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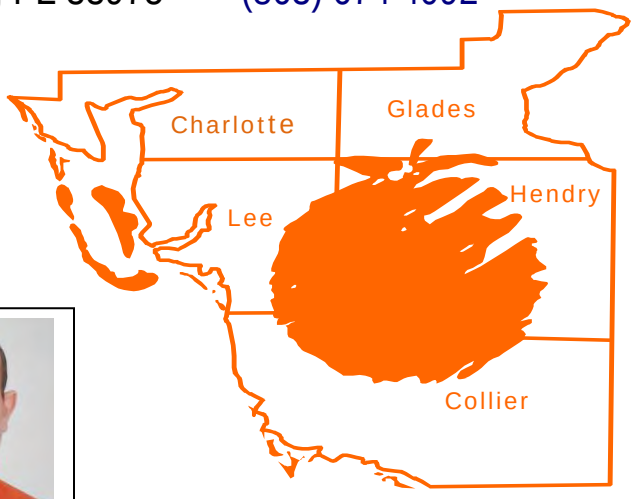

Vol. 26, No. 10 **October 2023**

Dr. Mongi Zekri
Multi-County Citrus Agent, SW Florida

Mongi Zekri

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October 31, 2023 Zoom Citrus Workshop

Date and time: Tuesday, October 31, 2023, 10:00 AM – 11:00 AM

Title: "Evolving management of Asian citrus psyllid and interactions with citrus pest complex."

Speaker: **Dr. Jawwad Qureshi**, Associate Professor of Entomology at the UF-IFAS Southwest Florida Research and Education Center in Immokalee

After the first find of Huanglongbing (HLB) disease in Florida in 2005, insecticide use to control the vector Asian citrus psyllid increased tremendously. For more than a decade, 12 or more sprays were implemented per year in citrus groves. Additional options for an integrated pest management approach including biological and cultural control; products, timing and methods of chemical control and protected citrus production systems were investigated and will be discussed.

To register and attend via Zoom, here is the Zoom link:
https://ufl.zoom.us/j/96967759646?pwd=UWswSG5nTWdkcmJBbG5wTVh1dnJBZz09

After registering, you will receive a confirmation email containing information about joining the Zoom meeting.

Coordinator: Dr. Mongi Zekri, UF-IFAS, maz@ufl.edu

1 CEU for pesticide license renewal

1 CEU for certified crop advisors

CEUs for pesticide license renewal

Earn CORE CEUs online through articles written by UF-IFAS Citrus Extension Agents in the Citrus Industry magazine

http://citrusindustry.net/ceu/

The following series of articles and quizzes are available with their expiration dates noted:

- 2023 #3: **A Guide to Safe, Effective Pesticide Use (7/31/24)**
- 2023 #2 **What To Do When You've Been Exposed to a Pesticide (4/30/24)**
- 2023 #1: **Key Terms to Know When Using Pesticides (1/31/24)**
- 2022 #4: **Making Sense of Pesticide Formulations (10/31/23)**

Each article grants one General Standards (Core) CEU when submitted and approved toward the renewal of a Florida Department of Agriculture and Consumer Services restricted-use pesticide license.

Florida Citrus Production Guide
https://crec.ifas.ufl.edu/resources/production-guide/

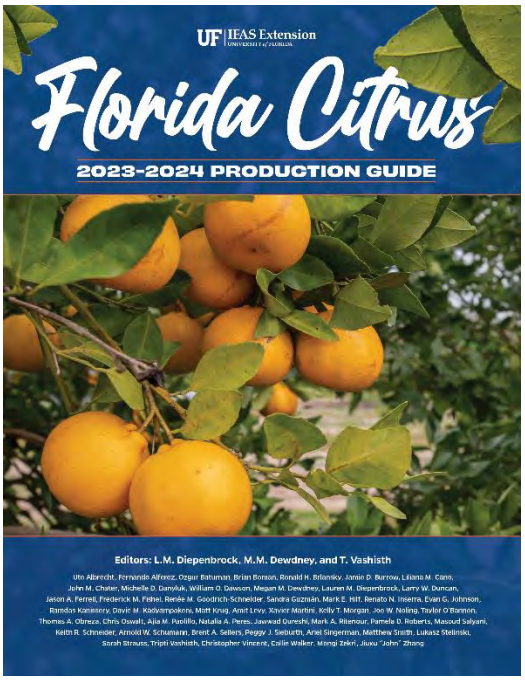
The objective of the Florida Citrus Production Guide is to assist citrus growers in the identification of pest management options and the selection of appropriate control measures. This publication should serve as a reference once it has been determined that control measures might be warranted. It is not intended to replace pesticidal product labels which contain important usage information and should be immediately accessible for reference. Violations of directions for use printed on the label are against State and Federal laws. Care should be taken to select only those treatments best suited for control of the specific pest(s) identified as requiring suppression. Products listed in all tables have been shown to be efficacious, non-phytotoxic to citrus, and relatively safe on non-target arthropods and microorganisms when used as directed. However, it is important to realize that results may not be consistent under different environmental, application, and tank mix conditions.

PRODUCTION GUIDE MENU

- General
- Horticultural Practices
- Mites, Insects & Nematodes
- Diseases
- Weeds
- Pesticides

If you did not pick up your hard copy of the newly updated Florida Citrus Production Guide at the **Citrus & Specialty Crop Expo**, you can find the electronic version online https://crec.ifas.ufl.edu/resources/production-guide/

If you need hard copies, you can get them free from your Citrus Extension Agent or from the Citrus Research & Education Center in Lake Alfred and the Southwest Florida Research and Education Center in Immokalee.



2023-2024 Citrus Production Guide Available at Florida Citrus Expo

An updated perennial resource for Florida commercial citrus growers is available to support their efforts to produce a successful citrus harvest

PUBLISHED ON **JULY 24, 2023**

The 2023-2024 publication includes the latest technical advice on citrus greening disease management, tree nutrition, grove management and other aspects of Florida citrus cultivation. (Courtesy Photo)

LAKE ALFRED, Fla. — An updated perennial resource for Florida commercial citrus growers is available to support their efforts to produce a successful citrus harvest. The 2023-2024 UF Institute of Food and Agricultural Sciences Citrus Production Guide will be available to growers at the August Florida Citrus Expo in Tampa and through their local UF/IFAS Extension citrus agents afterwards.

The document is a comprehensive reference meant to assist growers in development and management of citrus groves in Florida, said Tripti Vashisth, a UF/IFAS horticulture associate professor and a member of the guide's editorial team.

Additions this year include new fertilizer recommendations for some nutrients that have been recently changed and information on the plant growth regulator gibberellic acid (GA). Information on pesticides registered for use in Florida citrus is also updated in every new edition.

Topics covered in the guide include planting, irrigation, fertilization, weed control, insect management and disease management, she said. For a grove management practice to be recommend in the guide, a minimum of two years of field validated data is required. About 50 UF/IFAS personnel contributed to the latest edition.

"Each year, we update the guide with new information as it becomes available. This is a fundamental component of the UF/IFAS faculty mission to continue to meet the needs of our growers as we learn about and/or develop new tools and strategies for citrus production," Vashisth said.

Hard copies of the updated guide will be available at the UF/IFAS booth at the Florida Citrus Expo held at the Florida State Fairgrounds in Tampa, August 16 – 17. After that, they will be at local UF/IFAS Extension county offices (please see chart) in citrus growing counties.

For a directory of citrus agents, visit http://citrusagents.ifas.ufl.edu/locate/index.shtml. Another way to access the guide is on-line through the UF/IFAS Extension Electronic Data Information Source library at the EDIS website. It will also be available at the UF/IFAS Citrus Research and Education Center and the cirtrusresearch.ifas.ufl.edu websites.

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EL NIÑO/SOUTHERN OSCILLATION (ENSO) DIAGNOSTIC DISCUSSION

issued by

CLIMATE PREDICTION CENTER/NCEP/NWS
and the International Research Institute for Climate and Society

14 September 2023

ENSO Alert System Status: El Niño Advisory

Synopsis: El Niño is anticipated to continue through the Northern Hemisphere winter (with greater than 95% chance through January - March 2024).

In August, sea surface temperatures (SSTs) were above average across the equatorial Pacific Ocean [Fig. 1], with strengthening in the central and east-central Pacific. All of the latest weekly Niño indices were in excess of +1.0°C: Niño-4 was +1.1°C, Niño-3.4 was +1.6°C, Niño-3 was +2.2°C, and Niño1+2 was +2.9°C [Fig. 2]. Area-averaged subsurface temperatures anomalies increased compared to July [Fig. 3] in association with anomalous warmth in the central and eastern equatorial Pacific Ocean [Fig. 4]. Tropical atmospheric anomalies were also consistent with El Niño. Over the east-central Pacific, low-level winds were anomalously westerly, while upper-level winds were anomalously easterly. Convection was slightly enhanced around the International Date Line, stretching into the eastern Pacific, just north of the equator. Convection was mostly suppressed around Indonesia [Fig. 5]. The equatorial Southern Oscillation Index (SOI) and the traditional station-based SOI were both significantly negative. Collectively, the coupled ocean-atmosphere system reflected El Niño.

The most recent IRI plume indicates El Niño will persist through the Northern Hemisphere winter 2023-24 [Fig. 6]. Despite nearly the same ensemble mean amplitude as last month, the shorter forecast horizon means that the odds of at least a "strong" El Niño (≥1.5°C for the November-January seasonal average in Niño-3.4) have increased to 71%. However, a strong El Niño does not necessarily equate to strong impacts locally, with the odds of related climate anomalies often lower than the chances of El Niño itself (e.g., CPC's seasonal outlooks). In summary, El Niño is anticipated to continue through the Northern Hemisphere winter (with greater than 95% chance through January - March 2024; [Fig. 7]).

This discussion is a consolidated effort of the National Oceanic and Atmospheric Administration (NOAA), NOAA's National Weather Service, and their funded institutions. Oceanic and atmospheric conditions are updated weekly on the Climate Prediction Center web site (El Niño/La Niña Current Conditions and Expert Discussions). Additional perspectives and analysis are also available in an ENSO blog. A probabilistic strength forecast is available here. The next ENSO Diagnostics Discussion is scheduled for 12 October 2023.

Climate Prediction Center
National Centers for Environmental Prediction
NOAA/National Weather Service

Granular Controlled-Release Fertilizers

Most commonly used commercial fertilizers are water soluble, meaning they are readily available to plants when properly applied. Soluble fertilizers are applied to the soil dry in granular form, liquid through fertigation, or foliarly.

When applied in granular form to the soil, soluble fertilizers release nutrients relatively quickly, assuming the soil water content is at the appropriate level. Applying too much readily soluble fertilizer to crops at once can result in plant toxicity. In addition, heavy rainfall or irrigation can result in leaching of the nutrients. Therefore, it is suggested to split the soluble fertilizer into smaller doses.

Over many decades, the fertilizer industry has developed controlled-release fertilizers (CRFs). The Association of American Plant Food Control Officials defines CRFs as fertilizers that contain a plant nutrient in a form in which the plant uptake is delayed after application, or that provide a longer duration of nutrient availability compared with quick-release fertilizers. CRFs have become more popular in recent years.

CRFs are often called slow-release fertilizers (SRFs) or timed-release fertilizers. However, the terms CRF and SRF should not be used interchangeably. The main difference between CRFs and SRFs is that in CRFs, the factors affecting the rate, pattern, and duration of release are well known and controllable, whereas in SRFs, they are not well controlled. CRFs were initially developed for their horticultural benefits, but they have also attracted attention in the best management practices (BMPs) and citrus greening era.

CRFs have advantages in:
• inducing more growth and yield due to a continuous supply of nutrients.
• reducing rates and frequency of fertilizer applications.
• saving substantial labor and time.

CRFs are typically coated or encapsulated with inorganic or organic materials that control the rate, pattern, and duration of plant nutrient release. Soil moisture, temperature, and microbes have the greatest influence on nutrient release. CRFs have different N-P-K blends and may or may not include micronutrients. They can have different durations of release, expressed as months, which determine how long the CRF will persist.

Citrus fertilization research conducted in Florida within the past 30 years showed that tree growth and fruit yield where part or all of the fertilization program included CRF are similar or greater than growth and yield resulting from an all conventional water-soluble N fertilization program. CRFs are more efficient, have low plant toxicity hazard, and less leaching and volatilization potential than conventional soluble fertilizers. The improved efficiency of fertilizer use saves energy and reduces environmental pollution.

Applying Dry Fertilizers

Dry solid fertilizer spreaders should apply materials directly over the root zone. When applying fertilizers to young trees, managers should take advantage of manual or electronic spreader adaptations that deliver fertilizer rates accurately to small tree root zones while leaving out the area between trees where roots are not present. For economical and efficient fruit production, it is essential that spreaders be calibrated to apply accurate and appropriate amounts of fertilizers.

RESETTING IN CITRUS GROVES

For maximum efficiency of a production unit or grove, it is essential that every tree space is occupied by a healthy and productive tree. The average annual tree loss across the Florida citrus industry is currently around 6%. However, the extent of tree loss among individual groves can vary from 2 to 12% or more. Prompt replacement of unproductive trees means higher average long-term returns from the grove. If the declining trees remain in the grove, they keep getting weaker and yield less fruit each year and therefore the potential production capacity for the grove keeps declining even though production costs remain the same or even increase. It is very important to remove and replace such trees once it is clear that they are declining and they are no longer economically profitable. However, the reason for the decline should be determined and the condition should be corrected so that the replacement tree does not suffer the same fate.

Resetting should be considered if the tree is affected by an incurable disease such as blight, tristeza, or citrus greening. The resetting program should be conducted regularly rather than being delayed until serious losses in production have occurred. Resets should be planted with the same cultivar already in the block. Usually, it is more economical to keep resetting and not to push the entire block unless the cultivar and/or the tree spacing between rows is an undesirable one. Replanting in a mature grove seems justified only when a minimum of 8 ft between canopy driplines, (not from trunk-to-trunk), is available for canopy development of the new trees.

Replacement of dead, diseased, and declining trees in Florida citrus groves should always be an important part of the total production program. Today, tree replacement is more important than ever since overhead and production costs are dramatically increasing and a full stand of productive trees is essential to maximize production and profits. Freezes, blight, tristeza, Phytophthora, Diaprepes, and other pests and diseases have been particularly

troublesome to Florida citrus growers for the last two decades. Citrus canker and greening have been devastating citrus groves since their introduction to Florida. Extensive tree losses coupled with the economic necessity of regular resetting have caused many growers to investigate ways to achieve new efficiencies in reset management.

NOT AN EASY TASK

Caring for young citrus trees is always troublesome because they require far more attention than larger, established trees. Florida's sandy soils, high summer temperatures, possible low winter temperatures, and scattered rainfall patterns complicate young tree care by forcing growers to protect, fertilize, and weed young trees regularly or face extensive losses. Young trees are more sensitive and more attractive to pests than mature trees due to high levels of vegetative growth. Therefore, special care is needed to insure pests are adequately controlled. Resets often present an even greater problem because trees are usually scattered throughout a block of larger trees, where they compete with large, full-grown trees for limited supplies of water, nutrients, and sometimes sunlight. Scattered resets frequently have serious weed problems since removal of the previous tree allows the area to receive more sunlight and provides more favorable conditions for weed growth. Since resets are usually scattered throughout a block of much larger trees, they are often difficult to locate and may be accidentally overlooked, resulting in inadequate care. Researchers, growers, and production managers are continually developing and improving methods of dealing with reset care.

PLANNING THE RESET PROGRAM

Grove managers should include tree removal and resetting as a routine part of the production program and assign special crews to deal specifically with young tree care. Planning ahead is very important because there is often a lag period between the time when replacement trees are ordered and when they are received. The wait time for the most desired rootstock and scion combination may be as great as 1 to 2 years, so replacement tree needs should be anticipated (when possible) and orders placed so they can be obtained when needed.

PURCHASING TREES

High quality reset trees are essential for maximum young tree growth. These young trees will be placed in an intensely competitive situation and may sometimes receive less than ideal care, so there is no room for compromising tree quality. Only healthy and properly sized trees from registered sources should be purchased since the initial cost is only a small fraction of the total cost of bringing such a tree into production.

SITE PREPARATION

The planting site should be well prepared. Weeds should be removed before planting. At a minimum, a non-residual herbicide should be applied to the reset area to get weeds under control before the young tree is planted.

Planting sites should be prepared well in advance of receipt of the trees. Ideally, trees should be planted on the same day they are received. Under no circumstances should trees be allowed to dry out. To minimize root desiccation and damage, they should be kept cool and moist until they are planted.

PLANTING THE TREES

Trees should be removed from the container and inspected for evidence of pot-binding. Make several vertical slashes about one inch deep through the root ball to encourage root branching. These slashes also allow the potting soil and roots to interface more closely with the soil in the planting site. It may be easier to cut some of the roots with pruning shears and pull them so they protrude from the ball.

A common problem with nursery trees is that the potting mixture is often highly organic. Such materials form areas, which are difficult to permeate with water after the young tree is planted in sandy soils and irrigated. The outer third of the organic ball should be removed so that the outer roots are exposed and can extend into the soil in which the tree is planted. Otherwise, the tree may not grow off quickly and satisfactorily.

WEED CONTROL

Keeping weeds under control during the establishment period of the reset is very important. Weeds compete with young citrus trees for water, nutrients, soil applied pesticides, and sunlight and they must be properly controlled. Weed control around a reset site should be considered at pre-plant, early post-plant, and after the tree is established. Control of weeds prior to planting should be provided. If residual herbicides are used, they should be used at proper rates and at least 30 days in advance of planting so that residues do not impact reset growth. Prior to planting, contact or growth regulating herbicides may be preferred since they do not leave residual effects in the soil.

Weed control during the establishment period or approximately the first year is frequently quite difficult. Hand labor is scarce and expensive. Trunk damage by hoes or other cultivation equipment further compounds the problem. Chemical weed control provides at least a partial solution to the problem during this establishment period. There is now a fairly wide selection of residual herbicides available, which can be used around young trees. These materials should be applied at reduced rates. Be sure to read labels carefully for restrictions on the use of herbicidal materials around young trees.

After the reset has been planted for a year or more, modifications of the weed control program can be considered. Labels of materials under consideration should be checked carefully for restrictions prior to use. Some herbicides require reduced rates around young trees to minimize potential damage to resets planted among older trees. Specially modified herbicide applicators are available which enable the equipment operator to deliver reduced rates or a different herbicide mix around young trees.

To minimize herbicide contact to young trees, many growers apply a wrap or guard around the lower 12 to 16 inches of the tree trunk. When using these wraps be sure to monitor the protective structure for ants or other pests that may damage the tree trunk.

SPROUTING

Resets require periodic sprout removal. The use of tree wraps usually reduces the need for sprout control. Wraps often stay in place for up to 3 years. They should, however, be checked periodically for the presence of ants or fungal diseases. Reduced sprouting may be enough to justify their use. There are no simple answers to the use of wraps. Each situation is different and requires careful horticultural and economic consideration to arrive at the best procedure of maintenance, inspection, and management.

IRRIGATION & DRAINAGE

Young citrus trees require frequent but moderate water application for survival and proper growth. Competition for water is accentuated by nearby older trees or if weeds are allowed to grow close to the young trees. Anything that can be done to discourage competition for available water should be beneficial to the young tree. Irrigation systems should be in place before planting trees. Special modifications to the irrigation pattern by inverting the micro-sprinkler so that the surface wetting area is reduced or by increasing irrigation frequency can be good strategies to supply water for resets. However, the irrigation frequency necessary to sustain a mature grove is rarely adequate for good growth of newly-set trees, and young trees should be checked frequently to be certain they are receiving sufficient water. Drainage is as important as irrigation. Excess water must be removed from the rootzone. The concept of total water management must be practiced. If either system -irrigation or drainage- is not designed, operated, and maintained properly, then the maximum profit potential of a grove cannot be achieved. In Florida, both surface and subsoil drainage is necessary to obtain adequate root systems for the trees.

FERTILIZATION

Reset fertilization requires an extra effort beyond the needs of the bearing grove. Frequent application of water-soluble fertilizers with irrigation water (fertigation) can increase overall fertilizer use efficiency. If the grove is under a fertigation program, there is no need for special care in terms of nutrition for resets. Great care must be taken to ensure that proper rates of fertilizer materials are dispensed to prevent nutritional deficiencies or toxicities. Frequent light applications usually produce best results and lessen the danger of leaching but these practices need to be evaluated for cost effectiveness. The use of controlled-release fertilizers for resets is a better option than making multiple trips throughout the year to scattered resets throughout large blocks.

PEST CONTROL

Because young trees have more frequent flushing cycles than mature trees, they are more attractive and sensitive to pests. Therefore, special care is needed to keep the citrus psyllid and leafminer under control to reduce their damage to new leaves and to reduce the severity of citrus canker and the spread of citrus greening. Relying solely on foliar contact insecticides for resets is not a good strategy. Soil-applied systemic insecticides (neonicotinoids) which provide 6-8 weeks of control are the most effective tool for managing psyllids and leafminers on resets. Currently, three neonicotinoid products are registered for use in citrus: imidacloprid (Admire, Alias, Couraze, Nuprid), thiamethoxam (Platinum), and clothianidin (Belay). Various generic formulations are also available. Resets should also benefit from foliar contact pesticides and from foliar nutrition used on mature trees.

GROVE PLAT

Since resets are usually scattered throughout a block of much larger trees, they are often difficult to locate and may be accidentally overlooked, resulting in inadequate care. An annually updated grove plat is probably the best method for assessing general grove condition and productivity. Plats can be prepared by hand or with the assistance of a computer. This can help determine the number of trees which will be needed and where they should be placed. Reset plats can be prepared to later help equipment operators locate newly-planted trees for periodic care.

Scattered resets in a citrus grove.

FINGER LIME: AN ALTERNATIVE CROP WITH GREAT POTENTIAL

Aditya Singh, Edward Evans, Jeff Wasielewski, Manjul Dutt, and Jude Grosser

INTRODUCTION

The aim of this article is to draw attention to a potential alternative niche crop, namely finger limes. Currently, commercial production of this crop in the United States is extremely limited, and data on the agronomic and economic aspect of domestically producing and marketing the crop are sparse and, in most cases, unavailable.

FINGER LIME ORIGIN

The Australian finger lime (*Microcitrus australasica*) is native to the rainforests located in the coastal border regions of Queensland and New South Wales (NSW) in Australia. Finger lime is classified as a citrus fruit. Its taste has been described as a combination of lemon, lime, and grapefruit. The cylindrical fruit, which comes in varied colors such as pink and green, grows to about three inches in length (comparable to a gherkin in size and shape and resembles the index finger, hence its name). The fruit consists of hundreds of tiny, tangy juice vesicles, which some refer to as citrus caviar due to their shape, desirability, and high price (Figure 1). Like other types of citrus fruit, finger limes have nutritional value, few calories, and a high vitamin content. Demand for finger lime in Australia has grown steadily since 2010, mainly because of its unique caviar-like pulp, attractive color range, and bushfood status (i.e., a food native to Australia and used as sustenance by Aboriginal Australians).

Figure 1. Finger lime fruit (Credit: USDA)

AGROCLIMATE REQUIREMENTS, INTERCULTURAL OPERATIONS, AND ESTIMATED ECONOMICS OF PRODUCTION

Ideally, finger lime planting sites should be frost-free and protected from prevailing winds. Commercial orchards do well if planted in full sun. Like all citrus varieties, finger lime requires well-drained soils. The trees are highly susceptible to wind and sunburn, so windbreaks should be established before planting. Finger lime is reported to require less fertilizer than other commercial citrus varieties partly due to less nutrient demand: the trees have smaller leaves and smaller canopy area. It is reported that growers use 25%–30% of the total annual amount of N-P-K fertilizer applied to other commercial citrus varieties. Yields vary with cultivar, but a well-managed 5-year-old tree can produce up to 44 pounds annually.

Finger lime is very delicate and susceptible to skin damage, with close to 50% of the harvest ending up as second grade or processed fruit due to injury caused by its own thorns during harvesting. Apart from prospects of high returns, other attractive features of the crop include the fact that is reported to be highly resistant to *Phytophthora citrophthora* root disease. Preliminary studies have also indicated that finger lime is tolerant to Huanglongbing (HLB), or citrus greening, a devastating citrus disease that is now endemic in Florida. Field trials to evaluate the appropriate rootstock and nutritional requirements for optimum plant growth are currently underway at the University of Florida's Citrus Research and Education Center (CREC) in Lake Alfred, FL. Varieties currently available to growers include DPI-50-36, DPI-205-1, and DPI-205-4. However, these varieties are the typical non-pigmented type. CREC is in the process of importing the commercial red-pigmented type grown in California (VI 697 accession) to evaluate a population of seedlings from this and other red-pigmented finger limes.

The growth habit of finger limes can range from a large shrub to a medium size tree (up to 20 ft) (Australian National Herbarium). It should be noted that some growers in California are using spacing of 12 feet by 12 feet, or about 300 trees per acre. Furthermore, assuming a conservative farm gate price of $12 per pound (estimated at 40% of the retail price of $30 per pound for small [0.37 ounces per fruit]), we arrive at a gross revenue of about $57,420 per acre. In order to arrive at net return per acre, we further assumed the production cost to be around 50% of gross revenue (47% based on earlier studies carried out on 'Tahiti' lime), given the high labor requirement for harvesting. Even with this assumption, the estimated net return would still be close to $28,700 per acre. Again, it is worth emphasizing that these are conservative preliminary estimates and much research remains yet to be done on the economics of finger lime productions under Florida conditions.

MARKETING AND MARKET OPPORTUNITY

Australian government data estimate the total national production of finger limes at around 10 tons, with about half of the fruit exported to Europe and Asia. The US domestic retail price ranges from $30 per pound for the fruit (0.35 to 0.39 ounces) to about $50 per pound for the premium fruit (weighing more than half of an ounce per fruit). Once harvested, finger lime has a four-week shelf-life if stored in a cool room. The fruit, which retains its shape and flavor when frozen, is available year-round and can be a substitute to lemon and lime varieties, which do not sustain such prolonged freezing periods during storage after harvesting. Commercially, finger lime can also be used in a wide-range of pharmaceutical and nutraceutical products; however, information on market prices is not readily available.

Within the United States, finger lime is beginning to gain popularity and could eventually become more mainstream as crop supply increases and crop prices decrease. California's Central Valley between Visalia and Bakersfield is the main growing area for finger lime, with about 15,000 trees owned by less than a dozen growers. Due to its small-scale production, the fruit is somewhat difficult to find in the marketplace. The main distribution is in large metropolitan areas, where it is sold primarily to high-end retail markets and upscale hotels/bars/restaurants. Mixologists use finger lime fruit in drinks; chefs primarily use them in seafood and Asian Fusion recipes and as a caviar-type garnish. At certain markets in California, a one-ounce container sells for as high as $8. The reason for such an exorbitant price is because production volumes are still small and demand outweighs supply. As mentioned earlier, around 50% of the Australian finger lime production is exported to markets in Europe and Asia, where demand is growing; hence, the US market is not crowded.

CONCLUDING REMARKS

While commercial production of finger lime in Florida has not yet been undertaken, evidence suggests that it is likely to do well in this environment and possibly replace some of the existing crops. The varied ranges of the colors of fruit flesh and rind certainly make finger limes appealing to high-end hoteliers and those consumers wishing to try something new. Moreover, with increased production, prices on the local market will likely decline somewhat further, stimulating local demand as it becomes accessible to a wider cross-section of consumers. The crop has several attractive features, including its tolerance to some of the most devastating citrus diseases and its relatively low fertilizer requirements. Most importantly, as our preliminary desk analysis reveals, the crop has the potential for high returns. Drawbacks include the current high retail price for the crop limiting growth in demand, labor requirements for harvesting the crop, and the need to optimize production practices.

Challenges notwithstanding, the prospects for the finger lime industry look promising for Florida. Growers who would like more information on the agronomy of the crop, as well as where to obtain budwood planting material, may contact **Dr. Manjul Dutt** (**manjul@ufl.edu**), (863) 956 8679 at the Citrus Research and Education Center in Lake Alfred, FL.

SOIL HEALTH AND FERTILITY

Tina McIntyre, Rachel Gutner, Tiare Silvasy, and Esen Momol

INTRODUCTION

Integrating practical pest management strategies, addressing plant nutrition and proper irrigation scheduling are very important for successful cropping. This publication provides growers with key agricultural concepts and tips to enhance the health and fertility of soils while protecting the environment. Healthy soils result in improved production, fruit quality, and a more resilient environment.

This publication specifically addresses Best Management Practices (BMPs) for building soil and maintaining soil health. Florida soils are naturally sandy and low in organic material, resulting in leaching and low nutrient levels. Soil amendments are important in the success of plant production.

ASSESSING SOIL HEALTH

The foundation for growing healthy plants begins with healthy soil. If soil quality is compromised, plants will produce poor yields. Soil structure and type affect a plant's ability to grow roots and uptake water and nutrients. Organic matter is vital to healthy soil because it provides nutrients and habitat for microorganisms and binds soil particles, which improves the water-holding capacity of soil. Following fertilizer recommendations can help prevent nutrient deficiencies, improve tree health and increase crop yield.

INCREASING SOIL HEALTH AND FERTILITY

BENEFITS OF ADDING COMPOST AND MANURE

Manure can be used similarly to compost and greatly improves organic matter content in soil. Animal manure should always be composted before use because raw manure can be a risk to food safety. Adding compost to your soil will increase the amount of organic matter and improve the health and production of plants.

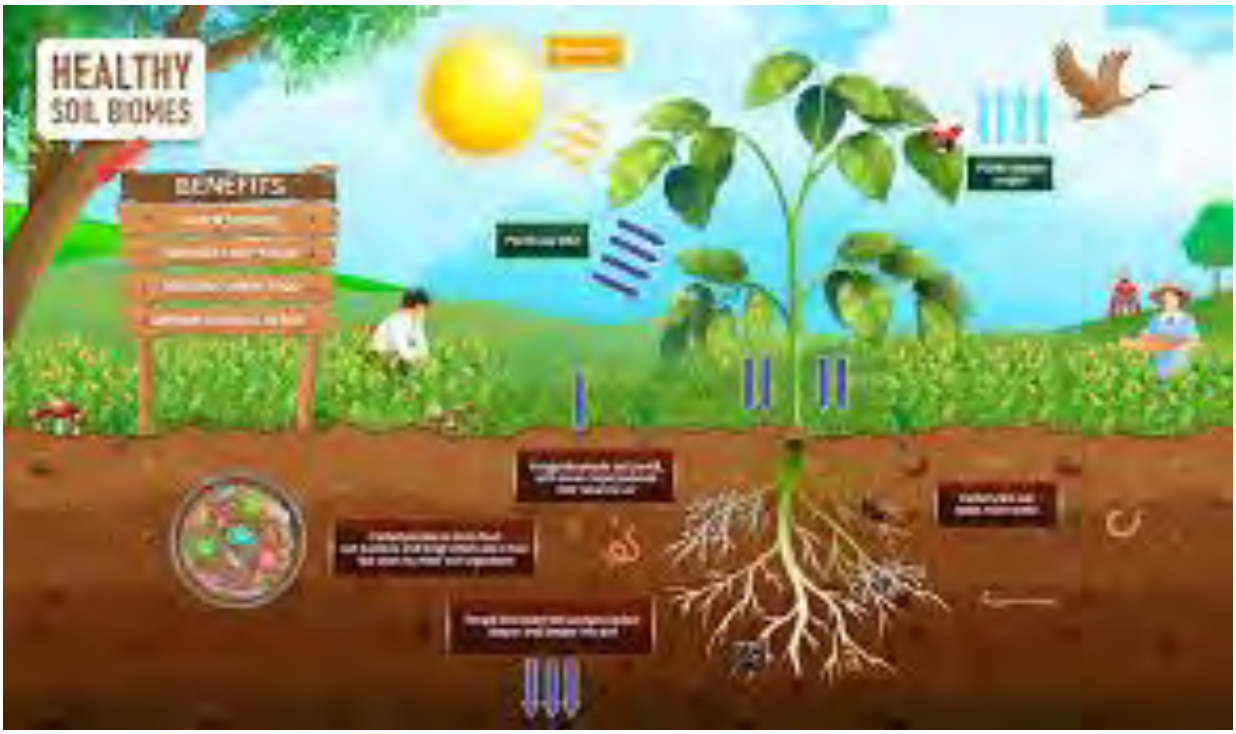
WATER MANAGEMENT

Proper water management is an essential practice. Overwatering can lead to nutrient leaching, which can seep into the underground aquifer or runoff into nearby water bodies. Saturated soil may encourage harmful pathogen growth due to root rot. It leads to shallow root systems, making soil more vulnerable to erosion. A great way to ensure proper watering is to invest in a reliable irrigation scheduling system. Controlling the time and rate at which your trees are watered prevents water waste and pollution. Appropriate and efficient irrigation reduces water use and improves nutrient uptake by plants.

CROPS TO FORTIFY SOIL

There is a good opportunity to increase soil organic matter by utilizing cover crops. For legumes, when tilled into the soil and allowed to decompose after harvest, approximately two-thirds of their nitrogen is available for the main crop. When composted, nutrients are recycled into the soil system for crop use. Legumes also improve the soil's microbial activity and physical and chemical properties. Cover crops, such as cowpea, clover, winter rye, buckwheat, and sunn hemp also help in soil recovery, reduce erosion, and aid in pest and weed management. Some are referred to as "green manure," a crop primarily used for soil amendment and as a nutrient source.

SOIL MICROBIOME



The plant soil microbiome is the dynamic, living community of microorganisms that live in soil and interact with plants. Plant soil microbiomes are underground communities made up of bacteria, archaea, and fungi that have potentially harmful or beneficial aboveground implications. The microbiome can help plants adapt to drought, heat, and other stressful conditions. Because the soil microbiome affects plants and vice versa, treating the soil with care is tied to the health of the microbiome. The soil microbiome is affected by a variety of factors including the soil composition and physical properties, nutrient availability, and plant species. Regularly applying compost and manure contributes to soil building and is essential to microorganisms and the environment.

Soil is considered by many to be inert, but it is one of the most diverse ecosystems, consisting of a vibrant community of microorganisms and a thriving food web. This food web connects fungi, bacteria, microarthropods, nematodes, and protozoa that live in healthy, productive soil. Each plays a vital role. Fungi decompose dead wood and replenish organic matter into the soil, then bacteria break down wood and other plant material, and microarthropods shred organic matter, stimulating microbial activity. Nematodes cycle nutrients and can suppress disease; however, some may be harmful. Protozoa can cycle nutrients.

The soil microbiome is invariably tied to soil health. Microorganisms that live in the soil have been shown to prevent and fight against plant pathogens and improve nutrient availability for plants. Mycorrhizae (fungi) systems have been shown to form beneficial relationships with the roots of plants and form a protective cover around the roots, as well as provide the plant with nutrients, primarily phosphorous, and water.

Individual Protective Covers (IPCs)

An increasing number of citrus growers and researchers in Florida are using individual protective covers (IPCs) for their young citrus trees. They are called Tree Defenders, Tree Sleeves, TreeTubes, TreeGuardians, and mini-cups. These covers are installed immediately after the new trees are planted and are usually kept for two years. With no psyllids getting through the cover, trees avoid infection for the time the covers are on the trees. Without infection, trees enter the fruit-producing stage disease free. The delay in HLB infection maximizes yield for many years to come. The covers not only help prevent psyllids from infecting citrus trees with greening, but they also help trees grow faster and larger. Research demonstrated that IPCs stimulate growth due to increased leaf chlorophyll, reduced vapor pressure deficit, and increased stomatal conductance and photosynthesis. IPCs are a cost-effective and an efficient tool in growing healthy citrus trees. The covers cut the costs of chemical treatments to control psyllids, leafminers, weevils, aphids and other pests. Citrus canker infection and spread are also reduced. Although the primary target is the citrus psyllid, IPCs also protect trees from deer, wind, frost, and hail damage. Typically, the optimum profitability for use of small, cheap IPCs is 2 years, but IPCs can be reusable for several more years on future resets. In conclusion, IPCs provide an effective solution to citrus greening by preventing psyllids from infecting trees during their first two years. They are a highly profitable investment for citrus growers who plant young trees. They create a micro-environment that keeps insect pests out and promote healthy vegetative growth.

IPCs are useful for newly planted solid blocks as well as for resets. IPCs come in different sizes and shapes. Larger size IPCs can protect trees for up to 4 years.

However, like any other tool or strategy, these covers are not perfect. They allow some scale insects, mites, and mealy bugs inside some covers. These tiny pests or creatures can multiply to heavy populations because of the lack in biological control with parasitoids and predators not being able to get inside the covers.

BIOSOLIDS

Biosolids are nutrient-rich organic materials. Although classified as a waste material, biosolids can be beneficial to agriculture because they contain many essential plant nutrients and organic matter. Following proper treatment and processing, biosolids can be recycled as fertilizers or soil amendments to improve soil chemical and physical properties with negligible negative impacts.

Application of organic wastes like biosolids to agricultural land provides several benefits, including:

1. Reduction of the chemical fertilizer requirement, since biosolids are sources of many plant nutrients;
2. Improvement of soil chemical properties by increasing the nutrient pool, promoting an increase in pH of acid soils, and increasing soil buffering capacity;
3. Improvement of soil physical properties, such as structure and particle aggregation, aeration and drainage, and water retention;
4. Enhancement of biological properties by increasing microbial communities and soil fauna and contributing to disease suppression.

Biosolids are generated when solids, accumulated during domestic sewage processing, undergo pathogen control treatment that meets federal and state sewage sludge regulatory requirements before being applied to the soil. Wastewater treatment facilities monitor their incoming wastewater stream to ensure that the water and the accompanying organic material are safe to recycle and are compatible with the treatment plant process. This pre-treatment has resulted in dramatic decreases in metal concentrations of biosolids nationwide. The biosolids of today are cleaner and of better quality than those that were produced one to two decades ago.

Once wastewater reaches the treatment plant, domestic sewage is subjected to physical, chemical, and biological processes that kill pathogens and remove solids. The overall mass and volume of solids are reduced as the organic matter is degraded and digested by microorganisms. At some treatment plants, the solids are further treated with lime (calcium oxide or calcium hydroxide) to raise the pH, which reduces bad odors. Lime treatment also decreases the amount of pathogens and the attractiveness of the material to insects and other organisms capable of transporting diseases.

Agricultural uses of biosolids that meet strict quality criteria have been shown to produce improvements in crop growth and yield when applied at recommended rates. Nutrients found in biosolids, including nitrogen, phosphorus, sulfur, calcium, magnesium and micronutrients, are necessary for crop growth and production. Most biosolids contain micronutrients in a natural organically-chelated form. Crops

use nutrients from biosolids efficiently because they are released slowly as the biosolids break down. Biosolids application does not necessarily replace inorganic fertilization. Organic wastes lack the proper balance of nutrients necessary to fully meet crop requirements. They can, however, be used in conjunction with fertilizers to reduce chemical fertilizer inputs. At high rates, the organic matter in biosolids can improve water and nutrient holding capacities of the soil.

Because the fertilizer value of biosolids is so well established, most recent investigations in Florida have focused on various environmental or health risk evaluations. Research has addressed "heavy metal" (cadmium) availability to plants, toxic organic behavior, and possible molybdenosis risk to cattle grazing biosolids-amended pastureland. A major current interest in Florida is the biosolids-phosphorus relationship because many states, including Florida, are moving to restrict biosolids application rates based on phosphorus concerns associated with water quality impairment (leaching and runoff). Researchers are studying phosphorus forms, solubility, leachability, and availability to plants.

Decades of worldwide research have demonstrated that biosolids can be safely used in agriculture. As previously mentioned, some biosolids are treated with lime to reduce pathogen concentrations. These lime-stabilized biosolids have an alkaline pH and can increase soil pH the same way agricultural lime does following application to soil. A major land application issue in Florida is the use of lime-stabilized biosolids on pastures where "acid-loving" grasses like bahiagrass grow. Addition of an alkaline material can result in elevated soil pH, which in turn leads to poor grass growth caused by micronutrient deficiencies. For a citrus grove that has been receiving alkaline irrigation water and/or has been limed to obtain a soil pH of 6.0 to 7.0, a lime stabilized material could possibly induce a micronutrient deficiency because it has a pH greater than 12. Florida's sandy soils have low capacity to resist changes in pH. Thus, soil pH can increase quickly and substantially in fields where lime-stabilized biosolids have been land applied. Production managers using soil amendments should be aware that biosolids may contain lime, and should apply biosolids stabilized by other means where acid-loving plants are growing.

Biosolids are land-applied across most of the state of Florida without restriction beyond the basic federal and state guidelines. However, since biosolids contain considerable amounts of phosphorus, application has recently been limited or banned outright in phosphorus-sensitive regions (e.g. the area adjacent to Lake Okeechobee) due to water quality concerns. FDEP and the USEPA continue to support land application of biosolids and insist that, when conducted correctly, the practice is safe. USEPA continues to support research to improve testing and verification procedures confirming that treatment practices accomplish intended pathogen reductions.

There are several types of municipal biosolids available for land application in Florida, and they can vary widely in moisture content: a) Fresh Materials--2-6% solids; b) De-watered materials--18-

35% solids; and c) Pelletized (granular), like Milorganite and Granulite organic fertilizers--more than 90% solids. The stabilization process used to treat wastewater significantly alters the nutrient composition and the rate of nutrient release or mineralization of the resulting biosolids. Mineralization values ranging from 40 to 50% of the organic N from aerobically (with oxygen)-digested sewage sludge and 25 to 40% of the organic N from anaerobically (without oxygen)-digested sludge have been reported during the initial crop season. Mineralization rates of approximately 40%, 15%, and 10% have also been estimated for waste-activated sludge, anaerobically-digested sludge, and composted sludge, respectively.

The two main types of biosolids produced in Florida are based on the stabilization process: 1) lime-stabilized, and 2) stabilized by other processes (chemical, physical, or biological). Most biologically stabilized materials undergo an aerobic or an anaerobic digestion process. The typical compositions of lime-stabilized and anaerobically-digested biosolids are shown in the Table next page.

Economic values of biosolids are determined by the marketplace of goods and services for which people are willing and able to pay. Grower should be willing to pay for biosolids only if the product increases overall net returns. An increase in net returns can be achieved by reducing production costs and/or increasing crop yield or quality. Growers and farmers purchase fertilizers and liming materials, and the extent to which biosolids provide plant nutrients and/or liming capacity provides a basis for valuing biosolids.

Biosolids pose a management challenge in that they do not deliver plant nutrients in the same proportion required for crop production. The economic value of biosolids can be expanded to include micronutrients. Most biosolids contain micronutrients in a natural "chelated" form. Commercially available chelated products can be expensive.

Computing a value for biosolids is a worthwhile exercise for growers who are considering supplying a portion of plant nutrient requirements with biosolids rather than with commercial sources. While the actual material may be "free," other costs such as transportation and field application have to be considered. If the "value" of the biosolid is less than these costs, applying biosolids will not be a wise economic decision. The value of a biosolid will depend on the nutrient analysis of the material and amount of nutrients which will be utilized at a specified application rate. Improvements to soil tilth, microbial populations, and disease suppression are other benefits associated with applying biosolids, but they are difficult to be quantified in terms of yield gains.

Selected characteristics of two types of municipal biosolids.

	Type of Biosolids	
Characteristic	**Anaerobically Digested**	**Lime Stabilized**
Solids (%)	25	25
Nitrogen (%)	5.6	3.8
Phosphorus (%)	2.2	1.0
Potassium (%)	0.2	0.4
Copper (ppm)	566	236
Molybdenum (ppm)	23	5
Zinc (ppm)	1484	321
Arsenic (ppm)	4	1
Cadmium (ppm)	11	4
Chromium (ppm)	91	10
Lead (ppm)	195	17
Nickel (ppm)	59	33
Mercury (ppm)	2	2
Selenium (ppm)	3	1
pH	8	12

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__Hispanic
__White, non-Hispanic
__Black, non-Hispanic

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__Female
__Male