- Exterior landscape specimens
- Interior landscape specimens
- Mass market (containerized after harvest from the field)
- Seed production
- Cut palm frond production

It is important to determine the potential market before the nursery is put into production because labor and setup costs and nursery design vary. For example, seed production is probably the least labor-intensive type of palm field operation. Field growing of mass-market palms allows for the largest number of palms per acre since they are harvested at a smaller size than specimen material. However, it has the greatest labor costs because of the need to containerize the material after harvest. In the case of palm frond production, a serious consideration for domestic producers is competition from offshore producers for whom labor costs are much lower.

Site Considerations

Palms are adaptable to a wide range of soil types for field production. In Florida, successful field nurseries have been established on sand, marl, and muck. Ideally, the soil on the site should be well drained to provide adequate aeration for root growth and easy harvest during periods of heavy rain. A slope of 1%–2% is usually adequate for surface water drainage. In soils such as marl and muck, which have high water-holding capacity and often occur in areas with high water tables, it may be necessary to "bed up" the planting rows (i.e., raise the root zone above standing water). Palms have even been successfully grown on shallow soils (18–24 in.) overlying rock, though such poor sites should be avoided if possible. Avoid low-lying areas susceptible to cold air drainage if marginally hardy palms are selected for production. If standing water or high water tables are a year-round feature of the site, select species with high moisture tolerance rather than those native to desert or semi-arid areas.

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Product Mix

The greatest diversity of palm species suitable for field production exists in South Florida, where many tender tropical species can be safely grown. Most of these species cannot be produced where freezing temperatures are experienced regularly. In choosing species to produce, growers should consider some of the slower-growing or less common trees that can fetch a high market price, rather than using only fast-growing, well-known, and potentially overproduced species (e.g., Queen palm [*Syagrus romanzoffiana*]). In some cases, intercropping allows both types of palms to be integrated into the same production area (see Intercropping section).

Production Density and Nursery Layout

The growth habit of many palms allows great flexibility in terms of the production density. Populations of field-grown palms can vary from 450 to 4,000 plants per acre, depending on the market size to which the palms are grown. The other main consideration for planting density should be the method of harvest. Palms that will be mechanically harvested must be planted with sufficient room between rows and between plants for machinery access without damage to the trees. If the palms will be dug manually, density can be increased. It has been estimated that a 25% increase overall in planting density can be implemented in most palm field nurseries without increasing non-labor costs. A 3-ft. center planting distance is possible for palms grown for the mass market since they will be harvested for containerization at a smaller size than specimen material. Most palms intended for the exterior and interior specimen market can be planted at 4-ft. centers without a noticeable decline in quality. One exception is Mexican fan palm (*Washingtonia robusta*), which requires larger spacing (8-ft. centers). Coconut (*Cocos nucifera*) and royal (*Roystonea regia*) palms may also benefit from larger spacing. Field palms are produced in one of two ways: monoculture or intercropping.

Monoculture

In this type of field, a single species is grown per row, usually on large centers (8 ft.). This is the most land-intensive layout design for palms, but it is the best suited for mechanized harvest. Mexican fan palm (*Washingtonia robusta*) is one species often grown in this manner because it is not as well adapted to intercropping as other species and requires a large amount of space. However, some growers have successfully intercropped this species.

Intercropping

Many field palm growers in Florida have found that intercropping palm species or other ornamentals with their palms maximizes yield per acre without substantially increasing non-labor costs (Fig. 1). Most often, a slow-growing species is intercropped with a faster-growing species. Palms situated at 4-ft. centers from each other have been successfully intercropped with broad-leaved trees, such as live oaks (*Quercus virginiana*) and royal poinciana (*Delonix regia*), but the tree species should be planted at 8-ft. centers from each other within the row. When intercropping, harvesting must be timed so that undesirable shading of one of the intercrops does not occur. Empty space should be reused quickly to maximize yields per acre. In some cases, a shade-tolerant second intercrop can replace the first after it is harvested.

Figure 1. Palms interplanted in a South Florida field nursery
Credits: A.W. Meerow

Nursery Layout

Space between rows depends primarily on the size of the equipment used for harvest. Eight to 12 ft. between rows is common and allows for the movement of heavy equipment through the field. Many Florida growers "bed up" the planting rows, raising them 1–1 ½ ft. above the surface between the rows (Fig. 2). This can be mandatory where high water tables create drainage problems in the field. The beds are usually from 2 to 4 ft. wide. Two advantages of this method over a flat planting field are easier manual harvest and averting the danger of "burying" the base of the palm with soil thrown up by machinery when cultivating a flat planting surface. The main disadvantage of bedding occurs during high wind and rain, when weak-rooted palms such as queen palm may be blown over if planted in raised beds. A staggered, diamond-shaped double row (approximately 4 ft. wide) maximizes both sunlight penetration into the canopy and yield per acre.

Starter Material and Planting

For field-grown palms intended for the specimen market, liner stock is usually 3–5 gal.-sized material. Lining out larger material (7–10 gal.) is not uncommon but may be cost prohibitive. Liners for the containerized mass market can be slightly smaller, from 1- to 3-gal. containers. Smaller liners, though lower in cost, are likely to experience higher mortality rates after transplanting. Palms, as a rule, are intolerant of being planted too deeply. Liners should be planted in the field such that the bottom of the stem is about 1 in. below the soil surface. Irrigate lining stock soon after the field is planted and apply a controlled-release palm fertilizer (see Fertilization section) either in the bottom of the planting hole or as a surface application. If a foliar fertilization program will be used, it can begin immediately after the field is planted. Research by Broschat and Elliott (2009) has shown no benefit to adding commercially available mycorrhizal inoculants to the backfill.

Irrigation

Irrigation frequency in a palm field nursery depends on soil type, the hydrology of the site (i.e., height of the water table), the species grown, and their age in the field, fertilization intensity, and the amount of rainfall received at the nursery. Some palm species (e.g., Mexican fan palm [*Washingtonia robusta*]) can suffer rapidly from overwatering, particularly when planted in soils with high moisture-holding capacity. Daily irrigation may be necessary for newly planted fields on soils with poor water-holding capacity for the first 6–12 months of establishment, especially if high temperatures and little rainfall are experienced. On marl and some muck soils, much less frequent irrigation may suffice for establishment. One- to 2-year-old fields may require three or four irrigations per week; 2 - to 3-year-old fields may require two to three irrigations per week. It may be possible to eliminate supplemental irrigation for older fields on soils with high moisture-holding capacity, such as marl. Fast-draining sandy soils require more frequent irrigation. Irrigation duration should be sufficient to moisten the soil to a depth of 2–3 ft. on deep, well-drained soils. Shallow soils should be moist down to the underlying rock after irrigation. Fields devoted to highly drought-tolerant species can be allowed to dry out within the top few inches of soil once liners have established (after the first year or two of growth). If interplants of species with very different drought tolerances are used in the field, irrigation frequency needs to be adjusted to a median level.

The majority of palm field nurseries in Florida use overhead irrigation. Some palm fields have no irrigation system at all, but these operations are likely to suffer the greatest losses during cold weather (see Cold Protection section). Drip irrigation is a useful alternative in soils with good lateral movement, especially where water restrictions are in effect or where water costs are prohibitively high.

Fertilization

Little or no research exists on fertilization rates for field-grown palms. Rates vary with the soil type and size of the palms. In general, granular fertilizers are applied to the soil at rates starting at ½–1 lb. for small, recently planted palms. Controlled-release fertilizers are typically broadcast in plantings of larger established palms at rates up to 30 lb. per 1,000 sq. ft. of canopy area or bed area. These fertilizers should be applied four times per year for maximum growth, but on the more fertile marl and muck soils, fewer applications may be adequate. If granular fertilizers will be used with drip irrigation, the fertilizer should be banded directly below the drip emitters. Fertility varies greatly among soil types in South Florida, but certain nutrient elements are consistently lacking in most soil types and must be applied through fertilization. These are nitrogen (N), potassium (K), magnesium (Mg), and manganese (Mn). An analysis of 8N-0 or $2P_2O_5$-$12K_2O$-4Mg plus micronutrients is recommended for field -grown palms in Florida. It is very important that N, K, Mg, and preferably also boron (B) be present in controlled-release forms. Micronutrients such as Mn and Fe (iron) must be in a water-soluble form such as sulfate or chelate (Fe only) to be effective. If water-soluble N, K, and Mg sources are used, they must be applied much more frequently to compensate for the rapid leaching of these elements through the soil. For additional information, see *Fertilization of Field-grown and Landscape Palms in Florida* (http://edis.ifas.ufl.edu/ep261).

Foliar fertilization is a fairly common practice in palm production. It is a rather inefficient method for providing macronutrient elements such as N, K, and Mg; however, it can be useful for supplying micronutrients such as Mn and Fe to the plants when soil conditions prevent adequate uptake of these elements by the roots. Foliar fertilization is best used to supplement a normal soil fertilization program, particularly for micronutrients.

Liquid fertilization programs are not recommended for field nurseries when overhead irrigation is used. The soluble nature of liquid fertilizer results in leaching or runoff of a great deal of the nutrients before uptake by the roots. To compensate, the grower often increases either rates or frequency of application, which results in waste and the potential for ground or surface water contamination. If drip irrigation is used in the field, injecting liquid fertilizer through the system may be cost effective, and the problems inherent in overhead delivery may be minimized. However, if fertilizers are delivered only through the irrigation system, palms may not receive sufficient nutrients during the rainy summer months when nutrient demands are the greatest, but because of the rainfall, irrigation is not required. Liquid fertilizer formulations should have the same ratio of elements as the controlled-release granular fertilizer described above. Depending on soil type and fertility, rates from 150 to 300 ppm N may be appropriate.

Troubleshooting Nutritional Problems

Potassium (K) deficiency (http://edis.ifas.ufl.edu/ep269) is a common problem in field-grown palms in South Florida. Symptoms appear first on the oldest leaves and progress up through the canopy as the deficiency becomes more severe. Symptoms include translucent yellow or orange and/or necrotic spots on the oldest leaves, marginal necrosis on the leaflets, discoloration of the oldest leaves, and a withering or frizzling of the leaf tips or entire older leaves. Potassium deficiency causes premature loss of older leaves, resulting in smaller canopies. In severe cases, the symptoms may be confused with Mn deficiency ("frizzletop"), and like that disorder, K deficiency can be fatal to palms if untreated. It is prevented by regular applications of fertilizers containing 10%–20% K from coated potassium sulfate. Correction can take 2 to 3 years or longer, so it is better to prevent this disorder through proper fertilization (see Fertilization section) than to try to correct it later. In addition to the routine fertilization outlined above, severe K deficiency should be treated with coated potassium sulfate at rates equal to those used for the regular fertilizer, plus a third as much slow-release magnesium sulfate (kieserite), four times per year.

Magnesium deficiency (http://edis.ifas.ufl.edu/ep266) is also a common problem in Florida palms. Like K deficiency, symptoms occur first on older leaves, but typically consist of broad light yellow bands along the outer margins of the leaves or leaflets. The center of the leaf or leaflets remains green. In *Phoenix canariensis,* both K and Mg deficiencies are often present, with K deficiency causing leaflet and leaf tip necrosis on the oldest leaves and Mg deficiency causing the yellow banding on mid-canopy leaves. Routine application of controlled-release 8N-0 or $2P_2O_5$-$12K_2O$-4Mg plus micronutrient fertilizer recommended above should prevent this problem, but severe Mg deficiency can be treated with kieserite, a slow-release form of magnesium sulfate . Foliar sprays are rather ineffective for treating K and Mg deficiencies since palms need far more of these elements than the leaves can absorb.

Manganese deficiency (http://edis.ifas.ufl.edu/ep267) is a common micronutrient problem in palms in Florida, with symptoms developing on newly emerging leaves. Manganese-deficient leaves emerge chlorotic, usually with extensive necrotic streaking in the leaflets. New leaves are small, weak, and, in severe cases, emerge completely withered, frizzled, or scorched in appearance. The palm may die if it is not treated promptly with a soil and/or foliar application of manganese sulfate. If the older leaves also appear off-color with frizzled tips, that problem is probably K deficiency rather than Mn deficiency.

Iron deficiency (http://edis.ifas.ufl.edu/ep265) is moderately common in field-grown palms, but it is invariably caused by poor soil aeration, excessively deep planting, or high soil pH, rather than a lack of Fe in the soil. Symptoms occur first on new leaves as a general chlorosis, but in queen palms they may be accompanied by diffuse green pea-sized spots on otherwise yellowish leaves. Although soil or foliar applications of iron chelates may sometimes temporarily relieve these symptoms, only correction of the soil aeration or planting depth problems that caused the deficiency will be effective in the long run.

Boron deficiency (http://edis.ifas.ufl.edu/ep264) is often seen in field-grown palms. Symptoms are extremely variable but occur on newly developing leaves. Leaves may be crumpled (accordion-leaf), stunted, truncated, or twisted, or they may fail to open normally. The presence of more than one unopened or partially opened spear leaf on a palm is an indication of chronic B deficiency. In some cases, the entire crown bends to one side. Palms with multiple symptomatic new leaves should be individually treated by drenching the root zone with a solution of Borax or Solubor® (2–4 oz. of material dissolved in 5 gal. of water). Because of the potential for phytotoxicity, do not repeat B treatments unless new growth does not improve after 6 months.

Weed Control

Use of pre- and postemergent herbicides in palm field nurseries can provide significant savings in labor costs for cultivation and can minimize competition from weeds for water and nutrients. It may be most economical to restrict the use of herbicides to the actual planting rows or beds and mechanically cultivate between the rows. When applied properly, most preemergent herbicides (metolachlor is an exception) are safe to use around palms, but keep in mind that most granular formulations are effective for about 6 months compared to about 6 weeks for liquid formulations. Sprays of nonselective postemergent herbicides, such as glyphosate, glufosinate-ammonium, or diquat, around the base of palms are safe if these materials are kept off the foliage. Grass-selective herbicides can be safely sprayed over palm foliage.

Pests

A number of insect pests or mites are host-specific to particular species of palms and are not dealt with here. Banana moth larvae (*Opogona sacchari*) can be a troublesome pest of palms, tunneling through the stems and ultimately killing them. Palmetto weevils (*Rhynchophorus cruentatus*) (http://edis.ifas.ufl.edu/in139) and silky cane weevils (*Metamasius hemipterus*) (http://edis.ifas.ufl.edu/in210) can be serious problems in Canary Island date palm nurseries. Other palm pests likely to be encountered in field production include scales, mealybugs, whiteflies, palm aphids, thrips, caterpillars (including palm leaf skeletonizer), and spider mites. A broad range of contact and systemic insecticides and miticides provide effective control of these pests. Fire ants should be controlled in the nursery, as these insects actively tend honeydew-secreting pests such as palm aphids, mealybugs, and scales. Removing affected leaves is a simple, though labor-intensive, method of dealing with spot infestations. Few chemicals are listed specifically for palms, but most with general labels for woody ornamentals can be used safely. Consult your county Extension agent for specific recommendations and run a test block before applying any chemical to the entire field. While ground equipment is used for treating spot problems in the nursery, some palm growers have found aircraft spraying efficient for chemical treatment of widespread problems as well as for foliar fertilization on large acreages. The propeller wash pattern of the airplane is particularly effective in getting coverage to the underside of palm foliage.

Diseases

Phytophthora bud rot can be encountered in palm field production, particularly with frequent overhead irrigation or rainfall, which keeps the foliage continuously wet. This soilborne disease causes collapse or brown-out of the younger foliage and emerging leaf. If the bud is cut open, discoloration is evident, often accompanied by a foul smell. Phytophthora bud rot can be prevented with foliar sprays of metalaxyl, phosphites, or fosetyl aluminum. Thielaviopsis trunk rot (http://edis.ifas.ufl.edu/pp143) is increasing in frequency in palms. This fungus enters the palm through wounds, including those caused by pulling leaves off palms prematurely, and causes the disintegration of the trunk or bud. A cross-section through the trunk reveals blackened fruiting bodies. Affected palms often buckle over. There is no known control for this disease.

Leaf spots (http://edis.ifas.ufl.edu/pp142) caused by various fungus species are usually not a serious problem in field-grown palms. Localized infections can be treated by removing leaves.

Lethal yellowing (LY) (http://edis.ifas.ufl.edu/pp146), a disease caused by a phytoplasma, is vectored by a leafhopper bug (*Haplaxius crudus*). The disease is largely confined to the southern third of Florida. The only practical control for the field nursery within LY areas is to avoid production of LY-susceptible palms. While the disease can be prevented (though not cured) with continuous injection of tetracycline antibiotics (but only on palms with a developed trunk), such a program is not economically feasible within a production context. A closely related disease, Texas Phoenix palm decline (http://edis.ifas.ufl.edu/pp163), primarily affects *Phoenix* species and *Sabal palmetto*. It is found primarily in West Central Florida at this time.

Petiole and rachis blights (http://edis.ifas.ufl.edu/pp145) affect a wide range of palm species but are most serious on *Washingtonia robusta.* It causes necrosis on one side of individual leaves and can result in loss of older leaves. There are no controls for these diseases, but they usually are not lethal. Similar symptoms are caused by Fusarium wilt diseases. Fusarium wilt of Canary Island date palms (http://edis.ifas.ufl.edu/pp139) is a lethal disease that is spread primarily through pruning tools. Fusarium wilt of queen and Mexican fan palms (http://edis.ifas.ufl.edu/pp278) causes a rapid wilt and decline in these species. It can be spread by wind-borne spores as well as pruning tools. There are no known controls for either disease.

Cold Protection

Cold temperatures slow the growth rate of palms, reduce root activity, and may weaken the plant enough to make it more susceptible to disease. Palms that have received balanced fertilization in the months before the period of coldest temperatures are much more likely to survive and recover from cold damage than nutritionally deficient palms. Frosts and freezing temperatures can kill the foliage of many palm species and can permanently reduce the function of water-conducting tissue in the trunk. Palm field nurseries do not have as many options for cold protection as containerized palms maintained in covered structures. On small acreages, if the plants are still small, coverage with one of several fabrics available for this purpose may provide adequate protection. Some growers recommend applying antitranspirants to the foliage, but there is no research that shows that these chemicals provide significant cold protection. Tender palms have also been adequately protected by tying up the leaves in a bundle over the bud.

Most palm field nurseries must depend on their irrigation systems to provide a measure of cold protection. Flooding the fields just before freezing temperatures occur and maintaining the water in place until temperatures rise above freezing have saved fields from damage, but available water resources or delivery equipment may be limiting. Weakly rooted palms may also topple over when the field is flooded. Icing the plants with overhead irrigation works well if performed properly. The irrigation must be turned on before temperatures reach freezing and should continue until the ice visibly melts from the plant surfaces or until temperatures rise above freezing. The weight of the ice can, however, cause palm leaves to break. If the irreplaceable bud or "palm heart" survives exposure to freezing temperatures, the recovery of the plant is possible. Proper care in the first few weeks after damage is essential. Leaves with any amount of green tissue should be left on the plants. It may even be wise to leave completely dead leaves attached until the danger of further cold weather is past since they provide some insulation to the growing bud. If the spear leaf can easily be pulled out, remove it and drench the bud with a copper-based fungicide to control both bacteria and fungi. If healthy leaves are present on the palms, or as soon as new leaves emerge, apply a foliar fertilization with a soluble micronutrient mix and repeat at monthly intervals until new growth is well under way. Apply a complete fertilizer to the soil if this has not been done recently. Proper fertilization has been shown to reduce cold damage severity in palms. For more information, refer to *Cold Damage on Palms* (http://edis.ifas.ufl.edu/mg318).

Harvesting the Crop

The number of years to harvest for a palm field crop ultimately depends on the market for which the crop has been targeted. Containerized mass-market material may be ready for harvest 2–3 years after planting, depending on species and age of liner stock at planting. Exterior and interior specimens may require 5–8 or more years of field growing before they are ready for harvest.

Palms can be dug by hand, with gas-powered tree spades, spades mounted on small tractors, or mechanical trenchers. Soils that cling to the root ball are the most amenable to mechanized harvest. Palms grown on very sandy soils, which may fall away from the roots, might require hand digging. Prior to digging, the soil around the root system should be thoroughly wetted to help keep the root ball together. Palms grown in sandy soils usually need to have their root balls burlapped after digging, while palms grown in soils with greater structural integrity may not require burlapping. If the dug palms will be stored in the field for some time before shipment, burlapping may also be necessary, regardless of the soil type. In such situations, the root ball, trunk, and foliage should be periodically moistened.

For palms less than 20 ft. tall, a root ball of 10–12 in. in radius from the trunk is a common industry average size. For larger specimens or palms intended for the exterior landscape, an incrementally larger root ball may be advisable to ensure successful establishment. Specimen-sized palms that are containerized after harvest for the interiorscape market and smaller, containerized mass-market palms usually have the root ball trimmed considerably more. It may even be necessary to wash native soil completely from the roots for shipment out of state. Such palms are moved into shade structures for acclimatization, where growing conditions are optimal for root regeneration. An obvious concern for the grower is minimizing soil loss from the field.

Research has determined that palms vary in their root regeneration response when dug. For queen (*Syagrus romanzoffiana*) and royal palms (*Roystonea regia*), the percentage of cut roots that branched and continued growing was directly proportionate to the length of the remaining root stub. This would argue for including the largest root ball possible for these species when digging, at least from the perspective of site establishment in the landscape. A 1-ft. minimum radius, but preferably 2–3 ft., is recommended for royal palms. Queen palms can survive with a root ball of 6-in. radius, but a larger root ball increases root survival at the landscape site. Root branching in coconut palms (*Cocos nucifera*) does not appear to be dependent on the size of the root ball, and root balls need only be large enough to ensure adequate water uptake and stability. In sabal palms (*Sabal palmetto*), virtually all of which are dug from native stands rather than nursery grown, no root branching occurs, and new roots must be initiated from the trunk. For this species, minimal root balls are acceptable. For palms that must regenerate new roots from the trunk, root pruning 2–3 months before digging provides time for new root growth within the ball.

When moving palms out of the field, they should be well supported to prevent injury to the tender bud. When moving certain species with slender trunks (e.g., Senegal date [*Phoenix reclinata*] and paurotis palm [*Acoelorrhaphe wrightii*]), a supporting splint should be tied to each trunk and should extend into the foliage to protect the bud. Stems of clustering palms should also be tied together for additional support. A tree crane is usually required to lift large palms out of the field. Palms should only be lifted with wide nylon slings because attaching chains, ropes, or cables to palm trunks can cause wounds that often become infected with Thielaviopsis trunk rot (http://edis.ifas.ufl.edu/pp143).

The greatest loss of water in newly dug palms occurs from transpiration through the leaves. To minimize this, half or more of the older leaves, as well as the leaves closest to the bud, should be removed. The remaining leaves should be tied together in a bundle around the bud with a twine that should be removed when the palms are installed. The best method of ensuring survival after transplanting to the landscape may be to remove *all* leaves on species like sabal palm that must regenerate new roots from the trunk. See *Transplanting Palms in the Landscape* (http://edis.ifas.ufl.edu/ep001) for more information.

It is essential that palms intended for the low-light conditions of the interiorscape be subjected to an acclimatization period of at least a year under shade. Leaves produced in full sun cannot survive under low-light conditions and must be replaced by new leaves produced in shade. The amount of time necessary for complete replacement varies by species, but one leaf per month is a typical rate for most palm species.

Additional Information

Broschat, T. K. 1991. "Effects of Leaf Removal on Survival of Transplanted Sabal Palms." *J. Arbor.* 17 (2): 32–33.

Broschat, T. K. 1994. "Effects of Leaf Removal, Leaf Tying, and Overhead Irrigation on Transplanted Pygmy Date Palms." *J. Arbor.* 20: 210–213.

Broschat, T. K. 2000. "Phytotoxicity and Longevity of Twenty-Two Pre-Emergent Herbicides Used on Three Species of Container-Grown Palms." *HortTechnology* 10: 597–603.

Broschat, T. K. 2010. "Fertilization Improves Cold Tolerance in Coconut Palm." *HortTechnology* 20: 852–855.

Broschat, T. K., and H. M. Donselman. 1984. "Root Regeneration in Transplanted Palms." *Principes* 28: 90–91.

Broschat, T. K., and H. M. Donselman. 1986. "Factors Affecting Palm Transplant Success." *Proc. Fla. State Hort. Soc.* 100: 396–397.

Broschat, T. K., H. Donselman, and D. B. McConnell. 1989. "Light Acclimatization of *Ptychosperma elegans*." *HortScience* 24: 267–268.

Broschat, T. K., and M. L. Elliott. 2009. "Effects of Fertilization and Microbial Inoculants Applied at Transplanting on the Growth of Mexican Fan Palm and Queen Palm." *HortTechnology* 19: 324–330.

Broschat, T. K., and K. A. Moore. 2010. "Effects of Fertilization on the Growth and Quality of Container-Grown Areca Palms and Chinese Hibiscus During Establishment in the Landscape." *HortTechnology* 20: 389–394.

Broschat, T. K., and K. A. Moore. 2012. "Fertilization Rate and Placement Effects on Areca Palms Transplanted from Containers or a Field Nursery." *Arbor. & Urban Forestry* 38: 146–150.

Donselman, H., and T. K. Broschat. 1986. "Phytotoxicity of Several Pre- and Post-Emergent Herbicides on Container Grown Palms." *Proc. Fla. State Hort. Soc.* 99: 273–274.